

# Breeding ecology of the Painted Stork *Mycteria leucocephala* in a managed urban wetland

Kulbhushansingh R. Suryawanshi & K. S. Gopi Sundar

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Kulbhushansingh R. Suryawanshi, Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570002, Karnataka, India;

Snow Leopard Trust, 4649 Sunnyside Av. North, Suite 325, Seattle, WA 98103, USA. [KRS]

K. S. Gopi Sundar, Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570002, Karnataka, India; Program SarusScape, International Crane Foundation, Baraboo, USA. [KSGS]

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## Abstract

Urbanisation is an important driver of global change. There is relatively little information on how urbanisation is impacting wetland birds in India. We studied the nesting of Painted Storks *Mycteria leucocephala* at Jakkur Lake in Bengaluru to document the seasonality and breeding success in an urban wetland in southern India. We recorded the total number of nests and chicks in the colony during the entire nesting season from January to May 2017. A total of 66 nests were recorded and they fledged a total of 137 chicks. Of 50 nests that were monitored closely, 10% were abandoned. The mean number of chick per nest was 2.36 (SD = 0.62) and ranged between two and four chicks per nest. We used abundance data from eBird and show that Painted Stork nesting at Jakkur Lake probably started as recently as 2017. We demonstrate that using a combination of primary observation and eBird data can provide valuable insights in to the nesting ecology of large waterbirds in urban areas.

## Introduction

Urban areas are hotspots of global change (Grimm *et al.* 2008). Urbanisation has especially significant impacts on the structure and functions of wetlands (Faulkner 2004). Urban development heightens rates of local extinction and native species are rapidly replaced by commensal or exotic invasive species (Blair 1996; Marzluff 2001). Despite their simplified structure and reduced function, urban wetlands provide important ecosystem services and critical habitat for birds in an otherwise modified landscape (Boyer & Polasky 2004). Several studies have assessed the effects of urbanisation on bird species richness and its determinants (McKinney 2008). However, there is little work on the role of urban wetlands in supporting bird density and diversity (Sundar *et al.* 2015).

The Painted Stork *Mycteria leucocephala* is a Near Threatened large waterbird found in South- and South-east Asia (BirdLife International 2016). It is an obligate piscivore and shows a wide variation in nesting times across its distribution range (Urfi 2011). Despite being an obligate piscivore feeder (Kalam & Urfi 2008), the Painted Stork is known to nest in a diversity of habitats ranging from urban areas (Delhi zoo; Desai 1971), villages (e.g., Kokkare Bellur; Manu & Jolly 2000), protected wetlands (e.g., Sultanpur, and Koeladeo Ghana National Park; Ali 1959; Urfi *et al.* 2007), and mangroves (Bhitarkanika; Gopi & Pandav 2007). In northern India the species nests from August to March while in southern India it nests between January and June (Urfi 2011). Detailed information on Painted Stork ecology is biased towards nesting studies, and a vast majority of these are from northern India with few observations of behaviour and breeding success metrics from southern India (Urfi 2011). There are no observations on Painted Stork ecology and requirements from urban settings in southern India. We conducted observations on the nesting of the Painted Stork in the Jakkur Lake to document the seasonality and nesting success of the species in an urban wetland in southern India. The Jakkur Lake is situated in the residential part of the Bengaluru city and provides an interesting opportunity to understand the nesting demography of this species in an urban wetland in southern India.

## Study area

Jakkur Lake (13.086°N, 77.610°E) is a publicly managed perennial human-made lake in north-eastern Bengaluru (Unnikrishnan & Nagendra 2015). It is about two kilometers long in the north–south direction, and about 500 m at its widest. It is part of the interconnected lake system in Bengaluru, comprising nearly 93 lakes (Alaknanda *et al.* 2011). It is connected to the Yelahanka Lake in the north and the Rachenahalli Lake in the south. It also receives partially treated water from the Jakkur sewage treatment plant. There is a wetland area at the inlet of the lake with emergent vegetation of *Typha* sp., and water hyacinth *Eichhornia crassipes*.

