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Woolly-necked Stork  
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# Status of Woolly-necked Storks in Kerala, south-western India

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**Abstract** Woolly-necked Stork is a large wading bird found in wetlands and reservoirs in Kerala. Using bird checklists uploaded on eBird, we analysed the distribution, seasonality, flocking propensity, breeding and trend of reporting of Woolly-necked Storks by bird-watchers in Kerala. We found no long-term variation in the annual rates of reporting in checklists between 2000 and 2020. Reports of Woolly-necked Storks were largely of solitary birds, with reports of flocks of more than five individuals being infrequent. Although widespread in the state during winter, Woolly-necked Storks are found concentrated in central Kerala during the summer months. Only 16 nesting sites were identified, most of which were in central Kerala, and included both trees and man-made structures such as cell-phone towers. From our analyses of checklists, we infer that Woolly-necked Storks in Kerala have a small resident population with indications of seasonal movements.

**Keywords** Breeding, distribution, Kerala, seasonality, Woolly-necked Storks, Kerala.

## Introduction

Woolly-necked Stork *Ciconia episcopus* is a large wading bird that inhabits various wetland habitats including natural wetlands, manmade reservoirs, paddy fields, and other cultivated fields in Kerala (Sashikumar *et al.* 2011). Among the three subspecies recognised, *Ciconia episcopus episcopus* (Boddaert 1783) is the subspecies found in Kerala and throughout India (del Hoyo *et al.* 2020; Gill *et al.* 2020). Together with *Ciconia episcopus neglecta* (Java and south Sumatra), the Asian population is accorded species status by BirdLife International as ‘Asian Woollyneck’ and its threat status is assessed as Vulnerable (BirdLife International 2020).

Historical records of the species in Kerala date back to before the 1920s from the Bharathapuzha river basin in central Kerala which was then a

known hotspot for these birds. K K Neelakantan, also known as Induchoodan on his book “Keralathille Pakshikal”, mentioned sighting records of these birds during the 1930s by Salim Ali (Sashikumar *et al.* 2011). During 1938-1960, Induchoodan himself sighted up to nine birds (at least one each time) when he was travelling by train via Bharathapuzha. He also mentioned sighting of a flock of 14 birds in Periyar during the summer, which was the highest count then. Thus, the bird was referred as “uncommon” in Kerala (Induchoodan 2004). Later, with more records available from within the state, the bird was referred as winter visitor in Kerala with 180 birds recorded in 1999 at Cheruvallor in Thrissur district (Sashikumar *et al.* 2011).

There is no systematic long-term monitoring of Woolly-necked Storks in Kerala, and we have no information on its general habits, potential seasonal variations in distribution, and nesting ecology. In other locations in India and Nepal, Woolly-necked Stork densities, flock sizes and habitat use varied by location and by season potentially due to

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**Figure 1.** Long-term trends in frequency of reporting for Woolly-necked stork in Kerala on the online portal eBird.org. In the graph, tick marks on the x-axis are placed at the median year of observation in that particular time-period. Shaded regions represent 95% confidence intervals that include random effect variance estimated from Generalized Linear Mixed Effects models.



changing landscape conditions brought about by cropping patterns and climatic variations (Sundar 2006, Kittur and Sundar 2020). Using citizen data uploaded on the online platform eBird (eBird.org), we undertake the first analyses of distribution, seasonality, flocking propensity, breeding and trends in rates of reporting of Woolly-necked Storks by bird-watchers in Kerala. We specifically hypothesized that: (1) reporting trends of the species over time has increased (2) flock sizes would vary by month in response to changing seasons; and (3) the species' distribution across Kerala would vary by season also in response to changing seasons.

There is very little information on the breeding ecology of the species, though it is known to use both trees and man-made structures such as cell phone towers to nest on (Hasan and Ghimire 2020). Using available reports on the portal eBird, we summarised nest locations of Woolly-necked Storks in Kerala.

