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Impacts of Ecotourism on Bat Habitats in Caves of Kanger Valley National Park, India

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ABSTRACT

The roosting microchiropterans mostly prefer caves and are highly sensitive to anthropogenic disturbances. The caves of the Kanger Valley National Park, is becoming day by day the most crowd puller spot for Central India and due to which it often overruled all the laws of ecotourism. In the present study, two microchiropteran species were found to roost together in the caves of the Kanger Valley National Park, India with distinct microhabitats. *Rhinolophus rouxii* was found in the twilight to dark zone of the cave while *Hipposideros cineraceus* was found to occupy the more stable zones of the cave and was highly sensitive to anthropogenic disturbance. The population sizes of the bats roosting inside the two major caves have been estimated and compared with the earlier available records and this provides evidence of a decline in abundance. Further, the gestation/reproductive phase of these bat populations was also found to coincide with the period during which the caves remain under the highest anthropogenic pressure. In the present study several aspects which could threatened the existences of the cave bats have been noted and proper strategy to re-establish their populations have been discussed by maintaining more or less the tourist pressure intact in the caves.

Key words: Subterranean caves, microchiropteran, anthropogenic pressure, microhabitat, eco-tourism

INTRODUCTION

Ecotourism is the most practicable plan to exploit and simultaneously preserve the natural resources while providing long-term and sometimes sufficient profitable, economic alternatives to logging, agriculture or wildlife extraction (Honey, 1999).

The unusual breathtaking biosphere of any subterranean cave remain always a matter of curiosity for the people who loves nature, indeed we often forget that such subterranean landscapes are also harbour a large biodiversity in itself . The organisms survive in such a peculiar ecosystem after several adjustments with their biological processes (Vandel, 1965; Gunn, 2004; Harries *et al.*, 2008; Biswas, 2009, 2010; Biswas and Shrotriya, 2011; Sahu *et al.*, 2011). Day-by-day the anthropogenic pressures in the form of eco-tourism are increasing in every renowned caves of the world. Sometimes; especially during vacations, this pressure increases up to that extent which often breaks every rules and regulations of eco-tourism.

Microchiropteran use caves for their day-roosting and in return it also serves as the major energy carriers for the other inhabitants of the caves (Vandel, 1965; Gunn, 2004;

Biswas, 2009, 2010). In fact, subterranean caves offer them a wide variety of roosting subhabitats in the form of textured walls/ceilings, small crevices and rock outcrops. Microchiropterans select sites within caves suited to their microclimatic preferences and accordingly from time to time alter their positions (Betts, 1997; Krystufek, 2004). Possibly, the roost temperature and humidity are the key factors on which specific roost selection depends. Variation in latitude, altitude, depth and volume as well as the presence of blow-holes inside the caves collectively provides them the hospitable microclimatic conditions suitable for roosting (Murray and Kunz, 2005). Due to having negligible disturbances, from the very beginning these landscapes have always proven to be the best suited roosting sites for the microchiropterans. Unfortunately the increasing anthropogenic pressure for any cave not only threatens the existence of its microchiropteran inhabitants but it also affects the composition of its complete biodiversity (Biswas, 2009).

Kanger Valley National Park is situated in the central part of the Indian subcontinent (state Chhattisgarh); which is bestowed with the presence of large number of natural subterranean limestone caves. The park covers around 200 sq. km area. The tributaries of River Kanger flow throughout the National Park. Recently, this park has become a major eco-tourist spot for Chhattisgarh, after it was carved out from the state Madhya Pradesh as a new political entity. The Kotumsar (18°52' 09" N; 81°56' 0" E) and the Dandak (18°51' 30" N; 81°57' 00" E) caves are the two major crowd pullers of this park which are exist at about 500 m apart (geographical distance) from each other. Both the caves support a wide range of inhabitants (Biswas, 1992, 2010; Biswas and Shrotriya, 2011). During a recent survey made by Zoological Survey of India (Government of India organization) ten different species of bats belonging to three different genera were revealed from this particular national park. Interestingly, out of ten only two species of microchiropterans were found to be the cave dwellers i.e., *Hipposideros cineraceus,* from Kotumsar and *Rhinolophus rouxii* was reported from the Dandak cave (Chakraborty, 2008). However, earlier only single available report supports the inhabitation of mixed population in Kotumsar cave (Biswas and Kanoje, 1991), though the mentioned species were possibly misidentified.