The lake has three artificial islands. Two of the islands are close to the main entrance while the third and the largest island is closer to the geometric centre of the lake. Painted Storks only nested on the two islands close to the main gate, though they visited the largest third island to collect nesting material (XX1). Both these islands are about 25 m wide and roughly circular in shape. The largest island was mainly used for roosting by Spot-billed Pelicans *Pelecanus philippensis*, Great Cormorants *Phalacrocorax carbo*, Little Cormorants *Microcarbo niger*, and Black-headed Ibis *Threskiornis melanocephalus*.

## Methods

One of us (KRS) surveyed the three islands inside Jakkur Lake 17 times between 31 January and 24 June 2018. During each visit, the location of each Painted Stork nest and the phase of the nesting was recorded. All observation were made using spotting scopes and binoculars, and conducted from the walking path at the edge of the lake. Nests were not approached directly. The nesting phases were recorded as nest building, incubation, nest with recently-hatched chicks, nest with chicks that could stand, and nests with pre-fledged young. 'Nest building' was defined as the phase where one or both the storks made repeated forays to bring nesting material and build the nest, but there were no eggs or chicks in the nest.

During this phase, the pair often did courtship bill clattering and copulation. The 'incubation' phase was where one of the two partners remained seated in the nest for incubating eggs. It was not possible to see inside the nest in most cases; thus we relied on the seated posture of the stork to assume incubation. 'Nest with chicks' was defined as the phase where the parent storks were not sitting in the nest and we could see at least one chick in the nest. 'Nest with standing chicks' was defined as the phase where the chicks were old enough to stand up in the nest and were clearly visible. This was the phase where we could count all the chicks in the nest. Standing chicks at this stage reached the hock of adult birds. 'Nest with pre-fledged young' was defined as the phase where the young could move around outside the nest, and standing young reached the wings of adult birds. During this phase the young flapped their wings often. We considered nests to be abandoned when adults left nests and did not return before chicks fledged. This meant that the pair failed to raise any chicks.

We gave individual numbers to the first 50 nests and followed their fate over all subsequent visits. Nests that were built later were counted together with the number of chicks and fledged young in them. We use data from only the 50 nests that were monitored in detail to estimate nest survival and chick survival. The aggregate count of nests and chicks was used to estimate the total nesting population and breeding success, respectively, at the study site.

To understand the past history of Painted Stork nesting at Jakkur Lake we used data from eBird.org. eBird is a global citizen science initiative that collects, manages, and stores bird observations of birdwatchers in a globally accessible unified database (Sullivan *et al.* 2009). eBird data is being used by amateur birders, scientists, and conservationists to record bird observations and have the potential to improve our understanding of avian diversity and its conservation challenges. We downloaded all the data on Painted Stork and Spot-billed Pelican for all dates from the eBird database (eBird 2012). We used only the data uploaded under the 'Jakkur Lake, Bengaluru' hotspot. We examined the breeding codes of eBird data to assess the nesting of Painted Stork for past years. We checked if observed patterns were due to increasing number of birds or the increased frequency of birders visiting the site, and uploading the data to eBird, by plotting the same data for a similar large sized piscivore, the Spot-billed Pelican. We also plotted the same eBird data for the Painted Stork from the Hoskote Lake, which is on the outskirts of Bengaluru. There were not enough sightings of pelicans from Hoskote for similar analysis. We plotted the relationship between effort (distance walked and duration) with the number of Painted Storks and pelicans reported by observers in Jakkur (Appendix s1 & s2). There was no relationship between the two, suggesting that changes in numbers were due to changes in bird numbers. Hence we plot all the reported number of birds by the date of observation and fit a generalised additive model (GAM) to assess trends in the total number of birds using the Jakkur Lake across the year ( $n = 213$ ; number of observations in 2014 = 7, 2015 = 33, 2016 = 38, 2017 = 73, 2018 = 62). We visually assessed the trends to examine whether Painted Storks nested at this site in the past years and whether there is a trend in the total number of birds nesting at this site.

