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Factors influencing roost site preference of Rose-ringed parakeets (*Psittacula krameri*, Psittacidae, Psittaciformes) in urban areas of north Gujarat, India

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Abstract

The study investigated the roosting patterns of Rose-ringed parakeets (*Psittacula krameri*) across six locations in the state of Gujarat, India. Roost sites included 383 trees, of which 228 were used for final roosting and 155 served as pre-roosting sites. The study was conducted over a period of four months from 2019 to 2020. A total of 20 different tree species were identified as roost sites, with *Ficus benghalensis* being the most utilized. Overall, 228 roosting trees, spread across 12 locations, hosted 50,161 parakeets, with the highest concentration occurring in gardens. Tree height and canopy cover significantly correlated with parakeet numbers, with taller trees (>15 m) and those with canopy cover >100 m² supporting the most parakeets. Pearson correlation analysis confirmed these relationships (R^2= 0.1661 for height, R^2= 0.3610 for canopy cover, both P< 0.01). No significant monthly variation in parakeet numbers was observed. Normalized difference vegetation index (NDVI) values ranged from 0.007 to 0.51, with a mean of 0.16 for roosting sites, suggesting suitable roosting areas are scattered in dense vegetation, predominantly on the city periphery. The study underscores the significance of tree height and canopy cover to parakeet roosting site selection.

Key words: Bird behavior, roosting patterns, site selection, tree canopy cover, tree height

Rose-ringed Parakeets (*Psittacula krameri*) belong to the Order Psittaciformes and Family Psittaculidae, and have become naturalized in many countries throughout the world that they are not native to (Forshaw, 1989; Juniper and Parr, 1998). They are one of the most common parakeet species inhabiting the Indian sub-continent, and apart from Asia, they are also found in some countries in Europe but rarely in Africa and North America (Butler, 2003; Ahmad et al., 2011). The Rose-ringed parakeet is listed as Least Concern on the IUCN Red List, as it appears to have stable and sustainable populations in different ecological habitats (Zeeshan et al., 2016). This species of bird is mostly unwanted and un-appreciated as it is a pest of agriculture, establishes and reproduces rapidly, aggregates in large roosts in human-inhabited areas, and are disruptive to humans because of noise and fecal pollution (Menchetti et al., 2016; Crowley et al., 2019; Shiels and Kalodimos, 2019).

Roosting is a typical bird behavior (Richner and Heeb, 1996), and the Rose-ringed parakeet is a communally roosting species during its non-breeding season (Ali and Ripley, 2001; Prasanth Narayanan et al., 2018).

The word 'Roost' is derived from the German language and means "a sleeping house of birds;" where winged animals, especially birds or bats, rest or sleep; and it may be permanent or temporary, communal or solitary (Jayson, 2018). Rose ringed-parakeets are known to be social and sedentary birds. Social assemblages are essential for reproduction and survival for birds and nocturnal roosts might also be important social centers (Harms and Eberhard, 2003). Communicating information, about avoidance of predation and food sources is a significant function of communal roosting (Jayson, 2018) and communal roosting is practiced by birds when large flocks or colonies roost together, usually in trees, with several hundred individuals in each.

They prefer to roost in tall trees with dense crowns. Nearby human habitation and large trees with dense canopy cover provide them with shelter and safety, along with anthropogenic feeding opportunities. The quality of these roosting habitats can significantly influence parakeet populations, causing them to vary over time (Arscott et al., 2002). The populations can be dependent on differential habitat requirement and habitat specialization (Kannaiyan and Pandiyan, 2018). This study was planned to identify the characteristics of communal roost sites selected by Rose-ringed parakeets by evaluating their roosting localities, population numbers, and habitat preferences. The information gathered is useful in effective parakeet management for agriculturalists and naturalists. Urban bird population management helps to reduce and prevent future damage and economic losses caused by these birds. Wildlife conservation in urban habitats is increasingly important due to the current trend of urbanization and development in small towns. Studying urban birds may help to understand the conservation approaches needed for urban ecosystems.