Although both the caves are very close to each other, it was a matter of curiosity why these two distinct species might chose separate caves for roosting or if in the case of both the populations abiding together in these caves then do roost preferences differ? Further, do the increasing anthropogenic pressures inside the cave exert any negative impact on their existence? Are the recent structural developments in the park threatening the existence of these bats? By keeping in mind the above all facts we made an attempt to verify the following facts:

- What are the micrchiropteran species roosting in the crowd pulling caves of Kanger Valley National Park, India?
- Do any microclimatic variations influence the roosting behavior of specific species inside the caves?
- Do any microchiropteran species prefering the cave for their any particular phase of reproduction?
- Does the ever increasing tourist pressure in these caves exert any negative impact on the habitats of the roosting microchiropterans?
- Do the various civil constructions/alterations carried in and around the caves for the convenience of the tourists have an impact on the existence of the bats?

MATERIALS AND METHODS

Study sites and natural history of microchiropterans (Fig. 1): Kotumsar cave opens via narrow and convoluted vertical fissure, existing in the wall of a hill which further extends inward up-to 500 m with several lateral and downward passages which either open to any chamber or ends blindly. Few chambers are hard to approach for routine tourists and thus remain almost free from anthropogenic pressure throughout the year. Air and water temperatures were already reported to be relatively stable with an annual average of 28.25±1.23 and 26.33±0.96°C, respectively (Biswas, 1992). The cave is subjected to frequent flooding during the monsoon season which generally begins from the middle of June and continues till the mid of October. Besides it, few water-pools of about 3-4 m diameter also exist which are fed by seepage water throughout the year. Due to convolution in entry passage, the twilight zone area of this cave is negligible. Further, the complete cave system of Kotumsar can be safely divided into transition and deep zone, though the possibility for existence of any stagnant zone is almost negligible (Vermeulen and Whitten, 1999; Biswas, 2009, 2010).

Dandak cave is composed of two identical chambers with almost equal volumes connected to each other via two small, narrow and twisted passages. The main entrance of the cave is a wide hollow cavity existing at the base of the rocky wall which opens directly to a big hall (the outer chamber). Additionally a few narrow openings also exist near the main entrance and contribute to a high external environmental impact on the outer chamber of the Dandak cave. The external light penetrates the far end of the outer chamber and the major portion of the chamber remains lightened during the day time and thus the chamber as a whole could be referred to as twilight zone. The inner chamber is comparatively narrow in dimension, possessing an unexplored deep well-like vertical pit nearer to entrance. The small passages connecting both the chambers with

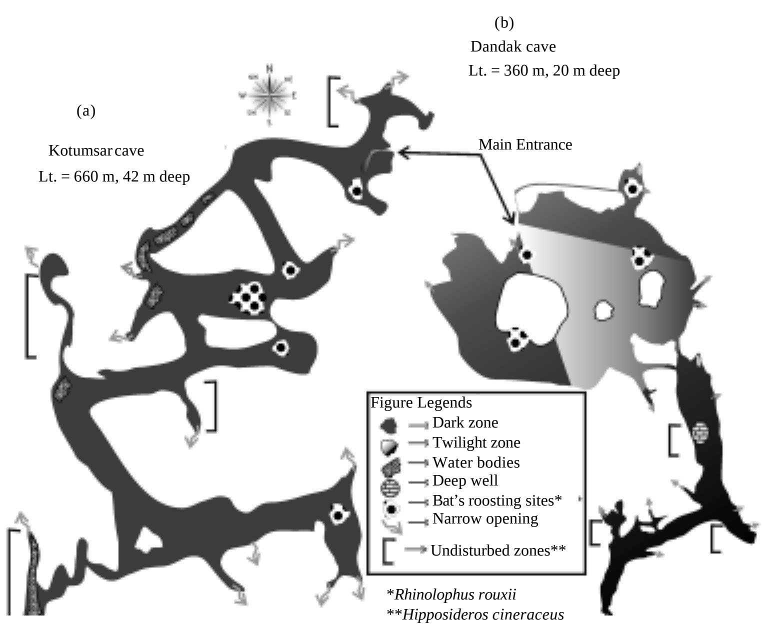

Fig. 1(a-b): Tentative layout of (a) Kotumsar cave (b) Dandak Cave, indicating the major roosting sites of the microchiropterans other could be referred to as the transition zone of this cave. Finally, the inner chamber is effectively the deep zone of the cave. However, whether any stagnant zone exists inside the vertical pit of the inner chamber is yet to be explored.