Our primary data and analysis script is available at: [https://github.com/kulbhushansinghs/Kullu\\_eBird\\_data\\_analysis\\_repo.git](https://github.com/kulbhushansinghs/Kullu_eBird_data_analysis_repo.git).

## Results

Painted Storks had started nesting at Jakkur Lake a few days before the first visit on 31 January. On the first visit, a total of ten nests were recorded, of which storks were incubating in six. The nesting peaked by mid-March, and 66 nests were recorded in the first two weeks of April (Fig. 1). The maximum number of chicks aggregated across all nests was 137 and was counted in mid-April (Fig. 1). Only seven nests with chicks remained by 03 June. There were still five nests on 24 June, although by that time all the young in the nests had fledged. The number of adult birds recorded at the study site increased from 30, during the first visit, to an estimated 200 individuals on 03 June. It should be noted that the surveys were conducted at different times of the day, which could explain some of the variation in the numbers of adults at the site.

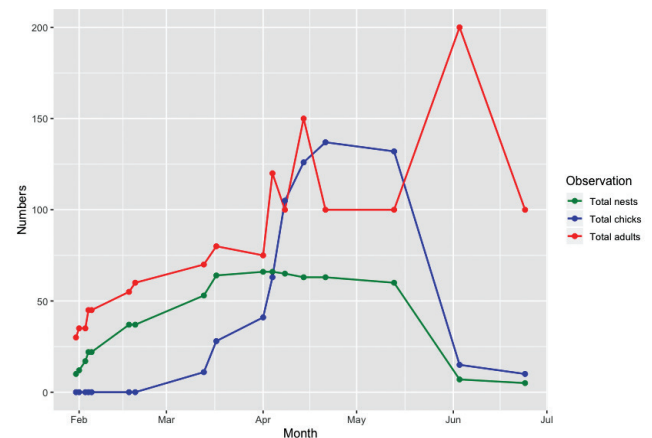


Figure 1: Total number of nests, chicks and adult Painted Storks recorded at Jakkur Lake between January and July 2018.

Ten percent of the nests monitored in detail (5/50) were abandoned due to unknown reasons (Fig. 2). The first nest to be abandoned was soon after nest building. We could not document whether the parents laid an egg before abandoning the nest. All the other nests were abandoned after two to three weeks of incubation. None of the nests were abandoned after the eggs hatched. The proportion of nests in the incubation phase peaked in March, while those with nestlings peaked in April (Fig. 2). Chicks started fledging by 14 April. Chicks from 80% of the nests (36 out of the remaining 45) had fledged by the 13 of May. The remaining nine nests had nestlings at that time. The mean number of chicks hatched per nest was 2.48 (SD = 0.78) and ranged between two and four chicks per nest. The mean number of chicks surviving to fledging per nest was 2.36 (SD = 0.62) and ranged between one and four chicks per nest.

There was no information on the breeding code in eBird data for the Painted Stork at Jakkur Lake for the years before 2018. The trend in the number of Painted Storks at Jakkur Lake in the eBird data over the years clearly showed that the maximum number of storks were observed in 2017 and 2018, during the nesting season, suggesting that active breeding colonies were present during those years. However, it is not clear whether they nested there from 2013 to 2016 (Fig. 3). The trend also suggested that the number of Painted Storks during the nesting season were higher in 2018 than 2017. Overall, the eBird data suggested that this may be a new nesting site with breeding colonies initiated in 2017.

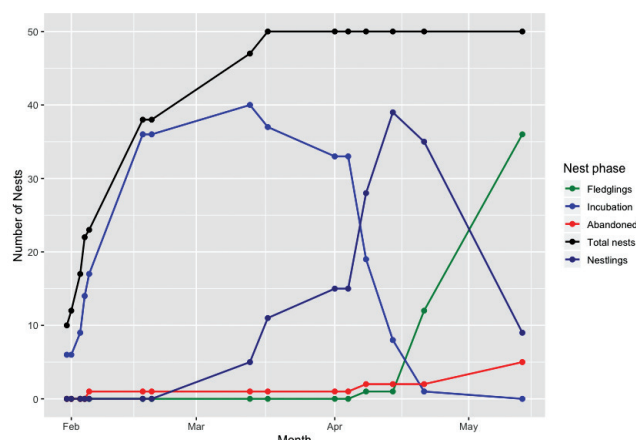


Fig. 2: The number of nests in different phases out of a total cohort of 50 nests of Painted Storks at Jakkur Lake. Total number of nests and abandoned nests are presented as cumulative total, while other categories are total numbers on the day of visit.

