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Population abundance of Greater Flamingo *Phoenicopterus roseus* (Aves: Phoenicopteridae) in district Gurugram of Haryana, India

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Abstract: We quantified the population abundance of Greater Flamingo *Phoenicopterus roseus* in Najafgarh Drain (Jheel), Basai Wetland, and Sultanpur flats of district Gurugram, Haryana from October 2018 to December 2020. A total of 72 visits were made to the study sites. In this study, we explored the uses of an unmanned aerial vehicle (UAV) equipped with a 5-megapixel camera to census the population and distribution of Greater Flamingos. The Nikon 10 x 50 field binoculars were used for observations. A photographic record was taken using a Canon Powershot sx70hs camera. To estimate the population size, point count method was used and videos and image analysis were carried out for a more accurate count in densely packed flocks. The mean population of Greater Flamingos was 267 ± 47 observed throughout the study period from the three sites. For three years, the highest mean population of Greater Flamingos recorded was 745 ± 76 at Najafgarh Drain and the lowest was 19 ± 8 at Sultanpur Flats. The Greater Flamingos were found to be residents at Najafgarh Drain. At the Basai Wetland, two major human activities were the construction of highways along wetlands and wetland drainage have been observed that resulted in habitat fragmentation and shrinkage, which is responsible for the huge decline in their population. While at Najafgarh Jheel fishing activities and overgrowth of water hyacinth were a major threat that affect the Greater Flamingo population. The findings in this study will be beneficial for the conservation efforts of the flamingos in this area.

Keywords: Distribution, drone, population abundance, Najafgarh Drain, UAV.

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Author contributions: SR and AK conceived and designed the study. Both the authors equally contribute in field data collection, preparation of draft of the manuscript and data analysis.

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INTRODUCTION

Greater Flamingo *Phoenicopterus roseus* is a significant species of the family Phoenicopteridae, it is one of the long-legged water-wading birds belonging to the order *Phoenicopteriformes* (Ali et al. 1987). Flamingos are gregarious birds that are found in groups, extending from a few to thousands or lakhs and their group is termed 'Pat' (Tere 2005; Johnson & Cezilly 2007). Presently, six species of flamingos are known globally, among which four species namely the Caribbean Flamingo *Phoenicopterus ruber*, the Chilean Flamingo *Phoenicopterus chilensis*, the James Flamingo *Phoenicopterus jamesi*, and the Andean Flamingo *Phoenicopterus andinus* are found in Asia, Europe, South America, and North America (Ogilvie & Ogilvie 1986). Two species of flamingos, namely, the Lesser Flamingo *Phoenicopterus minor* and Greater Flamingo *Phoenicopterus roseus* are found in India (Grimmett et al. 1998).

Flamingo groups extend from a few individuals to thousands and are seen in freshwater, saltwater, brackish water habitats, shallow lagoons, alkaline lakes, saltfans, and mudflats (Del Hoyo et al. 1992; Grimmett et al. 1998). Greater Flamingos continuously cluster in large feeding flocks or groups during the non-breeding season (Allen 1956). Both of these flamingo species are known to breed at Little Rann of Kachchh in Gujarat in large colonies (Rameshchandra 2014). Greater Flamingos are reported continuously from western Africa to southwestern and southern Asia, and throughout the sub-Saharan region of Africa.

The population of western Africa, Iran, and Kazakhstan seem to be expanding, while the Asian and sub-Saharan African populations seem to be constant (Delany & Scott 2006). The Rann of Kutch in Gujarat, India is a well-known breeding location at the India-Pakistan border (Ali & Ripley 2001), where the world's largest aggregation of Greater Flamingos can be seen (Shivrajkumar et al. 1983). Greater Flamingos have been recorded from Gujarat, Andhra Pradesh, Odisha, Maharashtra, 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).

Limited studies have been reported on the Greater Flamingo in India (Ramesh & Ramachandran 2005; Tere 2005; Arjun & Roshnath 2018) and most of the studies are limited to the coastal wetlands.

From the literature reviewed it was found that no

previous work has been made so far in Haryana, to study the distribution pattern and population size of Greater Flamingos apart from Kumar & Rana (2021). The present study was undertaken to assess the pattern of distribution of Greater Flamingos in Gurugram, Haryana. As a part of a detailed ecological study of flamingos, we surveyed the selected sites in Gurugram Haryana; their numbers were counted from 2018 to 2020 to understand their abundance and population size.

