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Research article

# Population status and spatiotemporal distribution of greater and lesser flamingos in Gulf of Mannar Lagoons, Tamil Nadu, India

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## Abstract

Flamingos are the most widespread among other species of Phoenicopteridae. This study examines the spatiotemporal distribution and population status of greater flamingos *Phoenicopterus roseus* and lesser flamingos *Phoeniconaias minor* in Tamil Nadu. We used systematic monthly survey data (2020–2024) at Valinokkam and Kothandaramar Lagoons in the Gulf of Mannar region, and a decade-long eBird dataset (2014–2024) and compared them with available historical data. Standardized morning surveys (6:00–10:00 hours) and point-count methods were employed, with GIS mapping to analyze distribution patterns. For greater flamingos, 22 key sites met strict criteria (≥5 years of data, ≥20 individuals/year), while lesser flamingo sites required ≥10 individuals in any year. Results revealed peak congregations (6,040–7,200 flamingos) in February–March at the two lagoons, aligning with optimal foraging conditions in receding wetlands. Greater flamingos were widely distributed, with major populations in Point Calimere (peak: 15,000), Pulicat Lake, and saltpans (200–500 individuals), showing 40% peak abundance in November–February in the eBird dataset. Point Calimere, Pulicat Lake, Valinokkam and Kothandaramar Lagoons also support the 1% global population of greater flamingo. In contrast, lesser flamingos were restricted primarily to Pulicat Lake (max: 800). Key threats include habitat loss from saltpan expansion, pollution, and aquaculture. The findings emphasize the importance of coastal wetlands and managed saltpans for flamingo conservation, advocating for integrated protection of critical sites and sustainable land-use practices. This study is important as the Tamil Nadu Forest Department has recently declared Dhanushkodi/Kothandaramar Lagoon as the first flamingo sanctuary in the state.

**Keywords:** Biodiversity hotspots; Flamingo sanctuary; Lagoon; Population estimate; Rameshwaram; Wetland

## 1 | Introduction

The Order Phoenicopteriformes and the family Phoenicopteridae include flamingos (Ali et al. 1987). There are currently six flamingo species known to exist worldwide: Andean flamingo *Phoenicopterus andinus*, Caribbean flamingo *Phoenicopterus ruber*, Chilean flamingo *Phoenicopterus chilensis*, James's flamingo *Phoenicopterus jamesi*, which are found across Asia, Europe, South America, and North America (Ogilvie & Ogilvie 1986). Greater flamingo *Phoenicopterus roseus* is the most widespread and largest among all. In India, including Tamil Nadu, two species—the lesser flamingo *Phoeniconaias minor* and greater flamingo are recorded (Grimmett et al. 1998).

Flamingos are highly gregarious birds that form aggregations ranging from a few individuals to thousands, with such groups commonly referred to as a 'Pat' (Tere 2005; Johnson & Cézilly 2008). They live in a variety of wetlands, such as freshwater bodies, saltwater lagoons, brackish water, alkaline lakes, saltpans, and mudflats (Del Hoyo 1992; Grimmett et al. 1998). During the non-breeding season, greater flamingos usually congregate in sizable feeding flocks (Allen 1956). The greater flamingo distribution range is found throughout sub-Saharan Africa, extending from western Africa to southwestern and southern Asia. While populations in western Africa, Iran, and Kazakhstan appear to expand, those in Asia and sub-Saharan Africa have remained relatively stable (Delany & Scott 2006). The lesser flamingos are largely found in Asia and Africa, including Saudi Arabia, Yemen, Oman, UAE, Pakistan, Sri Lanka and Bangladesh (Ogilive & Ogilive 1986; Mundkur 1997). In India, the lesser flamingos are reported from Gujarat (Tere 2005), Rajasthan, Maharashtra, Andhra Pradesh, and Tamil Nadu (Rastogi et al. 2005; Tere & Parasharya 2011). Meanwhile, greater flamingos have been widely recorded from Gujarat, Maharashtra, Andhra Pradesh, Odisha, Karnataka, Kerala, Rajasthan, Uttar Pradesh, and Tamil Nadu (Grimmett et al. 1998; Ramesh & Ramachandran 2005; Tere 2005; Kidwai & Bhattacharjee 2016; Arjun & Roshnath 2018; Parasharya & Gadhvi 2020). Some of the largest congregations of this species in the world may be found in Gujarat's Rann of Kutch, which is known as a key breeding ground and is close to the India-Pakistan border (Shivrajkumar et al. 1983; Ali & Ripley 1988; Rameshchandra, 2014).