Present status of both the caves and its surroundings: The Dandak cave was discovered in 1995 by forest staff of the National Park (Biswas and Shrotriya, 2011), although other sources indicate that the existence of Kotumsar cave was known to the people since the mid nineteenth century. Earlier the cave, Kotumsar was like a hidden glory for a few naturalists and relevant researchers but in recent years this park has become a major ecotourism site for the state Chhattisgarh and this particular cave is a very popular visitor site. In addition, from the very beginning Kotumsar cave was well-known religious site for the local handful tribes; with the time the same sentiment is simultaneously growing in ever increasing tourists too.

Both the caves remain open for tourism from November till May and visits take place between 9:00 AM and 4:00 PM. It could be estimated that on an average around 500 tourists visits the Kotumsar cave per day and these number may triple during the national holidays or on religious-festival days. The caves entrances of both the caves have been covered by grilled gate which remain only open during the visitors' hours. The sites around the entrances are maintained very airy and open by uprooting all the floral growth around it.

During summer (February-May) the complete park zone suffers from forest fire. Besides natural wild fires the local tribes and also unsocial elements regularly start fires. To increase the fertility of the soil, local tribes frequently burns the dried ground level of the forests which usually remain covered with dried leaves and litter during summer. It often destroys some of the big trees of the area.

Study of microclimatic variations inside the caves: During wet (rain) and dry (summer) seasons, we recorded the air temperature and humidity for both the caves with the help of digital thermo-hygrometer (Pacer make™) and compared this with the ambient external environment. The two existing chambers of the Dandak cave were considered as two different sites in our study where as the complete cave system of Kotumsar was considered as a single site. From each site, five replicates of temperature and humidity were tabulated and at least 40 m distances were maintained between every two consecutive sites. Two way ANOVA and Duncan's multiple range test was employed the significance of differences among different sits and seasons (Duncan, 1955).

Population dynamics and reproductive phase estimations of cave microchiropterans: Throughout the study period, all the possible roosting sites existing in the conspicuous and accessible areas of both the caves were monitored carefully to locate the microchiropteran populations and to understand their respective habitats. Population estimations were done by a direct head counting method, using torches fitted with red filters. To count the individuals roosting in large group(s) digital photographs were also taken with the camera having 16 X zooming and 10 mega-pixel capacity and abundances were estimated by employing the method of Elliott (2008). The census was carried out at a gap of every three months and continued over a span of a year. Care was taken not to disturb the roosting bats during census. Close-up photographs of the individuals were randomly taken with the same camera for species identification. Mist net capture technique was also employed during the month of May (summer) when the tourist pressure is at its peak. This was done to identify the species and to examine their gonadial status.

RESULTS AND DISCUSSION

Irrespective of the season and anthropogenic pressure inside the caves, the temperature and humidity of Kotumsar cave and both the chambers of Dandak cave were found to be significantly different from the ambient external environmental conditions (Fig. 2a, b). During the dry season, humidity level between the two chambers of Dandak cave were also found to vary significantly from each other; though such differences were not apparent during wet season (Fig. 2b). Further during dry season, the humidity level of the outer chamber of Dandak cave was also found to be significantly low as compared to the Kotumsar cave. Results of ANOVA revealed a significant difference in air temperatures among the different sites at 0.01% percent. The recorded temperatures were also found to differ between seasons (dry vs. wet; $p<0.0001$). Further the interaction effects between sites and season were also found to differ significantly ($p<0.001$). Similarly, results of ANOVA on humidity parameters also revealed almost same types of results with much more significant values ($p<0.0001$). Conclusively, the Kotumsar cave (as a whole) as well as the inner chamber of Dandak cave remains almost unaffected by its ambient

