Arthropod Ecology of Bat Cave, Naracoorte, SA

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INTRODUCTION

Bat Cave, situated in the Naracoorte Caves World Heritage Area, South Australia (Figure 1), is one of only two maternal sites for the large bent-wing bat, *Miniopterus schreibersii bassanii*, in Australia's southeast. The invertebrates inhabiting the extensive guano deposits in the maternal chamber are believed to have suffered a catastrophic decline over the last several years (Hamilton-Smith 2000). The current study follows an honours project (Bellati 2001) that investigated the diversity, distribution and abundance of the guanophilic arthropod assemblage in Bat Cave. Bellati (2001) identified the abundance and diversity of arthropods in three zones of varying light intensity; the entrance zone, flyway and maternal chamber of Bat Cave and compared these with the diversity of arthropods in the entrance and dark zone of Cathedral Cave, Naracoorte, which contain very little guano deposition. The arthropods in the maternal chamber consist of guanivores, fungivores, predators, parasites and parasitoids. The Bat Cave contains several endemic species including, *Tomogenius ?ripicola* (Coleoptera: Histeridae), *Ptinus exulans* (Coleoptera: Anobiidae), *Derolathrus* sp. (Coleoptera: Jacobsoniidae) and *Monopsis crocicapitella* (Lepidoptera: Tineidae) (Bellati 2001).

Bat Cave is primarily occupied from October to March by the large bent-wing bat where the maternal chamber is used for giving birth and rearing young. The maternal chamber houses approximately 36,000-50,000 bats during this time (Reardon, 2002, pers. com.) and there is a corresponding increase in guano deposition during these months. Over the winter months all bats vacate the maternal chamber, hence there is no guano deposition during that time. Temperatures in the maternal chamber remain nearly constant, ranging between 19°-21°C (Sanderson and Bourne 2002). The maternal chamber also shows a vertical temperature gradient with temperatures of 30°C recorded from bat roosts in the chamber roof (Baudinette et al 1994).

This study seeks to expand upon the arthropod diversity study of Bellati (2001) by conducting a longer-term investigation in the hope of elucidating and explaining temporal and spatial patterns of arthropod diversity and abundance in the maternal chamber. A range of environmental factors including pH, moisture content and guano deposition rates are being examined to evaluate their micro- and meso-scale affects on arthropod populations. The affect of varying guano deposition rates, both spatially and temporally, should aid in determining how and why the arthropod populations change.

METHODOLOGY

The study commenced in July 2002, and is planned to include two years fieldwork in Bat Cave incorporating two consecutive seasons, 2002/2003 and 2003/2004. The cave will be accessed bimonthly from October 2002 until August 2004. The first sampling period was conducted from 10th - 12th October 2002. Target species selected from data compiled by Bellati (2001) show both high abundance and potential important roles in the food web of the maternal chamber. They include predators; *Tomogenius ?ripicola* (Coleoptera: Histeridae), *Speotarus lucifugus* (Coleoptera: Carabidae) and *Protochelifer naracoortensis* (Arachnida: Pseudoscorpionida) and also fungivores/guanivores such as *Monopsis crocicapitella* adults and larvae (Lepidoptera: Tineidae), Acarina spp. (Arachnida), *Ptinus exulans* (Coleoptera: Anobiidae) and *Derolathrus* sp. (Coleoptera: Jacobsoniidae).

Pitfall traps are being used in this study because it was found by Bellati (2001) that target species were most easily captured using this method. Sticky traps were found to collect considerably fewer individuals, and lower species diversity (*Monopsis crocicapitella* adults and Phoridae sp. composed 92% of total abundance), compared to pitfall traps in the maternal chamber (Bellati 2001). Sampling consists of 36 pitfall traps, 55 mm in diameter and 70 mm deep positioned in a systematic pattern throughout the maternal chamber (Figure 2). The pitfall traps are placed in pairs at the top and bottom of 18 separate guano piles. The piles were selected for both their position within the chamber as well as showing signs of guano deposition within the past two years. During sampling periods pitfall traps are held within sections of plastic pipe permanently positioned in the guano to a depth of approximately 10 cm and which remain *in situ* for the duration of the study. This consistency will ensure pitfall traps remain in the same location throughout the study to enable the temporal analysis of data. Between sampling periods the pipes are capped. Displaced guano from pitfall sites has been placed in the immediate vicinity of pitfall traps to keep arthropod populations in their respective microhabitats. The pitfall traps, containing salt water and a small amount of detergent, are open for approximately 48 hours each sampling period and are set and retrieved at night, coinciding with minimum bat numbers in the cave to ensure disturbance of the maternal chamber is kept to an absolute minimum.

