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## A Study about Human Interference on the Two Caves of Khandagiri of Odisha State, India in the Viral Pandemic Year (2020), in Comparison with a Normal Year (2021)

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### Abstract

The subterranean karst system with its unexplored fauna and flora is an area of curiosity for researchers. The present study on the faunal diversity of the twin caves of Khandagiri, located in the capital of Odisha, is one of such less explored terrains. The seasonal variation of the vertebrates (including bats, geckos, frogs) and invertebrates (including ants and cave beetles) is compared with temporal changes in the two caves of Khandagiri, Bhubaneswar, Odisha, India in the COVID 19 pandemic year of 2020 with the normal year of 2021. These caves are a tourist destination; the faunal distribution is disturbed by human activities. The comparative diversity of animals in such caves is of high implication to understand the bio-geological phenomena and its reflex to anthropogenic activities.

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### Keywords

Caves, fauna, Anthropogenic, Odisha, Khandagiri Cave.

### Introduction

Caves are a type of karst landscape formed in soluble rocks (e.g., limestone, dolomite, gypsum, halite) that roughly coincide with the global distribution of carbonate sedimentary rocks of all geological ages (e.g., Ford and Williams, 2007). Karst covers about 15–20% of the Earth's ice-free land surface. These underground karst systems of horizontal caves and vertical abysses are distributed throughout the Earth and are fragile natural resources that may contain records of archaeological, palaeontological and palaeoenvironmental change.

The density, frequency and number of voids in karst are important for the development of cave and karst ecosystems. (e.g. Ford and Williams, 2007; Palmer, 2007). There can be three main habitat zones of a cave that are connected to the surface, based on light

penetration and intensity: entrance, twilight, and dark zone. Each zone has specific physicochemical and nutrient conditions associated with geochemical gradients that influence the colonization potential and distribution of life (Bonacci *et al.*, 2009).

Although the understanding of the geo-microbiological and biogeochemical role of cave and karst microbes in metal and nutrient cycling, including carbonate dissolution and precipitation, has made important advances, many new challenges lie ahead. One line of research that will undoubtedly continue is the unexplored faunal diversity of the karst habitat. This is a common thread running through most cave ecology and environmental microbiology studies. At present, more baseline data are needed to test hypotheses about the distribution, dispersal, and reservoir size of the different, and possibly distinct microbial and micro-faunal groups

in these subterranean habitats (Hoyos *et al.*, 1998; Groth *et al.*, 2001).

Over the past decade, cave biodiversity has emerged as a growing interdisciplinary field involving the efforts of biologists, geologists, and chemists to address challenging questions of microbial metabolism and biogeochemistry. The research is also helping land managers to recognize the importance of species in cave ecosystems, thereby further protecting cave environments. With the advantage of living in close proximity to two very important historical caves, out of which two caves have been explored for their micro-fauna richness; the present piece of work is an attempt to study the faunal diversity in two caves of Khandagiri in the COVID 19 pandemic year 2020 and compare it with the normal year 2021 to see how human interference affects the animal population. Further to sensitize the appropriate authority to take steps to limit human interference and thus conserve the bio-habitats of caves within the two different caves studied i.e. Khandagiri and Khandagiri located in Bhubaneswar, Odisha. This work is the first of its kind in the region to study the biodiversity of these historically important caves.

## Materials and Methods

### The study sites

The latitudinal and longitudinal extent of Odisha ranges from 17°49' N to 22°34' N and from 81°29' E to 87°29' E respectively on the eastern coast of India, with an area of about 1, 55,707 sq. km. Physically, Odisha can be divided into three broad regions: the coastal plains; the middle mountainous country: the plateaus and the hilly uplands. Most of the caves are found in the plateaus and hilly regions. The sub-mountainous area in the coastal plain is also dotted with some typical cave formations.

Khandagiri (Lat 20°15' N, Long 85°47' E) are located on Kumari Hill at an altitude of 82 m above MSL (Mean Sea Level). The Caves of Khandagiri are partly natural and partly artificial caves of archaeological, historical and religious importance located in the capital of Odisha, India i.e. Bhubaneswar and occupy a unique position in rock carving architecture, art and religion. The caves are located on two adjoining hills, mentioned as Kumari Parvat in the Hathigumpha inscription. The number of existing caves at Khandagiri is 18, while Khandagiri has 15.

Two caves taken in Khandagiri for present study is not within the generally mentioned 15 nos of caves but is present at the base of north side slope of the hill.

