A preliminary survey of the invertebrate fauna of the Gunung Mulu World Heritage karst area, Sarawak, Malaysia.

Dr Timothy Moulds[1,2], Jay Anderson[3], Ross Anderson[3] and Patrick Nykiel[2]*
1. Principal Ecologist, Invertebrate Solutions (www.invertebratesolutions.com)
2. Speleologist, Western Australian Speleological Group.
3. Speleologist, Cavers Leeuwin Inc.
** Corresponding author tim@invertebratesolutions.com*

Abstract

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 . The area contains significant karstic limestone, with some of the world's largest caves by volume known from the area.

In 2012 a team of Australian speleologists undertook a preliminary survey of the invertebrate biodiversity of eight caves within Mulu. The caves were a mix of tourist, adventure and wild caves within the park. Invertebrates were recorded from a mixture of different microhabitats found within the caves and reference specimens from each cave were collected and preserved for future study.

The aims of the study were to:

1. Document the biodiversity of the caves.
2. Provide a photo inventory of species recorded.
3. Compare the invertebrate diversity and abundance between different cave zones and microhabitats.
4. Compare the invertebrate diversity and abundance between caves used for different tourism purposes.

The survey recorded over 19,000 specimens using a combination of collection and observation of species that presently represents 100 different morpho-species, from 28 orders and 9 classes. The number of morpho-species is expected to increase with additional sampling. Forty different species have been photo-inventoried thus far.

Preliminary analysis of data has shown no discernible differences in invertebrate diversity or abundance between tourist caves and wild caves. Observed differences in invertebrate populations are related to microhabitat variability and availability within sampled caves, with greater invertebrate abundance related to bird and bat guano deposits. Longer term sampling and research will be required to provide a greater understanding of species diversity and patterns of abundance throughout the Mulu karst.

Introduction

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 km2. Gunung Mulu World Heritage Area contains significant karst and associated subterranean fauna. Although substantial research was undertaken on the bio-speleological values, this was more than 30 years ago and much has changed in regard to our knowledge of such fauna especially within tropical settings.

Aims of the preliminary survey

The current preliminary survey aims to provide a basis for future biological surveys in Mulu by building upon the only other substantial biospeleological survey undertaken in the area by Chapman (1982). The current preliminary survey aims to provide an initial 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 primary survey aims were to:

- Preliminary overview of the biodiversity and initial insights into the cave ecosystems as a baseline and starting-point for future ecosystem studies of the cave systems.
- Provide a photo inventory of species recorded.
- Compare the invertebrate diversity and abundance between different cave zones and microhabitats.

- Compare the invertebrate diversity and abundance between caves used for different tourism purposes.
- Provide management strategies to facilitate fauna survival and mitigate threats.
- Provide recommendations for future works to compliment the findings of the current study.
- Preparation of recommendations for further cave biodiversity studies, potentially focusing on sustainable cave management and adequate tourism development

Methods

Surveys for subterranean fauna may use many different techniques according to the type of fauna being targeted and the amount of time available for the survey. 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. The caves sampled are shown in Figure 1. The majority of caves sampled during the current biospeleological survey were not sampled as part of Chapman's survey, with much of his sampling concentrating on the Clearwater System and other associated caves, as well as more remote caves further to the north (Chapman 1982). Green Cave, Deer Cave and Deer Water Cave were common to both surveys, albeit in differing sampling intensities.

Each cave was sampled in the Entrance Zone, Twilight Zone and Dark Zone with a selection of the main microhabitats sampled from each zone. The following microhabitats were identified as occurring within the Mulu caves; Fresh guano, Old guano, Massive guano, Damp sediment, Dry Sediment, Walls/Speleothem, and Streamway/Water pools.

In each light zone of a cave the overall site was photographed and the location on existing cave maps was recorded to facilitate repeat sampling in the future. Each sampling site was then assessed for the presence of microhabitats, with each microhabitat identified in the site sampled for 20 minutes each. The abundance of each species was recorded using a combination of collection of voucher specimens (maximum of five specimens per morpho-species per cave) for future identification and observation of total species abundance within each microhabitat. The location of any cave infrastructure, such as paths or lighting was also recorded. The intensity of sampling varied between caves, as a function of accessibility, diversity of microhabitats, time available for the survey, availability of guides to facilitate access to some caves and other stochastic factors.

