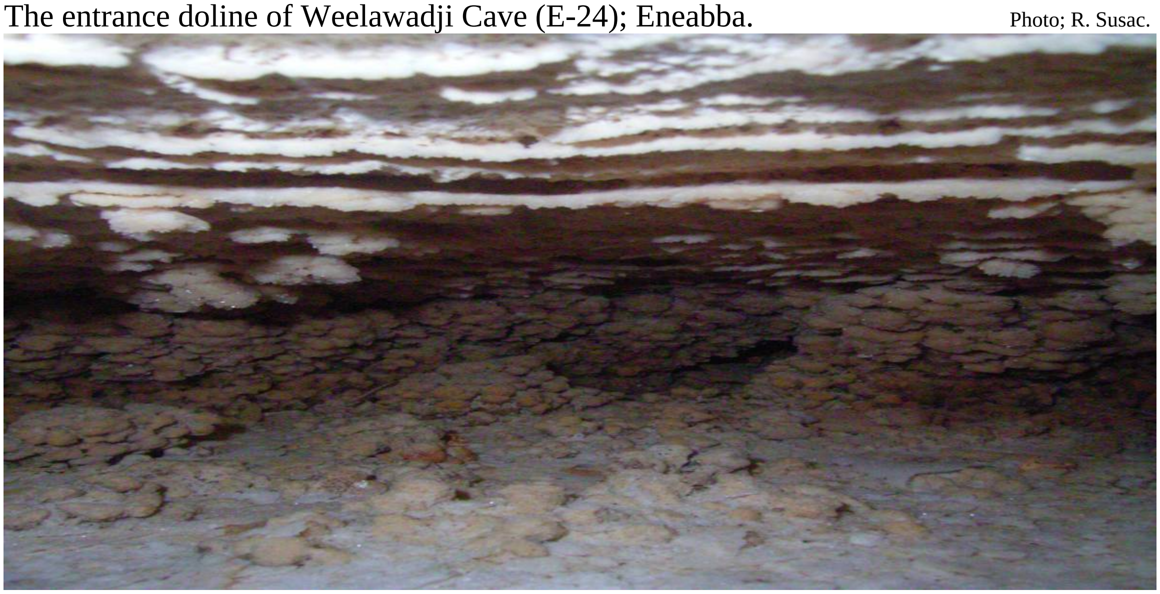
A Literature Review & Report of Karst Biodiversity, Palaeontology & Hydrology in the Northern Agricultural Region, Western Australia.

August 2007

By R.A.J. Susac on behalf of the DEC

The entrance doline of Weelawadji Cave (E-24); Eneabba. Photo; R. Susac.



Below the false floor (E-24).

Photo; C. Williams.

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Introduction

Karst processes have an intrinsic influence on biodiversity in both a contemporary and historical context. The historical account is translated through the presence of fossil and sub-fossil (bone) material. The maintenance of biological processes throughout karst environments is intrinsically linked to the evolving hydrological regime. This requires an understanding of the specific processes of influence and the ongoing flow trends and patterns. The information compiled here is presented as a summary of records that have been published or recorded by amateur speleologists, academics and scientists. It is therefore not always consistent in the degree of detail that is recorded due to the differing paradigms from which the information was sourced. The information should be considered within its historical context as fauna may not be currently present, or in the same abundance as when recorded. This is particularly relevant with regards to caves with references to water, or vertebrate fauna.

Karst of the Northern Agricultural Region (NAR)[1]

Caves of the Northern Agricultural Region are formed in older aeolian calcarenite than more southerly lying caves such as those found at Yanchep. In general; the caves increase with age in a south-north direction and towards the interior with the youngest caves being closest to the coast and oldest closer to the Yilgarn Craton. The coastal plain karst is syngenetic; processes of speleogenesis and lithogenesis occur concurrently (Jennings, 1997). Distinctive features of syngenetic karst include; shallow horizontally developed, collapse-dominated systems with extensive breakdown and subsidence; low irregular chambers clustered at the limestone-groundwater interface; palaeosoil horizons; vertical solution pipes which locally form dense fields; a variety of surface and sub-surface breccias and large collapse dolines with limited surface karren (Grimes, 2006). Development of these features in host sediments that are predominately highly porous and weakly consolidated is eogenetic; being prior to deep burial (Grimes, 2006). This provides a biolithogenic aquifer which is exploitable by surface flora and provides faunal refuge. The presence of karst in the landscape increases landform heterogeneity and supports a higher biodiversity in epigean (surface) and hypogean (sub) biota as well as the provision for fire refugia.

