“POPULATION ESTIMATION AND DIFFERENT BEHAVIOR OF INDIAN GREY HORNBILL IN VALLABH VIDYANAGAR”

A

DISSERTATION THESIS SUBMITTED TO

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY

VALLABH VIDHYANAGAR

GUJARAT, INDIA

FOR THE PARTIAL FULFILLMENT OF DEGREE OF

MASTER OF SCIENCE IN

ZOOLOGY

SUBMITTED BY

ABHISHEK P. NENA

EXAMINATION NO.: 15

APRIL 2020

UNDER THE GUIDANCE OF

DR. UJJVAL B. TRIVEDI& DR. RUPAL A. VASANT

B. R. D. SCHOOL OF BIOSCIENCES

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DEDICATED TO THE MOTHER NATURE AND MY FAMILY

DECLARATION

I, Abhishek P. Nena, declare that work presented in this thesis, entitled "POPULATION ESTIMATION AND DIFFERENT BEHAVIOR OF INDIAN GREY HORNBILL IN VALLABH VIDYANAGAR" is being submitted for the degree of Master of Science (M. Sc.) in Zoology of Sardar Patel University was carried out under the supervision of Dr. Ujjval B. Trivedi and Dr. Rupal Vasant at B. R. D. School of Bio sciences, Vallabh Vidyanagar, Gujarat. It is an original work and has not been submitted previously for degree/diploma of any other institute. I declare that all the information given is correct and true to my knowledge.

Date: Abhishek Nena

Place: P.G. Department of Biosciences

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Abhishek Nena

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I. INTRODUCTION

GENERAL INTRODUCTION: AVES

Birds have a special place in human science and culture: they capture our hearts, arouse our curiosities, and inspire a sense of wonder. We may revel in the diversity and simple beauty of their forms, but birds also fuel fascinations that drive us towards deeper scientific inquiries into their varied ways of life (Lovette and Firzpatric, 2016). Birds are highly mobile and easy to observe. They are relatively easy to recognize and their occurrence and habits are noted by millions of passionate birdwatchers or just interested persons (Fielder 2016).

A Bird has been described as a 'Feathered Biped.' This description is apt and precise, and can apply to no other animal. Birds are warm-blooded animal, whose temperature remains more or less constant and independent of the surrounding temperature. To assist in maintaining an even temperature, the body of a bird is covered with non-conducting feathers. Their rate of metabolism is greater than that of mammals. They lack sweat-glands (Ali, 1941). Birds have unique skeletons: every bird is equipped with specialized forelimbs and fused hand bones that together form a wing (Lovette and Firzpatric, 2016). Many of their larger bones are hollow and often have air sacs which function principally as accessory respiratory organs. This makes for lightness without sacrificing strength, and is a special adaptation to facilitate aerial locomotion (Ali, 1941).

Aves are extensively distributed throughout the world as compared to other vertebrates. Avifauna is categorized according to their behavior, habitat and feeding mechanism. Birds are found from pole to equator almost everywhere on the earth and exhibit great

diversity by their habitat and geographical conditions (Dave, 2019). Birds have similarly influential standing in our efforts to conserve the natural world. Birds serve as flagships for imperiled habitats and ecosystems, and as early warning systems for environmental toxins or other destructive forces. Conservation efforts focused on birds often help preserve many other less conspicuous organisms. And owing to their charisma and popularity with humans, birds can help inspire all of us towards being better stewards of natural systems and biodiversity (Lovette and Firzpatric, 2016).

There are around 9702 bird species recorded throughout the world (Sibley and Monroe, 1990), after 2014 world's 9,993 recognized bird species (Walter et al., 2014), out of which Indian subcontinent is home to 1,313 bird species (Grimmett et al., 2011). In 2004, according to the list, a total of 526 species (Parasharya et al., 2004) were recorded, and in 2016 Ganpule recorded 574 species of birds from the state Gujarat (Gangue 2016). Birds are common dwellers of ecosystems and have been considered as environmental bio-indicators of inhabited areas (Blair 1999). Birds are of the most important indicators of the health of an ecosystem; react very rapidly to changes in their habitats (Morrison, 1986).

CLASSIFICATION OF BIRDS

Kingdom	:	Animalia
Phylum	:	Chordata
Subphylum	:	Vertebrata
Class	:	Aves

The first step of classification is Kingdom. Birds are classified into the Kingdom Animalia (i.e. Animals). The kingdom is further divided into the Phylum. Birds are

belong to Phylum Chordata (Animals with a backbone). Next in classification is the Class. The Class for birds is Aves then classification lead to different orders according to habitat, feeding behavior, morphological patterns and phenotype of birds.

The bird population in the nation is separated into 23 orders, 107 families and 498 genera (Praveen et al., 2016).

There are lot of species of birds that attracts enthusiasts to study ecological and biological aspects of birds, from which I was attracted to hornbill, specially Indian grey hornbill. Kinnaird (2007) described hornbills as "ideal subjects for studying ecological and behavioral questions."

BACKGROUN: HORNBILL

Hornbills are an interesting group of birds among all avifauna and they are among the largest birds in tropical lowland forests. They have a casque surmounted over their bill that looks like a horn, thus the name 'Hornbill' (Kasambe 2011). They are boldly colored, give loud, distinctive calls, and are noisy in flight and hornbills of any given species vary in color patterns, the size and shape of bills and casques, and even the pitch of their calls (Kinnaird, 2007).

Hornbills occur across sub-Saharan Africa, through India and southern Asia, and the Sunda Shelf islands of Indonesia. However, Asian Hornbill species are believed to prefer well developed forests that can provide large trees for nesting and a variety of fruiting trees with strangler figs (Kinnaird, 2007).

Hornbills are considered taxonomically unique enough to be placed in two separate families, Bucerotidae (savannah and forest hornbills) and Bucorvidae (ground hornbills), under the order Bucerotiformes. Earlier they were placed along with birds such as kingfishers, bee-eaters, rollers, trogons, and hoopoes in the order Coraciiformes (Raman & Mudappa1998). There are 54 species of hornbills in the world (Kemp 1995) and nine species occur in India (Ali & Ripley 1987) namely, Austen's Brown Hornbill *Annorhinus austeni*, Great Hornbill *Buceros bicornis*, Malabar Pied Hornbill *Anthracoceros coronatus*, Narcondam Hornbill *Rhyticeros narcondami*, Oriental Pied Hornbill *Anthracoceros albirostris*, Rufous-necked Hornbill *Aceros nipalensis*, Wreathed Hornbill *Rhyticeros undulatus*, Malabar Grey Hornbill *Ocyceros griseus*, and Indian Grey Hornbill *Ocyceros birostris*.

