Bats in a cave tourism and pilgrimage site in eastern India: conservation challenges

Subrat Debata

Abstract Caves and other subterranean habitats are crucial for the survival of many bat species, but often deteriorate as a result of visits by tourists. The aim of the study was to understand the conservation challenges associated with the cave dwelling bats at Gupteswar cave tourism and pilgrimage site in eastern India and to develop conservation recommendations. I counted bat populations and monitored tourist visits once per month for 12 months during September 2016–August 2017. Roosting and breeding activities of eight species of bats, including two nationally threatened species, were recorded from five caves. The number of bats counted during the 12 survey days was 785–940 individuals. Tourism activity occurred throughout the year but was higher during local festive seasons; the maximum number of tourist entries recorded in a single day was 2,769. Installation of gated entrances, scheduling of visits to control overcrowding, restriction of access to caves with maternity colonies during breeding seasons, and minimal use of electric bulbs for illumination would minimize disturbance to the bats. Installation of educational display boards would help to create awareness of the conservation importance of bats amongst the cave visitors.

Keywords Bats, cave tourism, Chiroptera, conservation, disturbance, Gupteswar cave tourism site, India, tourism

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Introduction

Nature-based tourism expresses the relationship between nature and society, and the sustainability of such tourism is largely dependent upon ecosystem services such as provisioning, regulation and cultural services (Pueyo-Ros, 2018). Cave tourism makes an estimated contribution of USD 100 million annually to the global economy (Cigna & Forti, 2013) and brings direct benefits to local communities (Pennisi et al., 2004; Cousins & Compton, 2005). However, poorly managed tourism can pose significant threats to cave biodiversity by negatively affecting cave habitats and microclimates (Mann et al., 2002; Paksuz & Özkan, 2012), for which cave dwelling organisms such as bats have specific requirements (IUCN SSC, 2014). Bats are one of the most abundant and widely distributed mammalian groups; they provide services such as pollination, seed dispersal, insect pest control, and distribute materials and nutrients (Boyles et al., 2011; Kunz et al., 2011), and are essential for maintaining cave biodiversity (Deharveng & Bedos, 2012). As cave ecosystems are inherently devoid of primary productivity, bat guano provides organic input that supports the survival of endemic and highly specialized cave fauna whose life cycles depend upon the nutrients from guano (Fenolio et al., 2006; Deharveng & Bedos, 2012). Many nectarivorous bats inhabiting caves in fragmented habitats are the most important pollinators of various agricultural crops (Sritongchuay et al., 2016). Unfortunately, populations of many bat species, including cave dwelling species, are threatened by loss and degradation of habitat, hunting, persecution, emerging diseases and climate change (Meyer et al., 2010). Of these, habitat loss and degradation are the greatest threats to bats over most of their range (Mickleburgh et al., 2002; Racey & Entwistle, 2003; Jones et al., 2009; Kingston, 2010; Meyer et al., 2010).

Globally, c. 449 species of bats prefer caves and other subterranean habitats (Luo et al., 2013) for roosting, hibernating, mating, aggregating and raising their young (Kunz, 1982; Hutson et al., 2001; Kunz & Lumsden, 2003; Murray & Kunz, 2005). Preference of bats for such places depends on the characteristics and quality of the habitat (Murray & Kunz, 2005; Struebig et al., 2009; Phelps et al., 2016). Human activities such as caving, tourism, guano harvesting and other deliberate or accidental disturbances in and around roosting caves put negative pressure on bats and cause declines (Özgül et al., 2000; Furman & Özgül, 2002, 2004; Papadatou et al., 2009; Luo et al., 2013; IUCN SSC, 2014). Protection of caves can contribute to the conservation of bats and other cave dwelling organisms (Niu et al., 2007; Paksuz & Özkan, 2012; Luo et al., 2013). There is increasing interest from government agencies, academics, NGOs and corporate agencies in conservation of cave dwelling bats (Bat Conservation International, 2013; Furey & Racey, 2016). For example, human activities have been regulated and roosting sites have been protected from disturbance in Turkey (Paksuz & Özkan, 2012), USA (Richter et al., 1993; Martin et al., 2003) and Spain (Alcalde et al., 2012). Many organizations have developed guidelines for protection of cave roosts (Sheffield et al., 1992), and conservation

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codes for cave visitors (Hutson et al., 1988) and guano harvesters (IUCN SSC, 2014).