Study area

The present study was carried out from September 2019 to January 2020. Since the Rose-ringed parakeet is one of the most common and popular urban birds, the roosting preferences and roost site characteristics were studied in Patan city, Gujarat, India (Fig. 1) which is spend over 16.525 km^2. The Patan city and country layers were derived from Survey of India portal, and site locations noted using GPS were plotted on city layer using QGIS (Version 3.36) software for map preparation. The human population of Patan city is around 1.3 million. The climate is warm, sub-humid and sub-tropical with 765 mm annual rainfall and the annual average temperature ranges from 12 °C–40 °C (Kumar et al., 2017). Patan city has semiarid lands, with diverse habitats, and equally diverse flora and fauna (Patel et al., 2021). Twelve different roost sites were identified in the city and confirmed for the roost count. The authors divided Patan city into six land use (LU) sites (road, commercial, education, sports, garden and religious) based on a survey, and this was helpful in identifying which place is more suitable as a roost site for Rose-ringed parakeets.

Data collection

Active roost sites were searched at least one hour before sunset by direct observation at each LU site. Information about parakeet congregations was gathered from the local people living/working near each site. Observations were made on alternate days of the week, in the morning (06:00 am to 11:00 am) and afternoon (03:00 pm to 06:00 pm) using a pair of binoculars (Olympus 10×50 DPS I FIELD 6.5º) by three observers. The morning and evening count of the parakeets leaving and returning to the roosts, respectively, were conducted from an 8 - 10-meter distance to avoid any disturbance to the parakeets. Accumulated fecal matter was also used as indirect evidences of bird roosting beneath the crowns of the trees (Shalini and Pant, 2023). A total of twelve roosting locations were selected for the study. The roost site characteristics, such as the number of roosting trees used by parakeets and non-roosting trees on the site were counted; and roost tree species, were identified and noted (Shabnam et al., 2017). Further, the height and canopy cover of roosting trees were also measured. Roost tree height (m) was measured by use of a rangefinder (Nikon forestry pro 6×21 6.0º). Canopy cover of roost trees was determined by measuring the radius (m) of the tree crown, with the help of a measuring tape, from the edge of the crown to the estimated center of the trunk (Saiyad et al., 2017). In addition, the number of parakeets was also counted in the upper, medium and lower canopy of roost trees by simple approximate "Roost Count Method" (Bibby et al., 2000; Vasundriya et al., 2011; Chavan et al., 2017; Jayson, 2018). The tree species were identified using Singh (2008).

The total count of Rose-ringed Parakeets was made, as described by Mabb (1997), by counting the number of parakeets flying into the roost in each occupied tree and subtracting the number of parakeets flying away from the roost in the same observation period.

Data analysis

The data were analyzed to determine parakeet roosting preferences based on tree height, canopy cover, the localities within the town, and the time of year. Non-linear regression analysis using Gaussian normality distribution function was used to check the relationships between tree height, canopy cover and number of roosting parakeets. Further, Pearson correlation test was employed between tree height and canopy cover with the number of roosting individuals (Koli et al., 2019). One-way ANOVA test was employed to check the significance between different tree height categories at the different localities and in different months of the year. We performed Normalized difference vegetation index (NDVI) analysis to assess the vegetation cover of roosting sites. Satellite data from Landsat-8 was obtained from USGS Earth Explorer. The image was preprocessed, followed by atmospheric correction to further calculate the vegetation health of the study area. Using ArcMap 10.5 software, we generated an NDVI map and extracted values for the roosting sites. NDVI was calculated with the Raster calculator tool applying the following formula:

(NIR – RED / NIR + RED)
(Band 5 – Band 4 / Band 5 + Band 4)

Here, NIR (Band 5) is Near-infrared reflectance, high in healthy vegetation. RED (Band 4) indicates Red light reflectance, absorbed by vegetation. This formula measures vegetation health, with values ranging from -1 to +1, where the higher values indicate denser, healthier vegetation (Rouse et al., 1974).

Table 1: GPS location of six surveyed roost sites of the Rose-ringed parakeets (*Psittacula krameri*).