The main food for flamingos is crustaceans, decomposed plant material, phytoplankton, zooplankton, molluscs, and sedge seeds, (Ali et al. 1987; Tere 2005). Water depth, food availability, predator presence and water quality all affect their temporal and spatial distribution (Arengo & Baldassarre 1995; Baldassarre & Arengo 2000; Pirela 2000; Tuite 2000). They rely on dynamic wetland habitats for feeding, roosting, and breeding. Although they are flagship wetland species and vital indicators of ecosystem health, habitat degradation, anthropogenic pressures and hydrological

changes are posing threats to their populations (Ali et al. 1987; Grimmett et al. 1998).

Most studies on greater flamingos in India have concentrated on coastal or western wetland systems, with limited long-term ecological investigations carried out along the southeastern coast (Ramesh & Ramachandran 2005; Tere 2005; Arjun & Roshnath 2018). In the Gulf of Mannar (GoM), greater flamingos are reported from Dhanushkodi Lagoon (Byju et al. 2024a), Pillaimadam (Byju et al. 2025), Karangadu mangroves (Byju et al. 2023a), Valinokkam (Byju et al. 2023b), and Sikkal (Byju et al. 2024b). Although flamingo distributions in India have been previously documented, a thorough assessment of Tamil Nadu's important sites, especially the lesser-studied lagoons and man-made habitats like saltpans—remains limited. Additionally, the fact that flamingos depend on both protected and unprotected wetlands emphasizes the necessity for management strategies at the landscape level. This study provides a scientific basis for targeted conservation measures by understanding the peak congregation seasons and challenges and recommends ensuring the protection of these birds in rapidly changing environments.

## 2 | Methods

### 2.1 | Study area

#### Kothandaramar/Dhanushkodi Lagoon

Kothandaramar Lagoon (KR Lagoon) (9.233148 N, 79.34805 E) is situated in Rameswaram Island, surrounded by the Bay of Bengal and the GoM. Its saline water leads to plenty of phytoplankton, including diatoms, dinoflagellates, and blue-green algae, providing a

