SO WHAT LIVES at MULU?
PRELIMINARY SURVEY of CAVE FAUNA in the GUNUNG MULU WORLD HERITAGE AREA, SARAWAK, MALAYSIA

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The Gunung Mulu World Heritage Area (Mulu) is situated in the north eastern corner of Sarawak, Malaysia on the Island of Borneo, adjacent to the South China Sea. The area was prescribed as a National Park in 1974 and is the largest national park in Sarawak covering an area of 528 km^2. Mulu contains the second highest peak in Borneo, Gunung Mulu, a sandstone mountain situated to the east of the Melinau Limestone that contains the extensive caves that are the subject of the current study (Figure 1).

Many ACKMA members will be familiar with this site as a number of members were privileged to be able to visit MULU when ACKMA held its AGM and associated field trips at Mulu in May 2010. We all remember that was such a fantastic trip and we had been so overwhelmed with the size of the caves, and the active cave life. As our key speleological interest is biospeleology, we had wondered what study had occurred in relation to the biology of the Mulu Caves. So we began some discussions with Brian Clark and started to put together a plan…

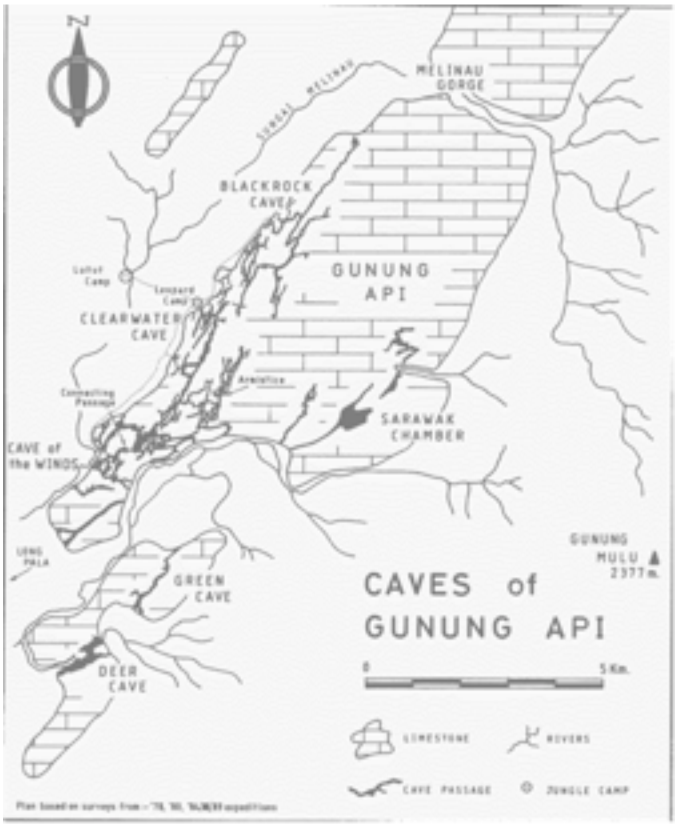

Figure 1. Cave locations within Gunung Mulu World Heritage Area
Right. Clearwater Cave. Photo: Ross Anderson.

From late April to mid May 2012, 12 Speleologists from Australia visited Mulu to undertake a preliminary subterranean biology survey in selected caves. The project was led by Mrs Jay Anderson and Dr Tim Moulds and included experienced speleologists from several states of Australia. A special permit had been obtained from the Malaysian Government, which would allow the team to undertake the research on the cave life at Gunung Mulu.

The current preliminary survey aimed to provide an overview of the invertebrate fauna in the cave systems near the Park Headquarters and predominately in those used as tourist caves and adventure caves. The survey will assist to provide a basis for future biological surveys in Mulu whilst building upon the only other biospeleological surveys undertaken in the area by Philip Chapman in the early 1980s as part of the British expeditions to the area.

The survey aimed to:

1. Identify and photograph the majority of invertebrate fauna within each cave.

2. Provide a repeatable survey methodology to enable future comparison of relative species richness and abundance.

3. Identify key habitats used by the fauna.

4. Identify any potential threats to the survival of the fauna.

5. Provide management strategies to assist in retaining fauna.

6. Provide recommendations for future works to complement the findings of the current study.

The caves chosen were a mixture of tourist caves, adventure use caves and wild caves and included a range of habitats and use levels. The caves examined are shown in Table 1.

Caves were divided into several distinct biological zones to aid interpretation (Figure 2). These correspond to the amount of available light and varying environmental conditions (Humphreys 2000). The team would collect some specimens of cave fauna as part of the project.

The Entrance Zone is the area directly around the cave entrance; it is generally well lit, often supports photosynthetic plants, and undergoes daily temperature and humidity fluctuations.

The Twilight Zone is just beyond the entrance zone and is often dominated by lichen and algae that require low light conditions. The temperature and humidity are still variable but fluctuations are dampened compared with epigean variation.

Deeper into a cave, light is reduced to zero and the Dark Zone is entered, which is subdivided into three zones, the transition, deep cave and stale air zones.

The Transition Zone is perpetually dark, but still fluctuates in temperature and humidity determined by epigean conditions.

The Deep Cave Zone is almost constant in temperature and humidity conditions.