Sr. No.	Site type	Local name of place	Latitude	Longitude
1	Road	Kohinoor Cinema Road	23.8552	72.1277
2	Commercial	Navjivan Maternity Home	23.8522	72.1219
	Commercial	Civil Hospital	23.8511	72.1236
	Commercial	(U.G.V.C.L)	23.8508	72.1277
	Commercial	Jhuna Ganj	23.8491	72.1211
3	Education	P.K. Kotawala Technical College	23.8513	72.1261
	Education	Bagavada Kumarshala	23.8516	72.123
	Education	Taraben Prathmik Shala	23.8519	72.1227
4	Sports	Bagvada Sports Club	23.8522	72.1233
5	Garden	Gandhi Bag	23.8513	72.1275
	Garden	Chaturbhuj Bag	23.8508	72.1222
6	Religious	Baliya Hanuman Temple	23.8497	72.1269

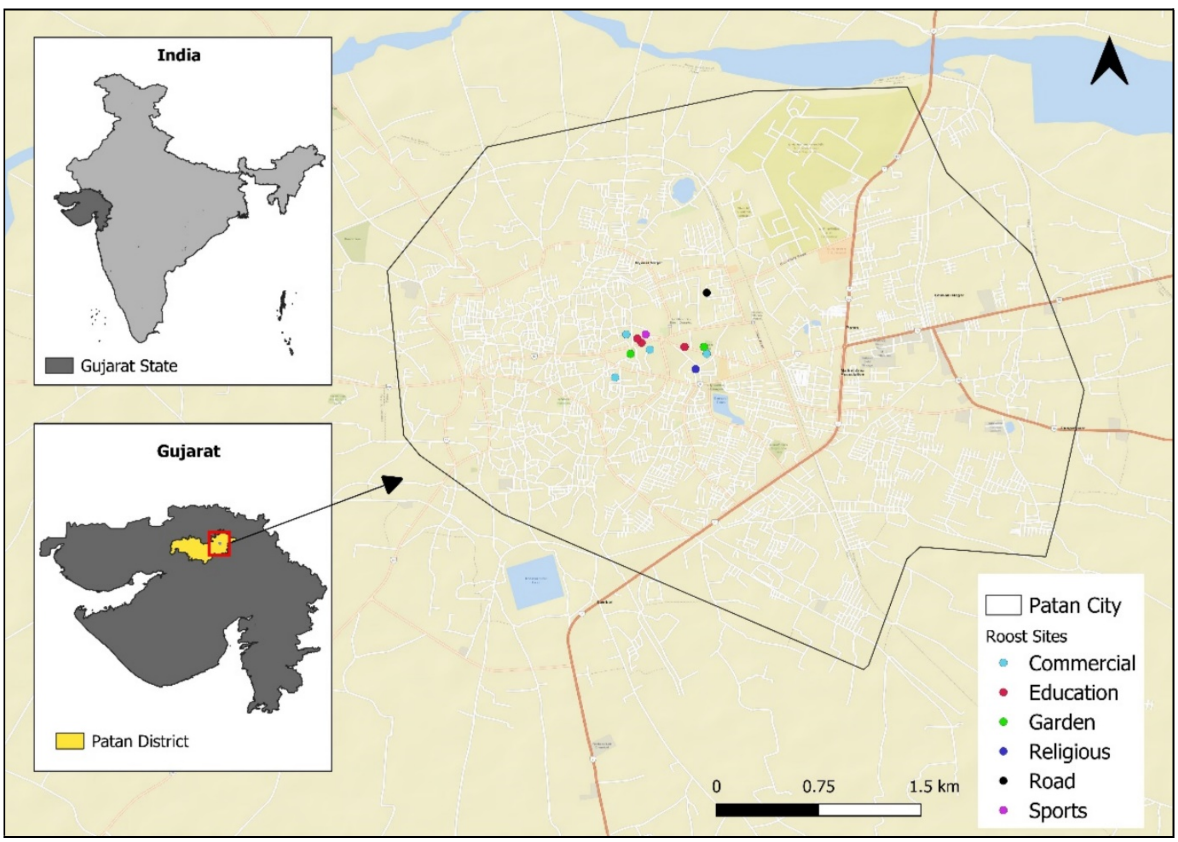

Figure 1: Map showing the location of communal roosts of Rose-ringed parakeets (*Psittacula krameri*) in Patan city, Gujarat, India.