Relative rates of guano deposition have been calculated from samples collected from all pitfall trap locations throughout the maternal chamber. During sampling periods, fresh guano has been collected in large high sided containers (approximately 0.8 m^2) covering pitfall sites. These samples have subsequently been measured for weight and moisture content. The fresh guano samples allow an accurate measurement of the differing guano deposition throughout the maternal chamber. Guano will not be collected between sampling periods to allow the buildup of fresh guano that provides habitat for taxa such as Jacobsoniidae and other fungus-feeding guanophilic arthropods. The moisture content and pH of guano surrounding the pitfall trap sites has also be measured by random sampling within 20 cm of the sites. The measurement of moisture content of both falling (freshly deposited) and *in situ* guano will enable a correlation analysis between taxa and guano moisture content.

All samples are sorted to species, and their abundance recorded. Samples containing greater than 1000 individuals will be estimated to avoid excessive sorting time. Such samples are placed on a 10x5 cm grid with 5 mm squares, with 10 randomly selected squares, counted and averaged to provide an estimation of total numbers.

PRELIMINARY RESULTS AND DISCUSSION

The most abundant species collected (Table 1) were Oribatidae sp. (Acarina, 16,952 individuals), *Protochelifer naracoortensis* (Acarina: Pseudoscorpionida, 291), *Tomogenius ?ripicola* (Coleoptera: Histeridae, 263), *Ptinus exulans* (Coleoptera: Anobiidae, 112), Phoridae sp. (Diptera, 61), *Monopsis crocicapitella* adults (Lepidoptera: Tineidae, 28), *Speotarus lucifugus* (Coleoptera: Carabidae, 26), *Apanteles ?carpatus* (Hymenoptera: Braconidae, 21) and Nycteribiidae sp. (Diptera, 8).

Total species abundance was greatest in the central area of the maternal chamber (Figure 2) with over 95% of total individuals, followed by the rear and front areas with approximately 2% of total individuals each. Individual taxa including Oribatidae sp., *Apanteles ?carpatus* and Nycteribiidae sp. show this overall abundance pattern with greatest numbers found in the central area. *Protochelifer naracoortensis*, *Ptinus exulans* and *Speotarus lucifugus* show decreasing abundance with increasing distance from the cave entrance. The abundance of Phoridae sp. was greatest in the rear area of the maternal chamber, although due to an extreme concentration of individuals (56) on a single guano pile this pattern may not be indicative of actual distribution within the chamber. The abundance of *Monopsis crocicapitella* adults is greatest in the middle and rear areas of the maternal chamber.

Preliminary data show a generally clear distinction in arthropod diversities and abundances between the top and bottom of guano piles. Several taxa show clear preferences for these micro-habitats, with the most obvious trend concerning *Tomogenius ?ripicola*, which was collected at up to nearly 25 times greater numbers at the tops of piles than at the bottom of the same pile. Only two guano piles (8 and 10, Figure 2) showed greater numbers at the bottom and in each of these cases the total number of individuals was five or fewer. The adults of *Monopsis crocicapitella* appear to exhibit this trend to a lesser extent, but further collecting will be required before any clear trend can be established. The abundance of *Protochelifer naracoortensis* also follows this trend, and individuals were collected more often from tops of piles than the bottoms. The opposite trend is believed to be exhibited by *Ptinus exulans* which was collected predominately from the bottom of guano piles. The low numbers of individuals collected in some taxa, such as *Apanteles ?carpatus* preclude any speculation concerning preference for the top or bottom of piles. The low numbers of individuals of *Speotarus lucifugus* collected from any one pile, combined with the weak association for either the top or bottom of guano piles suggests a widely distributed, generalist predator within the maternal chamber.

Environmental factors measured at each sample location are the amount and moisture content of falling guano and the pH and moisture content of *in situ* guano within 20 cm of each pitfall trap. Harris (1973) stated that guano becomes more basic with increasing age. Preliminary results from this study indicate that tops of guano piles in the front area of the maternal chamber are generally slightly less acidic or the same as the bottoms of the piles. Guano piles in the rear area of the chamber showed similar trends but tops of piles ranged from extremely basic to slightly acidic. The central area of the maternal chamber showed the greatest variation with tops of piles ranging from highly basic to mildly acidic with bottoms of piles showing respective inverse pH levels.

The central area of the chamber showed the highest deposition rate of fresh guano and urine in the first sample period (Figure 3). The greatest deposition was recorded on the top of Pile 11 with approximately 88 g/m^2, containing 83% H_2O by weight. The average guano deposited in this area was 57.46 g on pile tops and 11.16 g on pile bottoms. These values contrast sharply with guano deposition rates in the front and rear areas of the chamber where average deposition rates were considerably lower, recording 0.07 g/m^2 at tops of piles. The water content of guano piles in the front and rear areas was also lower than that recorded from the central area with values as low as 23% H_2O by weight on pile tops.