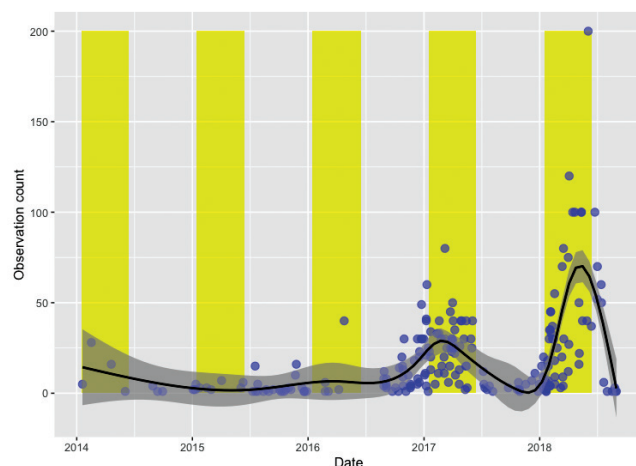


Figure 3: Number of Painted Storks reported at Jakkur Lake on eBird from 2014 to 2018. The line (black) represents the trend using a GAM function smoother with a standard error envelope (in grey). The vertical yellow bars indicate the nesting season (15 Jan – 15 June) of Painted Stork in south India. The graph shows peaks in the number of birds reported during the breeding season in 2017 and 2018.

The Painted Stork data on eBird, from Hoskote Lake, showed a slightly different pattern as compared to Jakkur Lake. Painted Storks used the Hoskote Lake mainly during the non-nesting season (Appendix S3). Also, the Painted Stork numbers at Hoskote did not show any increase or decline. Similarly, the pelican numbers at Jakkur did not show any trend (Appendix S4). Together, this suggests that the trend of increasing Painted Stork nesting at Jakkur Lake is not an artefact of the way people report counts on eBird.

## Discussion

The urban Jakkur Lake supported 66 Painted Stork nests, and appears to be a newly established breeding colony. We observed relatively low nest failure, and high recruitment of fledglings, at this site. We did not observe any egg or nestling predation. Only 10% of the observed nests failed and 80% of the nest fledged at least one chick successfully; the remaining 10% nests still had nestlings at the time of our last visit. Painted Stork nesting survival is highly variable, ranging from less than one percent in Keoladeo National Park in 2014–2015 to over 95% in Khanpur in 2013–2014 (Tiwar

& Urfi 2016). Similarly, nesting success at Sultanpur National Park ranged from nine percent in 2004 to 46% in 2005 (Urfi *et al.* 2007). The primary cause of nesting failure in Sultanpur was predation by House Crow *Corvus splendens*, Marsh Harrier *Circus aeruginosus*, and Greater Spotted Eagle *Clanga clanga*. Several other factors such as parasites, food availability, competition from other species, and weather are all thought to be important factors driving nesting success (Urfi 2011). At Jakkur, the water level was managed closely and islands were never accessible to mammals such as feral dogs. Potential avian predators such as crows and kites were seen at the study area but never around the nesting islands. The mean clutch size for Painted Storks is estimated to be between 2.2 and 2.8 (Meganathan & Urfi 2009). We could not estimate clutch size because it was not possible to observe the eggs [39]. The observed mean number of nestlings, as the ratio of maximum number of chicks to number of nests, was 2.07. This is similar to the estimates from other studies (Urfi 2011).