STUDY AREA

Primary visits were made to a few wetlands of Gurugram (Haryana) to select a suitable investigation site. Finally, three sites in Gurugram—Basai wetland (28.471N, 76.985E), Najafgarh Drain (28.498N, 76.946E), and Sultanpur Flats (28.455N, 76.890E)—were selected (Figure 1). Basai wetland is a perennial shallow-water wetland, located in the village of Basai on the outskirts of the Gurugram district of Haryana. Najafgarh drain, located at Delhi-Haryana border, is estimated around 7 km long and is the part of dying Sahibi river. Much of the region covered by the Najafgarh Drain is located in two villages, Kherki Majra and Dhankot. As untreated sewage flows into it, the Najafgarh drain is one of the most contaminated, but productive habitats for many species of birds and plants. Sultanpur flats are the area around Sultanpur National Park and include various habitats such as grasslands, fields, and uncultivated lands. Paddy fields, wheat, and mustard were the dominant vegetation observed in each study area.

MATERIAL AND METHODS

Monthly visits were made to selected sites. The unmanned aerial vehicle (UAV) system (drone) was used to study the population and distribution of Greater Flamingos in Gurugram (Haryana). In the present study, the DJI Tello UAV drone (Image 1) in combination with Apple iPhone 11 mobile devices were used. This drone, a quadcopter (having four rotors) equipped with a 5MP HD camera with 720p recording. The drone is controlled by the smartphone app 'Tello'. The Nikon 10 x 50 field binocular was used for observations. Photographic records were taken using a Canon Powershot sx70hs camera. The total count method has been used to count flamingos for small congregations (Bibby et al. 2000; Sutherland 2006). To make an accurate count of densely packed flock drone was used to capture aerial photographs and videos, then an analysis of aerial photographs and videos was done. A manual tally counter

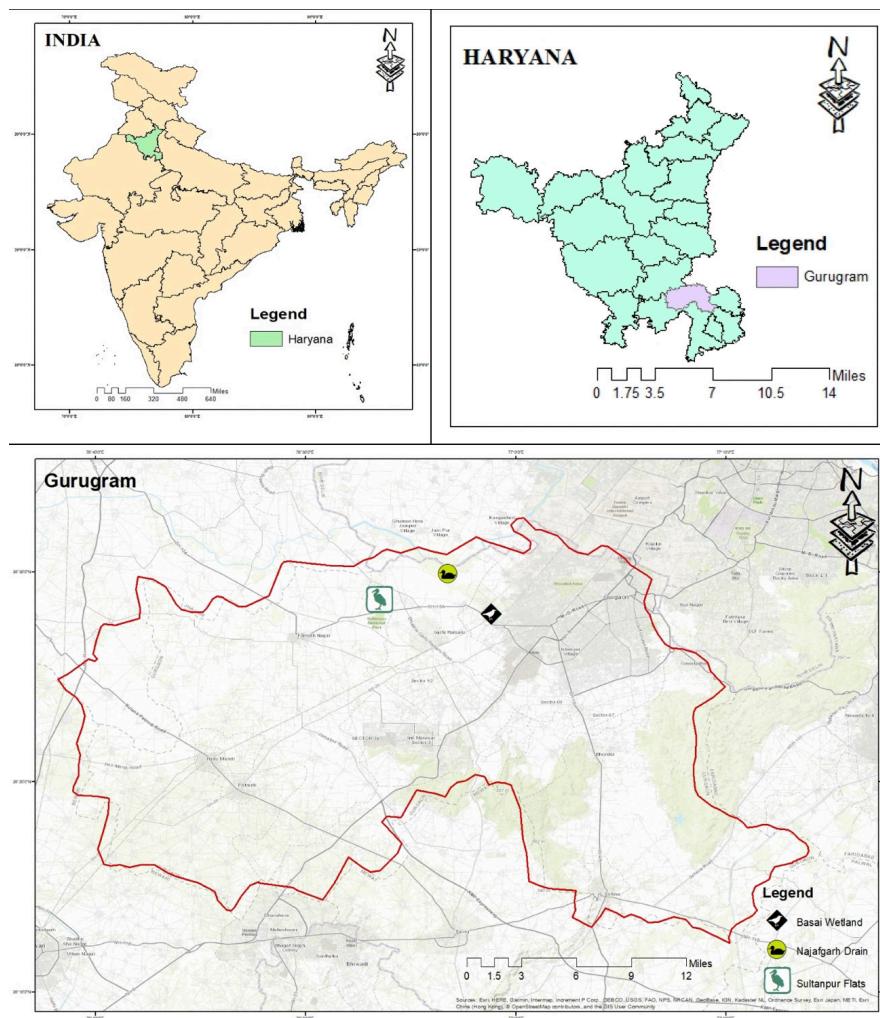


Figure 1. Study area map showing various study sites in district Gurugram.