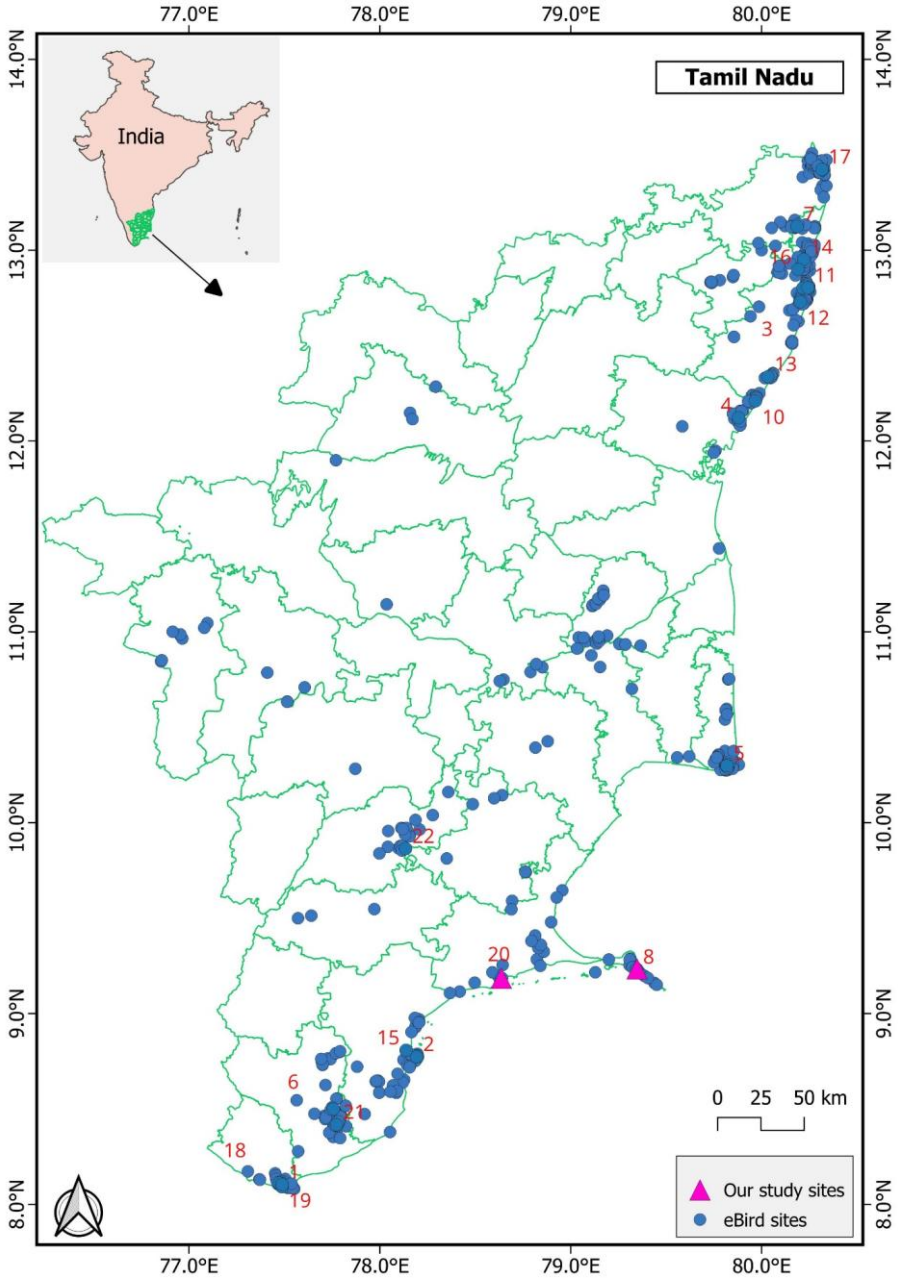


**Figure 1**. Map showing two lagoons in GoM (our study sites) and locations in eBird for greater flamingo in Tamil Nadu, along with numbered locations used for analysis and representation. 1. Andivilai Saltpans; 2. Hare Island; 3. Kelambakkam; 4. Kazhuveli Bird Sanctuary; 5. Point Calimere Wildlife Sanctuary; 6. Koonthakulam Bird Sanctuary; 7. Korattur Lake; 8. Kothandaramar Lagoon; 9. Manakudy; 10. Marakkanam Saltpans; 11. Muttukadu Backwaters 12. Nemmeli Saltpans; 13. Odiyur Lake; 14. Pallikaranai Marsh; 15. Pattinamaruthr; 16. Perumbakkam Lake; 17. Pulicat Lake; 18. Puthalam Saltpans; 19. Swamithoppu Saltpans; 20. Valinokkam; 21. Vijayanarayanam Tank; 22. Samanatham Tank.

foraging ground for flamingos. The area of brackish swamp around the KR lagoon is highly productive for flamingos during the entire winter, mostly during January, February, and March. KR Lagoon and Dhanushkodi Lagoon are used interchangeably since both refer to the same area.

**Valinokkam Lagoon**

Valinokkam Lagoon (9.184135 N, 78.63704 E) is situated on the southeast coast of India, in the Kadaladi Taluk of Ramanathapuram District in Tamil Nadu. The Lagoon is approximately 10.12 km long with an area of 1,145.84 ha. The State Salt Corporation pumps extra water from the sea and stores it in bunds for salt extraction, forming a man-made Lagoon. This region gradually transformed into a mudflat home to several species of migratory and resident waterbirds. The area near the Brahmakulam marsh of Valinokkam Lagoon is where flamingos are seen in flocks.