Nevertheless, information about the location of caves and the species they support, population estimates, local threats and conservation activities remains insufficient in most tropical regions, particularly in Asia. Information is needed to identify areas with the highest conservation needs (Furey & Racey, 2016; Tanalgo et al., 2018). In India, human disturbance and artificial illumination in cave tourism sites are known to have caused the decline of the bat population in Borra cave in southern India (Srinivasulu & Srinivasulu, 2003) and Kotumsar and Dandak caves in central India (Biswas et al., 2011). Here I make recommendations for conservation of bats inhabiting Gupteswar cave tourism and pilgrim site in eastern India. I gathered information on the seasonal abundance and reproductive phenology of bat species and on tourism activity. I also evaluated the knowledge and attitudes of local people and tourists towards bats inhabiting the caves.

Study area

Gupteswar cave tourism and pilgrimage site (Fig. 1) lies in the Koraput district of Odisha state, eastern India, adjoining Kanger Valley National Park of neighbouring Chhattisgarh state. The area is within the riparian zone of Gupteswar reserve forest, which is tropical mixed deciduous vegetation (Champion & Seth, 1968). Such habitats are often characterized by a highly heterogeneous vegetation structure with multiple layers of stratification, providing a wide range of foraging niches for bats (Struebig et al., 2008). The area receives a mean annual rainfall of 1,522 mm and temperature varies from a minimum of 12 °C during winter (January) to a maximum of 38 °C in summer (May). There are five multi-chambered and multi-entrance limestone caves (Fig. 1b; Gupteswar, Swargadwara, Parabhadi 1, Parabhadi 2 and Dhabaleswar), within 80–295 m of each other. Gupteswar and Swargadwara are illuminated with electric bulbs throughout the day and night. All five caves have sacred importance for the local villagers and therefore are major pilgrim and tourism sites. Tourists visit from both nearby areas and neighbouring states. Hunting and persecution of bats in the caves are strictly prohibited by the local people because of the associated sacred beliefs.

Methods

Bat surveys

The study was carried out over 12 months during September 2016–August 2017, with field support from local people and volunteers. Surveys were on 2 consecutive days in each month. Estimation of the abundance of bats in each cave and investigation of their reproductive phenology was carried out on the first day, and monitoring of visits and assessment of people's knowledge of and attitude towards bat conservation were carried out on the second day.

In areas of the caves used for roosting, I captured bats using a scoop net, mounted on an extendable rod when required, recorded morphological measurements and characters for identification, and released the bats immediately afterwards. Species were identified using Bates & Harrison (1997) and Srinivasulu et al. (2010). I examined the reproductive status of all captured bats, following Racey (2009). Care was taken to avoid harming the bats, following the protocols described by Mitchell-Jones & McLeish (2004). No voucher specimens were collected. I used the direct roost count method (Thomas & Laval, 1988) for counting the total number of bats in each cave. For this, I divided each cave into sections and systematically counted the number of individual bats roosting, using a spotlight to ensure no areas were missed and there was no double counting. Counting of bats was early in the morning, prior to capturing them and when they were less active and there were no visiting tourists. As I was unable to identify and count all of the individual roosting bats there may have been unintended biases in the counts. As it is difficult to identify bat species without capture, the total counts of bats in each cave were categorized by family only.

Visitation

Visitation was monitored by counting the number of groups and individuals visiting the caves. A volunteer assigned to each cave monitored tourists during 7.00–17.00 on each survey day, with a total effort of 600 hours of monitoring throughout the caves during the study period. The number of people in each group and their time of entry into the cave was recorded. The appearance of one person in each group was memorized, so that their group's exit time could be recorded and thus the time spent by that group in the cave calculated. If a group comprising N individuals visited n caves, I considered the total number of individual entries to be $N \times n$. Activities of the visitors inside the caves were also monitored and noted.