Material collected was placed in 70% ethanol for preservation, and sorted using a Premiere (20x - 40x) stereomicroscope. Specimens were identified to lowest practical taxonomic level using the resources available at the time of the survey in Mulu. Preliminary identification of material was identified by Dr Timothy Moulds. All material collected remains the property of the Republic of Malaysia, and has been kept by the Sarawak Department of Forestry office in Mulu NP.

Results

The survey recorded over 19,000 specimens using a combination of collection and observation of species abundance that presently represents 93 different morpho-species, from 25 orders and 8 classes. The number of morpho-species is expected to increase with additional sampling and further identification effort. Forty different species have been photo-inventoried thus far.

The spider *Heteropoda* sp. (Sparassidae) was the most widespread species found in all caves sampled, followed by the millipede sp. A, Opilione Phalangodidae? sp.A, Lepidoptera: *Tinea*? sp. and Araneae: Pholcidae sp. A that were recorded in six of the seven caves comprehensively surveyed (excluding Clearwater Cave and Deer Water Caves). The majority of species (44.6%) were recorded from a single cave, with very few species recorded from five or more of the caves surveyed. The most diverse order was Coleoptera with 13 species recorded, followed by Araneae (10 spp.), Isopoda (10 spp.), Diptera and Hemiptera (9 spp. each) and Diplopoda (8 spp.). Eleven orders are represented by single species

