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An Inventory of Chiropteran Fauna in Bhubaneswar City, Eastern India

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ABSTRACT

An inventory of chiropteran fauna was carried out in Bhubaneswar city, Odisha, eastern India during October 2015 and March 2016 following roost survey and mist net survey techniques. During the study a total 19 species of bats belonging to seven families including the nationally threatened *Rhinolophus rouxii* were recorded of which family Vespertilionidae was the most diverse one, represented by five species. Majority of 11 species are found roosting and breeding in old temples and caves and are vulnerable from renovation activities, persecution and tourism. Therefore, long term monitoring of these sites are essential to understand the population trend over time and derive appropriate conservation implications.

1. Introduction

Urbanization greatly affects the composition and structure of the inhabiting animal communities by transforming the natural habitats into environments dominated by human constructions (McKinney 2006). This situation is more problematic in developing countries as there is sporadic effort for maintaining the ecological requirements necessary for the inhabiting wildlife population (Pickett *et al.* 2001; de Araújo and Bernard 2016). However, certain species are adapted to this change corresponding to their high degree of ecological and behavioural plasticity (Luniak 2004). Among the mammalian communities, bats are the most successful group occurring in both natural and human modified landscapes. They also help in ecosystem functioning through pollination, seed dispersion, and insect pest control as well as recycling and distribution of essential nutrients between habitats (Kunz *et al.* 2011) for which conservation of bats and their roosting sites are essential. Although loss and degradation of habitats out of urbanization is major threats to bats today (Jung and Threlfall 2016), certain species take advantage of roosting in human induced structures (Voigt *et al.* 2016) and foraging on easily available food resources (Blake *et al.* 1994; Rathinakumar *et al.* 2016). However, in the long run it may alter the species richness by favouring the highly adaptive species and removing the less adaptive ones. So, regular monitoring of bats in an urban landscape can help in understanding the change in their community structure over time and formulating management plans.

In eastern India, Bhubaneswar is one of the fast growing cities and the capital of Odisha state. During the last few decades, the city has grown so rapidly that it has even outstripped the planning process (Kalia 2006) and altered the natural vegetation cover (Chatterjee *et al.* 2016). So, it can be predicted that it might have negatively affected the local biodiversity. Even though bats are one of the most abundant and widely distributed mammalian groups in Odisha, eastern India (Bates and Harrison 1997; Menon 2014), few studies have been carried out to document their diversity in the capital city. Khaparde (1977) reported three species of fruit bats; *Cynopterus sphinx, Pteropus giganteus, Rousettus leschenaulti,* and seven species of insectivorous bats; *Hipposideros speoris, Megaderma* sp., *Pipistrellus tenuis, Rhinolophus rouxii, Rhinopoma hardwickii, Rhinopoma microphyllum,* and *Taphozous melanopogon* from Bhubaneswar and its adjoining areas. Subsequently bat fauna of the city was explored on several occasions during faunal inventories of Odisha by the Zoological Survey of India, the results of which, describing ten species were compiled in the state fauna series (Das *et al.* 1993). However, referring to recent growth and development of the city, there is no updated information on its bat fauna. The purpose of this study was therefore to gather information on diversity of bats in Bhubaneswar city on which future comparisons can be carried out.

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2. Materials and Methods

2.1. Study Area

The Bhubaneswar city (Figure 1) lies between 20° 11' 33.30" to 20° 24' 33.41" N latitude and 85° 44'16.69" to 85° 54' 09.91" E longitude covering an area of 393.57 km². Biogeographically, the area comes under the Eastern Ghats hill range with an average altitude of 45 m above MSL. Vegetation is represented by Tropical dry deciduous and Tropical semi evergreen types (Champion and Seth 1968) along with monoculture plantations. The climate is tropical with temperature ranging between 12°C during January to 45°C in May. The average annual rainfall is 1542 mm (www.imdorissa.gov.in).