Knowledge and attitudes

Using a semi structured questionnaire (Supplementary Material 1) I opportunistically interviewed people visiting the cave complex, if they were willing to be interviewed, to examine their knowledge of bats and their attitudes towards their conservation. Conway et al. (2015) and Debata et al. (2016a) used a similar non-random selection of subjects for attitude surveys. The questionnaire included five statements (Table 1) that examined the knowledge of respondents on ecological importance, habitats and threats, and

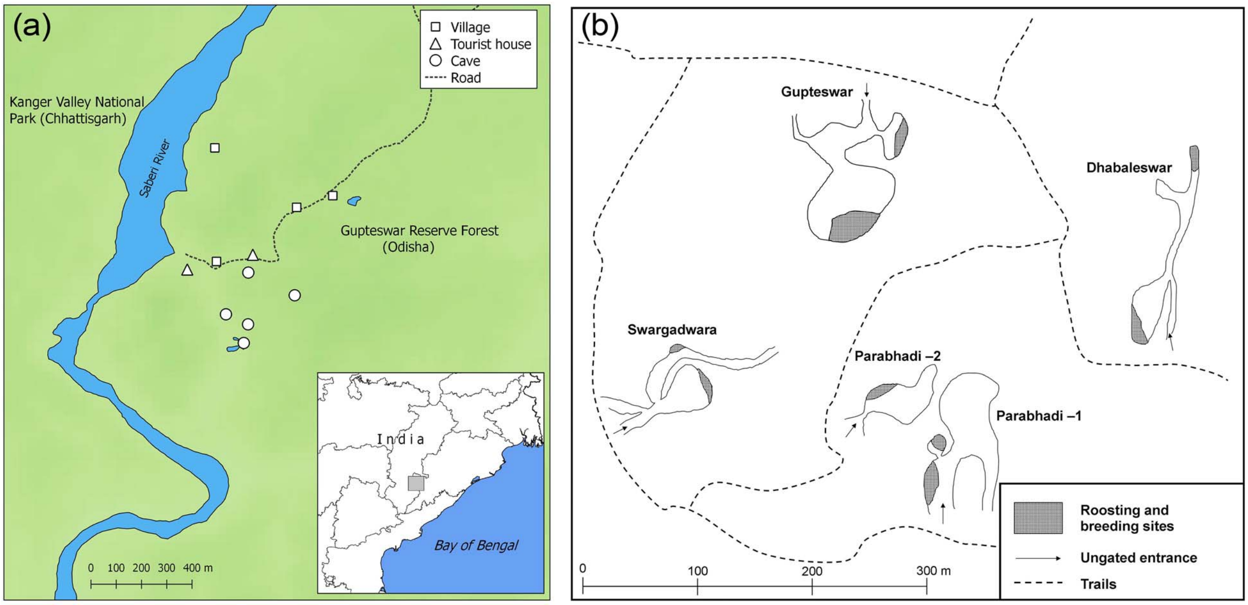

FIG. 1 (a) Gupteswar cave tourism and pilgrimage site in eastern India, showing the location of individual caves, villages, tourist rest houses and roads. The Saberi River acts as the boundary between the states of Odisha and Chhattisgarh. (b) The caves, showing the entrances and bat roosting and breeding sites. Cave openings without arrows are situated at a higher elevation and are not used as entrances.

TABLE 1 Comparison of knowledge on bats and attitude towards their conservation among 366 tourists and 76 local people visiting Gupteswar cave tourism and pilgrimage site (Fig. 1) during September 2016–August 2017. Per cent calculations are row-wise.

