



## Bioinventory And The Associated Ecosystem Developed Inside The Mandhip Khol Cave Complex

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<i>Abstract</i>	
	<p>For any fauna, the unusual and extreme geophysical characteristics of any subterranean cave demand many biological adjustments to establish a population in it. In the present study, the bioinventory of Mandhip Khol cave Complex has been done. This cave complex has two identical subterranean passages; one wet passage, and another dry passage, so it is interesting to know the types of fauna it harbours. The tabulated results indicated that both the passages harbour mostly the same species, except some extra accidental visitors were found in the wet passage which enters the cave when the water level increases in it. Further, a bat species has been noted, which is new for the caves of Chhattisgarh, India.</p>
CC License CC-BY-NC-SA 4.0	<b>Keywords:</b> <i>Cavernicoles, Troglaxene, Subtroglaphiles, Eutroglaphiles, Food pyramid</i>

### Introduction

Cavernicolous fauna that adapted themselves to live inside caves could be seen to prefer some specific habitats. As per their mode of habitat preferences, such faunas are categorized into four different types (Sket, 2008; Biswas, 2009, 2010, 2022). The cave Mandhip Khol is satisfactorily a big cave which could hold the fauns belonging to all the categories of the explained in the mentioned above references. But, due to high anthropogenic pressure inside the Mandhip Khol Cave Complex (Kumar et al., 2022, 2023) the possibility becomes bleak to locate them. Further, occasionally the local villagers wash the complete cavern system to celebrate their religious festivals which also check the establishment of any permanent cave-dwelling fauna inside it.

In this study, we tabulated all the faunas located to us right from the entrance zone till the last deep part of the Mandhip Khol Cave Complex *i.e.*, the two separate passages, one is a wet passage referred to as Shwet Ganga or Phyton Cave entrance other is dry passage *i.e.*, Mandhip Khol main entrance (Ruggieri & Biswas, 2011). The surveys for both the entrances were done continuously for two years. We have identified them till the genus level and designated proper categories based on our primary in situ observations.

## Methodology

We have identified the populations of the fauna, which are either permanently residing inside the Mandhip Khol cave in some crevices and other hindered spaces or regularly visiting the cave to fulfil their biological need. This study was carried out by qualitative collections based on direct or indirect evidence of animals abiding inside this cave. First of all, we pointed out all such nooks and corners of the cave which could be the hinder space for cavernicoles of Mandhip Khol Cave. A careful survey was done for the entire cave to identify all sorts of small and spacious habitats that could be used by any animal/organism. The observations were made at every one-month gap continuous for two years. During each field visit every nook and corner of the cave was carefully observed to document the direct /indirect evidence(s) of any fauna that used the cave for any purpose like shelter/ feeding/ reproduction/ escape from predators/ summer heat/ rain/ winter cold etc. Sheds of evidence were photographed and identified by the relevant taxonomist till the genus level. Attempts were also made to know the role of each visitor and/or permanent inhabitant inside the cave, in their particular zone of occurrence. A speculative food pyramid was drawn that may be operating within the cave (Figure-1).

## Observations and Results

During our study conducted for two years, we have visited the cave for six times. We noted the species encountered from the entrance zone followed by the twilight zone, transient zone and finally the Deep zones (as explained in Vandel, 1965; Gunn, 2004; Biswas, 2022). Most of the species we have noted were seen in most of the visits (more than six) and were photographed properly.

The species which we succeeded in identifying to genus level have been presented in this paper. We are presenting here the species name concerning their zone of occurrence and cavernicolous status, as classified by Sket (2008), followed by Biswas (2009, 2010, 2022).

## Vertebrates

### The Blanford's rock agama (Plate-1a)

Phylum:	Chordata
Class:	Reptilia
Order:	Squamata
Suborder:	Iguania
Family:	Agamidae
Genus:	<i>Psammophilus</i>
Species:	<i>P. blanfordanus</i>
Synonyms:	<i>Charasia blanfordana</i> , Stoliczka, 1871 <i>Charasia blanfordiana</i> [sic] Boulenger, 1885 <i>Psammophilus blanfordanus</i> M.A. Smith, 1935
Cavernicolous status:	Trogloxene (Regular)

Blanford's rock agama is a very common lizard for Peninsular India found mainly in the Eastern Valleys region. We always encountered this particular in the entrance zone of the Mandhip Khol and Swet Ganga cave complex. Sometimes it was also found to encroach even in the twilight zone of these two dry and wet passages of this cave complex. This lizard is commonly referred to as the Blanford's rock agama and is very common in the valleys areas of the Chhattisgarh region.