FUTURE RESEARCH

Bat Cave and especially the maternal chamber provides numerous opportunities for further research projects in many diverse areas. Following this preliminary research in Bat Cave, I plan to use the microhabitat and temporal data collected from throughout the maternal chamber to explain the population dynamics and community ecology. A food web for the predominant species present in the maternal chamber is also being constructed as data are collected from ongoing trips into the cave and from observations using the infrared cameras throughout the cave. This will incorporate the diet, feeding habits and life cycles of target species. This information is known only in a broad sense and this project seeks to further elucidate aspects of their diet and habits in the maternal chamber ecosystem. The genetic relationship between the species inhabiting Bat Cave will also be compared with similar caves in the south east of South Australia and western Victoria. Other research projects in the maternal chamber should encompass several different aspects including fungal and microbial diversity and conservation and management practices.

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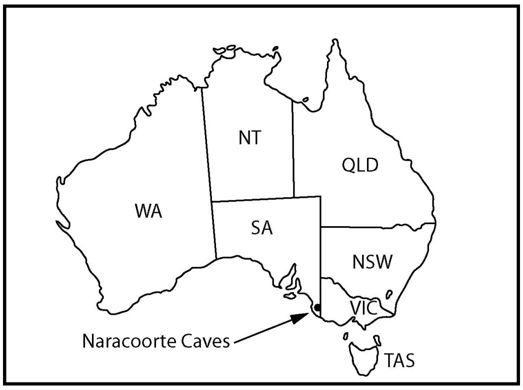