## Study area

Kerala state lies in the South Western coastal region of India between latitudes  $8^{\circ} 17'$  and  $12^{\circ} 47'$  North and longitudes  $74^{\circ} 52'$  and  $77^{\circ} 24'$  East. Kerala harbours a total of 44 rivers and a continuous chain of lagoons or backwaters along the coast that give rise to a number of wetlands. Kerala has 1,60,590 ha of wetlands which include shallow ponds, reservoirs, low lying coastal lands, brackish water creeks, lagoons, estuaries, mangroves, swamps, lakes, marshes, saline-tolerant paddy farming fields and floodplains (Chitra *et al.* 2020). But because many of these wetlands co-exist in a single site, wetlands are simply classified as lagoons, low lying cultivation, estuaries, beaches, inland reservoirs and mid elevation paddy fields (Nameer *et al.* 2015). The total wetland area in Kerala is dominated by natural or manmade inland wetlands

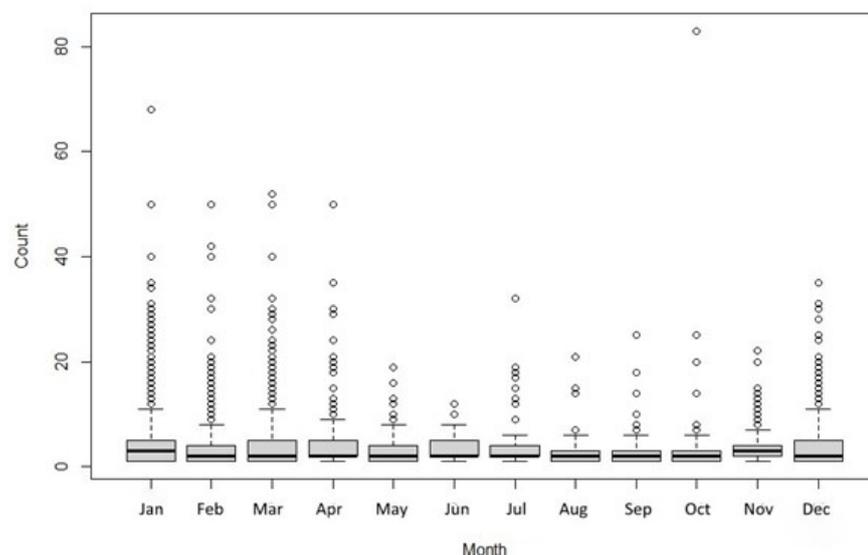
(73 %) while 25 % consists of natural coastal wetlands, and a small amount (2 %) are small wetlands not more than 2.25 ha. Kerala wetlands are also important stop over site for migratory birds and come under the Central Asian – Indian Flyway (Chitra *et al.* 2020).

Kerala is one of the most densely populated states in the country (859 persons per km<sup>2</sup>; Census of India 2011), with 93% growth in urbanisation between the year 2001 and 2011 (Pradhan 2013). Kerala is renowned for land reforms which eases conversion of natural areas to farmland and other human uses (Roy 2016), which in turn threatens existing wetlands.

## Methods

eBird is a global platform where bird-watchers upload bird checklists from individual events of bird-watching. This information is potentially useful to understand various aspects of bird ecology and habitats including distribution, habitat use and trends in the reporting rate of a particular species in the checklists. To understand trends in reporting rates, we used the 'rel-Jun2020' version of the eBird Basic Dataset (EBD) for India that contained data submitted up to 31 May 2020 and extracted all checklists from Kerala. We did not use count data to estimate abundance since methods of counting vary between the observers who upload checklists. Instead, we used the frequency of reporting of Woolly-necked Storks in checklists for our analyses. This reporting frequency of a species is a crude representation of its detectability (function of its biology, habitat structure, and observer ability) alongside its actual presence. We do not assume this index of reporting frequency to be proportional with the population size of a species (SoIB 2020). We also do not correct for observer ability, spatial and temporal variation in bird-watching effort of individuals, and group sizes of bird-watchers that were associated with each individual checklist. All of these aspects can affect observability and therefore reporting rates of