Although this species is very similar to *P. dorsalis*, a specimen of *P. blanfordanus* can be separated by several features. The hind legs are too long and could reach the eye or extend beyond it when stretched. The adult male is much like *P. dorsalis*. In the summer breeding season, the head and anterior part of the body of the males become scarlet or red while the posterior parts are nearly black. The male displays by head nodding. Females are slightly smaller than males (Smith, 1935).

### Horseshoe bat (Plate- 1b)

Phylum:	Chordata
Class:	Mammalia

Order: Chiroptera  
 Family: Rhinolophidae Gray, 1825  
 Subfamily: Rhinolophinae Gray, 1825  
 Genus: *Rhinolophus* Lacépède, 1799  
 Cavernicolous status: Subtroglophile

A few roosting sites of the microchiropterans bats from *Rhinolophus* genus, commonly referred to as horseshoe bats could be easily located in both caves. The shape of the nose of this group of bats resembles a horseshoe which helps to identify them very easily. This species exhibits a wide distribution across diverse habitats, encompassing forests, caves, and other roosting sites. The genus *Rhinolophus* species are the small to medium-sized range of bats.

The *Rhinolophus* species exhibit an insectivorous diet, with a primary focus on consuming insects. While examining their fickle matters, various undigested chitin matters of insects were found.

#### **Tailed bat (Plate-1c)**

Phylum: Chordata  
 Class: Mammalia  
 Order: Chiroptera  
 Family: Molossidae  
 Genus: *Otomops*  
 Cavernicolous status: Subtroglophile

This microchiropteran bat with a tail from the Molossidae family is commonly referred to as the tailed bat. We identified it as a member of the genus *Otomops*. A small colony of this species is also living associated with horseshoe nose bats in the dry passage of this cave complex. This particular species is mainly located inside the dry passage of the Mandhip Khol cave complex. This species is not a common one for the caves of the Chhattisgarh region (Biswas, 2010, Biswas & Shrotriya, 2011, Banafar & Biswas, 2016; Biswas & Banafar, 2017). In Mandhip Khol cave it is found in groups of 3 to 4 together.

The *Otomops* species exhibit an insectivorous diet, with a primary focus on consuming insects. While examining their fickle matters, various undigested chitin matters of insects were detected.

#### **Asian Common Toad (Plate-1d)**

Phylum: Chordata  
 Class: Amphibia  
 Order: Anura  
 Family: Bufonidae  
 Genus: *Duttaphrynus*  
 Species: *melanostictus*  
 Cavernicolous status: Subtroglophile

In most of our visits especially during rainy as well as winter season we noticed this particular species in 2 to 3 individual's groups in some moist places of both the dry and wet passages of Mandhip Khol Cave Complex particularly in some hidden rocky enclosure of the outer chambers of these passages. Perhaps it remains under torpid conditions in the remaining months.

#### **Bull Frog (Plate-1e)**

Phylum: Chordata  
 Class: Amphibia  
 Order: Anura  
 Family: Bufonidae  
 Genus: *Duttaphrynus*  
 Species: *melanostictus*  
 Cavernicolous status: Subtroglophile

In most of our visits, especially during rainy as well as winter season. We noticed it in 2 to 3 groups in some moist places of both the dry and wet passages of Mandhip Khol Cave Complex, particularly in some hidden

rocky enclosure of the outer chambers of these passages. Perhaps it remains under torpid conditions in the remaining months.

#### **Checkered Keelback (Asiatic Water Snake) (Plate-1e)**

Phylum:	Chordata
Class:	Reptilia
Order:	Squamata
Sub-order	Serpentes
Family:	Colubridae
Genus:	<i>Fowlea</i>
Species	<i>piscator</i>
Synonyms	<i>Hydrus piscator</i> <i>Natrix piscator</i> <i>Tropidontos quincunciatus</i> <i>Nerodia piscator</i> <i>Xenochrophis piscator</i>
Cavernicolous status:	Subtroglophile

We often encountered this non-poisonous snake at the entry-level of the wet passage Shwet Ganga of this cave complex.

This snake often raises its head as much as possible and expands its neck, just like a cobra hood, intimidating the threat. But, it is non-venomous to humans, so no fear of entering the cave with minimum precautions.

#### **Invertebrates**

Here we are presenting the list of the invertebrates which we often notice in both the dry and wet passages of Mandhip Khol Cave complex. As per their zones of occurrence and nature of reacting to the stimuli (light, sound and vibrations), we also tried to categorise their cavernicolous status.