Indian Grey Hornbill, *Ocyceros birostris:*

The Indian Grey Hornbill *Ocyceros birostris*, also known as Common Grey Hornbill, is reported to occur in India, Pakistan and Nepal (Ali & Ripley 1987). Its scientific name is *Ocyceros birostris*. In the scientific name *Ocyceros birostris*, the genus name *Ocyceros* stand for 'a spear-shaped horn' (*okua* in Greek stands for a spear and *keros* stands for a horn) and the species name *'birostris*' stands for 'double beak' (*bi* in Latin meaning two and *rostris* meaning beak) coined because of the presence of the protuberance or casque on its beak, making it appear like a double beak. It is a small pale brownish-grey hornbill with prominent pointed casque on blackish beak (Kasambe 2020).

Scientific Classification:

Kingdom	Phylum	Subphylum	Class	Order	Family	Genus	Species
Animalia	Chordata	Vertebrata	Aves	Bucerotiformes	Bucerotidae	*Ocyceros*	*O.Birostris*

(Bird Life International. 2016. *Ocyceros birostris*. The IUCN Red List of Threatened Species 2016.IUCN 2016.).

Order Bucerotiformes

This order contains the hornbills, hoopoe and wood hoopoes (Grill frank et al. 2019). Previously these birds belonged to order *Coraciiformes*, but now they are separated into particular order. Characteristic of this order is having long beak. Order includes74 species, 19 genera and 4 families. Families: *Bucerotidae* (hornbill), *Bucorvidae* (ground hornbill), *Phoeniculidae (WoodHoopoes), and Upupidae (Hoopoes).*

Family Bucerotidae

All the species of hornbills are included in the family Bucerotidae. According to Kasambe there are 60 species of hornbills in the world. Indian Grey Hornbill *Ocyceros birostris* is widely spread and most common species in Asia (Kasambe 2020). Name of the family refer to the shape of the bill, "buceros" being "cow horn" in Greek.

Morphometric characters:

Indian gray hornbill is a medium sized bird, slightly larger than Asian Koel, measuring 50 cms in length (Grimmett et al. 2011). It is clumsy grey bird with a heavy curved blackish bill surmounted by a peculiar pointed protuberance or casque; long black and white tipped graduated tail, the pattern particularly conspicuous when tail spread in

alighting. Bird have a Bill slaty black on basal portion including casque, waxy yellow or creamy white on culmen, tips, and most of lower mandible. Legs and feet are plumbeous to slaty black and claws are black (Ali & Ripley 1983). Male has larger casque on dark beak with yellowish culmen and lower mandible. Female has smaller, yellowish beak with black only on basal half and on smaller casque. Juvenile lacks casque on mostly pale-yellow beak (Kasambe 2020). Color of the iris is brownish orange to red male and brown in female (Ali & Ripley 1983). The circum-orbital skin color is easy to observe than the casque size and one can easily tell whether it is a male or a female. The bare circum-orbital skin behind the eyes in the female is slightly orange or dull pink, whereas in the male it is lead black. It is dull orange in juveniles (Kasambe 2020).

Figure 2: Indian grey hornbill male (up) and female (down)

Habitat:

The Indian Grey Hornbill is an entirely arboreal species, which is found in open deciduous forests and lightly wooded country, groves of ancient mango, banyan and Peepal trees, coming into gardens and avenue, and avoiding thick forest (Ali 1941; Whistler 1949).

Food habits:

The most important food of Indian Grey hornbills is figs of Ficus trees, namely Banyan *Ficus benghalensis*, Peepal *Ficus religiosa* and Cluster Fig *Ficus racemosa*. The hornbills are mainly frugivorous during the non-breeding season; but during the breeding season they become omnivorous to fulfill the requirement of calcium and proteins of the growing nestlings (Kasambe 2011). Indian grey hornbill largely feed on fruit, especially wild figs (Ficus spp.), berries and flower petals, insects (beetles, mantids, grasshoppers, wasps, etc.) and occasionally on lizards, mice and other small animals. Recorded eating the poisonous fruits of the Yellow Oleander- *Thevetia neriifolia* (Ali & Ripley 1983).

General habits:

The Indian grey hornbill is largely arboreal, but will occasionally descend to the ground and hop about with vertically cocked tail to pick fallen fruit. Similarly also for winged termites emerging from rain-sodden ground, the birds taking each insect in the bill-tip and jerking the upraised bill to transfer the morsel to the gullet.

The Indian Grey Hornbill keeps in pairs or small parties of 5 or 6, feeding on fruiting trees such as Banyan and Peepul (*Ficus spp.*) in the company of mynas, green pigeons, bulbuls and other frugivorous birds; where food is abundant, one can even see large assemblages of 30 birds. Under threat, they form small groups and get scattered in different directions, each small party in "follow-my-leader" style, uttering weird squeals. Their flight is undulating and noisy with few rapid flaps followed by a dipping glide and sailing with the wing tips strongly unturned (Ali & Ripley 1983). They have been documented to enjoy dust-bath on regular basis (Santharam 1990).

Breeding behavior:

Indian Grey Hornbills breed from March to July (Ali & Ripley, 1983) thus covering the entire summer months and early monsoon. The breeding habits of hornbills are unique in that the female of most species seals herself into a nest cavity and leaves only a narrow slit through which the male passes her food until the nesting period is completed (Kemp 2001).

Indian Grey Hornbills are quite choosy in selecting cavities for nesting. Available cavities are inspected following cleaning and expansion of entrance and subsequently courtship rituals are also initiated. During courtship, the male offers a variety of fruits, garden lizards and other food to the female. The male gradually increases the amount of courtship feeding and starts mating with the female. After mating and when ready to lay the female enters the cavity and seals herself inside. For nest sealing is being done by either mud or female excreta. A narrow slit is left in the entrance through which the male feeds his mate throughout the incubation period. Normally female lays 2 or 3,

rarely 4 eggs. Incubation period lasts for 65 to 70 days in case of the Indian Grey Hornbill. After the eggs hatch and the young are about a week old, the wall is broken down to release the female and then it is rebuilt with a narrow opening as before. Through this both parents feed the squabs till they are fully fledged. The wall is then broken down to let them out (whether by the parents, or chicks, or both). Female evidently moults her wing-quills during her incarceration. All Asian hornbills are considered monogamous and loyal to each other and claimed to mate for life (Ali & Ripley 1983; Kasambe 2011).