2.2. Bat Survey

The survey was carried out during October 2015 to March 2016 through roost survey and mist net survey techniques. The existing old and ruined temples, artificial caves and deserted buildings were intensively searched for availability of bat roosting sites. We also re-surveyed the earlier known roosting sites (Khaparde 1977). At each active roost, we captured some individual bats using an entomological net directly or mounted over an extendable rod whenever required with minimal disturbance for species level identification. We also estimated their population through direct roost count method following Thomas and Laval (1988). For mist netting, we have chosen four habitat types (Table 1) with four replicate sites in each (total 16 sites) to ensure the diverse range of broad habitats occurring within the urban landscape were adequately sampled. The sampling sites were separated by a minimum distance of two kms to ensure spatial independence. In each replicate site, standard ground level mist nets (Avinet, USA) were deployed for four consecutive nights between 1800 and 0200 hours and monitored at every 30 minute interval, with a total effort of 64 nights and 512 hours of sampling. The netting activities followed the standard protocol (Bat Conservation Trust 2007). Upon capturing of the bats (both in entomological net and mist net), required physical and morphological parameters were recorded prior to release and no voucher specimen was collected. Whenever any pregnant or lactating individual was caught, it was immediately released back without further examination. The species level identification was confirmed from Bates and Harrison (1997) and Srinivasulu *et al.* (2010). Chi-squire test (χ^2) was performed to elucidate the significant difference in bat species richness between habitats.

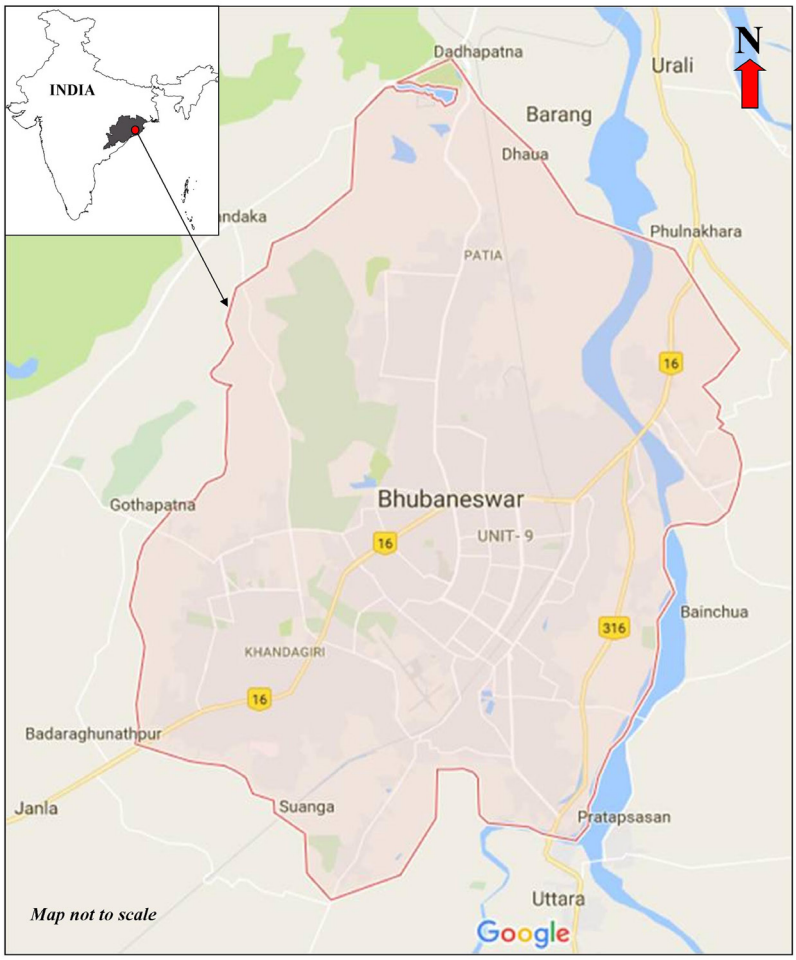

Figure 1. Map showing location of Bhubaneswar city in Odisha, eastern India

3. Results

During the study a total 19 species of bats in seven families were recorded from Bhubaneswar city (Table 2) of which the insectivores were dominated by 15 species over frugivores and carnivores. Detailed morphological measurements of the captured individuals are given in Table 3. In all, Vespertilionidae was the most diverse

Table 1. Descriptions of the four broad habitat types surveyed for bats using mist nets within Bhubaneswar city, Odisha, eastern India