#### **Cricket (Plate-2a)**

Phylum:	Arthropoda
Class:	Insecta
Order:	Orthoptera
Suborder:	Ensifera
Family:	Phalangopsidae
Subfamily:	Cachoplistinae
Tribe:	Homoeogryllini
Genus:	<i>Meloimorpha</i> Walker, 1870
Cavernicolous status:	Eutroglophile

This particular species could be easily observed in any wall, roof, nook and corner of both the passages of Mandhip Khol Cave Complex. Bearing long antennae, the *Meloimorpha* Walker, 1870 species are mostly cave-adapted and could be easily located in most of the caves of central and northern parts of Chhattisgarh (Jaiswara *et al.*, 2018; Biswas, 2022; Prasad *et al.*, 2023). Cricket always serves as the major energy source of the cave inhabitants in most of the caves (Biswas & Shrotriya, 2011).

The body shape of *Meloimorpha* species is characterized by elongation, which is consistent with other members of the Tettigoniidae family. A relatively elongated and slender morphology characterises their body. In terms of physical dimensions, *Meloimorpha* species exhibit a degree of variability, although they typically fall within the range of small to medium-sized insects.

During our study, we noticed nymphs during December-January, it shows that the reproduction period of this particular species is post-monsoon period.

In the fickle matter of bat, we found several undigested parts of this particular species which show it is one of the major source of diet for the existing bats of Mandhip Khol cave .

**Huntsman spiders (Plate-2b)**

Phylum:	Arthropoda
Subphylum:	Chelicerata
Class:	Arachnida
Order:	Araneae
Infraorder:	Araneomorphae
Family:	Sparassidae
Genus:	<i>Heteropoda</i>
Cavernicolous status:	Eutrglophile

The large-sized huntsman spider *Heteropoda* sp. can be easily noticed right from the entrance passage to the innermost passages of this cave. Several species of *Heteropoda* have already been reported from different Indian caves (Jager, 2005; Biswas, 2009; 2010; Biswas, 2022; Harries *et al.*, 2008; Prasad *et al.*, 2023). Adult specimens have a body length of 2.2–2.8 cm (about 1 inch), with a leg span of 7–12 cm (3– 5 inches).

During the study, we noticed that the egg sac was carried under the body, which keeps the female relatively immotile. All stages of development of juveniles and adults have been recorded inside the cave throughout the year. It has prominent eyes but generally remains unaffected by torch lights, as it is already reported that its eyes reflect light (Wallace, 1937). Cave crickets have been reported as preferred prey for *Heteropoda* sp. in other Indian caves (Harries *et al.*, 2008; Biswas, 2022).

**Opiliones (Plate-2c)**

Phylum:	Arthropoda
Subphylum:	Chelicerata
Class:	Arachnida
Order:	Araneae
Infraorder:	Araneomorphae
Family:	Pholcidae
Cavernicolous status:	Subtrglophile

Whenever we entered either from the dry or the wet passages, in the entrance or even in the Twilight zones, we encountered a dense colony of the Opiliones. This generally occurs in clusters inside the cave (Harries *et al.*, 2008; Biswas & Harries, 2011; Biswas, 2022; Prasad *et al.*, 2023). Nevertheless, in a few caves, it was also seen to exist in solitary positions (Prasad *et al.*, 2023). However, the inner zones of both the passages of the Mandhip Khol Cave complex were never seen to harbour its colony.

Unfortunately, due to lack of proper expertise available with us we failed to identify it even in genus level.

**Orb-weaver Spider (Plate-2d)**

Phylum:	Arthropoda
Subphylum:	Chelicerata
Class:	Arachnida
Order:	Araneae
Infraorder:	Araneomorphae
Family:	Araneidae
Genus:	<i>Argiope</i>
Species:	<i>anasuja</i>
Cavernicolous status:	Subtrglophile

*Argiope anasuja*, is a harmless species we often encounter while entering the caves either from the dry or the wet passages. The spider's web is common in the entrance or even in the twilight zones of both the dry and wet passages.

It builds a web with a zig-zag way somewhat resembling English letters. The mature female of *A. anasuja* rests in the midway of the orb with her head facing downwards (Sherriffs, 1935).