Local name of Indian grey hornbill:

Indian gray hornbills are distributed in different regions of India known by different regional names (Ali & Ripley 1983): *Dhanel, Dhanmar, Dhand, Selagilli* (at Saugar, MP) *Lamdar, Chalotra, Dhanesh*, all in Hindi, *Puttialv Dhanesh* in Bengali, *Rundu Mukkula Guwa, Supnati, Kommukasiri* in Telugu, *Munumukkulakaka, Irawakke i*n Tamil, *Chilotro* in Gujarati and *Bhinas* in Marathi. Recently I have heard a new name of Indian grey hornbill in Kutch region: *Chilor*.

In Sanskrit, common names for all Hornbills: मातृनिन्दक (सुश्रुतसंहिता) (Dave 1985).

Hence the name matrunindak for a male who unusually play the role of a mother to his female partner and chicks! *Sushrut Samhita* mentions the hornbill as ‘matrunindak' meaning one who criticizes the mother or one who puts a mother to shame.

Distribution of Indian Grey Hornbill

- **In India**

Indian grey hornbill is resident species found throughout the well wooded parts along the Himalayan foothills southwards throughout the Peninsula, plains and hills, excepting the more arid parts of Rajasthan and Gujarat (Kutch), and the heavy rainfall areas of Kerala. It is confined to the areas with deciduous forests. It prefers open but fairly well wooded country with a scattering of Ficus trees, roadside avenues, groves and rambling gardens, in the neighborhood of cultivation and habitation (Ali & Ripley 1987). In last few decades, it has been sighted in the drier parts of Rajasthan, such as Banswara (Bhatia 2000) as well as in the Thar Desert, Jodhpur (Chhangani 2005).

- **In Gujarat**

In Gujarat species has distributed in part of north Gujarat, central Gujarat and south Gujarat including protected area. Ali collected specimens from Juna Rajpipla and also noted from Ajwa (Vadodara), Hatiadhara (Palanpur), Songadh (Navsari), Galkund, Malegaon (Surat Dang), Gujarat (Fauna of Gujarat). Robert Grubh reported its sighting in the Gir forest of Gujarat (Grubh 1971).

- **In Vallabh vidyanagar**

Birding data and studies specifically of the region present no records of the occurrence of the species until 2012. A volunteer of Vidyanagar Nature Club had first recorded a single Indian grey hornbill near Amul Dairy campus, found from a conversation with Vidyanagar Nature Club. In February 2015, another Vidyanagar Nature Club volunteer sighted IGHB near Mota Bazar in Vallabh vidyanagar (Newspaper article).

A web search on www.ebird.org found that hornbill was sighted at Shashtri maidan, but observer was not sure about identification of bird. Since then, many bird lovers and wildlife enthusiasts have regularly spotted Indian grey hornbill but proper record or reporting not found in Vallabh Vidyanagar.

According to belief of kemp (1995) Asian Hornbills are ‘birds of forest’, but increasing population of Indian grey hornbills in urban area disproves that belief. 44% of the Indian Grey Hornbill population has been recorded around city park areas, highest among all nine species of Hornbills occurring in India (Datta et al. 2018).