Habitat type	Description
Woodland	Areas with well established native trees with few introduced exotic trees and under storey scrubs and grasses. Common tree species: *Bombax ceiba, Careya arborea, Ficus benghalensis, Ficus racemosa, Mangifera indica, Nux vomica, Pongamia pinnata, Syzygium cumini.*
Parks and gardens	Landscaped areas with little remnant natural vegetation and mostly planted with native and exotic ornamental evergreen plants. Common tree species: *Azadirachta indica, Ficus benghalensis, Ficus racemosa, Mangifera indica, Neolamarckia cadamba, Polyalthia longifolia, Syzygium cumini,* and *Borassus* sp.
Scrubland	Habitats dominated with native and exotic scrubs without any build up area.
Residential area	Habitats with little woody and non-woody vegetation in front and backyards. Common tree species: *Ficus racemosa, Mangifera indica, Psidium guajava.*

Table 2. Diversity, roosting sites and population of bats in Bhubaneswar city of Odisha, eastern India during October 2015 and March 2016

Species	Common name	Food habits	Site of capture	Roosting sites	Population
Pteropodidae					
Cynopterus sphinx	Greater short-nosed fruit bat	F	Roost, Foraging site	Fronds of *Borassus flabellifer* and foliage of *Polyalthia longifolia*	--
*Pteropus giganteus**	Indian flying fox	F	Foraging site	--	--
Rousettus leschenaulti	Fulvous fruit bat	F	Roost, Foraging site	Temples and deserted buildings	375
Rhinolophidae					
Rhinolophus lepidus	Blyth's horseshoe bat	I	Roost, Foraging site	Temples and caves	42
Rhinolophus rouxii	Rufous horseshoe bat	I	Roost; Mist net	Caves	32
Hipposideridae					
Hipposideros fulvus	Fulvous leaf-nosed bat	I	Roost, Foraging site	Caves	21
Hipposideros speoris	Schneider's leaf-nosed bat	I	Roost, Foraging site	Caves	19
Hipposideros lankadiva	Kelaart's leaf-nosed bat	I	Roost, Foraging site	Temples, deserted buildings and caves	82
Megadermatidae					
Megaderma lyra	Greater false vampire bat	C	Roost, Foraging site	Temples and deserted buildings	27
Rhinopomatidae					
Rhinopoma microphyllum	Greater mouse-tailed bat	I	Roost	Caves	43
Rhinopoma hardwickii	Lesser mouse-tailed bat	I	Roost	Temples, deserted buildings and caves	34
Emballonuridae					
Saccoliamus saccolaimus	Pouch-bearing bat	I	Foraging site	--	--
Taphozous longimanus	Long-winged tomb bat	I	Roost	Temples	79
Taphozous melanopogon	Black-bearded tomb bat	I	Roost	Temples, deserted buildings and caves	112
Vespertilionidae					
Pipistrellus ceylonicus	Kelaart's pipistrelle	I	Roost, Foraging site	Crevices and holes in building walls	--
Pipistrellus coromandra	Indian pipistrelle	I	Foraging site	--	--
Pipistrellus tenuis	Indian pygmy bat	I	Roost, Foraging site	Crevices and holes in building walls	--
Scotophilus heathii	Asiatic greater yellow house bat	I	Foraging site	--	--
Scotophilus kuhlii	Asiatic lesser yellow house bat	I	Foraging site	--	--

F: Frugivore, I: Insectivore, C: Carnivore; *: Only direct sighting; --: Information not available

family, represented by five species (Table 2). Maximum of 11 species were recorded both from their roosts and foraging sites followed by only foraging sites (5 species) and roosting sites (3 species) (Table 2). The roosting sites of 14 species were identified; those present in old temples, deserted buildings, artificial caves and foliage of ornamental plants. Majority of 11 species were found roosting in old temples and artificial caves and we could only estimate their population of which *Rousettus leschenaulti* was found to be the most abundant one with largest population size (Table 2). Although we could not report roosting site of *Pteropus giganteus* within the city limits, we found it foraging on the fruits of *Ficus benghalensis, Mangifera indica, Syzygium cumini,* and nectar of *Bombax ceiba* and *Neolamarckia cadamba* in parks and home gardens. Based on mist net capture records, maximum of 13 species were reported foraging along parks and home gardens followed by woodland (11 species), scrubland (9 species) and residential area (7 species). However, we did not find any significant difference between these habitats ($\chi^2 = 2$, df = 3, p = 0.5724). Among all the species, *Rhinolophus lepidus* and *Scotophilus heathii* were reported foraging throughout the sampling sites covering all habitat types (Figure 2).