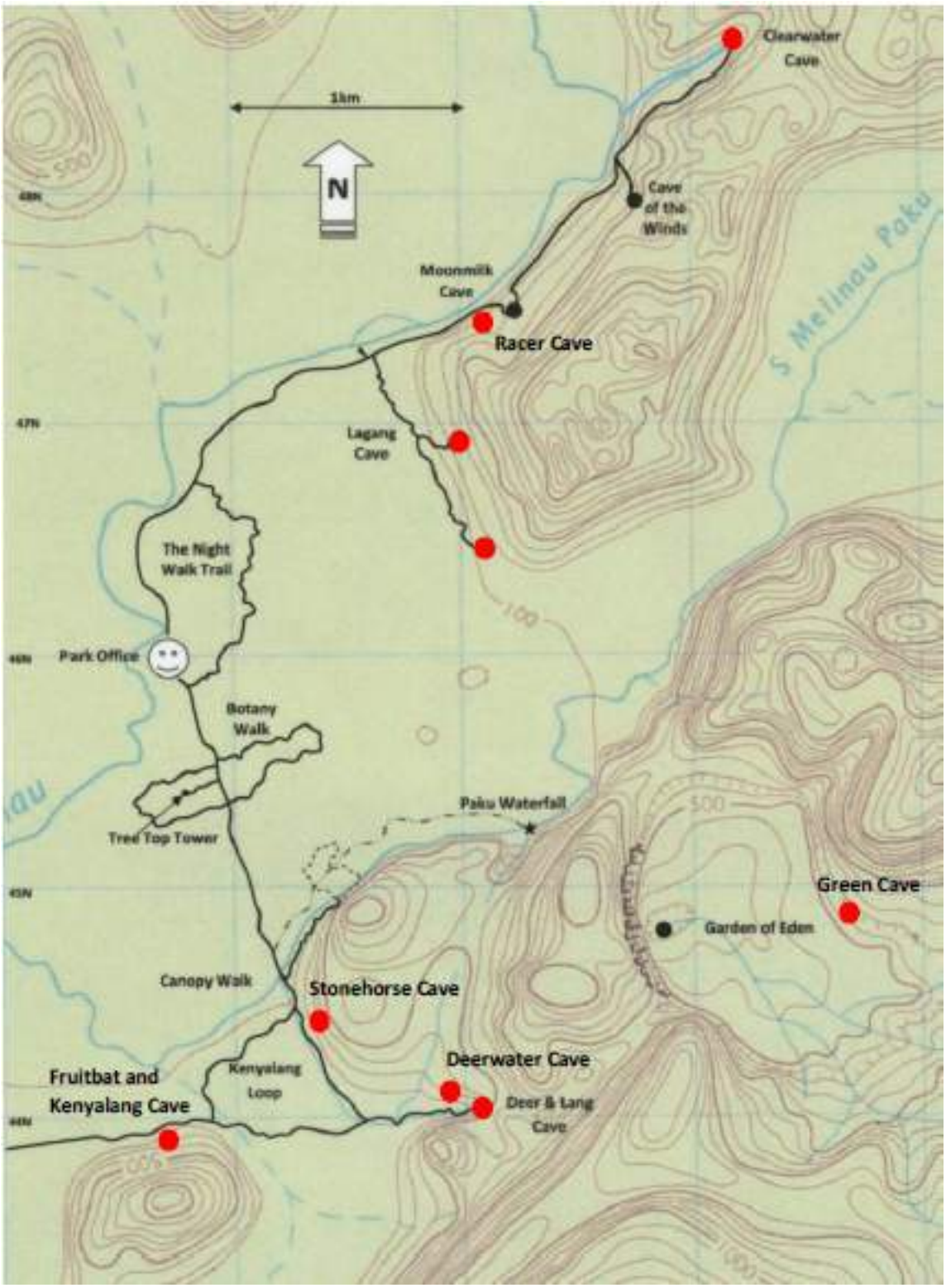

Figure 1. Locations of caves sampled for invertebrates within Mulu

PATN Analysis

The data were analysed used for similarity using PATN (version 3.12, Blatant Fabrications Pty. Ltd. 2009). Data were analysed using Bray and Curtis association, and nearest neighbour fusion algorithm. The PATN analysis by total diversity and abundance for each cave shows Racer, Lagang and Stonehorse Caves to contain very similar invertebrate assemblages and are also similar to both Kenyalang and Fruit Bat Caves. Green Cave and Deer Cave are the most dissimilar in their invertebrates assemblages (Figure 2).