**Pillbug (Plate- 2e)**

Phylum:	Arthropoda
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Class:	Malacostraca
Superorder:	Peracarida
Order:	Isopoda
Suborder:	Oniscidea
Family:	Armadillidiidae
Genus:	<i>Armadillidium</i>
Cavernicolous status:	Eutroglophile

A terrestrial isopod that was generally seen beneath the bat colonies, especially on the guano deposits in the inner zones of the dry passage of Mandhip Khol Cave. The species are about 15–20 mm in length and 5–7.5 mm in width. Pillbugs have also been previously reported from other Asian and even Indian caves (Gruia *et al.*, 1994; Schultz 1970; Harries *et al.*, 2008; Biswas, 2010, 2022). Unfortunately, we didn't find any species as albinic exhibited a negative phototropism, as it was reported from the Kotumsar cave of Kanger Valley National Park of Chhattisgarh (Biswas, 2010, 2020).

In addition to the above-identified species, during winter various other species like crabs, and snails were also seen in both the dry and wet passages of the Mandhip Khol Cave complex.

### Ecological Pyramid

On the basis of direct observation of fauna and the relevant organic matter inside both the passages of Mandhip Khol Cave Complex, a tentative Ecological Pyramid has been prepared, possibly operating inside the this cave complex.

### Conclusion

Establishing a population inside any cave is very challenging for any species, whether it is pre-adapted to live in the dark habitat or not. Caves are well-known for existing typical geophysical characteristics, and energy crises which always exist inside the cave. Thus, a high degree of physiology adaptation, behavioural adjustment and morphological alteration is always required (Vandel, 1965; Gunn, 2004; Biswas, 2022).

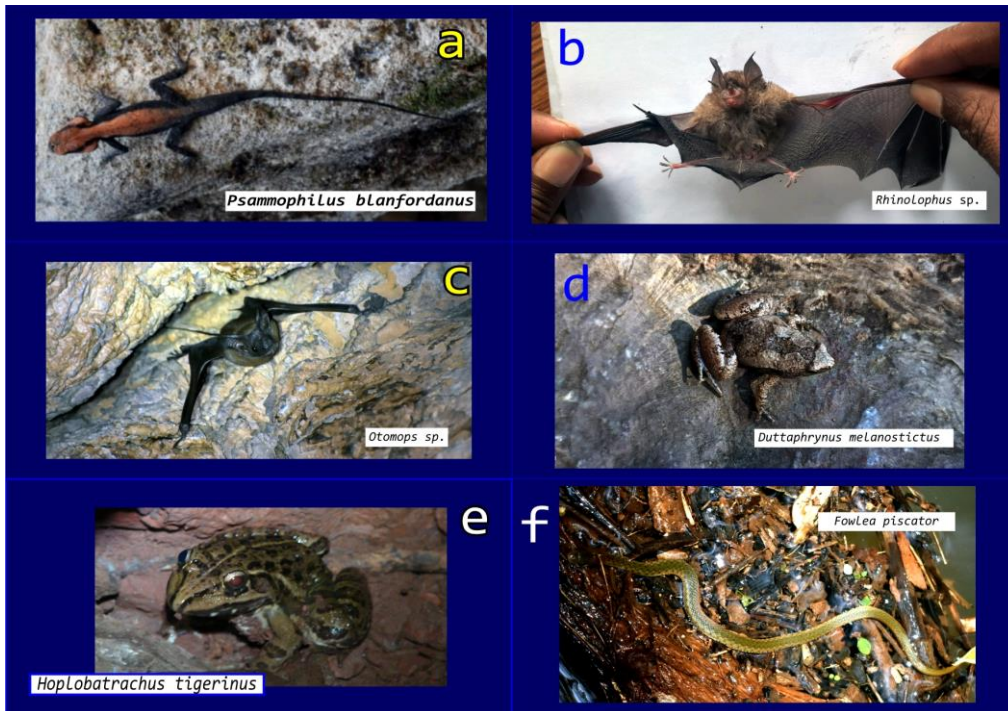
Various theories to explain the cave adaptations of any organisms inside the cave have been explained based on various established evolution-related mechanisms viz., Darwinism, Lamarckism, Neo Lamarckism etc. (Sket, 2008; Biswas, 2010, 2022). Among those theories, the Preadaptation theory is the most accepted one for cave organisms. As per the preadaptation theory the ancestors of cave-adapted animals which exist or are extinct and abide in the open natural habitat were pre-adapted to darkness by already leading semi-nocturnal or nocturnal lifestyles in environments with low-light penetration, simplifying their transition to life in caves (Racovitza 1907; Vandel 1965; Gunn 2004; Biswas, 2022).

In our study, most of the fauna we identified are common cave fauna that occurs globally. However, the tailed bats of the *Otomops* group we found inside the cave are not a common microchiroteran, usually identified in Indian caves. A further taxonomic study will be required to identify it properly. Further, we also noticed few species which we failed to identify even up to genus level. The proper works on them are in progress.