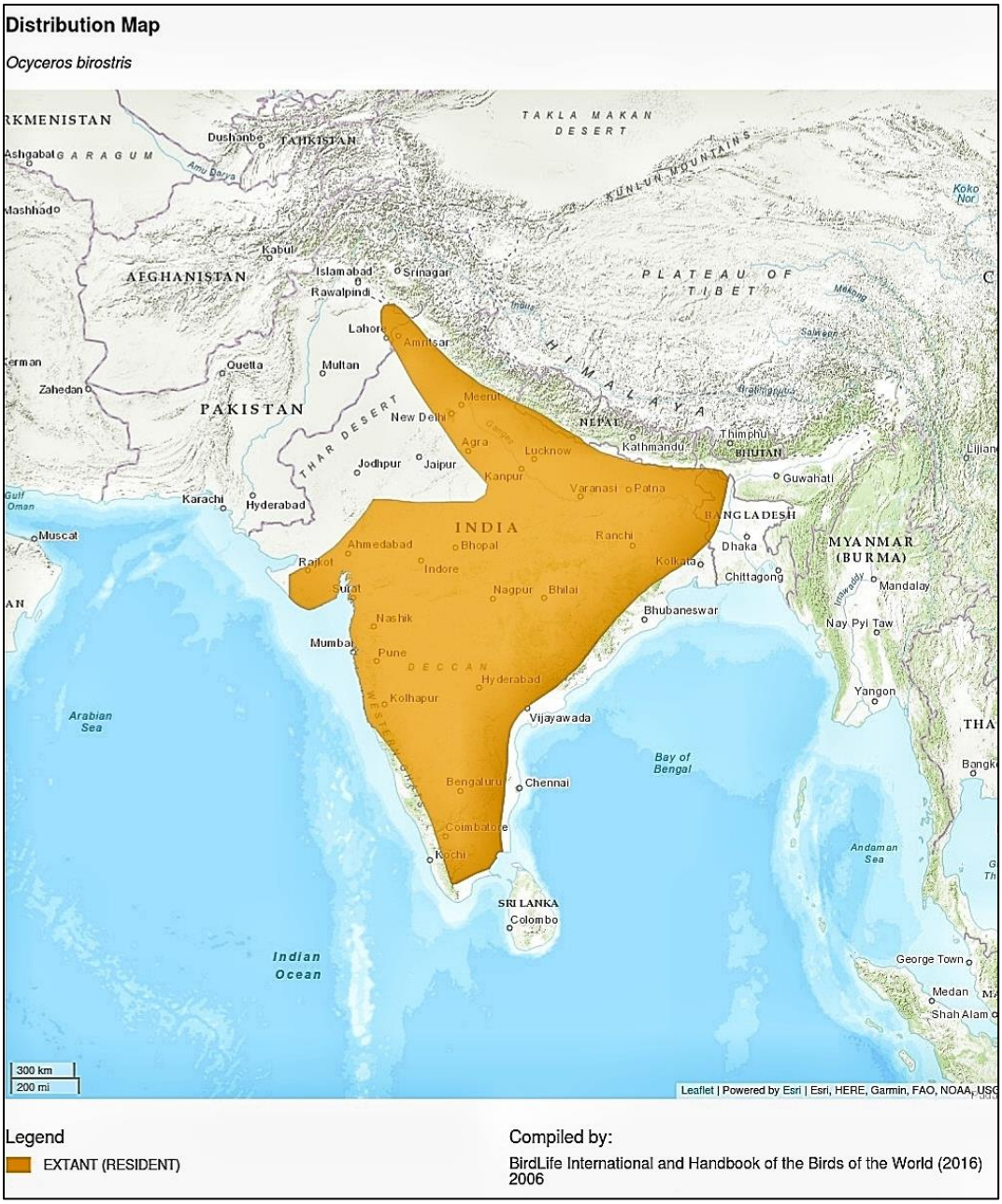

Figure 2: Distribution map of Indian grey hornbill

II. REVIEW OF LITERATURE

Indian Grey Hornbill (*Ocyceros birostris*) is the only hornbill species in India which is also found in urban habitats besides in forested areas (Kasambe2011).

Dutta and Sakthivel (2010) studied Status and distribution of four species of hornbills including Indian grey and 79 Indian grey hornbills were recorded from north and central western ghat and stated that species harbour from Narmada district of Gujarat to Sataradistrict of Maharashtra and in the Shimoga district of Karnataka. Out of four species of hornbills that are inhabited in Western Ghats, the Indian grey hornbills and Malabar Pied Hornbills were more in numbers.

Birasal NR (2014) studied density of Indian Grey Hornbills (*Ocyceros birostris*) in and around Haveri, Karnataka. In this study, the regular observations for Indian grey hornbill was made during summer and early monsoon season in and around Haveri for two decades (March 1994 to July 2013). As hornbills depend on tree cavities for nesting, search for nest cavities was carried out. This study evaluated that, prior to work of road widening, density of Indian grey hornbill was high on the trees of highways and with the removal of trees in the name of development, the number of these birds decreased in highway area. Highway birds moved into the Haveri town. He also noted that because of anthropogenic disturbances, Indian grey hornbill number dwindled as tree cavities are essential for nesting.

Balasubramanian et al. (2011) studied the vegetation features and restoration initiatives in the Indian grey hornbill habitats in Sathyamangalam wild life Sanctuary, Eastern Ghats, India. They noted various plant species on which Indian grey hornbill feeds in riverine forests and dry deciduous forests and concluded that wherever there is more

vegetation, the bird thrives well. They also stated that the riverine forests harboures the necessary trees required for survival (nesting and feeding) of Indian grey hornbill in Eastern Ghats.

Santhoshkumar & Balasubramanian studied seed dispersal by the Indian grey hornbill *Ocyceros birostris* in Sathyamangalam forest division, Eastern ghats, India. They studied nest middens (seeds and fruit deposited under the nest cavity), seed germination trial of hornbill-dispersed seeds and seedling abundance under nest trees, to assess its role in seed dispersal and forest regeneration. From this study they concluded that Indian grey hornbill is a legitimate seed disperser as seeds found in the nest middens were intact. Germination experiments on hornbill's diet species indicated that the seed germination efficiency of 15 out of 16 species is enhanced after defecation. Of the 2082 seedlings recorded under the nests, 55 percent were hornbill's diet species. The dispersal of 26 plant species during the breeding season alone indicates that the Indian Grey Hornbill is a "pivotal" species in the forest ecosystem maintenance.

Few records are available about its food: Patil et al. (1997) analyzed excreta contents of Indian grey hornbill and listed different types of fruit consumed by Indian grey hornbill including green leaves of unknown plant species in Sanjay Gandhi national park, Bombay suburban district. Neelakantam (1953) observed that Indian grey hornbill consumes the fruits of yellow Oleander. Kasambe & Pimplapure (2007) observed Indian grey hornbill plucks and swallows the leaves of *Ailanthus excelsa* in Maharashtra. The leaves of *Ailanthus excelsa* has medicinal properties and is known to be wormicidal. Newnham (1911) described that Indian grey hornbill always has conflicts with Parakeets and they remove young ones from nest holes. A study has been

carried out on food habits of Indian grey hornbill *Ocycerosbirostris* by Santhoshkumar, E. & P. Balasubramanian (2014) in Sathyamangalam forest division, Eastern Ghats, India. The study revealed that both fig and non-fig species are important for the survival of the Indian grey hornbill.

Very few studies and literatures are found on breeding ecology of Indian grey hornbill: Sant, 1995; Rastogi, 2001; Singh, 2003. Breeding behavior and nest tree use by Indian grey hornbill *Ocyceros birostris* studied by Santhoshkumar E, Balasubramanian P (2010) in the Eastern Ghats, India. They recorded 32 active nests during breeding season (Nesting started early in March and ended in late June). From this study concluded that the nesting period averaged 87 days, with the female sealed in the nest cavity for an average of 76 days and the nestlings fledging an average of 13 days after the female emerged. Nest-sealing materials used include the hornbill's own faeces, tree bark, cattle dung and mud. All nests were located in the riverine habitat. Six tree species used for nesting that belonged to five families; the majority (44%) of nests were in *Melia dubia* (Meliaceae) making it the most preferred nest-tree species.

The study on Indian grey hornbill in Gujarat is scanty as compared to other states of India. Dutta and Sakthivel (2010) studied Status and distribution of four species of hornbills including Indian grey hornbill from north and central western ghat, covering southern Gujarat. Out of 79 Indian grey hornbills, 13 recorded from Gujarat covering western ghat. The Gujarat population was recorded from the forests, mandvi range and Vansda National park.

- **AIMS AND OBJECTIVES OF THE STUDY:**

1. To estimate the population and status of Indian grey hornbill in Vallabh vidyanagar town
2. To study and record the different behavior pattern of Indian grey hornbill in Vallabh vidyanagar.
3. To observe and discuss about nest and nest tree of Indian grey hornbill in Vallabh vidyanagar.
4. To observe and discuss about roosting behavior and roosting site of Indian grey hornbill in Vallabh vidyanagar.

III. METHODS AND MATERIALS

STUDY AREA

Vallabh Vidyanagar

The present study was carried out in the Vallabh vidyanagar town of Anand district in Gujarat. It is situated between Vadodara and Ahmedabad, 6 km from India's milk city Anand. Vallabh vidyanagar known as educational hub of Gujarat, located between 22°33'1.18"N Latitude and 72°56'11.67"E longitude.