Table 3. External morphological measurement of 18 bat species (excluding *Pteropus giganteus*) captured during roost survey and mist net survey in Bhubaneswar city, Odisha, eastern India during October 2015 and March 2016. All the sampled individuals are non-breeding adults

Species (Number of individuals examined)	Length in mm (Range; Average ± SD)					Additional distinguishing characters
	FA	HB	HF	T	E	
C. sphinx (3M, 2F)	68.3-75.4; 70.7±2.7	77.1-83.6; 79±2.6	11.7-15.4; 13±1.4	6.5-9.3 7.8±1.2	18.9-21.8 20.2±1.4	Border of ears, metacarpals and phalanges are pale
R. leschenaulti (4M, 1F)	74.8-81.7; 77.6±2.8	111.9-113.9; 116.2±4.7	16.8-20.9 18.3±1.6	9.3-14.7; 12±1.9	16.7-21.3; 18.7±1.7	Metacarpals and phalanges dark; no pale border in the ears
R. lepidus (6M, 4F)	36.9-40.1; 38.1±0.9	36.7-41.7 38.8±1.5	5.9-8.1 7.1±0.8	16.8-22.9; 20.3±1.7	15.7-20 18±1.5	Connecting process is pointed; anterior surface of the sella is less conspicuously emarginated
R. rouxii (2M, 2F)	47.6-49.7; 48.2±0.9	49.4-51.7 50.7±0.9	7.8-8.4 8±0.2	16.3-28.1 24±5.4	15.7-17.1 16.2-0.6	Connecting process is rounded; lateral margins of sella are strongly concave
H. fulvus (2M, 4F)	39.9-43.2; 41.5±1.1	41.9-44.9 43.6±1.3	6.9-8.1 7.3±0.4	23.6-29.1 26.6±1.8	18.7-24.1 21.9±2.2	No supplementary leaflet; internarial septum is elongated; ears are larger
H. speoris (3M)	46.7-48.9 47.5±1.2	48.7-51.2 49.8±1.2	8.3-8.9 8.6±0.3	22.6-23.4 22.9±0.4	13.9-15.1 14.5±0.6	Three pairs of supplementary leaflets
H. lankadiva (3M)	81.9-93.2 85.9±6.3	94.1-102.7 97.5±4.5	14-17.9 15.5±2	43.6-55.8 47.9±6.7	16.3-21.7 19.8±3	Four pairs of supplementary leaflets; outer leaflets are slightly reduced
M. lyra (2M, 3F)	58.6-65.2 62.5±2.5	73.5-79.7 77.2±2.3	15.2-18.1 16.6±1.1	- -	31.9-36.7 33.9±2.1	Tail is absent; Noseleaf is tall, straight sided with a simple rounded horizontal base
R. hardwickii (3M, 5F)	53.1-59.2 55.7±2.2	55.9-63.7 59.3±3	12.7-17.7 14±1.6	55.6-65.3 60.6±3.3	17.8-20.7 19±0.9	Tail is longer than the forearm; Dermal ridge on the muzzle is well developed
R. microphyllum (5M, 2F)	59.9-64.9 62±2	62.5-71.4 65.8±3.7	15.6-17.9 16.7±0.9	50.9-57.8 52.4±2.4	18.5-21.5 19.8±1	Tail is shorter than the forearm
S. saccolaimus (1M)	64.2	81.7	13.2	22.3	17.9	Radio metacarpal pouch is absent in the wing
T. longimanus (2M, 3F)	55.8-60.9 58.5±1.9	73.7-80.2 76.7±2.7	9.6-13.4 11.3±1.4	21.7-27.8 23.9±2.6	17.6-18.7 18.1±0.5	Gular pouch present, but rudimentary in femles; wings attached to ankles
T. melanopogon (4M, 5F)	61.7-67.3 64.1±1.9	68.7-76.1 71.8±2.7	9.2-13.8 11.2±1.6	21.7-28.7 25.1±2.3	17.6-20.9 18.9±1.2	Gular pouch is absent; wings attached to tibiae; males have black beard
P. ceylonicus (4M, 3F)	33.7-39.5 36.2±2.2	45.5-54.1 49.8±3.5	7.3-10.9 9.4±1.4	30.7-39.7 34.9±3.7	9.9-13.8 12±1.6	Forwardly curved shorter tragus; interfemoral membrane sparsely haired above and below
P. coromandra (3M, 3F)	27.9-32.2 29.7±1.6	36.1-41.7 38.6±1.9	5.7-7.1 6.3±0.5	24.5-34.9 30.1±3.6	8.9-13.7 12.3±1.8	Interfemoral membrane is naked with few hairs adjoining to the body and tail
P. tenuis (4M, 2F)	26.8-29.5 27.7±0.9	36.5-41.2 38.9±1.6	4.5-6.3 5.2±0.6	24.5-27.9 25.7±1.2	6.2-8.3 7.3±0.7	Interfemoral membrane naked
S. heathii (9M,7F)	57.7-63.9 60.5±2.3	69.6-88.4 80.1±6	10.1-14.1 12.6±1.2	47.6-65.6 56.4±6.1	14.1-17.9 16.1±1.1	Ventral pelage on the body have distinct yellow tinge
S. kuhlii (4M, 4F)	48.9-53.9 50.8±1.5	64.7-69.1 66.9±1.4	8.9-10.7 9.9±0.7	49.3-56.5 52.7±2.3	10.9-13.1 12.1±0.7	Ventral pelage on the body is buffy brown