Tree selection

A total of 383 trees from 20 different species were counted from the six LU sites (see Table 1), of which 228 were used by Rose-ringed parakeets for roosting, however, the other 155 trees were not used for roosting but they were considered as pre-roosting trees (where the birds perch for a while before going onto the final roosting tree). Of the 20 tree species that were identified as used for roosting, the highest number of Rose-ringed parakeets were observed to roost in *Ficus benghalensis* L., followed by *Ficus amplissima* Sm., and various unidentified *Acacia nilotica*. Other trees species, like *Polyalthia longifolia* had the least number of roosting parakeets observed in them (Table 2). A total of 228 trees at the 12 different roosting locations were recorded with 50,161 parakeets, with a minimum of one to a maximum of 57 roost trees per site. The maximum number of roost trees were found in gardens (n= 81), which are green spaces with ample canopy cover and low human disturbance, followed by educational complexes (n= 65) such as schools and colleges, commercial (n= 46) such as shopping areas and office areas which are densely populated with fewer trees, and religious sites (n= 23) such as premises of worship. The minimum number of roost trees were recorded on road sides (n= 5) and sports complexes (n= 7), such as local play grounds.

Tree height

The maximum number of parakeets (312.4 ± 117.1 m) was counted in trees with a height of more than 15 m (Fig. 2)

Pearson correlation was used to measure the relationship between tree height and the number of parakeets and the result shows significant relationship between both parameters (R^2= 0.1661, df = 226, P< 0.01). There is no significant difference though, in the utilization of tree height categories between different localities by the parakeets (F= 1.87, df= 6.37, p> 0.01) (Fig. 3).

Tree canopy

A total 65 of the 383 trees had a canopy cover of less than 20 m^2 whereas 19 trees were recorded with a canopy cover between 80 to 100 m^2. Some very old trees with a canopy cover of more than 100 m^2 were recorded from religious places and educational campuses and the maximum number of parakeets (353.6 ± 58.2) were observed to roost in these trees with a canopy cover of more than 100 m^2 (Fig. 4).

Further, the pearson correlation between canopy cover and number of parakeets reveals the significant relationship between both parameters (R^2= 0.3610, df= 226, P< 0.01). There is a significant difference (F= 10.96, df= 11.55, p< 0.01) in utilization of different tree canopy cover categories by parakeets between the different localities (Fig. 5).

The One-way ANOVA shows a non-significant difference (F= 16.27, df= 13.69, p> 0.01) in the number of parakeets counted between different months. The study shows that the number of roosting parakeets does not show any monthly variation in respect to different roosting localities (Fig. 6).

Normalized Difference Vegetation Index (NDVI)

The NDVI value for the study area ranged from 0.007 to 0.51, indicating the absence of any major water bodies within the city area, with dense vegetation primarily located on the periphery and scattered intermittently throughout the area. The mean NDVI value of the roosting sites is 0.16. However, it is important to note that these values may be affected by the low resolution (30 x 30 m) of satellite imagery as the roosting sites are scattered and have smaller canopy cover than the spatial resolution of image data. The areas with similar NDVI values (around 0.16) and tree species, as mentioned in Table 1, appear to be the most suitable roosting sites within the study area (Fig. 7).

The choice of roost site by Rose-ringed parakeets is heavily influenced by human activity; and this may be done to deter natural predators. Predators, including domesticated dogs (*Canis familiaris*), cats (*Felis catus*), and wild birds of prey like shikra (*Accipiter badius*) and black kite (*Milvus migrans*), typically avoid areas with high human activity levels, allowing urban birds to choose human-dominated areas for roosting (Saiyad et al., 2017). Additionally, this choice will benefit the parakeets by providing easy access to food with minimal effort and flight costs (Harms and Eberhard, 2003; Khan and Zarreen, 2010; Kannaiyan and Pandiyan, 2018). Even though urban birds prefer to roost in places with a high concentration of people and their activity, human city dwellers do not let the birds roost on their properties because of the fecal mess they create. This selection of roost trees by urban birds are often based on two important factors, the height and the percentage canopy cover of a tree.

As canopy cover increases, the number of parakeets roosting in those trees also increases. Saiyad et al. (2017) reported that dense canopy cover is preferred by roosting birds to provide uniform and compact vertical arrangement for perching at night. Opit and Jones (2016) also recorded that roost trees within roost sites were found to be taller and more clumped which may influence the concentration of roosting birds. This indicates that apart from tree species and height, roosting selection also depends on other factors like canopy cover and location (Chavan et al., 2017; Saiyad et al., 2017). The dense canopy cover of a tree provides good hiding places, multi-tier arrangements of perches and a high level of predation protection for roosting birds.

