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Cover: A bag worm with its beautiful heap of junk. Acrylics on 300 GSM paper by Dupati Poojitha based on a picture by Sanjay Molur.

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COMMUNICATION

Assessment of nest and nesting activities of White-bellied Heron *Ardea insignis* Hume, 1878 (Aves: Ardeidae) in the broad-leaved forests of northeastern India

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Abstract: The discovery of White-bellied Heron *Ardea insignis* nesting in India in 2014 was a significant record since it was the second nesting report in India after one reported in Bhutan 'dooars (= Terai)' below Darjeeling. White-bellied Herons are known to build their nests in the riverine forests between 300 m and 1,500 m. The majority of the nesting records are from Chir Pine *Pinus roxburghii* forests of Bhutan. This article highlights heron's nest site selection and nesting activities in the broadleaved forests in Arunachal Pradesh, India. During the study period (2013–2017) in Namdapha Tiger Reserve, two active nests of this species were recorded one in 2014 and another in 2015. Though both the nests failed without producing any offspring, the findings, shed crucial information, especially on how the herons select their nesting sites and nest trees and the risks involved in the process. These findings will help implement conservation actions especially while safeguarding the known nesting sites in India.

Keywords: Arunachal Pradesh, behavioural ecology, Critically Endangered, eastern Indian Almond, Hollock, Namdapha, nest material trips, nesting tree.

Bengali: ভারতবর্ষে, ২০১৪ সালে, সাদা-পেটের বক তথা *Ardea insignis*-এর বাসা বাঁধার ঘটনাটি ছিল একটি উল্লেখযোগ্য আবিষ্কার, কারণ এই ঘটনাটি, দার্জিলিংয়ের নীচে ভুটানের 'ডুয়ার্স (তরাই)'-এর পরে, ভারতে দ্বিতীয় বাসা বাঁধার ঘটনা হিসাবে বিবৃত হয়েছিল। সমুদ্রপৃষ্ঠ থেকে ৩০০-১,৫০০ মিটার উপরে নদী-তীরবর্তী বনে, সাদা-পেটের বক, বাসা তৈরি করে বলে জানা যায়। ভুটানের চির-পাইন বা *Pinus roxburghii* বন থেকে এই পাখিটির বেশিরভাগ বাসা বাঁধার বিবরণ পাওয়া গেছে। এই নিবন্ধটি ভারতবর্ষের অন্তর্গত অরুণাচল প্রদেশের বিস্তৃত-পাতাযুক্ত বনে (broad-leaved forest), এই বকদের বাসা নির্বাচন এবং তাদের বাসা বাঁধার ঘটনাবলী উল্লেখ করে। নামদাফা ব্যাঘ্র প্রকল্পে (Namdapha Tiger Reserve) গবেষণার সময়ে (২০১৩-২০১৭), এই প্রজাতির পাখিটির, দুটি সক্রিয় বাসা পাওয়া গিয়েছিল, একটি ২০১৪ সালে এবং আরেকটি ২০১৫ সালে। যদিও উভয় বাসাই খুব সম্ভবত কোনও সন্তান উৎপাদন না করে ব্যর্থ হয়েছিল, তবুও তৎকালীন অনুসন্ধানগুলি, গুরুত্বপূর্ণ তথ্য প্রকাশ করে, বিশেষ করে এই প্রজাতির বক কীভাবে তাদের বাসা বাঁধার স্থান এবং বাসা বাঁধার গাছ নির্বাচন করে এবং প্রক্রিয়াটির সাথে কি ধরনের ঝুঁকি সম্পর্কিত। এই আবিষ্কারগুলি, এই বিরল প্রজাতির বকের সংরক্ষণকে কার্যকর করতে, বিশেষত ভারতবর্ষে, তাদের পরিচিত বাসা বাঁধার স্থানগুলিকে সুরক্ষিত করার ক্ষেত্রে, উল্লেখযোগ্য ভূমিকা পালন করবে।