M: Male, F: Female; FA: Forearm, HB: Head-body, HF: Hind foot, T: Tail, E: Ear

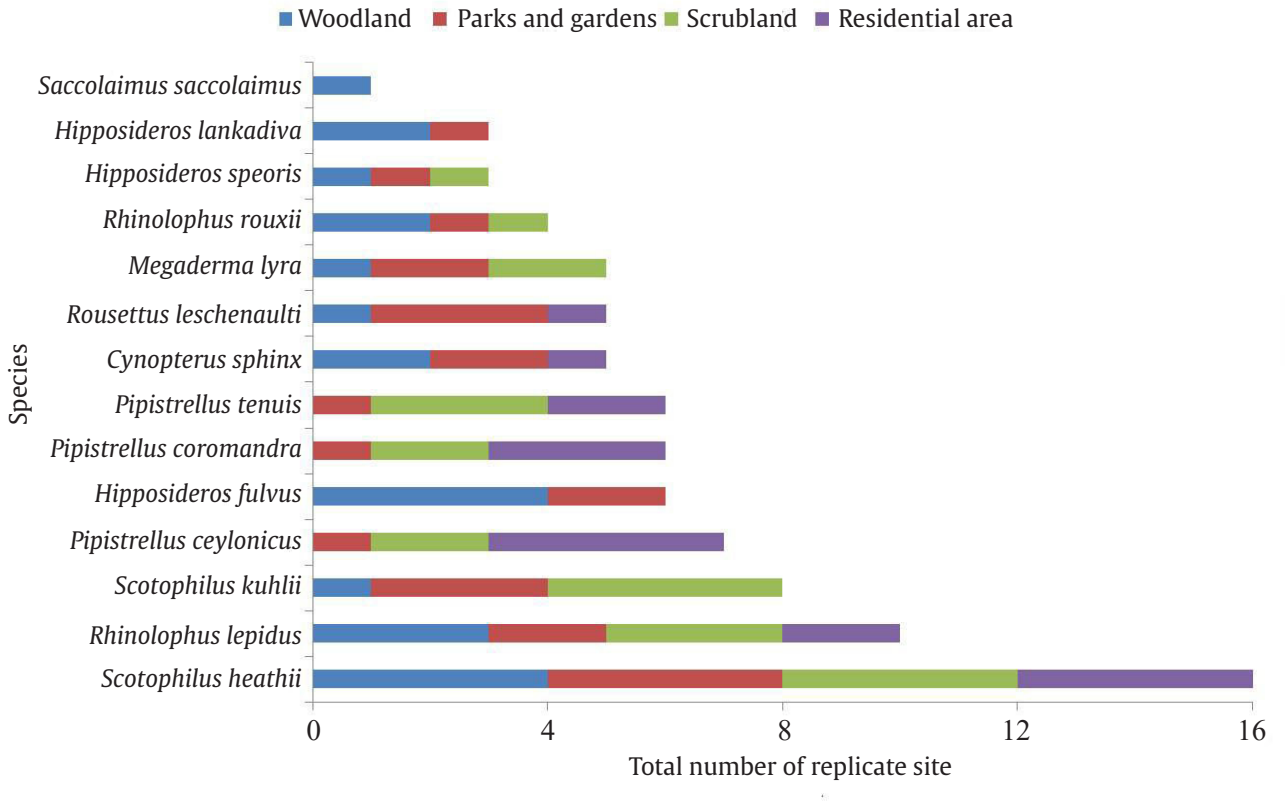

Figure 2. Occurrence of different bat species in four major habitats of Bhubaneswar city based on the mist net capture records