**Figure 2.** Box-plots showing flock sizes reported by bird-watchers of Woolly-necked Storks in Kerala.

species. After excluding duplicate checklists (when a checklist is shared with multiple eBird users), each unique checklist was treated as an independent sampling unit assumed to have a binomial error distribution. Detection/non detection (whether or not the species was observed in a checklist) information for the species was modelled as a function of list length (a measure of effort), season and year using Generalized Linear Mixed Effects Models (Walker and Taylor 2017). This modelling was used to obtain standardised frequency of reporting annually along with SE estimates. The year 2000 was taken as a cut off since checklists before this period were relatively fewer. The percentage change in standardized frequency of reporting in 2018 when compared to pre-2000 levels constitutes our index of long-term trend in reporting frequency (SoIB 2020).

Additionally, sighting data of Woolly-necked Stork available on eBird (from the year 1973-2020; 6,984 individual observations) for Kerala state was downloaded. We examined the flock sizes reported in each observation assuming that bird-watchers reported storks from a single flock when more than one bird was reported, and also that they always reported full flock sizes. With a monthly average of  $582 \pm 687$  SD checklist, the number of checklists varied considerably across the months (Jan to Dec; 2355, 1209, 748, 422, 224, 81, 69, 90, 105, 179, 383, and 1119). We assessed monthly flock sizes and used the non-parametric Kruskal-Wallis test to ascertain if flock sizes differed by month, but do not control for bird-watching effort in this analysis. We used box-plots to visually assess the monthly flock size information.

We then assessed if Woolly-necked Stork distribution in Kerala varied across two seasons: summer (April to September) and winter (October to March). We used a subset of the sighting data from January 2014 to May

2020 for this because eBird usage increased from 2014 in Kerala providing substantial information for both seasons. We studied the average ratio of checklists in summer and winter months in the state and concluded that the birding effort did not vary between summer ( $0.43 \pm 0.06$  SD) and winter ( $0.57 \pm 0.06$  SD) months. We obtained 5,711 observations of Woolly-necked Storks in winter and 962 observations in summer from eBird, and used these to map the distribution of the species in each of the two season.

Nesting sites were identified from published literature (Sashikumar *et al.* 2011; Greeshma *et al.* 2018) and from eBird data. Confirmed breeding behaviour such as nest building and occupied nests either with eggs or young ones were considered as nesting sites and each location was mapped separately. We additionally supplemented this information by personally communicating with bird-watchers and other professional colleagues in Kerala. Age of nests were unknown in almost all cases. For sites where multi-year monitoring was available, we provide year of first recording when the nest was observed first. From these sites, where current information was available, we provide information on whether or not nesting was still being observed. The nesting month provided refers to when the observation was made and not to when the nest was initiated. To understand the precise nesting period, we tried to get further information on nesting stage of that respective month from the observer wherever possible.

## Results

The long-term trend analysis using rates of reporting on eBird.org showed no significant change in the reporting frequency of Woolly-necked Storks (Figure 1). Most reports were of solitary birds (30% of all observations) or in small



groups of not more than 5 individuals (49% observations). Only less than one percentage (0.74%) of all observations reported large flock of more than 30 individuals mostly during December to February months. There was no significant difference ( $p = 0.07$ ) in their flock sizes sighted during different months across the state (Figure 2). Woolly-necked Storks were much more widespread during winter relative to summer when they were concentrated in central Kerala with very few observations from northern and southern Kerala (Figure 3).

A total of 16 nesting sites were identified (Figure 4). Most of these were from central Kerala except for one site in Periyar Tiger Reserve in Idukki district. Woolly-necked Storks were reported nesting on various nesting trees such as *Ficus religiosa* ( $N = 3$ ), *Mangifera indica* ( $N = 3$ ), *Alstonia scholaris* ( $N = 2$ ), and also on cell-phone towers ( $N = 4$ ). One nest was observed in March but this was historical data from 1954 (Table 1). Apart from the four nesting locations, all the sites had nests active over multiple years. Nests reported since 2002 were seen between September and December, with storks seen incubating one nest as late as November (Table 1).