The nesting season in southern India is distinctly different from northern India and the factors affecting nesting times are not clear. The monsoon is thought to be an important driver of the nesting time of painted stork. However, the evidence is weak and this needs to be investigated (Urfi 2011). Painted Storks are obligate piscivores and hence dependent on the availability of fish. This has led to the implicit assumption that their nesting will be tightly associated with fish availability. Urban wetlands are highly managed for their water level and fish. It is not clear how these changes in management can impact nesting of bird species like the Painted Stork.

We never found any Painted Storks feeding at the Jakkur Lake during the nesting season. We routinely observed adult storks flying in large flocks after, what we assume to be feeding bouts. This suggests that Painted Storks prefer Jakkur Lake for nesting for the security it provides to the nests rather than its fish availability. Fish availability in neighbouring wetlands will therefore be another important factor affecting Painted Storks nesting at larger spatial scales.

The observations on eBird suggest that Painted Storks did not nest at the Jakkur Lake in the years 2014, 2015, and 2016. There seems to have been some nesting in 2017. The number of Painted Storks reported on eBird were higher in 2018 compared to 2017, suggesting that nesting was higher in 2018. A comparison with similar information from Hoskote Lake suggests that Hoskote Lake was largely used by Painted Storks during the non-nesting season. We find that eBird data in combination with field observations can be useful to develop insights into the nesting ecology of large waterbirds such as the Painted Storks.

Detailed observations of breeding ecology of Painted Storks at colonies, such as that presented in this note, are surprisingly rare. Colonies in urban wetlands offer opportunities to conduct such observations due to proximity with residential areas. Such observations are invaluable to understand the ecology of the species while connecting urban residents with biodiversity. Given the lowered connections of humans in urban settings with the natural world, colonies such as this one in Jakkur can have a strong role in improving the well being of a near-threatened species and the people that live around it.

## Author contribution

KRS and KSGS conceived of the idea. KRS conducted the field work and the analysis. KRS wrote the first draft of the manuscript. KRS and KSGS edited and finalised the manuscript.





39. Nesting Painted Storks at Jakkur Lake.

## Acknowledgement

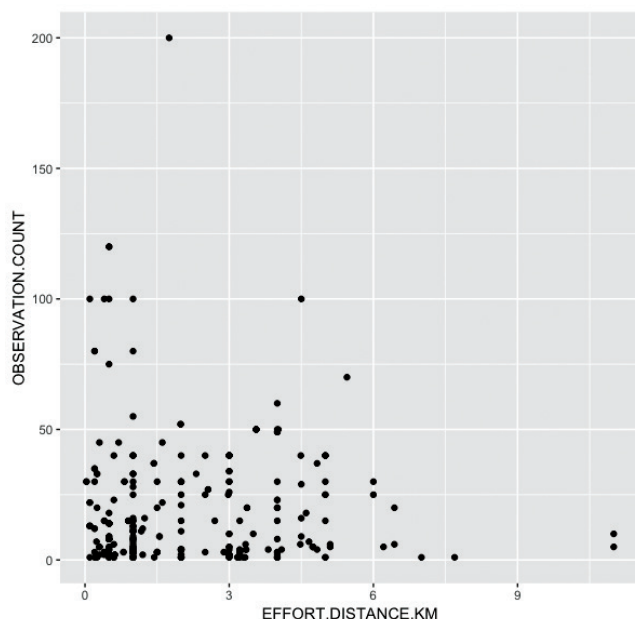
We thank Suhel Quader for comments on an earlier draft of this manuscript.

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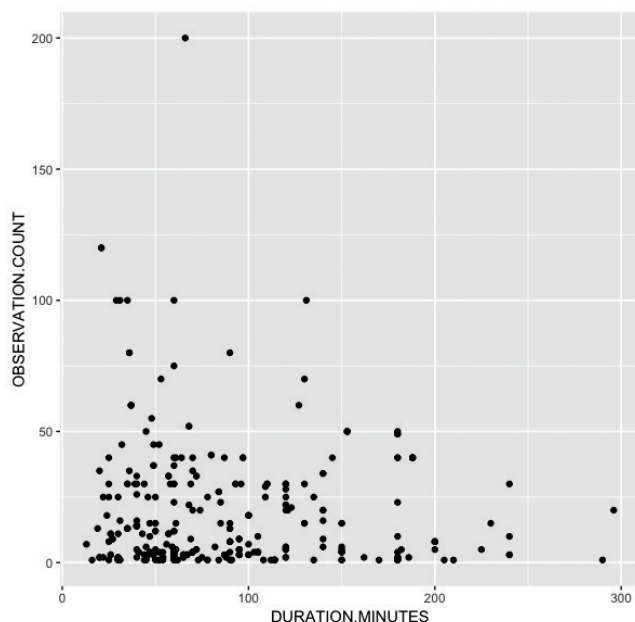
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## Appendix