Image 1. DJI Tello drone used to operate the drone for the aerial population census of Greater Flamingo in large densely packed.

was used for the census of large colonies of Greater Flamingos for an accurate count (Rameshchandra 2014). To reach study sites various modes of transport were used. For each sighting of Greater Flamingos, GPS coordinates were taken using the handheld GPS device Garmin Etrex 30x.

RESULTS

A total of 24 visits were made to each site for three years (Oct 2018–Dec 2020). The summary of Greater Flamingo numbers (N) observed at each site during sampling years (2018–2020) is enlisted in Table 1; 19,230 flamingos were observed during the visit, out of which the highest mean population of flamingos (745 ± 76) was recorded in Najafgarh Drain followed by Basai Wetland (34 ± 6) and Sultanpur Flats (19 ± 8). For the three years,

Table 1. Greater Flamingos in the various reservoirs of Gurugram censused from October 2018 to December 2020.

	Location	Coordinates	Year	Number of visits	Mode of flamingos seen	Mean \pm SE
1	Basai Wetland	28.478 N 76.982 E	2018	3	118	56 \pm 34
			2019	12	88	46 \pm 8
			2020	9	69	19 \pm 9
2	Najafgarh Drain	28.774 N 76.622 E	2018	3	957	794 \pm 100
			2019	12	1350	969 \pm 64
			2020	9	937	430 \pm 123
3	Sultanpur Flats	28.468 N 76.892 E	2018	3	170	61 \pm 54
			2019	12	51	13 \pm 5
			2020	9	70	13 \pm 8

*SE = Standard Error

the maximum number of Greater Flamingos counted per visit was 1,350 individuals at Najafgarh Jheel, 118 individuals at Basai Wetland, and 170 individuals at Sultanpur Flats.

Among three years of study, the highest mean population of individuals was observed at Najafgarh Drain in 2019 (969 ± 123) while the highest mean population in Basai Wetland (56 ± 34) and Sultanpur Flats (61 ± 95) was recorded during the year 2018. The mean number of individuals at Najafgarh Drain was similar during 2019 and 2020. In the case of Basai Wetland, the lowest mean population was recorded during the year 2020. The present study shows that Najafgarh Drain holds the maximum number of individuals (> 400) of Greater Flamingos in all three years as compared to other sites. There is a decline in the number of individual sightings observed during 2020 which may be associated with an increase in road construction and fishing activities at Basai Wetland and Najafgarh Jheel.

DISCUSSION

To implement the conservation measures for any species current population size and frequented habitats must be determined before management steps can be implemented. Earlier studies indicated that the Greater Flamingos favored coastal wetlands, but they can live in inland wetlands as well (Tere 2005). They are known to migrate in large flocks to the south-eastern coasts of India during the winter (Nagarajan & Thiyyagesan 1996; Balachandran 2006; 2012); and all year surveys are required to differentiate migratory populations from the resident ones. Greater Flamingos are the winter visitors in Lalitpur (Uttar Pradesh). The current research was

conducted on various Greater Flamingo inhabiting sites of Gurugram (Haryana) covering the freshwater bodies. The Greater Flamingos were found to be residents at Najafgarh Drain. As previously reported, flamingo abundance fluctuated in response to water level and rainfall patterns (Vargas et al. 2008). Najafgarh Drain is the major stronghold of Greater Flamingos in the area. Flamingos use various parts of the Drain for foraging predominantly in the shallow areas (Image 2A).

The Greater Flamingos were also found to be distributed at Basai Wetland and Sultanpur Flats, but only till water levels were adequate for their sustenance. The unavailability of water in these areas is one of the major reasons for their low abundance. We observed that flamingos leave these sites as water levels start to decline with the end of the rainy season.