The eBird locations and the case study locations of KR Lagoon and Valinokkam Lagoon are shown for greater flamingos (Fig. 1) and those of lesser flamingos (Fig. 2).

## 2.2 | Bird survey and data analysis

The selected sites of Valinokkam and KR Lagoons in the GoM regions were surveyed monthly once from 2020 to 2024. The data was collected only in the morning from 06.00 to 10.00 hours to avoid duplication in the evening. Birds were counted using the point count or block count methods (Sutherland 2006; Bibby et al. 2000), and locations of each flock were recorded with GPS locations. This method involves estimating 'blocks' of birds within a flock depending on the overall flock size. The 'block' is used to measure the remainder of the flock from our previous experiences in the field monitoring for more than a decade. The team had three experienced researchers on avian ecology, with a few assistants as volunteers on each visit at each site. Four vantage points, each from both lagoons, with a distance ranging from 250 to 750 meters. Any birds which came back from the enumerator during the count were not considered to avoid duplication of counts. A ten-minute settling period was observed at each vantage point to allow the birds to settle down to the human presence and counted for 15 minutes each.

We analyzed ten years of eBird observations (2014–2024) for greater and lesser flamingos, along with annual wetland bird monitoring data of Tamil Nadu (eBird Basic Dataset 2025). Although we recognize the limitations and biases of the citizen science data, eBird data was considered to understand the broader trend in flamingo populations in the state over the years and to identify sites with species presence and the key congregation sites. We also considered the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) criteria for both species. Observations were carried out using Nikon 8 X 40 field binoculars and various telephoto lenses.

For greater flamingo, we initially assessed approximately 254 locations in eBird after removing the duplicate records and grouping the adjacent or parts of a larger contiguous habitat under the main habitat (e.g. Anamalaicheri within Pulicat Lake). As stated earlier, considering the limitations in robustness of eBird data, sites were included in further analysis only if they met the following criteria:

1. At least five years of recorded observations
2. Minimum abundance of ≥20 individuals in each year

From this filtered dataset, we selected 22 sites for detailed evaluation. The annual peak count at each site was used for comparative analysis.

For lesser flamingo, we considered sites where a minimum of 10 individuals were recorded in any given year. Data from personal monitoring and eBird were used to construct a distribution map of the study area using the geographic information system (GIS) software (QGIS 3.36). Various threats were determined through direct observations.

# 3 | Results

Valinokkam and KR lagoons exhibited consistent peak flamingo counts during February-March across all observation years (2020-2024) (Fig. 3). The maximum recorded counts were 6,040 individuals at Valinokkam Lagoon (February 2020-21) and 7,200 at KR Lagoon (March 2023-24). The peak flamingo count fluctuated between 2000 and 8000 in the GoM area during the study period. Compared to KR Lagoon, Valinokkam showed more abundance in August, September, December-January, suggesting a seasonal use of the habitats. Although the peak counts are generally lower than KR Lagoon, Valinokkam have more consistent use across months. Valinokkam and KR Lagoons show an increase in peak counts in later years of our study period (especially 2023-2024).

The eBird data identified several key congregation sites for greater flamingos that maintained substantial populations (>200 individuals) for at least six months annually for multiple years (Fig. 4). These included Point Calimere (peak count: 15,000 in 2016), Pulicat Lake, and Pallikaranai marsh across multiple years. Odiyur