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Author details: Himadri Sekhar Mondal completed his PhD on the behavioural studies of Critically Endangered White-bellied Heron *Ardea insignis* from the Pondicherry University in 2019. He has joined BNHS as scientist on 2018 and has worked on different projects since then. He is currently working on the birds and wetlands of the Sikkim Himalaya. Gopinathan Maheswaran is presently working as senior scientist in Zoological Survey of India's HQ office at Kolkata mostly on the foraging behavior of long-legged wading birds. He is currently involved in another DST-sponsored project on White-bellied Heron in Namdapha Tiger Reserve of Arunachal Pradesh.

Author contributions: HSM involved in data collection, analyses, conceptualization and writing of this article. GM helped in writing of this article and also, involved in its correction and accrued the fund for this study.

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INTRODUCTION

The White-bellied Heron (WBH hereafter) is the only heron classified as 'Critically Endangered' by the IUCN Red List of Threatened Species (Maheswaran et al. 2021a; BirdLife International 2024). It is a resident in Bhutan, northeastern India and Myanmar with merely about 60 reported individuals (Price & Goodman 2015 Maheswaran et al. 2021b). In India, it is mainly reported from Namdapha Tiger Reserve (Mondal & Maheswaran 2022), Kamlang National Park and reserve forests in Walong area of Anjaw District, Arunachal Pradesh (Reddy et al. 2021).

In Bhutan, the first nest of WBH was reported in 2003 (Acharja 2019; Khandu et al. 2020); with 27 active nests identified by 2017 (Khandu et al. 2020). In India, Hume & Oates (1890) reported the first nest of *Ardea insignis* as a platform of sticks placed on the top of a large tree in an inaccessible swampland southern of Darjeeling, in the Bhutan dooars (= terai). No photographic evidence was available as it only mentioned that a large stick nest was placed high upon a large tree in a swampy and inaccessible area. The breeding period mentioned was during July–August. the present study documents two nests of WBH from the Namdapha Tiger Reserve. This article will be the first of its kind that will assess the nesting of this rare heron species in India and aid in further research and future conservation action and management plans.

MATERIALS AND METHODS

During the study period (2013–2017), in Namdapha Tiger Reserve (27.392–27.661 °N & 96.251–96.976 °E) (NTR hereafter) (Image 1), all the activities of WBHs were monitored and recorded along with their nest building activities. The studies focused on understanding how nest site/s were selected and followed by the nest building activities.

Behavioural observation

Studies on nest-building activities of WBH were conducted over two years (06–18 March 2014 and from 24 February 2015 to 10 May 2015). Nesting activities were observed for a total of 39 days—eight days in 2014 and 31 days in 2015. The longest continuous stretch of observation was from 24 February to 4 April 2015. During this period, observations were made for 25 days with intervals of 1–2 days in between. The continuous scan sampling method (Martin & Bateson 2007) was used to record various nest-building activities of WBH from 0530 h to 1730 h. Various behavioural activities of WBH were observed during this period: courtship (making calls for its mate and greet their mates when they come back to the nest), nest-material trips (when one of the pair flew to bring nest material to the nest), foraging (catching fish at the river). Observations were made from a distance of 300 m with a pair of 8 x 40 binoculars (Nikon) and a spotting scope (Nikon) and photographed with Nikon D70S SLR camera and Sigma 500 mm telephoto lens. Hideouts constructed at a distance of 100 to 150 m from the nest tree to observe behavioural activities without disturbing the nesting. Locating the active nest of WBH is merely a chance and can be found by following the adult bird from their foraging sites to the roosting area, especially during breeding season. As soon as WBH was spotted at its nest, or seen building the nest, the observation on the individual/pair started and continued till the heron(s) disappeared from the sight or flew away towards the Noa-Dehing River for foraging or nest material collection. As WBHs do not have any distinctive sexual dimorphism, identifying individual birds remained difficult.