As mentioned above it is famous for its educational institutions, is also aptly called "Vrikshanagar" as it is endowed with rich vegetation in spite of an increase in population and as well as concrete constructions. Vallabh vidyanagar has more than 80 species of trees planted on roadside; it has perhaps highest numbers of trees in the state of Gujarat in such a small area. As the vegetation is rich, a large avifaunal diversity found in and around Vallabh vidyanagar throughout the year. One more specialty about Vallabh vidyanagar is that town contains the largest colony (habitat) of rose-ringed parakeet; according to last count that was in 2003-4 and there were more than 63,000 ("Vidyanagar Nature Club", 2013. Available online, at: http//www.vncindia.org. Accessed 23rd September 2018). It shows the richness of diversity which is one of the aspects in keeping the ecology as an integral part of the city.

The following figure (MAP2) shows Vallabh vidyanagar town-the study site of present work.

Map 1: Gujarat

Map 2: Vallabh vidyanagar

Map 3: Botanical garden of Sardar Patel University

Figure 3: study site maps

Botanical garden

The Botanical Garden of Sardar Patel University is spread in 3.2 acres of land in Vallabh vidyanagar. There are approximately 200 plant species, including natural herbaceous flora, growing in this garden, out of which 60 species are trees. The germ plasm of some rare, endangered and threatened wild plants and other academically important species from various parts of Gujarat state and across India are collected and conserved here with proper care. Looking at the needs of present day, botanical garden has been reorganized with allocation of specific sections for different kinds of plants such as medicinal plants, horticultural plants, experimental plants plots and a nursery.

The botanical garden of the university has rich floral and faunal diversity. Floral diversity includes wild as well as cultivated trees, shrubs, climbers and herbs, all at one place which otherwise are found in varied geographical and climatic regions. Huge plant diversity attracts many faunas which indirectly in correlation with diversity of birds. Dense vegetation and bushes of botanical garden provides habitat for resting, roosting, foraging, nesting and breeding for birds. Faunal diversity includes different arthropods, reptiles and birds species. Total 43 bird species has been reported in the Botanical garden (Dave, 2019). Professor Ujjwal Trivedi and Rupal Vasant have been regularly visiting, studying and documenting avian fauna at botanical garden since last three year and contributed to explore the richness of biodiversity.

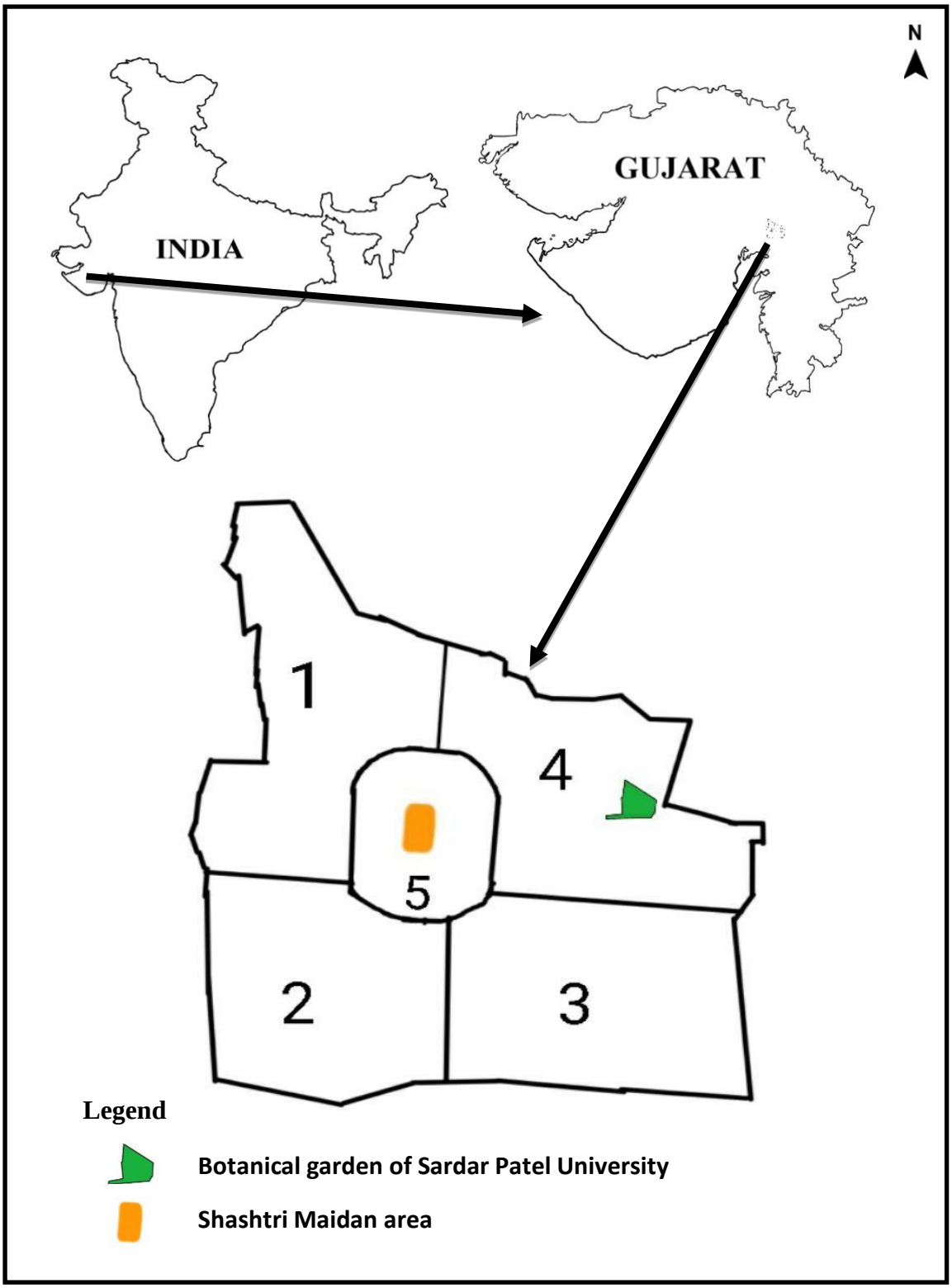

Figure 4: Location of selected study area

METHODOLOGY

The field work was carried out from December 2019 to April 2020 in Vallabh vidyanagar town as well as Botanical garden of university. The observations were made between 7:00 to 10:00 hours in the morning and 15:00 to 19:00 hours in the evening throughout the vidyanagar town. Rapid and extensive preliminary field surveys were carried out in the town and its surroundings during the first week of the study period. All residential area, road side area, large trees area and water bodies were investigated to get information about the presence or absence of IGHB and the habitat structure of the area. Most of the observations were made on foot and rarely by two-wheeler.