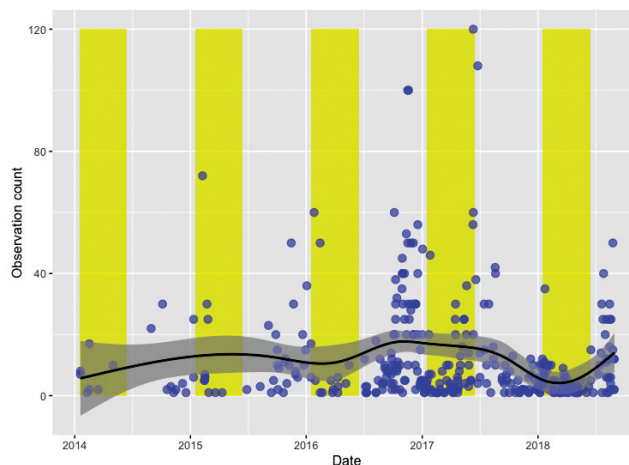
The appendix contains four figures that provide additional details about the analysis. These details are not necessary to explain the work but they are necessary to understand the analysis.



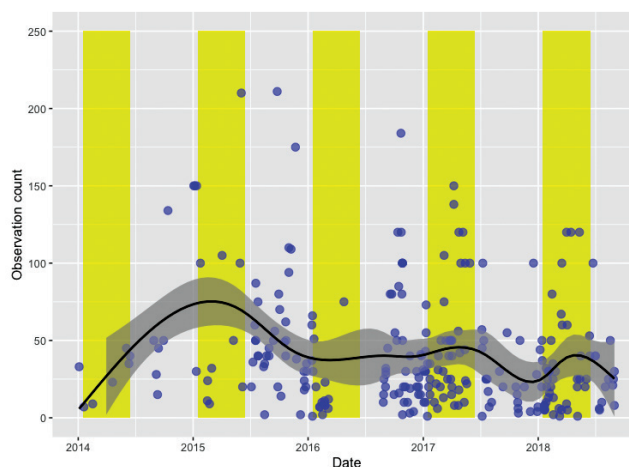
Appendix figure s1: Scatter plot of reported number of Painted Stork at Jakkur Lake, and the distance walked for each list as reported on eBird. There was no relationship between the two hence we used reported total number of Painted Stork for further analysis.



Appendix figure s2: Scatter plot of reported number of Painted Stork at Jakkur Lake and the duration of birding in minutes for each list as reported on eBird. There was no relationship between the two hence we used reported total number of Painted Stork for further analysis.



Appendix figure s3: Number of Painted Storks reported at Hoskote Lake from 2014 to 2018 on eBird. The line (black) represents the trend using a GAM function smoother with standard error (grey). The vertical yellow bars indicate the nesting season of Painted Stork in south India. The figure shows considerable variations in stork numbers with no clear peaks during the breeding seasons. Total number of observations on eBird were 357; observation in 2014 = 15, 2015 = 35, 2016 = 96; 2017 = 108; 2018 = 103.



Appendix figure s4: Number of Spot-billed Pelicans reported at Jakkur Lake over the years (2014–2018) on eBird. The line (black) represents the trend using a GAM function smoother with standard error (grey). The vertical yellow bars indicate the nesting season of Painted Stork in southern India. There is no clear trend in reported pelican numbers. Total number of observations on eBird were 267; observation in 2014 = 13, 2015 = 53, 2016 = 120; 2017 = 79; 2018 = 62.