Evaluation of the nesting sites and nests

The tree species used for nesting by WBH was identified using Chowdhery et al. (1996). The height of the nesting tree and the height at which the herons built their nests were measured using conventional methods of measuring a smaller tree nearby, using rope and then extrapolating that with the nest tree to arrive at the actual height. The diameter of the fallen nest was measured with the help of a measuring tape. Coordinates and elevations of the respective locations were recorded using Garmin GPS. Using Google Earth, the aerial distance were measured between the nesting tree and the regular foraging sites and human tracks and villages.

Data analysis

Nesting: Time spent by WBH in nesting was calculated for each day. The entire observation period of a day was divided into three categories:

(i) Morning: 0530–0930 h.
(ii) Mid-day: 0930–1330 h.
(iii) Evening: 1330–1730 h.

The percentage time spent by the pair in nest-building activities was calculated for different times of the day.

$$\frac{\text{Hours spent on nesting on a specific category of time of the day}}{\text{Total hours spent on nesting}} \times 100$$

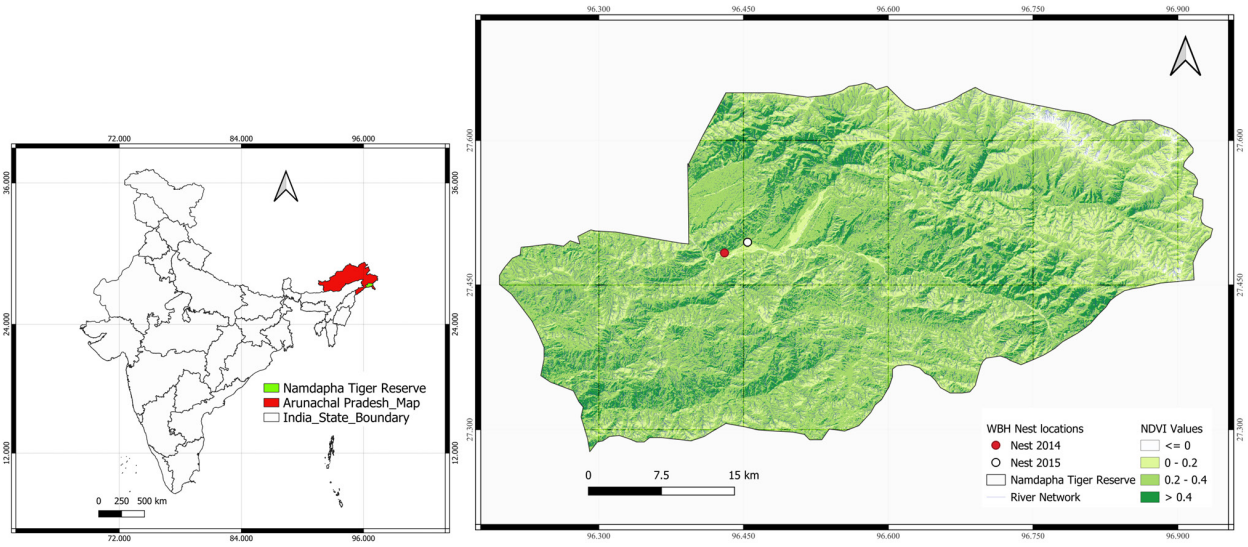

Image 1. Map of Namdapha Tiger Reserve indicating nests of White-bellied Heron.

Mean±SD of each of these categories were calculated to understand during which time of the day the species preferred to construct their nest.

Nest material trips

'Nest material trips' are the trips (flights) made by the adult nesting birds from their nesting tree to the nearby trees or land and return to their nest with sticks in their bills (Maheswaran & Rahmani 2005). These sticks or 'nest materials' are collected by the WBH, waiting in the nest. Whenever the herons returned to the nest with nest materials in their bills the time taken to make such trips was also recorded. At a time, WBHs were seen collecting only one piece of nest material. Percentage (%) of nest material trips and percentage (%) and Mean±SD value of time spent on such trips were calculated for each category during different times of the day and also for the years 2014 and 2015, separately.