Statements	Agree, % (n)	Disagree, % (n)	Do not know, % (n)
Bats are mammals			
Tourists	16.7 (61)	45.6 (167)	37.7 (138)
Local people	3.9 (3)		96.1 (73)
Total	14.5 (64)	37.8 (167)	47.7 (211)
Bats are ecologically important			
Tourists	27.3 (100)	18.6 (68)	54.1 (198)
Local people	1.3 (1)	5.3 (4)	93.4 (71)
Total	22.8 (101)	16.3 (72)	60.9 (269)
Caves are important for bats			
Tourists	58.2 (213)		41.8 (153)
Local people	90.8 (69)		9.2 (7)
Total	63.8 (282)		36.2 (160)
Human activities inside caves are a threat to bats			
Tourists	12.9 (47)	78.4 (287)	8.7 (32)
Local people		89.5 (68)	10.5 (8)
Total	10.6 (47)	80.4 (355)	9.0 (40)
Bats & their roosting sites should be protected			
Tourists	32.5 (119)	51.4 (188)	16.1 (59)
Local people	100.0 (76)		
Total	44.2 (195)	42.5 (188)	13.3 (59)

their views regarding the conservation importance of cave dwelling bats. The interview was in Odia, the local language, or in Hindi, depending on a respondent's preference. Based on the answer to the statement 'Bats and their roosting sites should be protected in cave tourism sites', attitudes towards bat conservation were broadly categorized as aesthetic (concerned with the physical attractiveness and symbolic appeal of animals), moralistic (strong opposition to presumed cruelty towards animals), eco-scientific (aware of the ecological importance of bats) or negative (fear, dislike, or indifference towards bats and their conservation), following Kellert & Wilson (1993).

Data analysis

I used a one-way ANOVA to examine any differences in abundance of bats between months and seasons, the correlation coefficient to investigate the effect of tourist visitation on the abundance of bats, and the Student's t test to compare visits between festive and non-festive periods.

Results

Species richness and abundance of bats

During the entire study period I captured, and released, 140 individual bats of eight species in the five caves: *Rhinolophus lepidus*, *Rhinolophus rouxii*, *Hipposideros ater*, *Hipposideros galeritus*, *Hipposideros speoris*, *Megaderma lyra*, *Megaderma spasma* and *Taphozous melanopogon*. Five species (*R. lepidus*, *H. ater*, *H. galeritus*, *H. speoris*, *T. melanopogon*) were recorded in Swargadwara cave, four (*R. lepidus*, *H. galeritus*, *M. lyra*, *T. melanopogon*) in Parabhadi cave 1, three (*R. lepidus*, *R. rouxii*, *H. galeritus*) in Gupteswar cave, two (*R. lepidus*, *M.*

TABLE 2 Mean ± SD total number of bats counted per day during the 12 survey days in the five caves at Gupteswar cave tourism and pilgrimage site (Fig. 1) during September 2016–August 2017.

Family	Gupteswar	Swargadwara	Parabhadi 1	Parabhadi 2	Dhabaleswar	*Total*
Rhinolophidae	388.08 ± 23.58	8.42 ± 6.44	9.25 ± 5.71		4.33 ± 2.46	410.08 ± 24.95
Hipposideridae	11.08 ± 1.56	136.67 ± 19.14	8.67 ± 1.67			156.42 ± 18.45
Emballonuridae		77.58 ± 4.98	84.42 ± 5.33			162.00 ± 6.71
Megadermatidae			15.75 ± 12.15	67.33 ± 9.19	26.55 ± 23.43	109.58 ± 24.63
Total	399.17 ± 23.14	222.67 ± 20.43	118.08 ± 19.62	67.33 ± 9.19	30.83 ± 23.54	838.08 ± 48.97