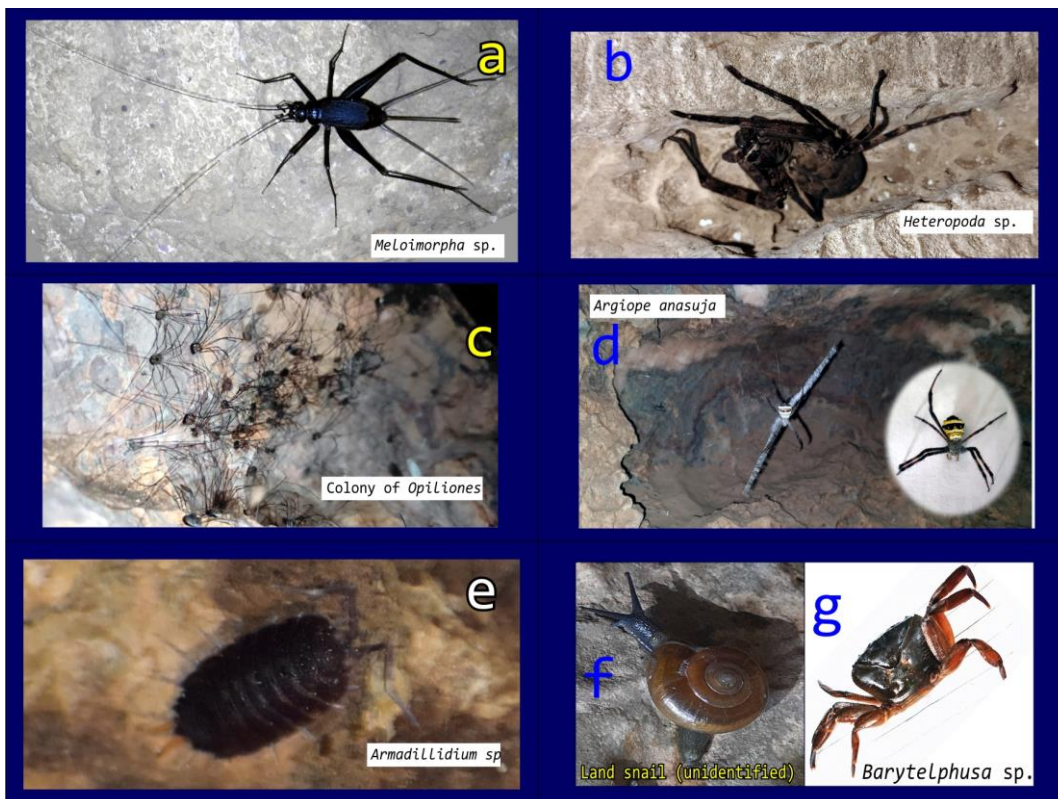
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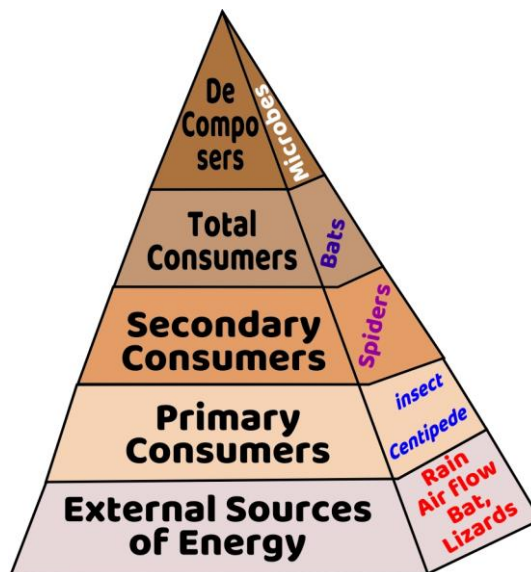


**Plate-1 :** The images of various vertebrates we often encountered in the Mandhip Khol Cave Complex. The Bull frog (e) and Water snake (f) were only found in the wet passage of this cave complex rest of the species are commonly apparent in both the passages.



**Plate-2 :** The images of various invertebrates we often encountered in the Mandhip Khol Cave Complex. Land snail (f) and Crab (g) were only found in the wet passage of this cave complex rest of the species are commonly apparent in both the passages.





**Figure 1:** Based on our observations and identification of species inside the passages of Mandhip Khol Cave, the possible ecological pyramid operating inside the Mandhip Khol Cave Complex