RESULTS

Nesting sites: Two nests of WBH, one each in 2014 and 2015, were located in different tree species (Table 1) that were 2.69 km apart. Each year, one pair of WBH was spotted building the nest. It could not be confirmed whether the same pair of WBH constructed both nests. Certain features were common for both nesting sites.

Forest type: The forest type of this area is categorized as the northern tropical evergreen forest or Assam Valley tropical wet evergreen forest. Champion & Seth (1968) mentioned three types of forests in NTR: (a)—northern tropical evergreen forest or Assam Valley tropical wet evergreen forest (dominated by *Dipterocarpus*) | (b)—northern Indian tropical moist deciduous forest (dominated by *Terminalia*) | and (c)—miscellaneous forest (no single species dominance). In both years, WBHs were seen building their nests only in the nearby riverine or fringes of the forests but not much in the interiors.

Forest edge: The trees chosen to build the nest were at the forest edge, between the open riverbed and the interior dense forest. Distance of the nesting tree from their regular foraging site was 663 m and 201 m in 2014 and 2015, respectively.

North-sided forest: WBHs were seen almost regularly foraging in the Noa-Dehing River that flows in an east-west direction at the 27-mi area of NTR. Both nests were recorded at the north-sided forest of this area. Also, the north-sided forest is less anthropogenically disturbed than the south-sided forest.

Nest Azimuth: In both years WBHs were seen building their nest facing east that ensured better reception of sunlight throughout the nesting period.

Human trails: The nearest human track was on the other side of the Noa-Dehing River (near south sided forest), more than 800 m away from the nest. The nearest human settlement was far more interior in the forest (at least 1.5 km away from the nesting site) (Table 1).

Nesting tree height: WBH selected 22–33 m trees to build their nests although there were many tall trees in the vicinity.

Position of the nest in the tree: WBH did not

construct nests at the top of the nesting tree but the nests were built at the middle, more specifically on the outer branches (Images 2, 3, & 4).

Nesting activities

In 2014 and 2015, in NTR, the courtship of WBH was observed starting from January onwards. In 2014, WBH already started building their nest by the time we noticed them on their nest for the first time (Image 2). On 24 February 2015, it was assumed that the WBH pair was seen to assess the trees to select the nesting tree as they were flying from one tree to the next and eventually settled for one, where they removed a few branches and leaves with their bill to create some vacant space to build their nest. From 26 February 2015 onwards, the pair started nest material trips that lasted up to 21 March 2015. The number of nest material trips gradually decreased towards the later phase of the nest-building period. During this time, WBHs were also seen spending a considerable amount of time on the nest without any nest material trips (Image 3). From 25 March 2015 onwards, at least one of the adult herons was seen in the nest throughout the observation period, indicating that the female had laid the egg(s). No drastic step like moving very close to the nest in the presence of the birds or climbing up the nesting tree were undertaken to observe the activities of adults and to look for eggs and chicks at any point in time ensuring zero disturbance in their habitation and activities.

Nesting activities of WBH were observed for a total of 93.74 h (17.67 h in 2014 and 76.07 h in 2015) in 34 days (8 days in 2014 and 31 days in 2015). During this period, WBHs were recorded completing 175 nest material trips (total duration – 17.8 h).

During the nesting period (mainly at the beginning), WBHs were spotted less frequently at their foraging site/s during morning hours as they were engaged in nest-building activities (Table 2 & 3). The majority (90.85%) of the nest material trips were also conducted in the morning (Table 3). These trips generally started from 0630 hr and were at their peak at 0700–0800 h. Each trip was 0.02 to 0.3 h long. The mean length of each nest material trip was 0.10±0.06 (Mean±SD) hr. On four occasions, the herons were seen returning to the nest without any nesting material (n = 1 in 2014 and n = 3 in 2015). Generally, the pair were seen to cease their nest-building activities around 0830 h and both of them flew (generally one after another) to their foraging site/s.