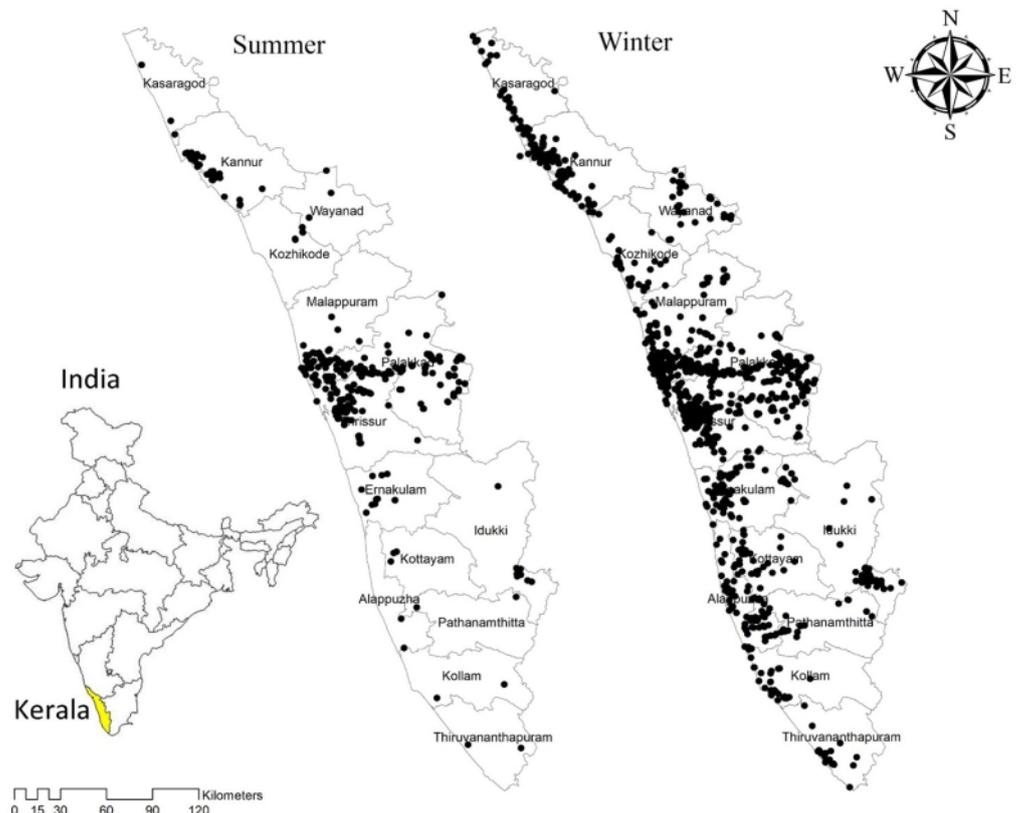
## Discussion

The trend of reporting of Woolly-necked Storks from 2000 to 2020 was similar year-to-year in

Kerala. We were able to use only available checklist data on eBird and therefore are unable to conclusively state anything regarding the abundance or population of Woolly-necked Storks in Kerala. Formal monitoring across Kerala using robust field methods are needed to derive current populations, and long-term monitoring is needed to understand if the species' population fluctuates in the state.