Cave-1 of Khandagiri is present at north side slope of the hill. The entrance of the cave is situated within a large hole of about 6-10 m diameter and of about 2-3 m depth from the surface level. The first entrance (Figs.II.7 and II.8) of the cave is about 3 m in height and 3-4 m in width. Then after about 9-10 m the second entrance of about 1-1 ½ m height and 2-3 m width of the cave is present. There is a main chamber of about 12 m length, 7 m width and 4 m height. The main chamber leads to one tunnel like opening and another chamber (Figs.II.9 and II.10). The tunnel like opening at the beginning is about 3 m in diameter, but after about 12 m ascent the diameter is within 1- 1 ½ m and it opens to outside. The second chamber is about 12 m in width and 15 m in length. The height at the beginning is about 4m but after a stiff ascent of the floor of the cave it becomes narrower at the end. The temperature inside the cave remains constant throughout the year (30±5°C).

Cave-2 of Khandagiri (Figs.II.11 and II.12) is a small cave of about 1 m height 2 m in width and 2 m in length. But presence of a perennial water hole of about 1m in diameter and about ½ m depth makes it very unique. The temperature inside the cave remains constant throughout the year (30±5°C).

The animals found inside and around the caves were also used as material for the study. Prior to the study, the following materials were arranged and kept on a suitable surface within the reach.

### Instruments Used

1. Measuring tape, ruler, string and straight stick were used for measuring the caves.
2. Sling psychrometer (OMSONS Instruments, model 80) was used to measuring temperature and humidity.
3. LED torch light and battery-powered emergency light were used as light sources inside the cave.
4. A digital camera of (make: Sony) was used for photographing the caves and their fauna.
5. Baits like piece of bread, piece of meat, sugar, piece of fruit were used to attract animals.
6. Small nylon nets were used for sampling.
7. Scalpel, needle, forceps, gloves were used to handle the sample.

8. Plastic collection jars, polyethylene bags, small cardboard boxes were used for sample collection.
9. Stereozoom microscope.
10. Ethyl alcohol of 70% was used as a preservative.
11. Hand tally counter for counting animals.
12. Google Map software and Google Earth software were used to locate the latitude, longitude and altitude of the study sites.

Geomorphological study of caves was done using Google Map software, Google Earth software.

The climatic study of caves:

Between spring to winter 2020 and spring to winter 2021, temperature and humidity readings were taken from the inside and outside of the two selected caves, Khandagiri-1, and Khandagiri-1. These readings were taken for four seasons i.e. spring, summer, monsoon & autumn and winter. A sling psychrometer was used to recorded temperature and humidity using the standard wet bulb/dry bulb method. Various observations such as sky cover, precipitation, unusual wet or dry conditions in the cave at the recording sites, etc., were also noted.

## **Data Collection on Cave Animals**

### **Counting**

- a) **Manual counting:** Animals are counted by hand tally counter (Biswas and Kanoje, 1992).
- b) **Square area method:** A frame of 30cm square area was taken for sampling (Harries *et al.*, 2008; Ruggieri and Biswas, 2011).
- c) **Photography:** After taking the photograph with a digital camera (Canon Power Shot A590 IS), it was analysed in a computer (DELL-Vostro-1510, Intel Core2 DUO) for the number of animals and their density (Biswas and Shrotriya, 2011).

### **Observation**

Observations were categorised as either direct or indirect. Direct observations included observation of invertebrates with the naked eye and hand lens. It was used for any type of invertebrate species.

Indirect observations included evidence of invertebrates, such as cast exoskeletons, spent body parts, or egg and larval stages.

Direct and indirect observations were made as follows:

Direct observations included observing wildlife with the naked eye observation of wildlife through binoculars. This technique was used for all species. Direct observations were made with or without collecting the organism. The probability of direct observation of small mammals, reptiles, and amphibians was increased by searching under debris, logs, and rocks.

Indirect observations included evidence of animals such as amphibian and bird calls, bird songs, tracks, droppings, burrows, runs, caches, and remains, such as feathers, bones, skeletons, etc. Bats were surveyed by direct observation, indirect observation, netting and photography (Biswas and Shrotriya, 2011).

### **Trapping of insects**

Insects were caught directly trapped with hands, forceps, sticks and polythene. Some insects were passively caught passively using funnels and bottle traps, some of which were baited with small pieces of sweet food (such as bread crumbs). In the present study, a small tube plugged with cotton was used as a pooter. A sweep net was used to collect flying insects.

### **Identification of animals**

In the laboratory of ZSI and RMNH, the animals were captured, photographed and the data were analysed. Detailed macro-analyses of the collected animals were carried out using stereo-zoom microscope. This led to the identification of the animals.

In all of the counting methods, when the number of organisms was numerous, they were grouped for a given number of organisms.

### **Results and Discussion**

The climatic conditions outside the cave are constantly changing. The light allows green plants to grow in abundance; these are eaten by herbivores, which in turn are eaten by carnivores. When any of these die, they may be eaten or decomposed by bacteria and fungi, the nutrients released being used by plants for new growth. All these organisms form a complex and constantly changing food web (Das *et al.*, 2007 and Romero, 2009). Many animals species are found in the caves studied. Of these, randomly only five species example: (Table 1) were used for comparison in the present study.