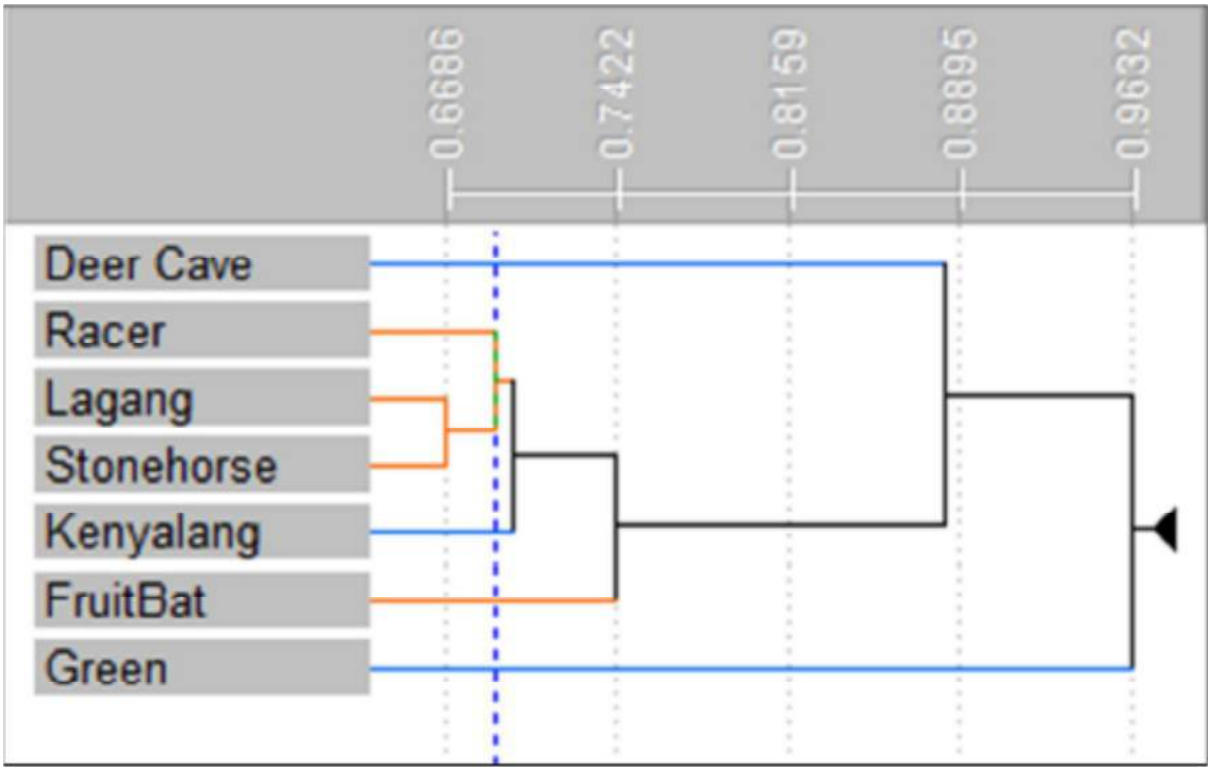

Figure 2. Column fusion dendogram nearest neighbour by cave

Management implications

The currently available data provide an insight into the diversity of subterranean faun in the Mulu caves. In the future this will provide a greater understanding of localised distribution within the karst system and eventually at a localised cave scale.

The current data do not enable a meaningful interpretation of cave invertebrate biodiversity as it relates to specific cave use for tourism, adventure caving or wild caving, however, it is readily apparent to the author that existing cave usage is not impacting upon the subterranean fauna observed in Mulu.

The author notes that the cave infrastructure within Mulu is of a very high world standard and promotes minimal impacts to both cave habitats and cave invertebrates generally. The Mulu Park staff provide excellent visitor education and supervision prior to and during cave tours eliminating predicable and avoidable impacts to the caves.

Concluding Remarks

The diversity of the Mulu karst area is very high and contains numerous obligate subterranean species, although the exact number is still currently unknown. The majority of species collected during the current survey appear to match those recorded by Chapman (1982), however, several previously unknown species were recorded. Further, more detailed identification will be required prior to confirmation. The patterns of diversity between the caves examined is complex with no obvious patterns evident from similarity analysis, although it would appear that caves are showing similarity based upon presence of similar micro-habitat rather than similarity of light zones. The Deer Cave, due to its complete dominance by massive guano piles appears to make it distinctly different in invertebrate composition to caves with far

less guano such as Stonehorse or Langang Cave. It is currently unknown whether there exists any difference in invertebrate composition between the different limestone blocks such as Fruit Bat/ Kenyalang to Deer Cave/ Green Cave to Lagang/ Clearwater local areas of Mulu. The caves do show some level of association (Figure 15) but the strength of the current analysis is weak and further data, and identification of existing collected specimens may alter the results significantly. The determination of this will require far greater knowledge of both specific cave diversity and will invariably be linked to the geological history and karst geomorphology of Mulu.

The Mulu karst most certainly contains endemic species, although the exact number is currently hard to determine as many of the invertebrate identifications are still incomplete, for both Mulu and other karst areas in Borneo and South East Asia. Some of the invertebrate diversity found in Deer Cave could possibly be endemic, including the 'Hairy earwig' *Arixenia esau* that is associated with the naked bat species *Cheiromeles torquatus,* although this is more likely associated with the endemicity of the bat host rather than the cave itself. Much of the other specialised invertebrate fauna recorded by Chapman (1982) was found to occur in other karst areas in Borneo, Java and Sulawesi.

The present study has provided a preliminary investigation of the invertebrate diversity across nine different caves within the Gunung Mulu World Heritage Area. This study compliments and builds upon the only other broad scale cave invertebrate diversity study of Mulu by Chapman (1982) and provides a modern context for future research in Mulu. The patterns of diversity are complex in Mulu, invariably due to the very high diversity of species, the large number of microhabitats present within caves, the multitude of energy inputs and the systems and the geomorphological history of the area. It will take considerable further effort to start to unravel these complexities but it should prove very rewarding as Mulu is undoubtedly a premier site of world cave tropical cave invertebrate diversity and provides a superb opportunity to investigate evolutionary processes in such a setting.

References

Chapman, P. 1982: The invertebrate fauna of the caves of Gunung Mulu National Park. *Sarawak Museum Journal* 51: 1-17