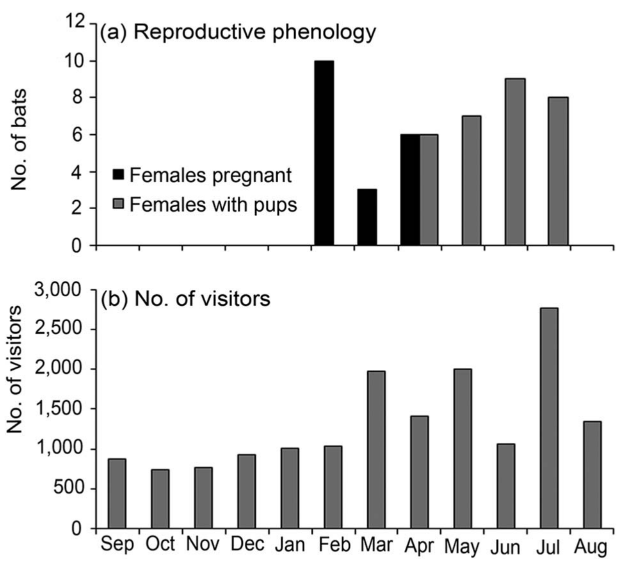

FIG. 2 (a) Reproductive phenology (numbers of females pregnant and with pups) amongst the 140 bats captured, and (b) number of visitors at Gupteswar cave tourism and pilgrimage site (Fig. 1), during September 2016–August 2017.

spasma) in Dhabaleswar cave, and one (*M. lyra*) in Parabhadi cave 2. The total number of bats counted on each survey day (all caves and species combined; Table 2) did not vary significantly between months ($F = 0.02$, df = 11, 48, $P > 0.05$) or seasons (summer, monsoon and winter; $F = 0.49$, df = 2, 12, $P > 0.05$). The number of bats counted on each survey day and in each cave are provided in Supplementary Table 1.

Reproductive phenology

Of the eight species, breeding of five species (*R. lepidus*, *H. ater*, *H. galeritus*, *M. lyra* and *T. melanopogon*) was recorded, during February–July (Fig. 2). Pregnancy in *R. lepidus* was first observed during February–April and females carrying non-volant pups were recorded during April–June. Pregnancy was observed in *H. ater* and *H. galeritus* during February and females carrying non-volant pups were recorded during April and June–July. Pregnancy in *M. lyra* was observed during March–April and females carrying non-volant pups were recorded during May and July. Pregnancy in *T. melanopogon* was observed during February–April and females carrying non-volant pups were recorded during April–July.

Visitation

A total 15,942 visitor in 1,248 groups (Group size range 1–88; mean 12.77 ± SD 8.67) were recorded (Table 3). Groups comprising 1–15 people were most frequent (73% of all visits), followed by 16–30 people (25%), 31–45 people (1.5%) and > 45 people (0.5%). On average each cave was visited by 3,188.4 ± SD 326.6 individual tourists during the 12 survey days. Visits were significantly higher during local cultural festivals associated with the caves, during February–July ($t = 2.66$. df = 6, $P < 0.05$; Fig. 2), coinciding with the reproductive period of *R. lepidus*, *H. ater*, *H. galeritus*, *M. lyra* and *T. melanopogon*. The overall monthly bat count was not correlated with number of visitors ($r = -0.29$, df = 10, $P > 0.05$).

Each tourist group spent a mean of 15.7 ± SD 9.4 minutes in the caves. The duration of cave visits by tourists was positively correlated with visitor group size ($r = 0.53$, df = 34, $P < 0.01$). The mean time spent by tourists inside each cave was highest (1.86 minutes) in Gupteswar, followed by Swargadwara (1.77), Parabhadi 1 (0.88), Parabhadi 2 (0.77) and Dhabaleswar (0.67). The activities of tourists inside the caves included religious and spiritual practices, photography and talking. The main purpose of the visits were cultural (317 respondents) and for leisure (49).

Knowledge and attitudes

A total of 76 local villagers and 366 tourists were interviewed. Information on their responses and demographic profiles are given in Table 1 and Table 4, respectively. Nearly 86% of respondents were not aware that bats are mammals, with 79% (62% of tourists and 93% of local people) indicating they are birds. Only 23% (27% of tourists and one local person) were aware that bats are ecologically important as controllers of insect pests, and 77% of the respondents believed bats are a nuisance, feeding in the fruit orchards and home gardens. Sixty-four per cent of all respondents (58% of tourists and 91% of local people) agreed that caves are important habitat for bats. Amongst all the respondents, only 11% agreed that human activities inside

TABLE 3 Number of tourists who visited the five caves at Gupteswar cave tourism and pilgrim site (Fig. 1) in each survey day during September 2016–August 2017. Values in parentheses are the number of tourist groups. The monthly totals are presented in Fig. 2b.