Table 2: Numbers of parakeets (*Psittacula krameria*) roosting in different tree species (N_{Tree} = 227, $N_{Parakeet}$ = 50,161).

No.	Tree species	Common name	# Individual trees	Mean # parakeets	# Parakeets / Individual tree
1	*Acacia nilotica* L.	Babul	3	228.3	76.1
2	*Azadirachta indica* A. Juss	Neem Tree	67	271.9	4.0
3	*Caesalpinia pulcherrima* (L.) Sw.	Galtoro	3	183.3	61.1
4	*Casia fistula* L.	Yellow Shower Tree	12	133.7	11.1
5	*Cordia dicotoma* G.Forst.	Gundo	2	129	64.5
6	*Delonix regea* (Hook.) Raf.	Gulmahor	5	193	38.6
7	*Derris indica* (Lam.) Benn.	Karanj	8	177.6	22.2
8	*Eucalyptus globulus* Labill.	Nilgiri	2	271.5	135.7
9	*Ficus amplissima* Sm.	Peepal	54	391.2	97.8
10	*Ficus benghalensis* L.	Banyan	4	478.7	119.6
11	*Ficus racemosa* L.	Umbaro	1	87	87
12	*Ficus religeosa* L.	Pipalo	7	185.4	26.4
13	*Manilkara haxandra* (Roxb.) Dubard	Rayan	1	185	185
14	*Mimusope elengi* L.	Borsali	1	274	274
15	*Polyalthia longifolia* (Sonn.) Thwaites	Ashoka Tree	91	183.3	2.01
16	Species - 1	(Unidentified)	2	177	88.5
17	Species – 2	(Unidentified)	3	224	74.6
18	*Syzygium cumini* (L.) Skeels	Jambu	9	262.8	29.2
19	*Tamarindus indica* L.	Imli	1	226	226
20	*Terminalia catappa* L.	Indian Almond	1	197	197

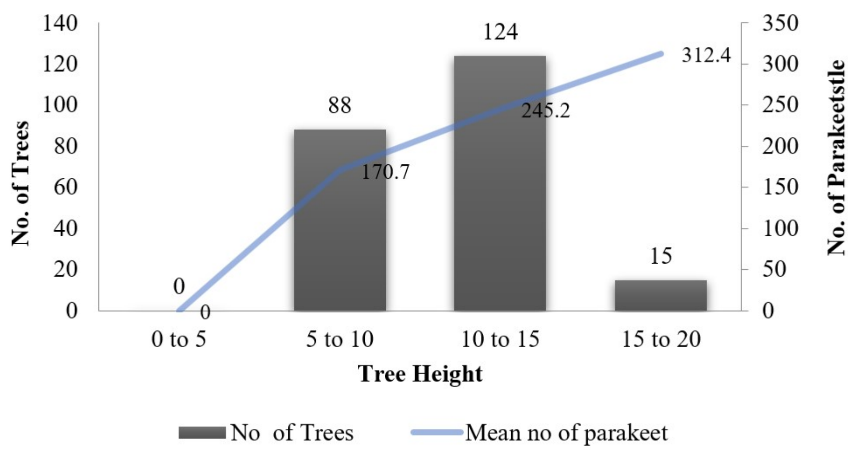

Figure 2: Average number of Rose-ringed parakeets (*Psittacula krameri*) according to tree height ranges (m) in Patan city, Gujarat, India.