Fate of the identified Nests

2014: The breeding success of the 2014 nesting pair was not known because that study could not be continued from mid-March 2014 onwards due to excessive rainfall and heavy floods in the study area. The nest that WBH built in 2014, could be seen on the same tree but found abandoned in 2015 (Image 4).

Table 1. Details of the nesting trees of White-bellied Herons identified in Namdapha Tiger Reserve.

Particulars	First nesting tree (2014)	Second nesting tree (2015)
Common name	East Indian Almond *Terminalia myriocarpa* (Van Heurck & Müll. Arg.)	Hollong *Dipterocarpus macrocarpus* (Vesque)
Local name	Hollock	Hollong
Altitude	426 m	410 m
Height of the nesting tree	22–27 m	28–33 m
Height of the nest from the ground	18 m	25 m
Distance from nearest regular foraging site	663 m	201 m
Distance from human settlement or road	1.55 km (nearest village) 0.86 km (from the nearest regular dirt track used by villagers)	1.90 km (nearest village) 1.36 km (from the nearest regular dirt track used by villagers)

Table 2. Time spent by White-bellied Heron while nesting during different times of the day in Namdapha Tiger Reserve.

Observation	Times of the day (h)		
	Morning	Mid-day	Evening
2014	16.37	0.72	0.58
2015	45.08	16.40	14.58
Total	61.45	17.12	15.17
Percentage (%) Mean±SD	77.96±36.71	14.07±29.86	9.51±23.52

Table 3. Nest material trips by White-bellied Heron during different times of the day in Namdapha Tiger Reserve.

Times of the day	Number of nest material trips		Duration of nest material trips		
	n	%	hr		%
			Total	Mean±SD	
2014	54	30.86	6.48	0.12±0.06	36.42
2015	121	69.14	11.32	0.09±0.06	63.58
Morning	159	90.85	16.87	0.11±0.06	94.75
Mid-day	13	7.43	0.77	0.06±0.03	4.31
Evening	3	1.72	0.17	0.06±0.04	0.94
Total	**175**	**100**	**1068**	**6.10±3.68**	**100**

Image 2. Nest-building activities of White-bellied Herons *Ardea insignis* at 27 mi in 2014 (Mondal & Maheswaran 2014).

Image 3. Active nest of White-bellied Heron at 27 mi in 2015.

Image 4. Abandoned first nest (nest built in 2014) of White-bellied Heron at 27 mi in 2015.

Image 5. A part of the broken eggshell near the fallen nest of White-bellied Heron at 27 mi in 2015.

Image 6. Fallen nest of White-bellied Heron at 27 mi in 2015.

2015: On 13 May 2015, it was found that the WBH nest amidst the boulders (almost dried stream) (Image 6). The maximum diameter of that nest was 141.8 cm. The fallen nest consists of only dry branches or twigs of 50–110 cm in length (average length 83.46±15.60 cm; n = 24). One large portion of the broken eggshell (3.6 cm length) was also found at the same site (Image 5), 28.2 m away from the fallen nest. It was presumed that it was of WBH as we could not see any other nest nearby. The outer colour of the recovered eggshell was

light blue with a white inner surface. No traces of yolk were present in the egg shells. As permission to collect samples were not granted, the egg shells and the twigs were left in place after being photographed. The reason why the nest had fallen remains unclear.

During the remaining study period (till January 2017) in the study area, we neither came across any other nests nor any juveniles of WBH in NTR.

DISCUSSION

Larger herons are generally known as colonial breeders (Kushlan & Hancock 2005; Stier et al. 2017; Byju et al. 2024) but WBH is a solitary breeder. In Bhutan, WBH were mainly known to nest in the Chir Pine *Pinus roxburghii* trees (Acharja 2019; RSPN 2024). The study discovered that WBHs also prefer broadleaved forests. In 2018, a similar record also from Bhutan (Nesting trees *Michelia champaca* and *Pterospermum acerifolium*; Khandu et al. 2020). In 2021, two WBHs with their active nest were spotted in Walong (1,123 m), Anjaw District, Arunachal Pradesh (Reddy et al. 2021), a habitat dominated by Chir Pine forests.