Karst Biology

Energy inputs into caves are the result of primary productivity on the surface which is then transported into the cave environment by trogloxenes (guano & prey), or fluvial processes. Other energy inputs include the intrusion of roots, troglophiles or accidental entrapment. Rainfall events in the NAR tend to be more episodic than caves of Australia’s south west (BOM, 2007). This leads to significantly more pulse driven flushes of biological activity that are stimulated by the increased resources available. Between these bursts, fauna either migrate or exploit interstices as refugia (Foulds, 1995). In general caves that have typically been known to hold water or have active streams have recorded consistently less water over the last decade. This situation certainly has been seen to hold true further south in the Yanchep Caves and the South West Region. The causes of these declines are rooted in alterations to hydrological regimes, increased abstraction/interception rates and climatic change.

[1] See Appendix II for map/figures.

Trogloxenes- Rely on external foraging for food sources. The most significant trogloxenes of the NAR are bats of the order Microchiroptera. Only a few species are known to prefer the karst environment as shelter over the more typically arboreal habitation species. The most common now found in caves being *Chalinolobus morio* Gray 'the chocolate wattled bat'[2]. The significance of bat inhabited caves should not be understated as bats are found to be quite sensitive to disturbances particularly during maternity periods (Buecher, 2006). Caves that have been mined for guano are nearly always abandoned by bats at least initially and there are instances of them never returning due to alteration of cave morphology and subsequent atmospheric and internal ecological conditions. Bat guano forms the basis of guanophile communities.

Hirundo neoxena Gould, 'the welcome swallow' is a common trogloxene associated with most of the more open cave entrances and provides valuable energy in the form of guano for invertebrates. This guano input although typically only found in the shaded or twilight zone can provide resources further into the cave's dark zone through fluvial transport or roaming troglophiles.

Troglophiles- Fauna that is adapted to living in the epigean environment and enters caves to take advantage of the physical properties and/or resources such as humidity/moisture, temperature, shade, nutrients, minerals, shelter and prey. They are typically able to undertake their entire life-cycle within the caves confines.

Troglobites- Terrestrial, obligate cave or karst dwelling organisms occurring almost exclusively within the dark zone of caves. This environment typically bestows adaptive characteristics to its inhabitants that can be generalized as follows. (Christiansen, 1992) (Gilbert *et al*. 1994) (Culver *et al*. 1995)

Morphological

- General lack of pigmentation, (cuticle thinning in terrestrial arthropods).
- Ocular regression and wing reduction.
- Appendage elongation, including spinulation and foot modifications.
- Convergence of vermiform body shape for different taxa.
- Highly developed chemo-, thermo, hygro, baro and mechanical receptors.

Biocenosis

- Slower metabolic rates, growth and reduced motor output.
- Lengthened lifecycle stages, late maturity and increased longevity.
- Unique behaviors; stereotropism, thigmotropism and thigmotactism.
- Increased sensitivity to vibration and reduced intraspecific aggression.
- Less frequent reproduction, lower fecundity – fewer eggs of larger size.

High levels of endemism are typical of subterranean taxa with endemic species tending to concentrate in habitats that support relatively diverse communities rather than random distributions (Armstrong & Higgs, 2002). Troglobites tend to fill predatory niches but this is variable (Lowry, 1980). Currently, very little scientific work has been published on the troglofauna of the Northern Agricultural Region.

