Height variations of Great Cormorant *Phalacrocorax carbo sinensis* nests in response to anthropogenic presence at two lakes in Bengaluru, India

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Abstract

Recreational walk paths and trails in parks and around lakes impact breeding birds by modifying habitats or the movement patterns of predators and people. This study investigated the nesting responses of Great Cormorants *Phalacrocorax carbo sinensis* to human presence, using an observational approach, hypothesizing that sensitivity to human presence can influence the nest building behaviour of cormorants. From November 2019 to January 2020, the study measured various parameters of Great Cormorant nesting on eucalyptus trees at Sankey and Kaikondrahalli Lakes, Bengaluru: Nests with fledglings, breeding pairs, height and Girth at Breast Height of the nesting trees, nest heights from ground level, visible predators, and the number of people walking/jogging below the nests along the walk paths. Average nesting heights of Great Cormorants varied significantly among sites ($p < 0.05$). Much of this variation depended on the distance of the nests from human movements ($r, = 0.9628$, $n = 17$, $P < 0.005$). The preliminary insights suggest that Great Cormorants seem to have adapted positively to human presence in an increasingly urbanizing world and the study thus has the potential to help alleviate the conflicts in urban development, and ecosystem diversity, and to employ the insights to intensify the conservation value of urban habitats.

Introduction

Human presence is regarded as a significant source of disturbance in urban environments, acting as a potential predation risk (Preston & Norris 1947; Ratcliffe 1962; Frid & Dill 2002; Hill et al. 1997), and is often mentioned as one of the principal issues of concern in biodiversity conservation. With ever increasing urbanization, the decline of biodiversity is a common phenomenon with a reduced and regimented suite of species (McKinney 2006). Consequently, urban dwelling animals must compete with challenges like exposure to anthropogenic sources of disturbance (McDonnell & Hahs 2015) causing impeded access to resources such as food materials, nesting sites, or roosting sites of birds (Gill 2007); movement patterns of predators (Dickens et al. 2005; Sih et al. 2010); reduction in the presence of prey species (Sih et al. 2010); changes in population sizes (Kushlan 1993; Zöckler 2005; Sekercioglu 2006); avoiding areas with human presence (Sih 2013), etc. Anthropogenic interruptions could also include several novel sources of disturbance like foot and vehicular traffic, pets, and anthropogenic noise (Banks & Bryant 2007; Mikula 2014). Urban residing animals are, thus, anticipated to have highly flexible or generalist behaviours to increase their chances of survival in human dominated environments (Callaghan et al. 2019; Sih 2013). Reacting appropriately to human presence is, therefore, likely to be a pre-requisite for the survival of urban wildlife in conurbations.

Parks and lakes in urban sprawls play an important role in protecting ecosystems and providing recreational opportunities for humans. However, recreational trails within/around them can cause subtle or indirect impacts on breeding birds that thrive in urban areas, having important consequences for parental behaviour, time allocation, chick or egg survival, and productivity (Burger et al. 1984). Nests are an essential prerequisite for reproduction in birds and several factors play important roles in various aspects of nesting such as, time of arrival at the breeding sites, height and girth of nest trees, distances between nests, intra- and inter-specific interactions, and nest height built in the tree (Dhindsa et al. 1989). Evading disturbance and finding or using resources are the significant drivers of animal behaviour decisions (Lima & Dill 1990). As a consequence, birds in urban areas, to increase their reproductive fitness, exhibit novel nesting behaviours like using buildings and other artificial sites for nests, protracted breeding seasons, incorporating anthropogenic materials such as twine, plastic, or even cigarette butts into the construction of their nests (Bressler et al. 2020, and references therein), or increasing nest height with increasing level of urbanization (Antonov & Atanasova 2002).

As a specific adaptation to living in close proximity to humans, birds may increase the heights of nests with increasing level of urbanization, since higher nests are considered more secure from humans and mammalian predators (Antonov & Atanasova 2002). Various research studies have shown that birds can alter the heights of their nests in response to human disturbance (Ratcliffe 1962; Smith et al. 1999; Reale & Blair 2005; Antczak et al. 2005; Weber 1975) because birds may identify humans as potential predators and nest in higher or more secluded locations after human intrusion (Antczak et al. 2005).