Nesting site selection is extremely essential for the continual survival and reproduction of the nesting bird species (Dyrcz et al. 1981; Nguyen et al. 2003). Forest fires at the Chir Pine forest nesting sites are quite frequent in Bhutan and Walong. Whereas, the nesting sites in the broad-leaved forest are less likely to suffer from forest fire (Khandu et al. 2020).

In NTR, WBHs selected 22–33 m trees to build their nests at the height of 18–25 m (Table 1), similar to the height of the nests (18.3±7.4 m) in the trees in Bhutan (Acharja 2019).

For the majority of the cases in Bhutan, WBH nests were at the top of the nesting tree (Acharja 2019). In NTR, WBH constructs their nests in the middle, more specifically on the outer branches. Such a position ensures easy entry and exit for a large bird-like WBH (wingspans approximately 2 m in flight), better visibility of their feeding sites and potential threats or disturbances nearby (Mondal & Maheswaran 2014).

The nearest human track and human settlement were on the other side of the Noa-Dehing River (near south-sided forest) (Table 1). Hence these nesting sites receive less anthropogenic disturbances. This is very important for a shy species like WBH (RSPN 2012; Acharja 2019) whose minimum tolerance distance to human presence was roughly estimated to be 150 m in Bhutan (Acharja 2019). In NTR, the herons are more shy and the tolerance distance to any human presence was around 200–300 m. WBH have been found to remain in their nests until any disturbance or threat from closer distance particularly during their initial phase of nesting.

From the information available on the WBH nesting sites in NTR, Bhutan (Acharja 2019) and Walong (Reddy et al. 2021), the following possible inferences can be drawn.

i) They nest at the riverine forest edges that are also close to their feeding grounds. Furthermore, the vast open river gave herons a clear view of any approaching threat.

ii) They prefer to nest in the north-sided forest maybe because it is less disturbed and they can build east-facing nests that can potentially aid in the incubation process by providing heat from direct exposure to the sun.

iii) They tend to abandon their older nests though this aspect needs to be studied further.

Both in India and Bhutan, nesting of WBH usually begins from late February to early March onwards. Herons generally build their nest during morning hours (Kushlan & Hancock 2005). The weather during morning hours seems less stressful to birds and morning fog in this area can soften the tree branches and make it easier for the WBH to break. Most likely it took almost a month for the pair to prepare their nest for laying eggs. After laying the eggs, they spent more time hatching or protecting the eggs/ chicks from danger.

The diameter of the fallen nest is similar to the nest diameter (1.5 m) of the large heron species, as suggested by Kushlan & Hancock (2005). In Bhutan, the diameter of the WBH nests was measured at around 87–120 cm (Acharja 2019). The larger diameter of the nest in NTR, can be attributed to the loosening of twigs when the nest fell from 25 m height.

Like Great Blue Heron, the broken egg shells found beneath the nesting tree might indicate the possible result of hatching (Cottrille & Cottrille 1958). No live or dead chicks were found near the spot in NTR. Acharja (2019) postulated that WBH nesting in the broad-leaved forest can result in breeding failure particularly because of predation. In Punatsangchhu, Bhutan, numerous droppings of small frugivorous mammals and monkeys were found near the unsuccessful nesting sites (Acharja 2019). No such droppings were found at the fallen nest site in NTR.

Though the observations on these two nests were anecdotal, their discovery in the riverine habitat of the broad-leaved forest indicates the importance of conserving this habitat not only to ensure future

conservation of the breeding pairs within NTR but also ensure long-term survival of the species in NTR (Mondal & Maheswaran 2022), particularly when this area is infamous for illegal logging, hunting (Datta et al. 2008) and fishing (Maheswaran 2007).

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