Accidentals- Such fauna found in caves can be effectively any organism that can reasonably fit within the caves entrance that may be dead, trapped, disoriented and/or injured and unable to leave. These are predominately terrestrial ground dwellers but not exclusively so. As an energy input source these organisms are typically sporadic in occurrence and vary greatly in their quality (Moulds, 2006).

Stygofauna- Obligate groundwater dwelling organisms that possess troglomorphic or specialised ecologically adaptive traits. Stygobite fauna occur in a wide range of subterranean aquatic environments and are often highly adapted in relation to their habitat and ecological niche. The distribution of stygofauna often appears more restricted than that of surface fauna analogues (Armstrong & Higgs, 2002). Dispersal of stygofauna may be considered to be extremely slow and is limited to the geological formation from which they are known to occur (Strayer, 1994). Physical variables such as dissolved oxygen have been shown to influence the distribution of some species over a local and microhabitat scale (Danielopol *et al.* 1994). Recruitment from epigean species can occur via flooding episodes.

Further south at Yanchep Caves, Jasinska *et al.* (1996, 1997) described a diverse ecological stygofauna community based on the energy inputs from the aquatic root mats of terrestrial flora. This is primarily the roots of tuarts (*Eucalyptus gomphocephala,* Duke) in contact with the cave streams branching out to form rootlets. These dense mats form a net like structure that catches detritus and grows in association with fungal mantles (Jasinska, 1997). The species richness and diversity associated with the root mats is higher than any other global record for subterranean waters (Jasinska, 1997). This accompanied with the high levels of endemism identified subsequently, enabled this ecological association to be recognized for its conservation value. The real significance is now acknowledged in individual species represented at Yanchep being phylogeneticaly linked to the suite of Gondwanic relics (Knott & Storey, 2001). This ecological community is now critically endangered primarily due to continually decreasing water levels through catchment interception from pine tree monocultures, increased abstraction and climatic change. The current Interim Recovery Plan is tasked with protecting this natural heritige icon but has had various implementation setbacks. Cave streams that have dried out and then later replenished have not been recolonized by larger species including Gondwanan relicts (Jasinska *et al.* 1996, 1997). The range of *E. gomphocephala* continues as far north as Geraldton although it becomes increasingly fragmented and isolated in its occurrence.

A biotic feature throughout the young syngenetic aeolian caves is the presence of 'moonmilk'[3] as a type of speleothem formation. These patches often occur near thermoclines as vents between the porous limestone and the cave atmosphere (pers. comm. R. Foulds, March 2007). This soft material combines a biological component as it is a result of a bacterial/calcite interaction within the particularly porous limestone sheltered in areas of high humidity. In warm climates such as that found in the NAR this material can also contain cyanobacteria, green algae, fungal hyphae and actinomycetes (Scheidt, 2001). The presence of this microflora accompanied by mineral precipitation converts the $CaCO_3$ into the moonmilk formation. Although moonmilk occurs in many forms and states, it is predominately the presence of the microbe *Macromonas bipunctata* Gicklhorn, which is responsible for metabolizing organic acids into precipitating calcite in another form of calcite crystal (Moore, 1997). The organic nuclei is the source of tiny calcite filaments which enmeshed in different life processes cause a micro-variation of the chemical environment leading to the deposition of discrete mineral grains. These combine to be exuded as rods diagonally impressed into alignment with the crystal structure of calcite (Moore, 1997). This formation can act as an energy source for organisms found within the cave. Moonmilk is readily exploited by roots[4] making it significant for its contribution to cave biology and has therefore had its presence noted.

Although not largely featured in this review the presence of fungi and nematodes is a given certainty in guano rich caves. This important biotic component is a ubiquitous feature of every other habitat in both epigean and hypogean environments (Moulds, 2004). This is true in regards to other micro-organisms in stygal ecosystems; protozoa, rotifers and diatoms are lacking from any comprehensive study in this area.