The aim of the present study was to investigate the responses of Great Cormorant to urbanization by evaluating their nest heights on eucalyptus trees *Eucalyptus tereticornis* at Sankey and Kaikondrahalli Lakes, Bengaluru. The study hypothesized that sensitivity to human presence can influence nest building behaviour of birds, and predicted that nest survival was positively associated with tree height (McDonnell & Pickett 1990) and, thus, if nest height is influenced by human disturbance, it should increase with increasing human disturbance. Furthermore, the study assumed that Flight Initiation Distance might not be an appropriate measure of sensitivity to disturbance if birds become habituated to people and respond differently to people walking along trails that pass by, rather than directly approach a nest.

Materials & methods

The Great Cormorant is an ideal candidate for studies on urbanization largely due to it being a widespread and conspicuous species in the study area. It is globally distributed in Asia, Africa, Australia, New Zealand, North America, and Europe, with the exception of South America and Antarctica (del Hoyo et al. 1992). Great Cormorants are obligatory fish predators.

In Bengaluru, as per anecdotal observations and records, they breed between July and February (George 1994). Their roosting colonies during the present study period were always situated on trees either on the banks (Sankey Lake), or in the water (Kaikondrahalli Lake).

Study area

Sankey Lake

Sankey Lake (13.01°N, 77.57°E) is a man-made waterbody, situated in the north-western part of Bengaluru, in the middle of the suburbs of Malleshwaram, Vyalikaval, and Sadashiva Nagar of Bengaluru District, Karnataka, India. It covers an area of about 12 ha with a surface elevation of 921 m, and a maximum depth of 2.7 m). It has one nesting island in the water (Ramachandra et al. 2015).

Kaikondrahalli Lake

Kaikondrahalli Lake (12.91°N, 77.67°E), is a community-maintained, 48 acres waterbody, near Kaikondrahalli, off Sarjapur Main Road, Bengaluru District, Karnataka, India, lying 20 kms south-east of Sankey Lake. The lake has a circumference of two kilometers, with a surface elevation of 911 m with one nesting island in it (Venugopal 2017).

Sampling methodology

Cormorant roosting sites at Sankey and Kaikondrahalli lakes (Fig. 1) were chosen based consultations with experienced birdwatchers of Bengaluru, and the 2015–2016 database of water bird census (http://www.bngbirds.com). Eight observers conducted the study from October 2019 to January 2020, between 0500–0900 h and 1600–1900 h. To maintain consistency in observations between both the sites, the study was conducted during winter (October–January). The nest locations at Sankey and Kaikondrahalli lakes were recorded using a GPS and displayed on the map of the study area. An Olympus 8x40 DPSI binocular was used to identify the nest trees of each species, and a Nikon Forestry Pro II Laser Rangefinder/Hypsometer was employed to measure the heights of the nest trees, and the heights of the nests. Diameter at Breast Height at 1.37 m above ground of the nesting trees were measured using measuring tapes. The total distance of the path, distance from the trees to walk path, and distance from trees to lake were calculated using Google maps distance calculator.

Data such as height of the tree (m); Girth at breast height (cms); number of nests; distance of the nests from ground level (m); were noted during the study period. Nest materials at both the lakes were natural materials. We collected opportunistic data on cormorant activities at, and away from the nests; in the presence/absence of humans (Eady 2013); during mornings and evenings; and the breeding behaviours of adults, including distraction displays, etc.