Months	Gupteswar	Swargadwara	Parabhadi 1	Parabhadi 2	Dhabaleswar
Sep. 2016	181 (20)	175 (19)	175 (18)	171 (18)	175 (18)
Oct. 2016	157 (18)	157 (18)	152 (17)	143 (16)	135 (15)
Nov. 2016	154 (14)	154 (14)	154 (15)	154 (14)	149 (13)
Dec. 2016	193 (18)	188 (17)	185 (17)	181 (16)	182 (16)
Jan. 2017	217 (20)	209 (18)	201 (17)	183 (15)	198 (16)
Feb. 2017	235 (22)	215 (20)	207 (18)	189 (16)	190 (17)
Mar. 2017	524 (30)	440 (27)	391 (26)	215 (14)	409 (26)
Apr. 2017	298 (25)	291 (24)	291 (24)	267 (23)	269 (25)
May 2017	420 (31)	414 (30)	417 (31)	382 (28)	371 (26)
June 2017	216 (21)	216 (21)	216 (21)	203 (19)	216 (20)
July 2017	773 (30)	504 (25)	550 (26)	400 (23)	542 (27)
Aug. 2017	288 (25)	283 (24)	257 (22)	257 (22)	263 (22)
Total	3,656 (274)	3,246 (257)	3,196 (252)	2,745 (224)	3,099 (241)
Monthly mean ± SD	304.7 ± 184.3	270.5 ± 119.3	266.3 ± 124.5	228.8 ± 84.3	258.3 ± 122.9

TABLE 4 Demographic characteristics of the local people (n = 76) and tourists (n = 366) interviewed to assess their knowledge and attitude towards bats at Gupteswar cave tourism and pilgrim site, eastern India, during September 2016–August 2017.

Variables	Local people, % (n)	Tourists, % (n)
Gender		
Male	93.4 (71)	84.4 (309)
Female	6.6 (5)	15.6 (57)
Age (years)		
18–29	31.6 (24)	30.9 (113)
30–39	34.2 (26)	35.2 (129)
40–49	14.5 (11)	26.0 (95)
50–59	11.8 (9)	7.9 (29)
60+	7.9 (6)	
Occupation		
Non-timber forest product collector	35.5 (27)	
Farmer	55.3 (42)	20.2 (74)
Government employee		42.4 (155)
Entrepreneur	9.2 (7)	37.4 (137)
Highest education level		
Illiterate	75.0 (57)	1.9 (7)
Primary	21.0 (16)	10.6 (39)
Secondary	2.7 (2)	18.6 (68)
Intermediate	1.3 (1)	29.8 (109)
Graduate		26.8 (98)
Post-graduate		12.3 (45)

caves are a threat to bats, and 80% of respondents (78% of tourists and 89% of local people) claimed they never teased or harmed bats. Regarding the conservation of bats at Gupteswar, all the local people but only 32% of the tourists agreed that bats and their roosting sites should be protected and their attitude was mostly aesthetic (55%) followed by moralistic (24%) and eco-scientific (21%). However, 68% of the tourists had a negative attitude towards the conservation of bats in caves because of the guano and the smell.

Discussion

Cave tourism is becoming increasingly popular as people are motivated to visit caves for their inherent natural landscape features (Okonkwo et al., 2017). The limestone Gupteswar caves lie within natural forest and, being associated with sacred values and accessible by road, attract tourists throughout the year. The assemblage of bats in caves is governed by two main factors; surface level disturbance, including anthropogenic activities and availability of forest, and the complexity of the caves, including availability of roosting sites, structural heterogeneity and number of entrances (Phelps et al., 2016). Gupteswar caves support at least eight species of bats, comprising 32% of the 25 species known in Odisha state (Debata et al., 2016b).