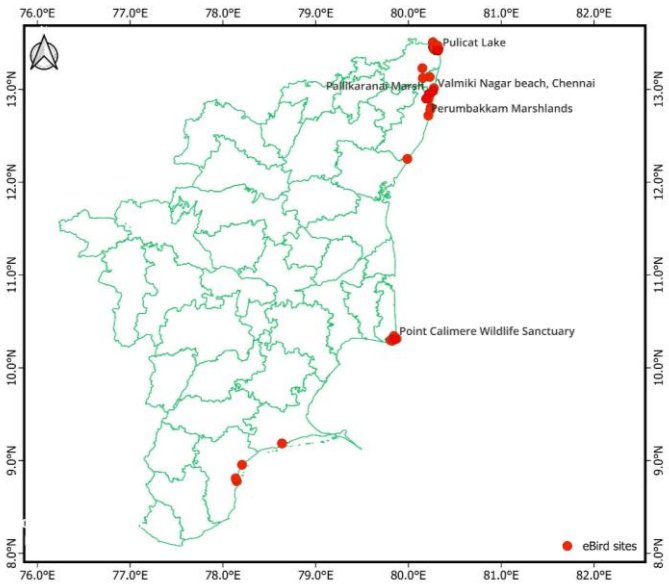


**Figure 2.** Map showing the eBird locations for lesser flamingo in Tamil Nadu, with sites recording ≥10 individuals

**Table 1:** Historical population abundance of greater flamingos in a few sites of Tamil Nadu

| Site/ Years | 1980s* | 1990s* | 2000-2008* | 2015-2018# |
|---|---|---|---|---|
| Point Calimere | > 40,000 | > 10,000 | 1500-5500 | 10000 |
| Pulicat Lake | > 30,000 | > 8,000 | 3000-15000 | 20000 |
| Dhanushkodi Lagoon | > 14,000 | > 7,000 | 3000-5500 | 12000 |

*(Balachandran 2012); # (Balachandran Pers.comm., 2018)

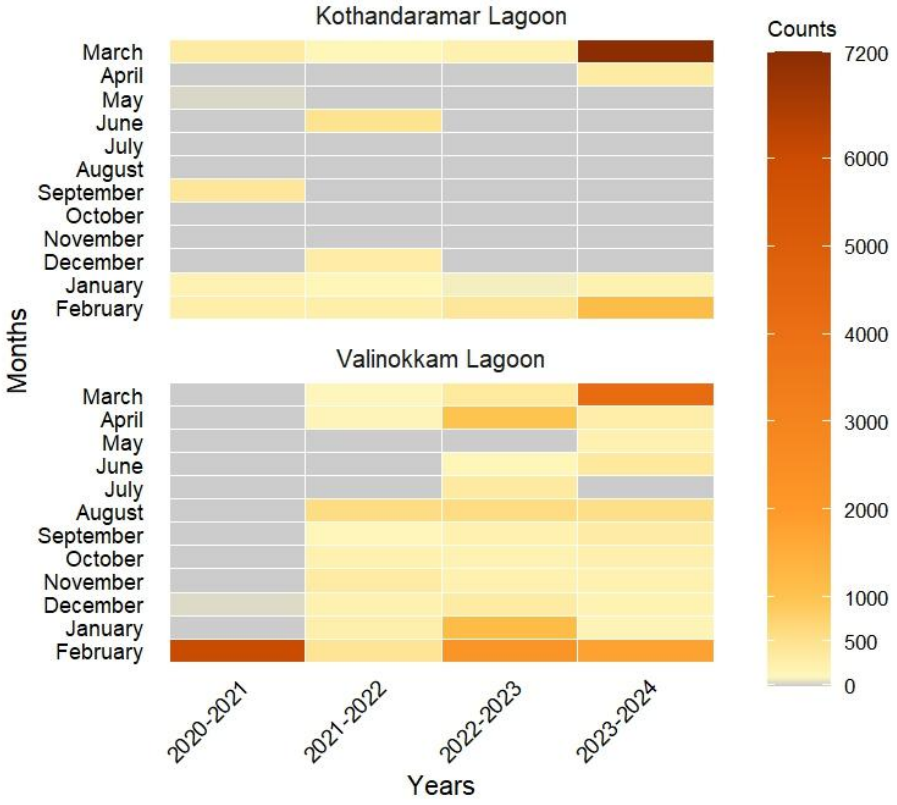


**Figure 3.** Monthly peak counts of greater flamingo in our study sites of Valinokkam and KR Lagoons

Lake, Korattur Lake, Marakkanam Saltpan and Muthukkadu Backwaters showed that these wetlands are used seasonally by the greater flamingos. Saltpan habitats such as Andivilai, Marakkanam, Nemmeli, Swamithoppu and Puthalam consistently supported 200-500 individuals. Protected areas, including Kazhuveli Bird Sanctuary (1,650 in 2018) and Koonthakulam Bird Sanctuary (1,000 in 2023), along with certain inland irrigation tanks like Vijayanarayanam Tank (400 in 2019) and Samanatham Tank (100 in 2022), also hosted significant congregations**.** Temporal analysis revealed that 40% of all annual peak counts occurred between November and