4. Discussion

Bat communities in urban habitats are usually dominated by few abundant species (Brosset *et al.* 1996; Lesinski *et al.* 2000) those are adapted to roost in buildings, mines and bridges and forage along open and edge habitats and around street lights (Geggie and Fenton 1985; Rydell 1992; Blake *et al.* 1994; Rydell and Racey 1995; Brosset *et al.* 1996; Jones *et al.* 1996; Fenton 1997; Johnson *et al.* 2008; Voigt *et al.* 2016). Although Bhubaneswar city constitutes around 0.25% of the entire geographic area of Odisha, 76% of the total chiropteran diversity of the state (Debata *et al.* 2016) occur here. In the city, availability of old temples and artificial caves for roosting and breeding, heterogeneous vegetation cover along with a wide range of fruiting and flowering plants in the Parks and home gardens for foraging may favour diverse bat community. Our inventory also added nine more species (Table 2) to the checklist from this region those were probably missed out in earlier studies (Khaparde 1977; Das *et al.* 1993). Even species like *Saccoliamus saccolaimus*, which was earlier known from a single locality in western Odisha (Das *et al.* 1993), was reported from Bhubaneswar city making their distribution much wider.

During the last few decades there has been a large scale change in land use pattern of Bhubaneswar city and more than 50% of the open shrubby and marshy habitats have been converted to residential areas out of urban sprawling (Chatterjee *et al.* 2016). Besides that for widening and modification of existing roads, roadside plantations are being cleared and broad white streetlights are being installed (Personnel observation). Studies have found that bats use such narrow strip of vegetation cover for communicating between habitats areas (Hourigan *et al.* 2006) and avoid white street lighting (Rowse *et al.* 2016). The insectivorous bats, in particular are highly sensitive to such landscape level changes because many species have narrow and specialised habitat requirements (Fenton 1990; Fullard *et al.* 1991). As species richness of Bhubaneswar city is dominated by insectivorous bats (>75%; Table 2), a heavy loss in their diversity and population can be predictable out of increasing human induced habitat alteration (Hourigan *et al.* 2006). A comparison of our data with Khaparde (1976, 1977) indicated that many roosting sites from the temples have been deserted and species diversity has been declined. Our informal discussion with caretakers of the temples also revealed that the inhabiting bat population has been severely declined. However, we could not quantify it due to lack of historic records. It was observed that most of the temples have been renovated and their tombs have been sealed (Figure 3). Our discussion with the temple authorities also revealed that this initiative has been taken only to discourage bats for further roosting because of

their guano which is a major threat to decoration of temple interiors and smell which is unpleasant for the visitors. Likely, bats roosting in the artificial caves are vulnerable from tourism activities (Figure 4). In India, such kind of persecution and threats are common to the bats those live in monument sites (Menon 2014). All the recorded species are categorized Least Concern in the IUCN Red List (IUCN 2016), however *Rhinolophus rouxii* has been assessed as a Nationally Threatened species and categorized as Near Threatened during the Conservation Assessment and Management Plan of south Asian bats (Walker and Molur 2003). So, further studies on its population trend, threats and ecology are essential.

The present study generated baseline information on diversity and population of bats in Bhubaneswar city (Table 2) on which future estimates can be carried out. Moreover, the study also highlighted the negative effect of temple renovation activities and persecution on inhabited bat population and it needs to be addressed in future studies and conservation interventions.

Figure 3. Persecution of bats by sealing the roosting areas with iron mess in renovated temples in Bhubaneswar city, Odisha

Figure 4. Tourism activity near the roosting sites of bats in the artificial Buddhist caves near Khandagiri of Bhubaneswar city, Odisha

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