Cave dwelling bats are often hunted for their meat and for medicinal uses (da Costa Rego et al., 2015; Tanalgo et al., 2016), but bats inhabiting sacred caves may benefit from local customary regulations and taboos (Metcalfe et al., 2010; Golden & Comaroff, 2015; Furey & Racey, 2016; Fernandez-Llamazares et al., 2018). Although bats roosting in the Gupteswar caves are not harmed, because of sacred beliefs associated with the caves, unregulated tourism activities inside the caves are a potential threat to the bats. As part of the development of any cave for tourism, structural modification and introduction of artificial lighting is a common intervention (Furey & Racey, 2016), including at Gupteswar. Tourists visit the Gupteswar caves throughout the year, and spend more time in Gupteswar and Swargadwara, which are only artificially illuminated. Larger tourist groups spent more time inside the caves and explored more areas within the caves, increasing the likelihood of approaching close to areas with roosting sites and maternity colonies. Anthropogenic disturbance from artificial illumination, noise and human activities increase alertness in bats, leading to increases in flight activity, vocalization intensity and energy expenditure (Song et al., 2000; Mann et al., 2002; Cardiff et al., 2012). Structural modification and artificial lighting can weaken the ability to avoid obstacles during flight, and affect roost use pattern, emergence time, and growth and development of juveniles (Srinivasulu & Srinivasulu, 2003; Boldogh et al., 2007; McGuire & Fenton, 2010). Human activities can also cause marked fluctuations in microclimatic condition of the caves by altering the temperature, relative humidity and carbon dioxide concentration (Pulido-Bosch et al., 1997; Gunn, 2004), the requirements for which are specific to individual bat species. Disturbances in breeding and maternity colonies can also cause adults to drop their young, from stress, and it is difficult for the young to be retrieved (Sheffield et al., 1992; Petit et al., 2006). At Gupteswar caves visitation was highest during the reproductive period of several of the bat species present. Similarly, in Cambodia the time of year with greatest visitation to caves coincided with the breeding of several cave dwelling insectivorous bats (Lim et al., 2018).

A study using an index of bat cave vulnerability revealed that caves with high species diversity are more vulnerable to anthropogenic activities than caves with low species diversity (Tanalgo et al., 2018). At Gupteswar, tourism related human disturbance is the major threat to bats; without appropriate management the bat populations may potentially decline or abandon these caves. Protection of roosting sites from anthropogenic disturbances should be an essential component of any conservation strategy (Furey & Racey, 2016). In India, however, there are no laws or guidelines to protect and conserve caves and their biodiversity (Walker & Molur, 2003; Biswas, 2016). Bats inhabiting caves opened for tourism may be persecuted, as in Borra cave in southern India (author, pers. obs.). Although none of the bats at Gupteswar appear to be harmed, because of the sacred beliefs associated with the caves, the uncontrolled human disturbance is a major challenge. Installation of gates at entry points and scheduling of visits to control overcrowding are required, and illumination inside the cave system should be turned off at night, when there are no visitors and during non-visiting daylight hours. The areas of the caves used as maternity colonies (Fig. 1b) should not be open for visitation during breeding seasons. Such initiatives have, for example, proved effective at a cave in the Rocky Mountains of Canada (Olson et al., 2011) and at the Dupnisa cave system in Turkey (Paksuz & Özkan, 2012). However, prior to installation of any gates it is important to understand the ecology and behaviour of the bat species present, as poorly designed and improperly placed gates can be detrimental to bats (Ludlow & Gore, 2000; Pugh & Altringham, 2005; Alcalde et al., 2012). Sharing of knowledge regarding the importance of bats can help to improve attitudes towards them and make people more aware of the species' conservation needs (Pennisi & Confer, 2005; Trewhella et al., 2005; Kingston, 2016; García-Cegarra & Pacheco, 2017). Bat watching has become a popular recreational activity in some European countries (Pennisi et al., 2004). Educational display boards on the conservation importance of cave dwelling bats have already been installed at the entry area of each cave at Gupteswar, to sensitize visitors. In addition, long-term monitoring of the behaviour and population dynamics of the bats of the Gupteswar cave system is required, in particular in relation to tourism activities.

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Conflicts of interest None.

Ethical standards Interviews followed the ethical guidelines of the Indian Council of Medial Research, India (Mathur, 2017), and this research otherwise abided by the *Oryx* guidelines on ethical standards.

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