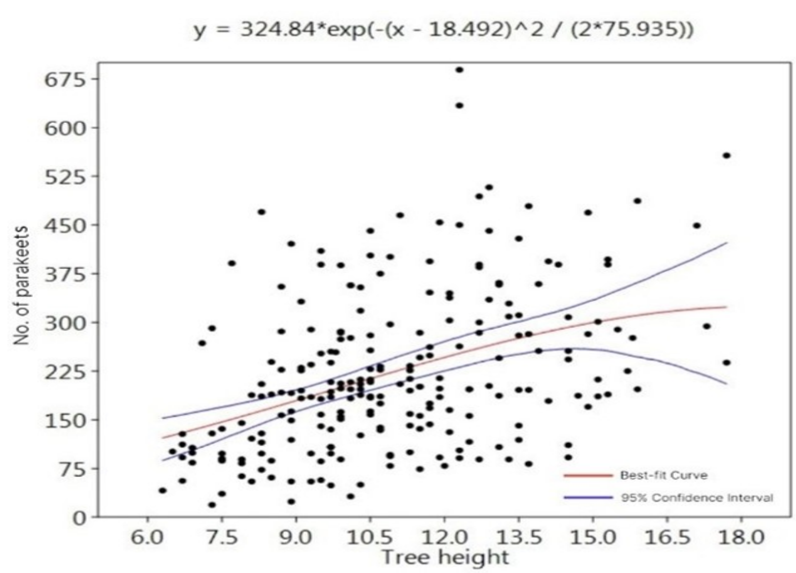

Figure 3: Nonlinear regression between tree height (m) and the number of Rose-ringed parakeets (*Psittacula krameri*) in Patan city, Gujarat, India.

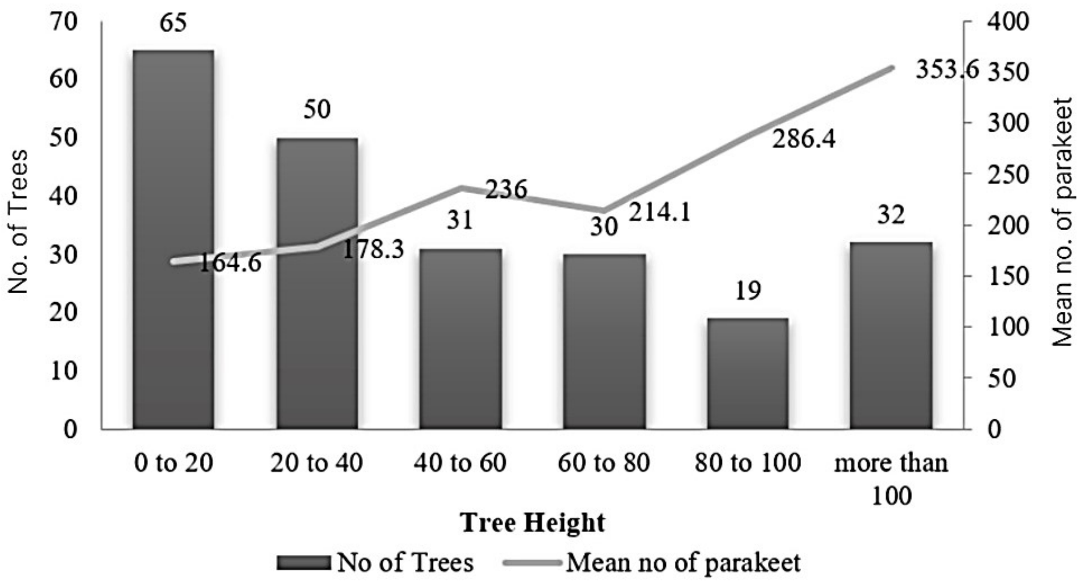

Figure 4: Mean number of Rose-ringed parakeets (*Psittacula krameri*) according to canopy cover (m²) in Patan city, Gujarat, India.