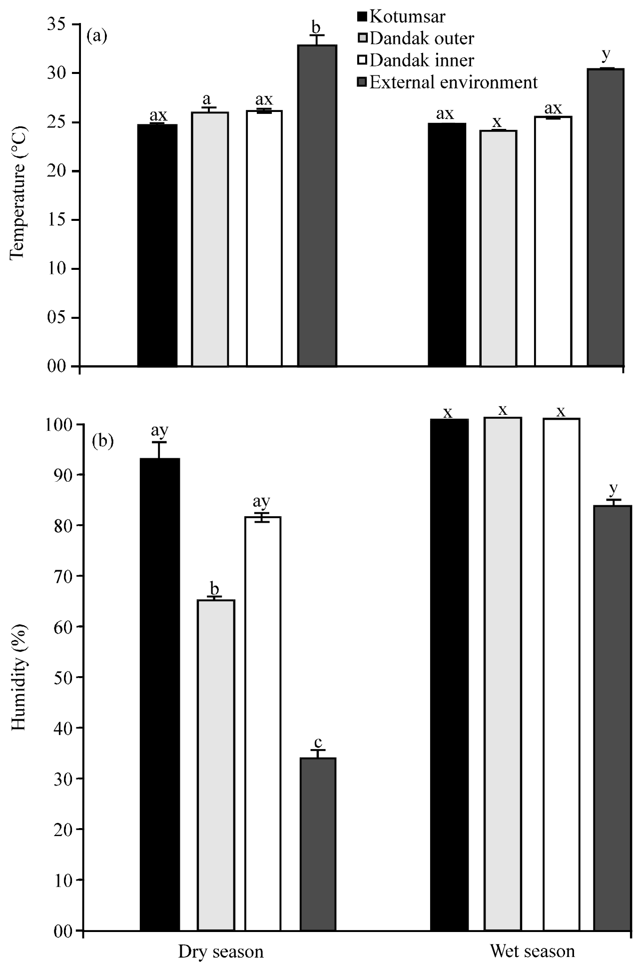

Fig. 2(a-b): (a) Histogram representing atmospheric temperature variations among four different sites recorded during two different seasons separately. (b) Histogram representing atmospheric humidity variations among four different sites recorded during two different seasons separately. Histograms having similar superscripts do not differ from each other at 5% (based on Duncan's multiple range test)

Fig. 3: Two Microchiropteran species, (a) *Rhinolophus rouxii* and (b) *Hipposideros cineraceus*

epigean environmental conditions and thus it may offer best suitable sites of that particular zone for roosting to those microchirpterans who needs cold, humid and almost stable conditions.

Bat census by direct counting method estimated a population of 180 (highest counting) individuals roosting in conspicuous/accessible areas of Kotumsar cave. Zoomed photographic evidence testified that the only member of Rhinolophidae family (horseshoe shaped nose); occupy the cave ceiling areas nearer to the intermediate zone and other conspicuous/accessible areas of this cave. Occasionally, few solitaries were also apparent in the deeper zones. However, not a single individual of this species was noticed to roost on the vertical walls of the cave. Species confirmation as *Rhinolophus rouxii* Temminck 1835 (Fig. 3a) was made by verifying the morphometric data of the specimens caught by mist net.

Unfortunately, photography proved impossible in the areas that remain undisturbed by tourists and are difficult to approach (hidden chambers). The species roosting in such inaccessible areas could be viewed from a distance. They exist in clusters and are very sensitive, even a small disturbance makes them alert and they fly away and so could not be photographed. Occasionally this species were seen to clinch walls of the cave. The taxonomic status of this species only got confirmed when the two different species were netted i.e., along with *R. rouxii* one additional species i.e., *Hipposideros cineraceus* Blyth 1853 (Fig. 3b) was found with abundances in the ratio of 3:2. Though the photographic evidences didn't support the existence of any member of family Hipposideridae in any accessible areas of either cave, it could be safely assumed that *H. cineraceus* occupied the hidden chambers of the Kotumsar caves which normally remain undisturbed from all the external epigean consequences and are atmospherically much stable and more humid.