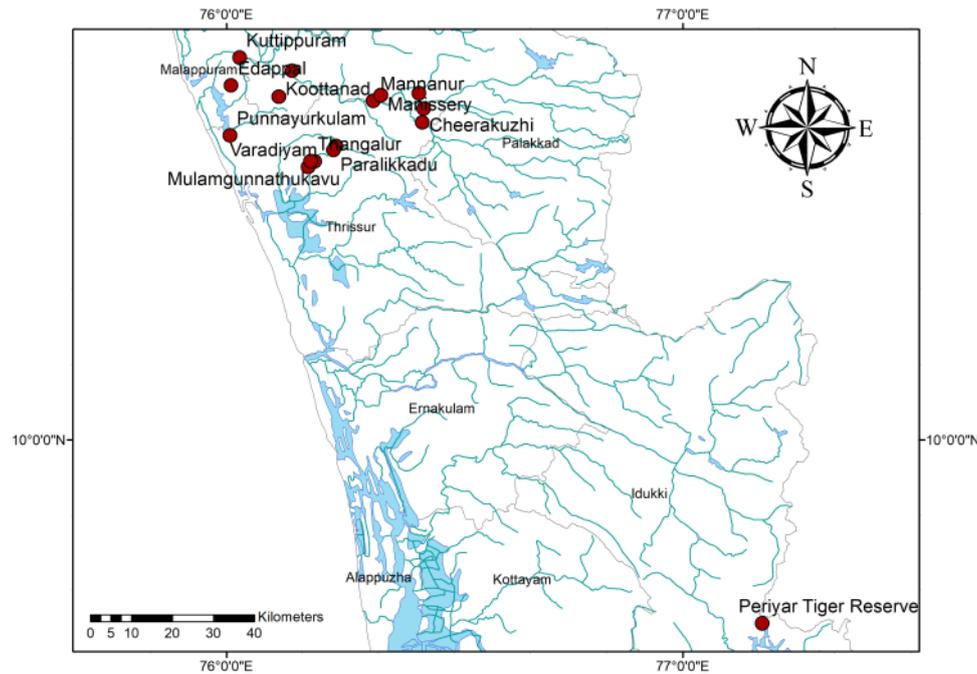
Reports suggest that Woolly-necked Storks were solitary, and mostly remain in small groups throughout the year, but flocks of more than 50 birds were sometimes seen in winter in wetlands of central Kerala including inland reservoirs (Nameer *et al.* 2015). Only 0.74% of the observations reported flocks more than 30 birds. This habit of largely being seen in small flocks with extraordinary large flocks being rare is similar to information available from other locations in Nepal and India (Sundar 2006, Kittur and Sundar 2020).

During summer months, most reports of the species were from central Kerala which hosts the Kole wetlands and the Bharathapuzha River. In winter months, bird-watchers reported this species from many more locations across the state. This suggests that the species displays strong seasonal variation in distribution at the level of the state. Such a large variation in distribution with season has not been observed during seasonal, long-term



**Figure 3.** Map of Kerala state showing the Seasonal distribution of Woolly-necked Storks in Kerala using eBird data.





**Figure 4.** Map of central Kerala showing breeding locations of Woolly-necked Storks reported on eBird.org and in additional reports since 1954.

monitoring efforts in northern India and in lowland Nepal (Sundar 2006, Kittur and Sundar 2020). It is not immediately clear why Woolly-necked Storks show a much smaller distribution in summers, but we suspect that the shrinking of wetlands and other water bodies may force this species to existing sources of water on the landscape. Existing accounts refer to Woolly-necked Storks as an “uncommon” species (Induchoodan 2004) and as a “widespread winter visitor” in Kerala (Sashikumar *et al.* 2011). Our analyses of bird-watcher’s reports suggests that while Woolly-necked Storks are a resident species in Kerala, it is possible that the number of birds reduces during the hot summer months. A more careful evaluation of distribution and numbers of Woolly-necked Storks using year-long field data is needed to understand if the species varies in distribution during the breeding season as well. If the distribution during the breeding season is also smaller than the observed distribution in the winter, it can be suggested that Kerala experiences inward movement of Woolly-necked Storks during the winter.

Woolly-necked Storks are solitary breeders nesting singly on trees (Ali and Ripley 1987), cliffs (Rahmani and Singh 1996) and on cell-phone towers (Choudhary *et al.* 2013; Vaghela *et al.* 2015; Greeshma *et al.* 2018; Hasan and Ghimire 2020). In this study, we found Woolly-necked Storks using large trees such as *Ficus religiosa*, *Mangifera indica*, and *Alstonia scholaris* for nesting in Kerala. In Paralikkadu, Thrissur, a pair was found nesting on a Jackfruit

tree (*Artocarpus heterophyllus*). After the tree was cut, the storks nested again on a nearby cell-phone tower (pers. obs.). We also obtained reports of four nests on cell-phone towers. Storks may view man-made structure like cell-phone towers as safer nesting sites compared to trees owing to the reduced accessibility of such nests to certain predators (Tryjanowski *et al.* 2009, Bialas *et al.* 2020).