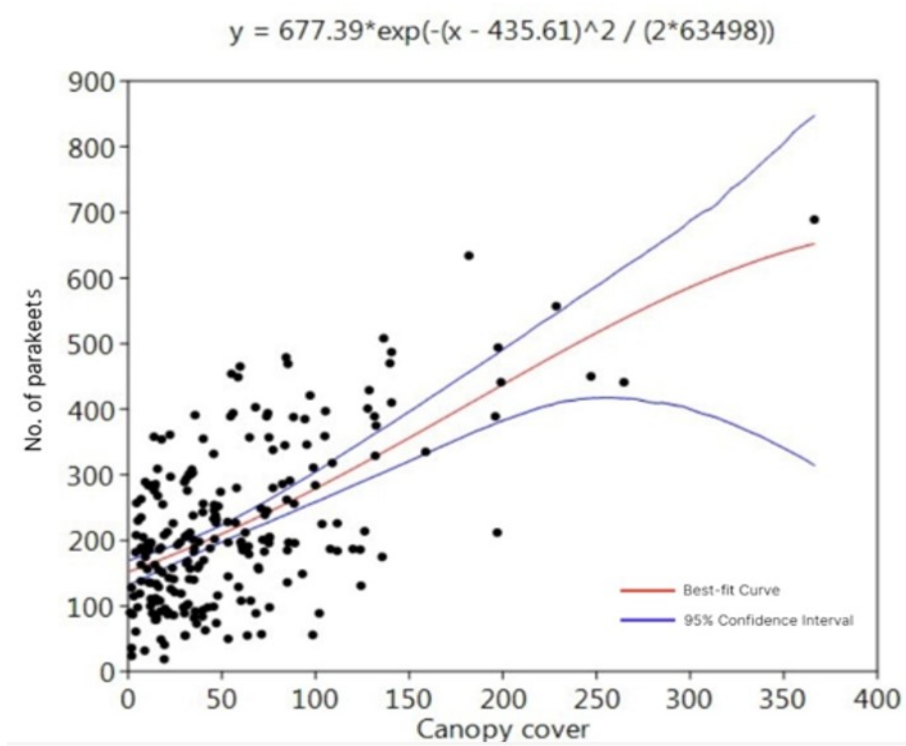

Figure 5: Nonlinear regression between canopy cover (m^2) and the number of Rose-ringed parakeets (*Psittacula krameri*) in Patan city, Gujarat, India.

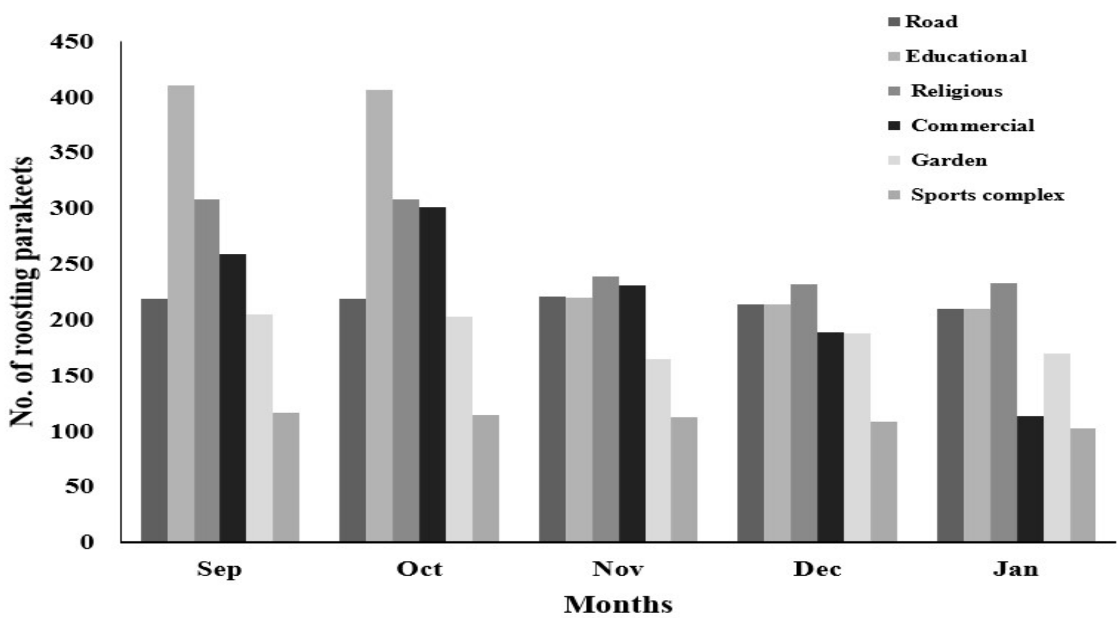

Figure 6: Monthly variation in Rose-ringed parakeets (*Psittacula krameri*) count numbers in different localities of Patan city, Gujarat, India.