In the present study, it is very much clear that the number of animals in both K1 and K2 caves (Table 2, Table 3, Fig. 3, Fig. 4) decreases significantly from the year 2020 to the year 2021, except for the ant species, which increases.

During the COVID 19 pandemic period, due to lockdown human interference is significantly less in the year 2020 than in the year 2021 due to the closure, which may explain why the number of animals seen in 2020 is

higher than in 2021. Human disturbance is greater in cave K2 than in cave K1 in 2021 than 2020, so the animal population decreases more in cave K2 than in cave K1. However, the ant population increases in both caves from 2020 to 2021 (Table 2, Table 3, Fig. 3, Fig. 4). This may be due to an increase in food debris as a result of increased human disturbance from 2020 to 2021. The increase in the population of other animals in 2020 may adversely affect the population of ants, as ant larvae are one of the rich food sources for many animals.

**Table.1** Cave-wise distribution of animals with their scientific names.

| Sl.No.   | Common name                | Scientific name  |
|----------|----------------------------|--|
| Beetle   |                            |  |
| 1        | Cave Beetle                | Species of Tenebrionidae (Latreille, 1802).                |
| ANT      |                            |  |
| 2        | East Indian Harvesting Ant | <i>Pheidologeton diversus</i> (Jerdon, 1851)               |
| AMPHIBIA |                            |  |
| 3        | Toad                       | <i>Duttaphrynus melanostictus</i> (Schneider, 1799)        |
| REPTILIA |                            |  |
| 4        | Gecko                      | <i>Hemidactylus leschenaultii</i> (Duméril & Bibron, 1836) |
| MAMMAL   |                            |  |
| 5        | Fruit Bat                  | <i>Rousettus leschenaultia</i> (Desmarest, 1820)           |

**Table.2** Annual diversity of fauna in Cave K1 across seasons.

| Season    | BAT  |      | ANT (1=50) |      | TOAD |      | GECKO |      | CAVE BEETLE (1=10) |      |
|-----------|------|------|------------|------|------|------|-------|------|--------------------|------|
|           | 2020 | 2021 | 2020       | 2021 | 2020 | 2021 | 2020  | 2021 | 2020               | 2021 |
| Spring    | 450  | 420  | 2          | 6    | 5    | 4    | 12    | 9    | 25                 | 22   |
| Summer    | 495  | 480  | 2          | 6    | 4    | 2    | 12    | 9    | 6                  | 5    |
| Mon & Aut | 480  | 450  | 3          | 8    | 8    | 5    | 15    | 12   | 15                 | 14   |
| Winter    | 460  | 440  | 2          | 5    | 4    | 3    | 12    | 10   | 18                 | 14   |

**Table.3** Annual diversity of fauna in Cave K2 across seasons.

| Season    | BAT  |      | ANT (1=50) |      | TOAD |      | GECKO |      | CAVE BEETLE(1=10) |      |
|-----------|------|------|------------|------|------|------|-------|------|-------------------|------|
|           | 2020 | 2021 | 2020       | 2021 | 2020 | 2021 | 2020  | 2021 | 2020              | 2021 |
| Spring    | 7    | 4    | 0          | 1    | 2    | 1    | 3     | 2    | 8                 | 6    |
| Summer    | 7    | 4    | 0          | 2    | 3    | 2    | 3     | 2    | 7                 | 7    |
| Mon & aut | 8    | 3    | 0          | 2    | 4    | 3    | 3     | 2    | 5                 | 4    |
| Winter    | 6    | 2    | 0          | 3    | 1    | 1    | 0     | 2    | 6                 | 5    |