Breeding season of Woolly-necked Storks in India has been reported during the rainy season in the months July to September in the south, but the species is reported to nest between December and March in the north (Ali and Ripley 1978). But, we found Woolly-necked Storks to breed largely during the post-monsoon season in Kerala. This pattern is similar to observations in Pune, which is slightly to the north of Kerala (Vaghela *et al.* 2015).

Several nesting reports of Woolly-necked Storks were from the Bharathapuzha River Basin in central Kerala (Sashikumar *et al.* 2011, Greeshma *et al.* 2018). However, the first nesting record for the species in the state is from Periyar Tiger Reserve that is not in central Kerala (Figure 4). Since the first report in 1954, a single pair has continued to nest in a large *Ceiba pentandra* tree near the boat landing centre in the Tiger Reserve (Induchoodan 2004). In 2018, three active nests were observed in the same site near to the lake (Patrick David pers. comm. 2020). During our study, we did not get any confirmed nesting reports from Edappal, Thiruvilvamala, and Kuttippuram where nests were recorded earlier



**Table 1.** Nesting location and present status of Woolly-necked Stork in Kerala.

District	Location	Nest found		Month	Nesting stage	Tree/substrate
		From	To			
Idukki	Periyar Tiger Reserve	1954	2019	Mar	-	<i>Ceiba pentandra</i>
Malappuram	Edappal	2002	Unknown	-	-	-
Malappuram	Kuttippuram	2002	Unknown	Sept	-	<i>Ficus religiosa</i>
Palakkad	Koottanad	2004	2019	Nov	With chicks	<i>Mangifera indica</i>
Palakkad	Mannanur	2004	2018	Nov	-	-
Thrissur	Thiruvilvamala	2004	Unknown	Oct	-	<i>Alstonia scholaris</i>
Thrissur	Paralikkadu	2015	2019	Dec	Nest building	Cell-phone tower
Palakkad	Manissery	2016	Unknown	Sept	Nest building	<i>Mangifera indica</i>
Thrissur	Punnayukulam	2017	2017	Nov	Nest building	<i>Ficus religiosa</i>
Thrissur	Varadiyam	2017	2017	Oct	With chicks	<i>Mangifera indica</i>
Thrissur	Wadakkanchery	2017	2019	Nov	With chicks	Cell-phone tower
Thrissur	Cheerakuzhi	2017	2018	Nov	Incubation	<i>Ficus religiosa</i>
Thrissur	Mulamgunnathukavu	2018	2019	Oct	With chicks	Cell-phone tower
Palakkad	Kodumunda	2019	2019	Sept	Nest building	-
Thrissur	Thangalur	2019	2019	Sept	Nest building	Cell-phone tower
Palakkad	Palappuram	2019	2019	Sept	With chicks	<i>Alstonia scholaris</i>

(Sashikumar *et al.* 2011). And part the above three nesting sites and Manissery, all the other nesting sites were found active over multiple years suggesting that the species remains faithful to nesting sites. Nest-site fidelity is known behaviour in Ciconiiformes (Cezilly *et al.* 2000). Thus, these nesting trees have to be given priority for conservation. From the evidence that we have collated, and from existing literature, it appears that Woolly-necked Storks do not have a very large breeding population in Kerala. This additional bit of information would also suggest that Woolly-necked Storks are likely primarily local winter migrants to the state.

Our analyses provide some initial understanding of the biology and habits of Woolly-necked Storks. However, a much more focused effort is needed to obtain robust metrics of population sizes, and to understand breeding propensity of the species in the state. We suggest that such studies can provide invaluable additional knowledge to understanding how Woolly-necked Storks – one of the least studied stork species in the world – is faring.

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