- ## Population study

On the basis of information obtained from the preliminary survey, the study area was divided into 5 zones to accomplish further study (MAP 4). For counting birds at each of the zone, three rounds were decided and each round with 40 days. Thus, 8 days count per zone in single round. To prevent double counting, two observers simultaneously surveyed adjacent zone and noted time, direction (if flying), number and sex (if possible to identify) of bird. All obtained data were compared by location and time of observation and possible double counts were eliminated. The observations were taken during day time. The most active periods are early mornings to mid mornings and late afternoons to evenings.

- ## Behavior study

On the basis of information from the preliminary survey and counting, 2 specific areas were selected where highest and regular sighting of IGHB were found to carry out behavior study. Selected area included: Botanical garden of Sardar Patel University and Shastri Maidan area. Ad libitum sampling method (Altman 1974) was used for recording behavioral acts of IGHB in selected sites. The birds were observed with the help of field binocular. To locate nests, visits and observations were increased in the month of March and April. Some behavioral activities were also photographed and videographed during study period.

To evaluate the food consumed by the IGHB, individual bird or group was followed and foods consumed were noted in non-breeding period. During breeding period, nest was observed from proper distance to avoid any type of disturbance to the bird. Number of visits by male and food materials delivered to nest was recorded.

Different parameters of roost tree and nest tree were assumedly measured and recorded.

- ## Instruments used

Field binoculars: Olympus 10×50.

Camera: Canon EOS 700D DSLR with 55-250mm lens and Nikon-P900 point and shoot.

Mobile applications: GPS Essentials, eBird.

IV. RESULT AND DISCUSSION

Population estimation and status of Indian grey hornbill in Vallabh vidyanagar

Population estimation and status of the Indian grey hornbill was carried out in Vallabh vidyanagar town. A total five divided zone were surveyed into three phases- prewinter (Round-1: 12/12/2019 to 20/01/2020), winter (Round-2: 21/01/2020 to 29/02/2020) and post winter (Round-3: 01/03/2020 to 09/04/2020- early summer) to estimate the population of Indian grey hornbill. Total forty-two IGHB were recorded and average data is presented in Table1. During study it was observed that the numbers of Indian Grey Hornbill are more in some areas (zone5) than others. The highest number of this bird was observed in zone 5, consisting 34% of total IGHB recorded during study period. This could be because of presence of high large tree density and canopy cover area of tree in zone 5. It was observed that IGHB prefers high trees with thick foliage to hide themselves. Overall tree density and canopy cover were high in zone 5 compared to the other four zones.

Count in zone 2 and 3 indicate that population of Indian grey hornbills were low as compared to others zone and it was the lowest number of this birds, consisting 12% of total IGHB recorded during study and canopy cover and tree density were high in these zone, although the density of large trees was very low. 20% and 22% of total birds recoded from zone 4 and 1 respectively. As mentioned in earlier, Indian grey hornbill largely feed on fruit, especially wild figs (Ficus spp.), berries and flower petals. So this population could be because of canopies of large ancient fig trees, like Banyan tree and other Ficus species that observed during the study period in many of parts of these zones. Many Species of Ficus trees were found in Botanical garden of department and

it has been noted that 4 IGHBs were regular visitors. It was also observed that IGHBs were more in number in certain months. The count of hornbill was normal until mid March but from ending of March to onset of April their number started decreasing. This may be due to breeding season. Breeding season of IGHB started from the March to July and female seals herself into a nest cavity and leaves only a narrow slit as mentioned in breeding behavior. Nesting females incarcerated in their nests and hence not detected during counting. The month wise distribution is as follows (Table-1).

Zone	**No. Of birds encountered**			
	Round-1	**Round-2**	**Round-3**	**Zone wise Average**
	12/12/2019 to 20/01/2020	21/01/2020 to 29/02/2020	01/03/2020 to 09/04/2020	
1	9	11	8	9.33
2	6	5	4	5
3	5	6	4	5
4	8	9	8	8.33
5	15	17	11	14.33
Total	43	48	35	
Average	42			

Table 1: Monthly distribution of Indian grey hornbill

Different behavior pattern of Indian grey hornbill in Vallabh vidyanagar.

Different behavior of Indian grey hornbill were observed and studied in Vallabh vidyanagar town. Context of behaviors were determined from observations of pair or flock of Indian grey hornbill were located, followed and observed different behavior. The main part of the study was focused on pre-breeding behavior. Table 2 shows the ethogram of Indian grey hornbill including different behavioral events.

Functional category	Behavior/ Behavioral act	Behavioral event
Maintenance	Cleaning	Preening, Stretching scratching, bill cleaning
	Foraging	Plucking, Pecking, Regurgitation, Swooping
	Elimination	Removal of excreta or Defecation
Movement	Locomotion	Hopping, Sliding, Flight
Communication	calling	Calls, whistling
Rest	Roosting	Standing posture, sitting posture
	Perching	
Sexual behavior	Courtship	Touching beaks, feeding each other
	Copulation	Matting
	Nesting	Nest searching, covering up the entrance, feeding the female

Table 2: Ethogram of Indian grey hornbill exhibited different behavioral events

Maintenance

It involves all the activity related with the maintenance of the body, including preening, stretching, scratching and bill cleaning. The terminology adapted from studies of Kemp (1976) for Tockus hornbills and Frith and Douglas (1978) for some of the Asian hornbill species. During study following behavioral activities were observed and recorded.

- **Cleaning**

Preening: It is way of cleaning feathers. It Involving contact between beak and breast feathers, upper portion of wings or tail feathers. While preening the breast feathers, the head was held upwards and then neck arched. Outer and inner surface eon the wing is preened by holding the wing completely spread and moved upwards, bending the neck sideward.

Figure 5: Wing preening (left) and belly preening (right)

The tail feathers were preened by making the tail slightly fan shaped and holding the feathers towards one side. Belly feathers were preened by bringing the head downwards and arching the neck to the maximum limit.