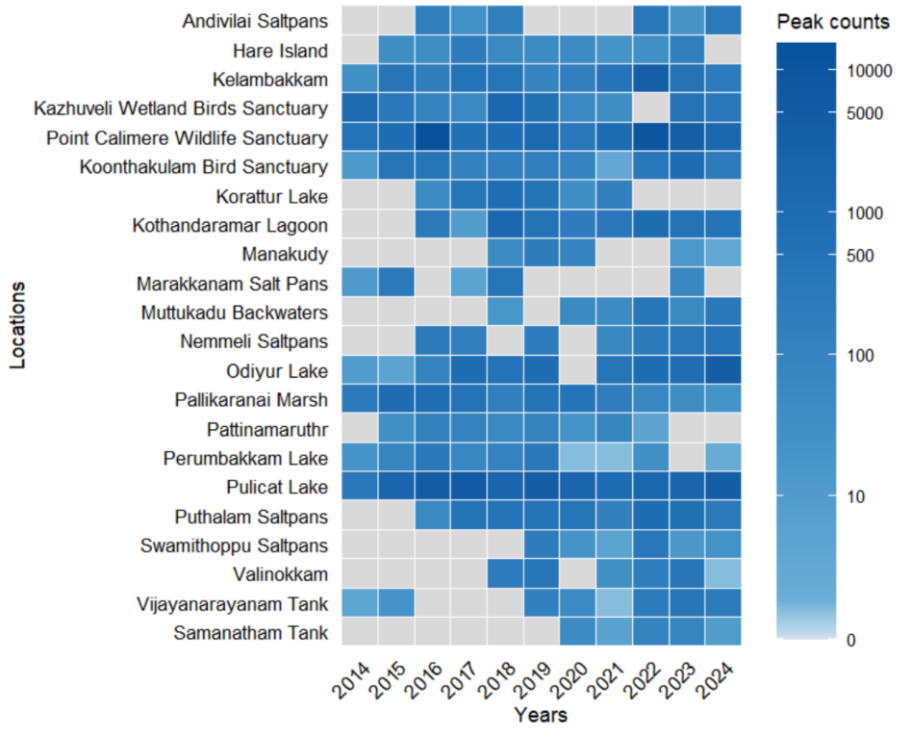


**Figure 4**. Yearly peak counts of greater flamingo in selected sites in Tamil Nadu from eBird

February, followed by 27% during March-May. Several wetlands show reduced counts or no data around 2020, likely due to COVID-19 related fieldwork disruptions.

For the lesser flamingo, out of eight selected sites, only Pulicat Lake supported more than 100 individuals for at least five years during the study period, with a maximum count of 800 recorded in April 2023 (Fig. 5). Observations over several years and various sites show no data, suggesting limited or irregular monitoring at some locations.

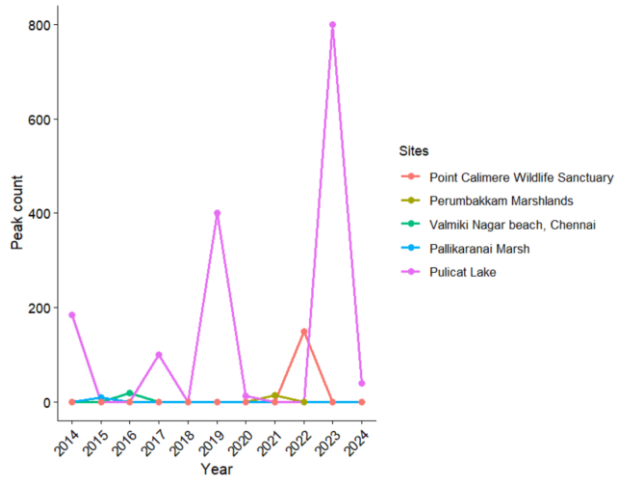


**Figure 5**. Yearly peak counts of lesser flamingo in selected sites in Tamil Nadu from eBird

## 4 | Discussion

Our findings highlight the ecological significance of coastal wetlands, saltpans, and inland water bodies as key habitats for flamingos in Tamil Nadu and reveal distinct seasonal patterns in their occurrence.