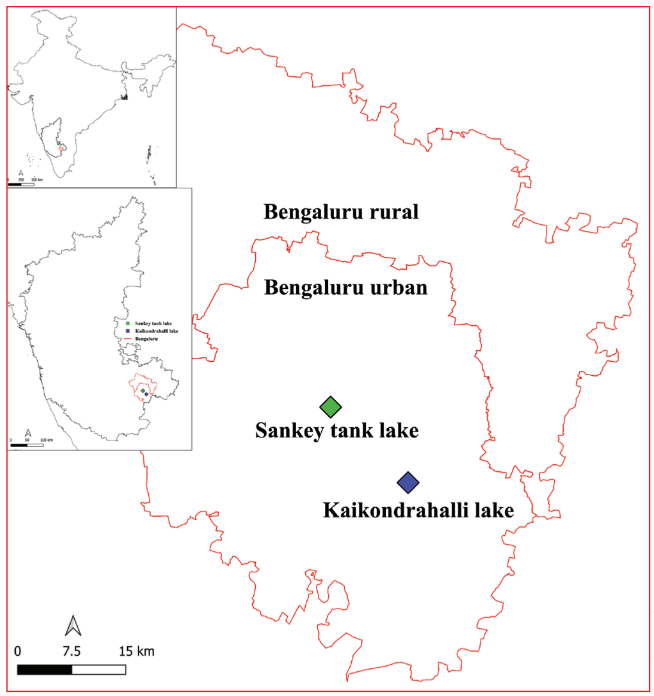

Fig. 1. Great Cormorant nest sites in two lakes of Bengaluru city.

The habitats of both the lakes were thoroughly surveyed for potential nest sites, and an inventory of tree species made. We measured daily human density (number of people per hour) on the park trail around the nests, both during morning and evening, during the entire study period, by taking Cordon counts. Cordon counts consider the number of people entering (or exiting) an area. They are most appropriate for locations where several entrance and exit points provide access to a study area. We recorded anthropogenic data such as gender, total number of people entering, stopping near the nest area, duration of stay (in minutes) near or below the nesting tree, activities near the nest areas: e.g., waiting, resting, conversing, observing animal behaviour, exercising, clapping, photographing, listening to music, and dog or kid walking. All the trees at the walking trail were recorded. All the statistical analyses, including Mann-Whitney statistical tests to detect differences between means, were calculated using PAST software (Hammer et al. 2001).

Results

Sankey Lake

The cormorants had selected seven live Eucalyptus trees, close to the walk paths (< 1 m), for nesting. 23 nests with 38 birds were observed on these trees. Nest heights on the trees varied from 8.4 to 12.6 m (n=23) from the ground level. The distance between nest-trees and walk path (hereinafter, WP) was 0–1 m, and WP with cormorant nesting trees were 368.56 m long and 2.96 m wide. Human density at the lake, during the study period, varied from 530–1,127 people in the morning, and 584–2,004 people in the evening.

Kaikondrahalli Lake

The cormorants' heronry occupied 13 dead Eucalyptus trees that stood in the water (not close to the walk paths). 12 nests with 56 birds were observed during the study period. Nest heights varied from 4.2 to 12.2 m (n=17) above the ground level. The distance between the nest trees and the WP was 40 m and the WP was 485.66 m long and 8.28m wide. Human density varied from 320–440 people (mornings) and 427–674 (evenings) at the lake.

Average nesting heights of trees varied significantly between sites / ($p < 0.05$). Much of this variation depended on distance of human movements from the nests.

Cormorants at the Sankey Lake were more vigilant at the nest sites during the heavy human movements and flew down for foraging once the human density at the walking sites decreased (Fig. 2), while no such behaviour was noted at Kaikondrahalli Lake (data not shown).

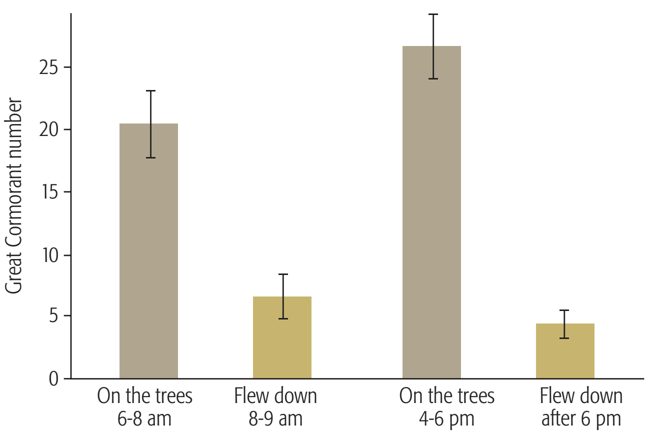

Fig. 2. Variations of Great Cormorant activity at the nesting site during dusk and dawn, in response to anthropogenic movements at Sankey Lake, Bengaluru