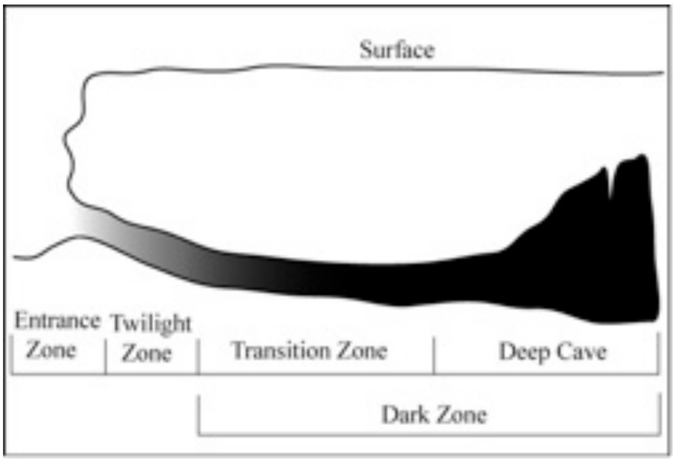

Figure 2. The environmental zones of a cave shown in cross section.

Stonehorse Cave. Photo: Ross Anderson.

Table 1. Cave usage and location within Mulu

Cave Name	Primary Use	Limestone Section	Visitation
Deer Cave	Tourism	Deer/Green Section	High
Green Cave	Wild	Deer/Green Section	Low
Stonehorse	Adventure	Deer/Green Section	Low
Fruit Bat Cave	Adventure	Kenyalang/Fruit Bat	Low
Kenyalang	Adventure	Kenyalang/Fruit Bat	Low
Lagang	Tourism/Adventure	Gunung Api	Moderate
Racer	Adventure	Gunung Api	Moderate
Goodluck Cave	Adventure	Gunung Api	Low

Cave Cricket Rhapidiphora sp.in Fruit Bat cave.
Below. Millipedes. Photos: Ross Anderson.

Cave invertebrates are generally classified according to their degree of cave dependence using the Schiner - Racovitza system (Schiner 1854, Racovitza 1907), despite numerous other systems and variations being proposed and adopted by various authors (see references in Boutin 2004).

The Schiner - Racovitza system classifies organisms according to their ecological association with subterranean environments, and relies upon detailed ecological knowledge of animals that is commonly lacking for most species. In order to circumvent this lack of knowledge, the concept of troglomorphy (Christiansen 1962), specific morphological adaptations to the subterranean environment, is used to define obligate subterranean species. The term troglomorphy, initially confined to morphology has since been used to describe both morphological or behavioural adaptations (Howarth 1973). This combination provides a practical system, easily applied in the field and with minimum of detailed ecological study required. The level of subterranean dependency for different ecological groupings is described below:

Above. Cave spider
Below. Bat. Photos: Ross Anderson

•Troglobionts are obligate animals that possess specific adaptations (troglomorphisms) such as loss or reduction of pigmentation and/or eyes, flightlessness, elongate appendages and specific sensory adaptations (Barr 1968, Poulson and White 1969). These species rely solely on the cave environment for food and reproduction. They are generally restricted to the deep cave zone where conditions are the most stable and are rarely found closer to entrances in the twilight zone.

•Troglophiles are animals that can complete their entire lifecycle within a cave but possess no specific adaptations to the cave environment. These species are capable of living outside caves in suitably dark and moist epigean habitats.

•Trogloxenes are animals that regularly use caves for part of their lifecycle or for shelter, but must leave the cave to feed. Common examples of these are bats and cave swiftlets.

•Accidentals are animals that do not use caves on a regular basis and cannot survive in hypogean environments.

Aquatic hypogean animals are classified using a similar system to terrestrial hypogean animals except the prefix 'stygo' is used instead of 'troglo' (Humphreys 2000a).

Due to the very limited amount of time available for the current preliminary survey it was decided to use active hand searching (hand foraging) to enable a wide variety of different habitats, and caves to be surveyed quickly and detect the majority of species present within. In order to undertake a more comprehensive survey of the subterranean fauna (vertebrate and invertebrate) a combination of multiple techniques in each cave over longer time periods would be required. This was beyond the scope of the current project.

Green cave entrance. Photo: Ross Anderson.

The research objectives included:

- Sample at least one site in each Zone (Entrance/ Twilight and Deeper Cave)
- Overall there will be two or three of the Sites in different light zones/location throughout the cave
- If there is more than one entrance, sample additional entrances separately
- Each site will comprise of one or more of the seven micro-habitat types
- Sample for 20 minutes in each micro-habitat type present
- Document and record each species seen and abundance
- Collect one representative of each morpho species if possible
- Photograph as many species as possible from each site
- Record proximity to track/Infrastructure in metres
- Ensure that each cave has a site sampled in close proximity to the track or under the track.

The team had two weeks at Mulu, and there was a lot to study and document. Each day the team members visited caves and examined what cave life was in particular zones. The results of the project will be report in another ACKMA Journal. We would like to thank Brian Clark and his team for their support of the project and assistance with accommodation and logistics.

From the Editor

This is the first part of a two part paper. The results of this survey will be published in a future journal once they have been presented to the management of Gunung Mulu World Heritage Area.

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