### 4.1 | Greater flamingo – seasonal trends and habitat preferences

Earlier studies had indicated that post-monsoon and early summer months (January-April) are crucial for flamingo congregations in southern India (Ramesh & Ramachandran 2005; Arjun & Roshnath 2018). This is supported by the steady peak flamingo numbers at Valinokkam and KR lagoons in February and March. As water levels drop exposing mudflats abundant in benthic invertebrates and algal biomass, the high abundance during this time likely reflects ideal foraging conditions (Childress et al. 2008). The significance of these

**Image 2.** Single nest mound of mud of greater flamingo

lagoons as non-breeding stop-over sites is highlighted by the one-time peak counts of 6,040 (Valinokkam) and 7,200 (KR Lagoon) which may be due to migratory movements along the Indian coastline (Balachandran 2012; Byju et al. 2023b). The presence of greater flamingo throughout the year in Valinokkam is significant as the population ranged from 200 to 8,000 individuals, and there is no breeding record from any nearby known locations in peninsular India. While greater flamingos are known to breed in the Rann of Kutch, Gujarat, there have been occasional sightings of juvenile flamingos in Tamil Nadu. For instance, in December 2021, two juvenile flamingos were documented in Point Calimere. However, experts suggest these juveniles likely migrated from breeding sites in Sri Lanka, as there is no conclusive evidence of breeding in Tamil Nadu.

Satellite tracking studies done by Bombay Natural History Society (BNHS) from 2011 in the Peninsular India, found that during summer, greater flamingos frequented the KR Lagoon and Pulicat Lake in Tamil Nadu- Andhra Pradesh, and Chavakachcheri in the Northern Province of Sri Lanka (Balachandran et al. 2018). Post-monsoon, the species is considerably preferred for the saltpans of Puthalam, Valinokkam, Vedaranyam, and Marakkanam in Tamil Nadu. Overall, all the birds spent most of the summer in Chavakachcheri Lagoon (Balachandran et al. 2018). During our decade-long observations, we observed some attempted nesting mounds built on mud in Koonthamkulam Bird Sanctuary, but no breeding activities (Images 1 & 2).

Approximately 40,000 greater flamingos were counted in Tamil Nadu's coastal regions during a synchronized bird census in January 2022 as part of the Asian Waterfowl Census (NBA, WISA & BNHS, 2022). According to our own observations, there were notable assemblages at Point Calimere (20,000), Valinokkam (10,000), Dhanushkodi (2,000), Thoothukudi (2,000), and Kanniyakumari (600) (Image 3). The eBird analysis found long-term congregation

**Image 1.** Attempted nest mounds built on mud by greater flamingos in Koonthamkulam Sanctuary

**Image 3.** Flock of greater flamingos *Phoenicopterus roseus* in Pulicat Lake

**Image 4.** Flock of lesser flamingos *Phoeniconaias minor* in Pulicat Lake

sites, with Point Calimere and Pulicat Lake supporting the highest numbers (up to 15,000 individuals). These results support the previous findings that flamingos depend on large saline wetlands serve as critical refuges due to their high productivity and undisturbed mudflats (Balachandran 2012). The fact that 200–500 individuals are regularly found in saltpans (like Puthalam and Marakkanam) highlights the importance of man-made habitats in sustaining flamingo populations (Balachandran 2012). The seasonal peak which accounts for 40% of annual counts between November and February, is consistent with trends seen in other wetlands in India, where resident populations are supplemented by winter migrants (Balachandran 2012).