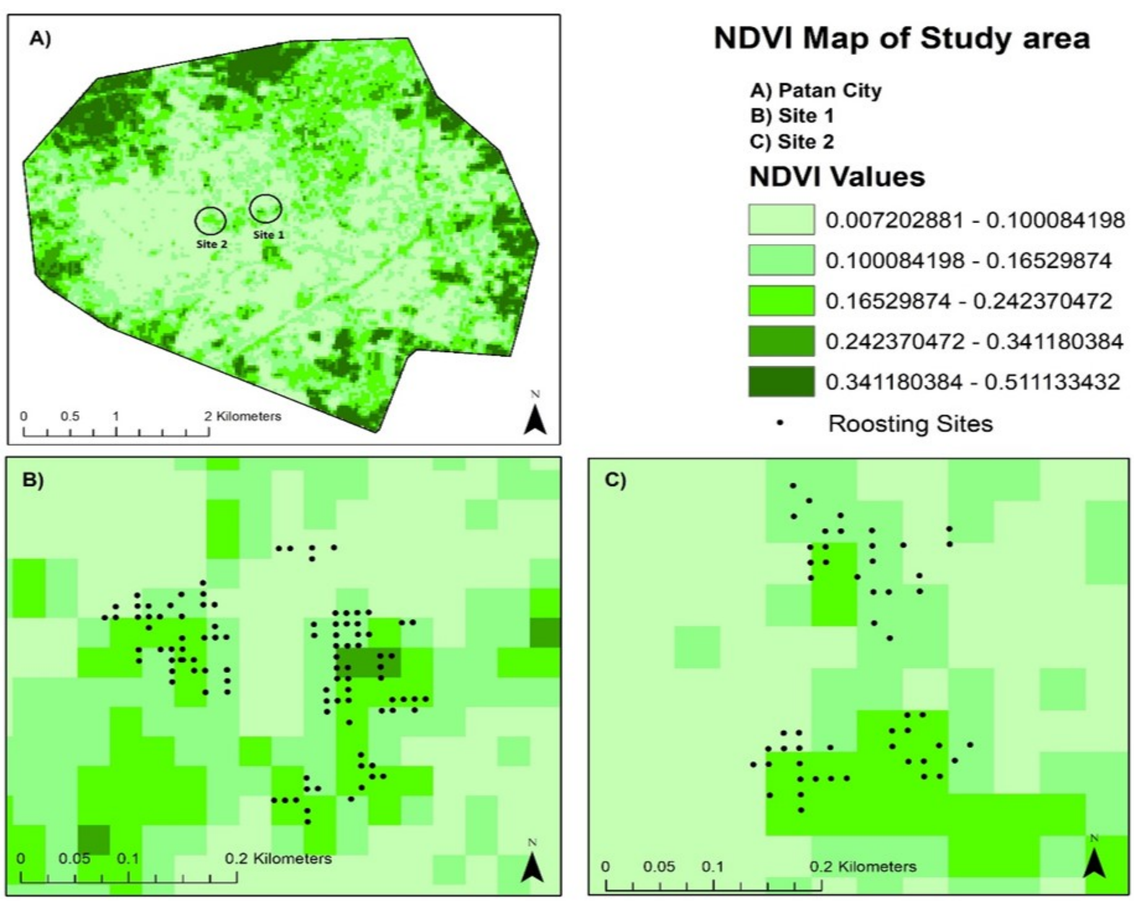

Figure 7: NDVI map of the Rose-ringed parakeets (*Psittacula krameri*) roosting sites in Patan city, Gujarat, India.

Trees with greater height and denser canopy cover also provide protection against heat convection and heat loss by reducing wind velocity and providing stable roosts for birds (Walsberg, 1986; Saiyad et al., 2017). Similarly, greater heights of roost trees provide extra protection from ground predators by making it difficult for predators to climb. Very few predatory threats to the parakeets were recorded during the study period. van Vessem and Draulans (1986) reported that the selection of tall roost trees was a compromise between possible anti-predator advantages and energetic disadvantages through increased wind exposure (Saiyad et al., 2017).

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Author contributions

JP, PD and VP collected data from the field. ND designed the methods and supervised the work. JP and PD wrote the first draft. PD and VP analyzed the data and worked on the second draft. ND reviewed and edited the final manuscript.

Conflict of interest

The authors declare that there are no conflicting issues related to this short communication.

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