Figure 6: tail preening (left) and belly preening (right)

Scratching the head portion was observed in IGHB. The body is held horizontal slightly and the supporting leg is bent so that the body almost touches the substrate. The head is bent back to one side, the wing on that another side is dropped slightly, and the foot on that side is brought up behind to scratch the head. Stretching also observed in IGHB. During courtship, male was seen to allopreen female. These different events of preening behavior in Indian grey hornbill were observed during study period. Mostly preening behavior was observed in time between 8.00 to 10.00 at morning and 17.30 to 19.30 at evening. Allopreening also observed during courtship.

Figure **7:** Scratching

Bill cleaning observed after a feeding. During study it was observed that hornbill performed bill cleaning by rubbing the beak to the branch by repeatedly changing the side.

Figure 8: male hornbill rubbing its beak to the branch

- **Foraging**

Mainly following foraging events were observed during the study period.

Plucking: During study it was observed that IGHB used plucking method to collect ripe fruit and other figs. While plucking the fruit, IGHB look around ripe fruit, stretches its neck and beak, plucked the fruit and tossed into the air before it was swallowed by jerking. They are fond of ripe figs and other fruit.

Figure 9: Male hornbill plucking ripe banyan fig

Swooping: Swooping involves obtaining food materials from ground and catching the flying insects. In Botanical garden of University, it was observed that IGHB would suddenly flaying downward from an elevated branch to catch fallen flower of *Bombax ceiba.* Swooping can be easily seen during the breeding season afterincarceration of

female into nest. It was observed that when food materials or barks that accidently fall off during delivery to nest, was captured by male hornbill in mid-air before falling to ground.

Regurgitation: This behavior noticed while watching video recording of hornbill. To feed incarcerated female, male hornbill used the regurgitation. Male hornbill collects different food materials and stores them in his gullet instead of swallowed and then feeds them to female.

Indian grey hornbills were never seen using their feet to obtain or carry food materials.

Figure 10: Male hornbill regurgitating a grasshopper stored in the gullet

Indian grey hornbill feed on figs of different ficus tree species as they are frugivorous during non-breeding season, but during study it was observed that onset of breeding season they start to consume animal matter also. It was observed that 12 plant species were utilized by Indian grey hornbill as food during the study period. Food consumed by Indian grey hornbill during study were noted and tabulated in following table 3.

Sr. No.	Plant food	Utilized part	Animal food
1	*Caryota urens*	Ripe fruit	Praying mantis
2	*Aphanamixis polystachya*	Ripe fruit	Bat
3	*Ficus racemosa* ઉંમરો	Fleshy fruit	garden katydid
4	*Ficus benghalensis* વડલો	Fleshy fruit	Grasshopper
5	*Terminalia bellerica* બેહડા	Ripe fruit	Unidentified larva
6	*Ficus religiosa* પીપળો	Ripe fruit	
7	*Polyalthia longifolia* આસોપાલવ	Dried fruits	
8	*Manilkara hexandra* રાયણ	Fleshy fruit	
9	*Bombax ceiba* શેમળો	Flower	
10	*Morus niagra* શેતુર	Ripe fruit	
11	*Melia azedarach*	Leaf	
12	*Sterculia foetid* જંગલીબદામ	Seed	

Table 3: List of the food items recorded in the diet of the *O.Birostris* during the study

- E**limination**

It involves the events of removal of feces from the body. It was observed that Indian grey hornbill defecates by jerking the tail slightly upwards when they are on branch. During incarceration of female, It was observed that the female turn in such a way that her defecation organ settle towards the nest slit and then squirts wet excreta from nest. The excreta were semi-solid, sometimes coloury and contained non digested parts. Color of excreta depends on what type of food hornbill consumed.

Figure 11: fallen excreta of Indian grey hornbill below the nest

Movement

Mostly aerial locomotion was observed during the study. Indian grey hornbill used their dark brown flight feathers wings to fly. Gliding behavior was observed when they were flying from higher to lower height. Their gliding flight is beautiful. Sub terminal darker band and white tip of tail feather can be seen during gliding. Very little movement of terrestrial locomotion was observed. Only two time birds were seen on the ground during the study. However in breeding season it was noted that male IGHB regularly descended on ground to bring mud pellets. The IGHB performed hopping on branch by propelling itself with its one feet then another feet.

Figure 12: Gliding flight pattern oh Indian grey hornbill

Communication

- **Call and whistling**

The IGHB gives whistles and shrill calls. In the early morning hours, they were seen performing series of monotonous clucks- kaaik- kaaik- kaaik….. ending in long whistles- ka..ka..ka…ka. The series of continuous were recorded up to the maximum 259 times during study. Calls of Indian grey hornbill are very noisy.

Rest

- **Perching or resting**

The Indian grey hornbill can be seen resting in the middle of the day by standing on both legs on tree branch. Indian grey hornbill often seeks silent shade. They prefer high trees with thick foliage.

Figure 13: Resting on tree branch

Sexual behavior

Generally the life cycle of Indian grey hornbill is divided into three phases: prebreeding, breeding, and post breeding phases. A pair of IGHB that was regularly found in Botanical garden of University was observed throughout study period. The main part of the study was focused on pre-breeding behavior. During the study following behavioral activities were observed:

- **Nest cavity search:**

The pair was spotted searching for the nest cavity in late January. On 2nd February, Male IGHB was seen flying and perched on twig of tree near nest cavity that was already occupied by Rose ring parakeet. Male and female were seen inspecting the nest cavity by peeping inside the nest cavity in absence parakeets.

Figure 14: A pair of Indian grey hornbill inspecting the nest cavity

Thereafter regular movement of the pair was noted to grab the nest cavity from parakeets. Day by day, visiting of this pair to the nest cavity increased and lasted till mid March. After that, the pair was regularly seen around the nest but stopped peeping into the nest. Possibly, the pair didn't like the cavity for nesting as many conflict occurred with parakeets. Common myna also seen visiting same nest cavity. After, it could not sure where this pair nested.

Another pair was seen visiting cavity of tree in zone-3. Activities of inspection of cavity were same as above. Once the nest cavity was selected, the pair then defended the cavity from other birds.