The global population estimation for greater flamingos is 550,000-680,000 individuals (BirdLife International 2018a), in which 1% of the estimated population range equals 5,500–6,800 individuals. The population estimate in South Asia is 340000-370000 with a 1% threshold of 3500 (Wetlands International 2025). Valinokkam Lagoon, KR Lagoon, Pulicat Lake, and Point Calimere each host ≥5,000 greater flamingos, meeting the 1% threshold of the global population.

### 4.2 | Lesser flamingo distribution and trends

The distribution of lesser flamingo, a species of global conservation concern (BirdLife International 2018), is restricted. Pulicat Lake was the only location where more than 100 individuals recorded for several years (Image 4). Greater flamingos on the other hand used a wide variety of habitats. The decline of lesser flamingos in many inland wetlands may be due to thier unique cyanobacteria-based diet (Vareschi 1978), which leaves them susceptible to habitat degradation. Although long-term monitoring is required to assess population trends, Pulicat Lake's highest population of 800 individuals indicates that this site continues to be a regional stronghold.

The overall global population of lesser flamingo is 2,220,000-3,240,000 individuals (BirdLife International 2018b), and none of the sites in Tamil Nadu falls under 1% of the estimated global population of 22,200–32,400 individuals. The population estimate of lesser flamingo in South Asia is 150000 with a 1% threshold of 1500 (Wetlands International 2025).

### 4.3 | Historical perspectives

In 2019, BNHS conducted a national flamingo count and recorded 4225 greater flamingos and one lesser flamingo from Tamil Nadu (Flamingo Count 2019). From the literature, it is well established that the greater flamingo abundance had been drastically reduced from sites like Point Calimere, Pulicat Lake and Dhanushkodi Lagoon by more than 50-75% from the 1980s (Balachandran 2012) (Table 1). Even though most of these give an approximate count of the birds, the new sites of Valinokkam and other wetlands, as mentioned above, do not show a decline in population abundance as alarming as described by Balachandran (2012).

### 4.4 | Potential threats and conservation implications

Our field observations indicated multiple potential threats, such as aquaculture operations, pollution from agricultural runoff, influx of sewage water into habitats like lagoons and habitat loss by saltpan expansion. Similar threats of population are also reported from other flamingo habitats in India (Baldassarre & Arengo 2000; Pirela 2000; Tere 2005). Among the four sites which met the 1% population threshold criteria of the Ramsar Convention for greater flamingo, two sites, Valinokkam Lagoon and KR Lagoon, are unprotected areas. The flamingos depend on both protected areas (e.g., Kazhuveli Bird Sanctuary) and unprotected wetlands (e.g., irrigation tanks), highlighting the need for integrated conservation strategies. The significance of managed landscapes such as saltpans necessitates collaborative management with enterprises to ensure sustainable practices, even while protected areas provide shelter (Tuite 2000). In June 2025, the Tamil Nadu government declared Dhanushkodi lagoon, located at the tip of Rameswaram Island, as a Greater Flamingo Sanctuary. This initiative aims to protect the area's diverse ecosystems, including sand dunes, marshes, and mangrove forests, which are important stopover sites for migratory birds along the Central Asian Flyway. Additionally, both greater and lesser flamingo are enlisted in CMS Appendix II and CITES Appendix II (BirdLife International 2018a, 2018b), emphasizing the necessity of transboundary cooperation in protecting both species from unregulated commerce.

## 5 | Conclusions

With distinct seasonal peaks and habitat partitioning between greater and lesser flamingos this study highlights the ecological significance of Tamil Nadu's wetlands for flamingo populations. A strong baseline for future monitoring is provided by the combination of surveys and long-term eBird data. Important locations like Pulicat Lake and Valinokkam Lagoon should be given priority in conservation and encourage the sustainable management of saltpans and irrigation tanks. Understanding the regional population dynamics of flamingos should be done with more research on movement ecology and breeding.

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## Authors' contributions

All authors contributed to the study conception and design. H.B., conceptualization, writing, editing, data curation and supervision; H.M., writing, editing, data curation and visualization; N.R., data curation; V.R., review and editing.

## Conflicts of interest

The authors declare no conflict of interest.

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