In Dandak cave, photography of the individuals of roosting microchoropteran were only possible for the outer chamber i.e., in the twilight zone. By direct counting 55 (highest counting) microchiropterans were found to roost in the outer chamber of Dandak cave. However, in the inner chamber of this cave sometimes a population of roosting microchiropteran was often encountered which was also found to be very sensitive to any disturbance. Photographic evidences and morphometric data testified that *Rhinolophus rouxii*, roosts in the outer chamber of this cave and interestingly mist net trapping again testified the existence of mixed populations of *R. rouxii* with *H. cineraceus* similarly to Kotumsar cave but with abundance in 1:2 ratio. Here, it has been confirmed that *H. cineraceus* only roosts in the inner chamber of the Dandak cave which is certainly more stable and much humid as compare to the outer one (Fig. 2a,b).

Surprisingly, irrespective to the season, during some of our visits in the accessible areas only few individuals were apparent in one or both the caves. However, repetitive visits confirmed that the bats often alter their roosting sites inside the caves. Due to this specific reason it was not possible to present any clear picture of seasonal cycles.

During the dry season, the gonadal statuses of the net captured microchiroptreans were also examined to ascertain their reproductive status. This season was reportedly the gestation/reproductive phase for these microchiropterans (Brosset, 1962; Ramakrishna, 1978). Though the intention of this study was only to confirm the species and to verify their reproductive phase, the mist net was set-up only to the sideward passages of the caves, instead of main entrance.

Irrespective of the species while testing the gonadal status of the netted microchiropterans, the enlarged testes was evidenced in all the mature males. A few lactating female specimens of *R. rouxii* were also trapped in mist net however, not a single female specimen of *H. cineraceus* from any of the two caves was netted. A few immature individuals from both the species were also trapped.

CONCLUSION

The selection of specific roost requirements in microchiropteran directly depends on its overall ambient ecology and evolutionary history (Murray and Kunz, 2005). Different species roost in different microclimatic conditions within a single cave/mine which often correlate with their respective body size, diet, physiology and also their ability to resist the torpid activity (Kunz and Fenton, 2003). *Rhinolophus* species are heavily reliant on caves for at least part of their life cycle, a rare mountainous *Rhinolophus* species (*R. euryale*) of Hungary is found to breed and hibernate in caves in mixed colonies with *Miniopterus schreibersii* (Hutson *et al.*, 2001). In the present study, two distinct species of microchiroptera were found to roost together in two major tourist caves of Kanger Valley National Park. *Rhinolophus rouxii* is a common microchiropteran species distributed in most of the parts of the Indian sub-continent (Bates *et al.*, 1994; Molur *et al.*, 2002; Das and Agrawal, 1973; Singaravelan and Marimuthu, 2003) and was first reported from this region by Das and Agrawal (1973). Recently, its range of occurrences has been found to extend in several other parts of South-Asia (Corbet and Hill, 1992; Bates *et al.*, 2000; Bumrungsri *et al.*, 2006; Gamage *et al.*, 2006). We found the individuals of this species roosting in small colonies nearer to the twilight and/or in intermediate zones of both caves. Occurrence of males with protruded gonads and lactating females strongly suggests that March-April is the gestation/reproductive phase for this population inhabiting in this region and this result is in agreement with earlier reports (Brosset, 1962; Ramakrishna, 1978).

Hipposideros cineraceus, was first reported from this region in caves by a team of Zoological Survey of India (Chakraborty, 2008). Earlier its distribution was thought to be tightly restricted to only the colder parts of India (Molur *et al.*, 2002). In recent years, it has also been reported from few neighborhood countries, adjacent to regions of known distribution in India (Suyanto and Struebig, 2007; Khan *et al.*, 2008; Matveev, 2005; Xiang *et al.*, 2004; Tan *et al.*, 2009). In the present study, this population was found to occupy the deeper parts of the caves which usually remain unaffected from anthropogenic activities. However, their preferences for comparatively colder and more humid roosting site could not be ruled out, as some of the microchiropterans enjoy the physiological advantage by roosting in humid areas. Some microchiropterans prefer humid roosting sites which directly help them to avoid the desiccation of their thin wing membranes (Neuweiler, 2000). Though this species is native to cold regions, its occurrence in the Kanger Valley National Park is not at all surprising, because the area is characterized by cold hilly plateau zone and possibly the assemblages of favorable flora and fauna also supports its habitat. The occurrence of male specimens with enlarged testes, from both the caves indicates that the timing of reproduction is comparable in both *H. cineraceus* and *R. rouxii*. Lack of evidence on mature *H. cineraceus* female also raised a question regarding its particular roosting preferences during various reproductive phases, because few microchiropteran prefers colder roosts before parturition, whereas warmer ones are selected by lactating females (Kerth *et al.*, 2001). However, such reports are only available from colder countries, whether the same phenomenon is operating here in India (a tropical country) is yet to be established.