Discussion

The current study investigates the nesting height responses (Fig. 3) of Great Cormorants to human presence. It shows that anthropogenic pressures could be a major factor affecting nest-building behaviour in these birds. The human density at Sankey was high, which was reflected in the birds constructing higher nests in comparison to those at Kaikondrahalli Lake. All through the study period cormorants at Sankey, with high human movements, were sensitive to human disturbance in comparison to Kaikondrahalli Lake (data not shown). As a result, the nests (close to the lake) were constructed much higher at Sankey than at Kaikondrahalli Lake where nesting trees were away from the human movements, and submerged in the lake (Fig. 4). Though greater heights may provide thermoregulatory benefits for the Cormorants or, more specifically, allow for more rapid drying of feathers, nest heights on the trees could be high at Sankey in response to human presence and nest survival stands positively associated with tree height influencing the nest building behaviour of birds. The study cautiously suggests that the inferences drawn on nest height correlations are from only two locations of Bengaluru, and could vary with a larger coverage of breeding colonies in and around Bengaluru. Anecdotal observations confirm Great Cormorants attempted to nest in the past, with little success, on the Eucalyptus trees at Lalbagh Island, Bengaluru, while roosting on tall Eucalyptus trees far away from the feeding grounds.

Interestingly, the Eucalyptus trees, which have earned a bad rap as bird habitat at both sites, were chosen in spite of the presence of native trees at both the lakes. Although too early to say, Great Cormorants chose only seven Eucalyptus trees (out of 52) at Sankey Lake, and at Kaikondrahalli Lake, perhaps owing to the closeness of these trees to the water source characteristic of colonial nesting waterbirds. A study by Rotternborn (2000) draws our attention to the fact that hawks nesting in eucalyptus, and other exotic trees, were found to have greater breeding success, owing to improved stability and protection offered by those trees, compared to native species, signifying the fact that tree height and diameter are the most significant predictors of suitability for nesting.

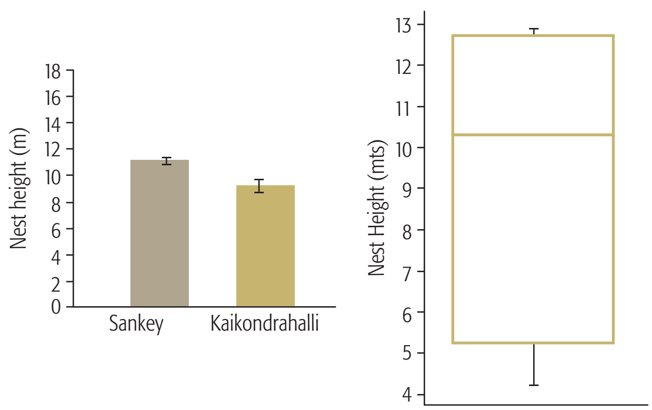

Fig. 3. Box plot of average nest heights of Sankey and Kaikondrahalli lakes (Median: 10.3, Minimum: 4.2, Maximum: 12.9, Interquartile range: 7.475)

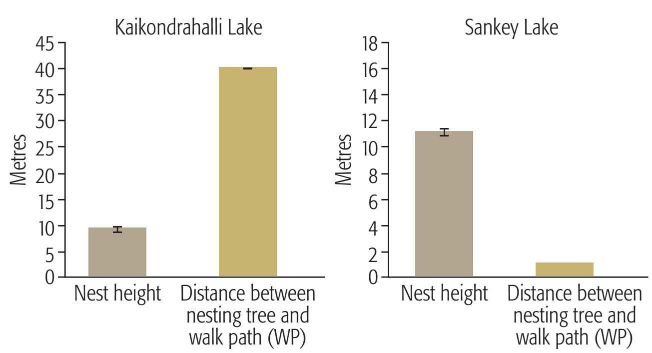

Fig. 4. A comparison of the variations in nest heights of Great Cormorants, on Eucalyptus trees, as a consequence to the distance of walk path from the heronries at the two lakes.

The current study did not find a co-relation between a tree's diameter and its suitability for nesting, at both the lakes, and is unable to answer questions like, 'was nest height a function of the availability of forked branches at appropriate heights for cormorants' nests?' The author could not measure average fork heights of the nesting trees at both the sites, to see if there was a significant difference between nesting heights. My pursuit of this question at the Sankey heronry came to an abrupt halt as, unfortunately, all the cormorant nests were removed. I did not attempt to answer this query at Kaikondrahalli, which may be one of the pitfalls of this study.