- **Courtship**

Courtship ritual started immediately after the cavities were selected or simultaneously run with cavity search event. It was observed that male was seen offering food materials and bark pieces to female. On many occasions, Male was seen offering figs, small insects, larva and other food materials to female and sometimes food was returned to male by female. This transferring of food between male and female continued till one of them dropped or swallowed. Such behavior observed mostly in morning time around 10.00hrs and in evening time around 17.00 hrs. Generally, Male was seen offering fruits and insects to female. Another rare observation made on9th March. Male was seen offering a bat to female. The male captured something in mid-air that looked like flower of *Bombax ceiba* and perched beside the female near nest cavity. Male crushed that flower like material by shaking his head and, raising his beak up, tossed and juggled it and then offered it to female. At first it looked like a flower but after watching the video recording it was confirmed that it was a bat instead of a flower.

Figure 15: Male hornbill offering fig and a bat to female as a part of courtship

- **Mating**

During the study it was observed that, as the date of mating approaches, Courtship rituals reached at its peak point and female becomes sedentary as the male keeps feeding the female. The female was seen moulted some of her tail feathers. It was observed that female looked very clumsy with some of her tail feathers. During the study two different mating occasions were observed. On 8 March late evening, male was seen offering food to female and after feed the female, male was seen mounted on female back and female turned her tail sideways and male mated with her. The mating lasted for about 40 seconds and after flapping wing male demounted.

Another matting occasion was seen in zone-5 on 23 March, mating process was same as observed above.

- **Cavity wall sealing**

Two nests were found in late March. It was observed that female had already incarcerated inside and sealed half of the cavity entrance. Male was seen providing tree bark and mud pellets to incarcerated female. Male was seen descending on ground and brings oval shaped mud pellets. Within a day female plastered the half sealed cavity entrance completely by using her beak as trowel. A narrow vertical slit is left in the entrance through which the male can feed her during the incubation period. The male was never observed to be involved in nest cavity plastering. Male supplying only mud pellets and food to incarcerated female.

Figure 16: Male hornbill carrying a bark piece and a mud pellet

Figure 17: The male hornbill collecting the mud pellet from the ground

Figure 18; The female's beak plastering the cavity entrance

Figure 19: The male hornbill providing a bark piece and Rose ring parakeet visiting the same cavity

Figure 20: The male hornbill providing food to incarcerated female

Nest and nest tree characteristics

An intensive search for active nest cavities was done. Active nesting was confirmed by following breeding male carrying food material.

A total of 5 nest trees of hornbill were found. Nesting was observed in 3 out of 5.Two nest were located in zone-5 and one nest was located in zone-4. All active nests identified were in live trees. All trees that were selected for nest by birds belong to Febaceae family. Nest entrances were oval or somewhat round. All trees that were used by IGHB as nest were tall with large girth. Different nest tree characteristics described in table 4. It was known from local people that the nest-1 was of Rose ringed parakeet and later occupied by hornbill as they are secondary cavity nester.

Variables	**Nest -1**	**Nest-2**	**Nest-3**
Tree family	Febaceae	Febaceae	Febaceae
Tree height	≈17	≈15m	≈16m
Tree condition	Live	Live	Live
Nest height	≈4.5m	≈6.5m	≈6.8m
Girth at nest height	≈64	≈54	≈62
Distance from nearest water point	≈12	≈15	≈17

Table 4: Nest tree characteristics

Roosting behavior and roosting site characteristics

Roosting behavior

During the study period it was seen that mostly Indian grey hornbill preferred communally roosting during nonbreeding season. During the breeding season male was seen roosting within periphery of 100-250m from the nesting site. It to be right for two nest site as observed during the study.

After performing various activities throughout the day, birds would directly reach the roosting tree. Different activities were noted including loud vocalization, hopping from one branch to another, play fighting and chasing each other. Finally at roosting time,they were found alighted on the top branches of the tree and then they would silently and gradually moved down to the lower branches to finally settle at their suitable twig with late evening. Since nothing could be seen under darkness, the observations could not be made during the night time.

Roosting site characteristics

Two roosting sites were located during the study period. One site was located in Botanical garden of University on trees of *Terminalia bellerica* and another roosting site was located near Shastri Maidan on trees of Eucalyptus. At botanical garden, roost consists of dense foliage of trees of *Terminalia bellerica.* Most of the branches of trees are found to be in such way that IGHB can camouflage themselves easily. IGHBs were found to change their roosting sites to nearby trees due to defoliation in autumn.

Near Shastri Maidan, Roost consisted of dense and high vegetation of Eucalyptus trees. Below the roosting trees, there are the huts of proleraite. Sometime there was continuous disturbance of smoke that produced from cocking by labor class during evening time. There was also disturbance of loud uproars and screaming from students as they were habituated to play there. Even with such high degree of disturbances, IGHBs used the same roosting site. They have probably got used to well adjusted and have adopted themselves to loud noise, labor activity and other disturbance. According to labour, the IGHBs have been roosting at the same place from last two months as they have been staying there from last two months. The highest number of about 12 IGHBs found roosting on 9thFebruary. A pair of red-napped ibis was also observed using roost trees neighboring those used by the hornbills.

V. CONCLUSION

The present study highlights the population estimation and basic behavior of Indian grey hornbill in Vallabh vidyanagar town. From the above observations and data, it can be concluded that the population of IGHB depends on various factors including type of area, tree density, canopy cover area of tree, availability of breeding habitat and availability of food. During the study, most of the sightings of IGHBs were recorded from area that comprises high tree density with large canopy cover area.

Frequently observed different maintenance behaviors such as preening, scratching, stretching and beak cleaning in IGHB. Observed a courtship display whereby a male offered different food materials including figs, small insects, larva and other food materials to a female. Observed incarceration of female hornbill in which female sealed herself in nest cavity to incubate eggs, during this period female totally depended on male hornbill for feeding, hence male hornbill can be considered as the most devoted male in avian diversity. Studied different roost and nest trees characteristics in which all the IGHB nests were found in live trees that are tall with large girth. Nesting in live trees may also have advantages as protection from predators (Arsenault, 2004) and cavities in live trees are warmer (Hoogeet al., 1999) hence protection and conservation of such trees in Vallabh vidyanagar is needed, specially in breeding season. In 2018, about 68 large trees have been removed for road widening purpose from Sardar Patel statue to Janta chowkdi. Cutting of old and large trees in the name of development in town should be monitored and regulated.

This study provides the basic data of Indian grey hornbill, different behavioral patterns and management plans for conservation of Indian grey hornbill in future. As the data presented in the Dissertation is four months observations, detailed study needs be

carried out in order to understand their courtship rituals, breeding behaviors and parental care in rural-urban area of Vallabh Vidyanagar.

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