It was reported that when the wetland dried up or when food became scarce, they were forced to relocate to a new environment, such as a nearby perennial water body or a location that was a long distance away (Johnson 1989). Najafgarh Drain supports the maximum population of Greater Flamingo as its large area and the availability of water is one of the main reasons for their large aggregation throughout the year. The Najafgarh Drain is a freshwater reservoir that provides a vast expanse of shallow water and food to sustain Flamingos all year round. On the other hand, a minimum number of flamingos counted in Basai Wetland and Sultanpur Flats. The availability of water in these areas is one of the major reasons for their minimum aggregation. At the end of rainy seasons when water levels start to decline and these sites start dry out, flamingos start to leave these sites. Any ecosystem that provides food in sufficient quantity and quality contributes significantly to the survival of its fauna. As a result, differences in the



Image 2. A—Aerial photographs of Greater Flamingos captured at Najafgarh Drain using DJI, TELLO UAV Drone (circle and other shapes are represents to show how a photo interpretation was done to count the flamingos) | B—Flamingos at the dried field | C—Greater Flamingo flocks foraging in shallow water. © Amit Kumar

number of Greater Flamingos inside and among lakes may be due to seasonal access of diet.

Utility of UAVs in surveying flamingoes

UAVs have a wide range of uses in ecological and behavioral studies but have been used infrequently in India. Outside India, UAVs technology has been used

for avian research for example, to count the number of nesting Wood Storks *Mycteria americana* (Rodgers et al. 1995), assessing the nesting success of species of canopy-nesting birds (Weissensteiner et al. 2015), common terns (Chabot et al. 2015), Lesser Black-backed Gulls (Rush et al. 2018), breeding population of Glossy Ibis *Plegadis falcinellus* (Afán et al. 2018), to survey five species of colonial marshbirds (McKellar et al. 2021) and waterfowl (Dundas et al. 2021). UAV technology has been also used for the study of other animal species such as to survey Nile Crocodile populations (Ezat et al. 2018) and basking freshwater turtle species (Bogolin et al. 2021). We used UAV, DJI Tello, for surveying densely packed Flamingos Group at Najafgarh Drain (Image 1). Aerial counting, for example, was more precise and reliable than ground counting using aerial photographs of penguin colonies (Fraser et al. 1999); geese (Boyd 2000), and similar advantages have been shown for imagery obtained by drones (Hodgson et al. 2016).

In this study, recent technological advancements such as the UAV were used. This will be fruitful to develop new field approaches for monitoring the population status and abundance of Greater Flamingos in Haryana, India. The advanced UAV system unmanned aerial vehicles, or drones, collect exceptionally high spatial resolution data with temporal versatility (Anderson & Gaston 2013). Drones equipped with a camera provide new opportunities for the study of population census and distribution of species (Koh & Wich 2012). Analysis of drone video data enabled us to review and pause on larger flocks, making them easier to count and recognize, resulting in more accurate counts (Dundas et al. 2021).

In the aerial photograph, each individual is easily recognizable as shown in Image 2A. Furthermore, the aerial picture made Greater Flamingo enumeration even simpler. Aerial imagery makes counting the densely packed flocks easier as compared to visual ground count. Flamingos were found to forage in various parts of the Najafgarh Drain, particularly in the shallow water areas (Image 2A) whereas in the area of Sultanpur Flats flamingos were found occasionally whenever the availability of water is sufficient for these birds (Image 2C). When compared to traditional ground counts, drone-derived counts are more precise (Dundas et al. 2021).

With the use of UAVs, the accuracy of manual waterbird colony counts has increased drastically. This eliminates visual interpretation bias and ensures that data is similar throughout time. Drones, in particular, can help to census the population of waterbirds and overcome the difficulties of assessing areas that are

difficult to reach on foot.

CONCLUSION

The present study was carried out at three selected sites in Gurugram (Haryana) to find out the population of Greater Flamingos. The Greater Flamingos were found to be residents at Najafgarh Drain. There is a continuous decline observed in the population of flamingos. At the Basai Wetland, there was a drastic decline observed in the flamingo population and road construction along the wetland was one of the major threats responsible for the decline in their population. We used a UAV drone to census the population of Greater Flamingos. At Najafgarh Jheel, drones proved to be an excellent tool for surveying the Greater Flamingos population and were found to be more accurate than ground counts. The findings in this study will be extremely beneficial to undertake conservation efforts of the flamingos in this area.

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