**Figure.1** Periphery of K1 cave



**Figure.2** Entrance zone of K1 cave



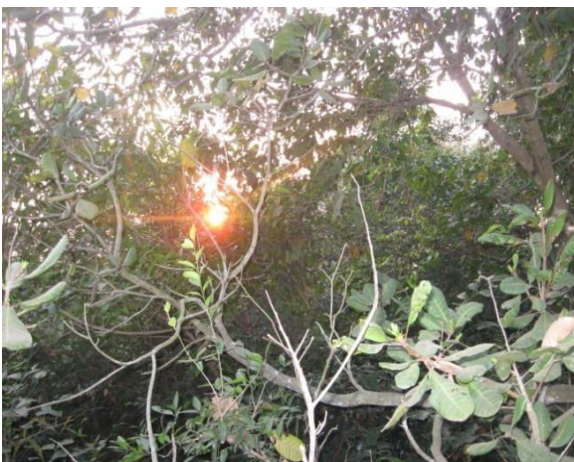
**Figure.3** Twilight zone of K1 cave



**Figure.4** Inner zone of K1 cave



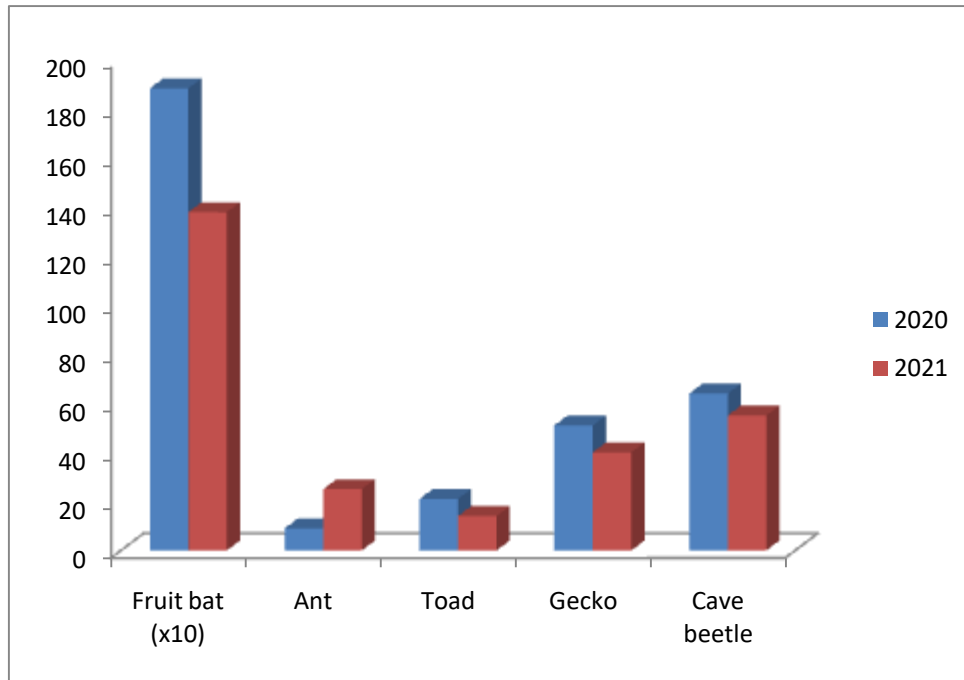
**Figure.5** Periphery of K2 cave



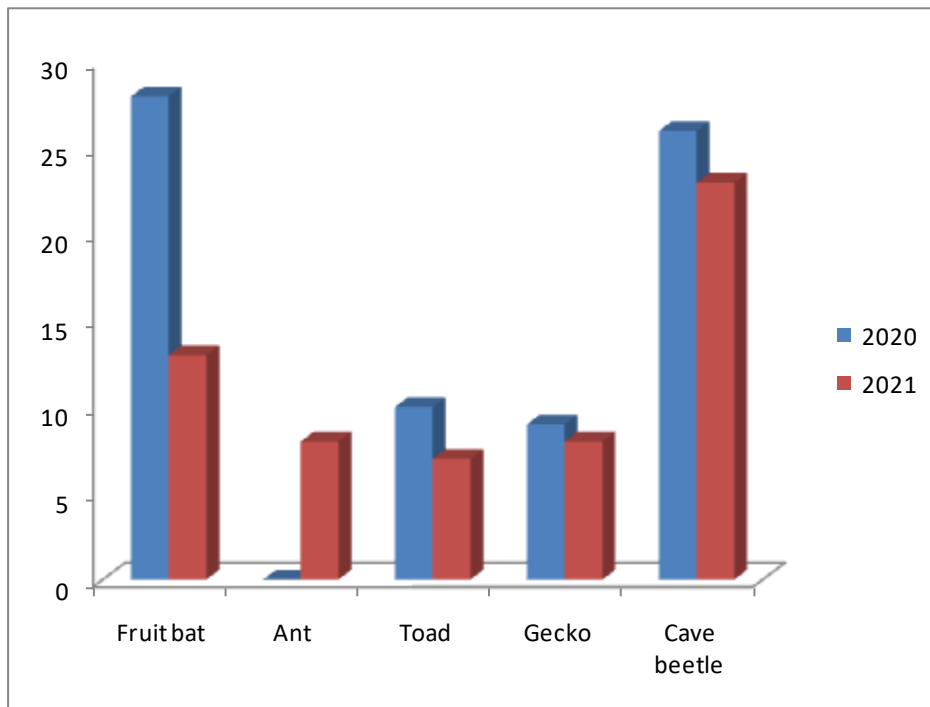
**Figure.6** Inside of K2 cave



**Figure.7** Variation of animal distribution across years in K1.



**Figure.8** Variation of animal distribution across years in K2.



**Conclusion**

From the present study, it is very much clear that human interference is always a key factor for the population of

other species. Even in the cave ecosystem, which is very much endemic and micro, but very much fragile. To protect such fragile ecosystem, human interference should be controlled.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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