The first documented available report on bats of Kotumsar cave was by Biswas and Kanoje (1991). Perhaps, in the report the authors misidentified both the species but they estimated about 1,500 individuals altogether roosting in this cave at that time. Unfortunately, in the present study i.e., after a long gap of twenty years, our calculations estimated around 300 individuals, including both the species (*R. rouxii* alone = 180 and the occurrence ratio is 3:2) are remaining in the Kotumsar cave which is indeed one fifth of the earlier record.

It is well established that the members of roosting family Rhinolophidae and Hipposideros are highly sensitive to disturbance of roosts and foraging habitats, moreover rhinolophids usually roost in very visible situations, making them even more vulnerable to disturbance (Hutson *et al.*, 2001). In addition, in India the subterranean caves posses' high religious importance, several Indian holy festivals comes during the month of April-June (summer) when in spite of the pilgrims; thousands of tourists visit these caves.

Besides the ever increasing anthropogenic pressure inside the caves, several other minor factors possibly acting the major threats for the existence of the cave roosting microchiropterans of this National Park some of which are discussed in the following:

- Inappropriately designed cave gates definitely caused bats to desert sites, as the habitual style of flight makes it difficult for the species to negotiate the barrier in the flight path
- Due to some unavoidable nuisance factors, the increased frequency of forest fires in the park destroys the foraging habitat of these microchiropterans
- Clearance of vegetation around cave entrances makes bats vulnerable to predators such as screech owls, snakes and others
- Burning joss/incense sticks or other relevant stuffs by the pilgrims inside the caves are also directly spoiling the microclimatic conditions of the roosting bats

Today Ecotourism is only meant to increase the quantum of economic benefit without caring for the short/long term impact on human and its relevant natural resources (Eneh and Agbazue, 2011). Earlier, the subterranean caves were the biggest refuges of the microchiroptrans but the increasing interest of the public in areas of natural beauty have increased anthropogenic pressure in such caves and which is adversely affecting the existence of the cave inhabitants. Tourism at its current levels is unlikely to be presenting a significant threat to cave-bat populations of Kanger

Valley National Park, India. The period when the caves of this park are open to the tourists (i.e., from November to May (dry season)) unfortunately coincides with the parturition and lactation phases of both the microchiropteran populations roosting in these caves. So, it is likely that reproductive success of the bats will be impaired.

Bat populations are diminishing worldwide with many species losing ground, listed as threatened or endangered or becoming extinct (Pennisi *et al.*, 2004; Mann *et al.*, 2002). However, efforts on bat conservation are also gaining momentum. Successful conservation measures for any microchiropteran should include the protection of the roost sites and foraging habitats (Hutson *et al.*, 2001; Kumaran *et al.*, 2006). Several investigations have been carried out regarding the installation of suitable gates in tourist cave entrances which can safely allowed the entry/exit of the resident microchiropterans (Ludlow and Gore, 2000; Fure, 2006; Patriarca and Debernardi, 2010). In tropical caves guano and carcasses of the bats acts as one of the major sources of energy inputs to the caves and in such case the depletion in their population will have an impact on the total biodiversity of the cave.

We strongly suggest the following effective measures for the conservation of microchiropterans:

- Monitor the tourist activity inside these caves so that the denser roosting areas can be left undisturbed
- No shouting or any other type of noise should be allowed inside the caves
- The entrance gate should be carefully designed so that it should not obstruct the exodus/inward movement of microchiropterans
- Light intensity must be kept very low and lights should not be directed on to the walls and roof of the cave
- Burning joss/incense sticks or other similar materials by the pilgrims inside the caves should be strictly prohibited
- Vegetation should be allowed to regenerate near the entrance of the cave to protect the bats from owl and other predators during their exodus activity
- Occurrences of forest fire in the vicinity of the caves should be minimized by observing tight precautionary measures

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