Even though Black Kites *Milvus migrans*, Brahminy Kites *Haliastur indus*, and crows *Corvus* sp., were seen around the nests, the author did not observe any aggression from these birds towards the nesting birds, during the study period in and around Sankey Lake and Kaikondrahalli Lake walking trails. Surprisingly, cormorant nests at Kaikondrahalli Lake were built on dead (in comparison to healthy living trees at Sankey Lake) Eucalyptus trees, perhaps owing to the fact that these trees are generally decay resilient, and their tall growth pattern and sizeable limb structure could be the imperative requirements for these birds, in comparison to the native trees. Albeit other trees, with desired features, were present in the locality, scientific literature suggests that birds prefer to nest in trees that were selected previously by their predecessors (Natusch et al. 2017; Kelsall & Simpson 1980; Visser et al. 2005; Roshnath et al. 2017) and this could as well be an explanation for cormorants choosing Eucalyptus trees at both these lakes.

A quick glance on the history of Great Cormorants in Bengaluru (George et al. 1994) reveals an interesting contrast of being rare sightings around the 1990s, to common occupants in and around tanks and lakes of Bengaluru now. Furthermore, cormorant colonies in recent years at Bengaluru might be a new phenomenon suggesting this might be an adaptive response to urbanization, and the birds seem to have become acclimatized to people.

There have been a lot of forceful suggestions to authorities by the walkers at Sankey Lake, to remove the existing cormorant nests on the trees alongside WP; but the study urged that no such hasty measures be taken by the concerned authorities, since nesting on eucalyptus trees is observed to be a rare phenomenon in southern India, especially for a duration of almost two decades. On 03 September 2021 I was shocked to see that despite my repeated requests to the contrary, all the nests had been removed from the Sankey Lake colony. Fortunately, nests at Kaikondrahalli remain undisturbed. The study recommends further investigation of cormorant nesting behavioural biology and conservation, and its relevance at these urban habitats in lieu of further damage from humans.

Declaration of competing interest and funding

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The author wishes to declare that the present study did not seek any financial supports from any organization, committee, group, or individuals and was entirely self-funded.

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Status of the Common Redstart *Phoenicurus phoenicurus* on the Indian Subcontinent: vagrant, passage migrant, or breeder?

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The nominate subspecies of the Common Redstart *Phoenicurus phoenicurus* breeds from Morocco, Spain, and Britain, in the west, to Lake Baikal (Siberia), northern Mongolia, and north-western China, in the east (del Hoyo & Collar 2016). A second subspecies, 'Ehrenberg's Redstart' *P. p. samamisicus* (hereinafter *samamisicus*), is restricted to the south-eastern part of the species' distribution, with its core breeding range stretching across Greece, southern Bulgaria, Turkey, the Caucasus, and the northern Middle East to south-western Central Asia (Martinez et al., 2022). The species, as a whole, spends the non-breeding season in the northernmost third of sub-Saharan Africa (north of the Congo Basin) and in south-west Arabia (Clement & Rose 2015). During work in various European museums (coupled with a systematic trawl of publicly accessible data in online databases, such as eBird and iNaturalist) designed to elucidate the precise distributional limits of the two subspecies of Common Redstart, and to evaluate levels and zones of intergradation between them, which issues have been subject to contradictory statements in the literature, we revisited the status of *P. phoenicurus* in Afghanistan, Pakistan, and India.

Vaurie (1959), Rasmussen & Anderton (2012), and Clement & Rose (2015) suggested that this subspecies may breed in Afghanistan. Note, however, that in mentioning that *samamisicus* is likely to be a summer visitor to north-west Afghanistan, Rasmussen & Anderton (2012) mentioned that the only specimen of the latter race reported to be from the Indian Subcontinent in fact emanates from Iran (their Appendix 2). We can assume that the more recent of these authors followed Vaurie (1959), but the latter's source is quite unclear, as none of the major sources he cites for Afghan distributions (e.g., Meinertzhagen 1938a–b; Whistler 1944a–b, 1945a–c) mentions *P. phoenicurus*, and neither does Paludan (1959). Furthermore, there appears to be no specimen of this species collected in Afghanistan by Koelz, whose material would be another obvious source for Vaurie's comment. Koelz's specimens are held in the American Museum of Natural History (New York), Field Museum of Natural History (Chicago), and the University of Michigan Museum of Zoology (Ann Arbor). The first published record of