Figure 1 - Naracoorte Caves, World Heritage Area, South Australia

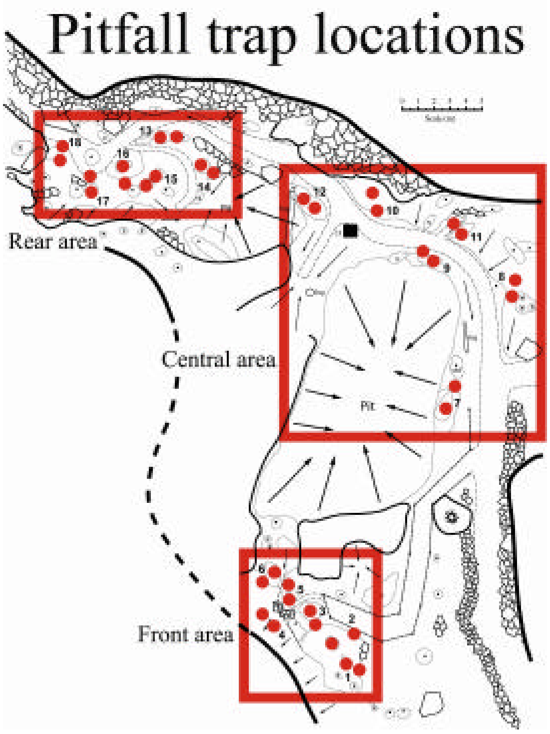

Figure 2 - Pitfall trap locations, maternal chamber, Bat Cave, Naracoorte Caves

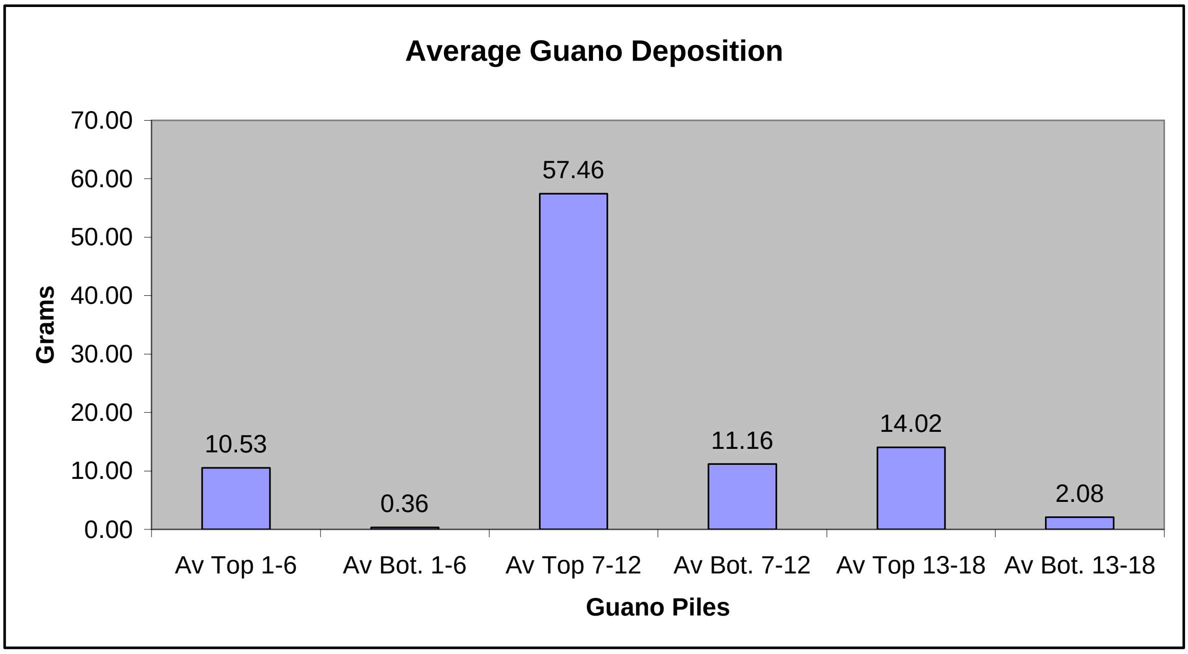

Figure 3 - Fresh guano deposition, maternal chamber 10-12 October 2002

Guano Pile	Sample	Histeridae	Anobiidae	Carabidae	Braconidae: *Apanteles ?carpatus*	*Monopsis*	Pseudoscorpionida	Oribatidae	Phoridae	Nycteribiidae	pH	Fresh Guano Wet Weight	Moisture Content %
1	Bottom	0	0	0	0	0	6	0	0	0	5.5	0.05	17.60
1	Top	1	0	1	0	0	9	2	0	0	9.0	5.90	76.95
2	Bottom	0	5	1	0	0	8	0	0	0	6.0	0.04	14.00
2	Top	7	0	2	0	1	18	0	0	0	6.5	2.19	72.60
3	Bottom	0	3	3	0	0	11	0	0	0	6.0	0.15	33.33
3	Top	18	16	3	1	0	50	5	0	1	7.5	0.10	23.60
4	Bottom	1	30	1	0	0	13	0	0	0	5.5	0.31	45.16
4	Top	6	1	0	1	1	23	98	0	0	5.5	29.73	80.83
5	Bottom	0	1	0	0	1	2	0	0	0	6.5	0.94	67.02
5	Top	0	0	0	0	1	8	0	0	0	8.5	18.43	83.72
6	Bottom	0	11	2	0	0	4	0	1	0	5.0	0.65	55.38
6	Top	3	0	1	0	2	18	3	0	0	5.5	6.84	76.75
7	Bottom	3	0	0	2	0	0	0	0	0	6.5	19.70	76.04
7	Top	22	9	1	8	0	25	0	0	3	7.0	10.17	78.17
8	Bottom	4	2	3	0	0	13	0	0	0	5.5	18.66	84.57
8	Top	0	0	0	2	0	10	6	0	0	5.0	0.44	54.55
9	Bottom	27	16	2	2	0	7	2218	0	0	6.0	11.99	67.47
9	Top	39	0	0	1	1	1	3020	0	0	7.0	119.03	83.73
10	Bottom	4	7	1	1	1	2	0	0	0	4.5	0.98	47.96
10	Top	1	0	0	1	1	9	693	0	0	6.5	26.89	82.67
11	Bottom	2	3	0	0	0	2	8	0	0	5.5	1.58	46.84
11	Top	49	3	0	0	7	0	10640	2	3	7.5	141.85	83.67
12	Bottom	1	0	0	0	0	7	0	0	0	5.5	14.04	68.23
12	Top	9	0	0	0	1	7	27	0	1	5.5	46.37	85.18
13	Bottom	1	0	2	0	1	1	0	0	0	5.5	3.58	70.11
13	Top	9	0	0	0	0	6	228	0	0	5.5	17.92	45.48
14	Bottom	3	1	1	1	2	0	0	1	0	6.5	4.65	51.61
14	Top	25	2	1	0	0	11	0	1	0	5.0	32.84	82.58
15	Bottom	2	1	0	1	1	0	0	0	0	6.0	0.15	6.67
15	Top	5	0	0	0	1	3	0	0	0	5.5	1.56	44.23
16	Bottom	2	0	0	0	1	3	0	0	0	6.0	1.82	56.04
16	Top	18	0	0	0	2	2	0	56	0	5.0	17.87	71.63
17	Bottom	0	0	0	0	0	1	1	0	0	6.5	0.53	54.72
17	Top	1	0	0	0	0	1	0	0	0	10.5	0.11	27.27
18	Bottom	0	1	1	0	3	8	0	0	0	8.5	1.75	67.43
18	Top	0	0	0	0	0	2	3	0	0	5.0	13.84	60.48

Table 1 - Diversity and abundance of dominant species collected in the maternal chamber

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