Cave environments can be dynamically fluxing systems throughout the year or over a broader climatic period. This reveals evidence to the extent of episodic flooding events. Alternatively, they may also remain in a state of physical inertia for extensive periods which can provide an encapsulated insight into a historical record of eustatic variances. Sub-fossil material and fossils including pezolithic and phytolithic material such as rhizomorphs or rhizocretions are revealed through the stratified geological sequence[5]. Some caves such as those at the Stockyard Gully System contain a distinct combination of both pulse driven flood systems and upper avens where a stable environment has preserved such features.

Karst Area Zones and Nomenclature

Karst zones have been ordered from north to south with coastal Tamala Limestone taking precedence over the palaeokarst dolomitic Moora area. Within each zone the karst features are ordered numerically in relation to their reference listing in the Australian Karst Index. References are based on the existing information presented in the Australian Karst Index (Mathews, 1985), the W.A. state prefix # (6) has been ommited throughout the report. Abbreviation found within the following record generally includes a distinction between the Dark Zone (Dz) and the Twilight Zone (Tz) sections of caves. For some fauna the identifier is indicated by [-] square brackets. Supertext numbers refer to a separate (Appendix II) figures and plates section. At the end of each significant cave's invertebrate list, a total species richness figure is recorded for the invertebrate cavernicoles (cave dwellers, not accidentals).

ENEABBA

The Stockyard Gully System has a very significant hydrology that has been influenced by alterations to the catchments drainage. The Stockyard Creek flows for much of the year and regulates fluvial inputs into associated drainage conduits. These may be traced to halocline salt lakes through subterranean vents. Feral bee nests (Hymenoptera: Apidae; *Apis mellifera* Linnaeus)[6] are a very common feature of many cave entrances in the area as the karst presents itself as an exploited substrate for colonies in the form of shelter, resources, moisture retention and location.

E-1 Stockyard Tunnel; The Stockyard Tunnel is significant as a bat shelter; *Chalinolobus morio* 'the chocolate wattled bat'. Of the population banded all were adults with 48/49 of the population being male (Hamilton-Smith, 1965). Frogs are common inhabitants in the stream area. Stockyard Tunnel is episodically flooded but an upper aven at the terminus of the main side fissure contains extensive phytolithic material. The lower areas of this side fissure are moist and damp and the humidity is elevated. Litter baiting yields predominately isopods and a pale Diplopoda (millipede) was sighted (Anderson, 2007). *Apis mellifera* nests are at the entrances. *Hirundo neoxena* nests in the entrance areas. This cave is being promoted for visitation and receives a sporadic influx of tourists on a daily basis. This increase in visitation is compromising this cave's integrity as a shelter for fauna.

A boobook owl (*Ninox novaeseelandiae* Gmelin) and other owl species have been reported roosting in the Twilight Zone of the outflow (large west end) area of the cave (Hosie, 2006) (pers. comm. P. Hosie, 30 May 2007). Honey possums (*Tarsipes rostratus,* Gould) have been found alive and disoriented within the cave (pers. comm. M. Newton, 2 June 2007).

Annelida; Oligochaeta: Microdrillidae –tiny red worms (Lowry, 1980).

Arthropoda; Arachnida; Araneae: Theridiidae: *Achaearanea* spp. –Tz from webs in fissure off main wall –Tz, Aphyctoschaema sp. –Dz. Linyphiidae; *Laetesia mollita* Simon -Tz, Lycosidae are found throughout the entire Stockyard System (Lowry, 1980), *Arctosa* sp. unknown sp. –Dz. Uloboridae [Waldock, 1996] (Foulds, 1996).

Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* (Beier, 1968) associated with human faeces (Lowry, 1980). (Author's note; despite faunal associations, caves are not considered appropriate places for human excretion as this short circuits food webs, introduces pollutants closer to groundwater and is very unpleasant for explorers).

Crustacea (Malacostraca); Isopoda (slaters): troglomorphic Oniscidea: Philosciidae: *Laevophiloscia yalgoonensis* Wahrberg, *L. unidentata* Vandel, collected from guano (Hamilton-Smith, 1965), *L. richardsae* Vandel, epigean -*Buddelundia* sp. – (dark bodied) feeding on bee remains in Tz (Foulds, 1996).

Myriapoda; Chilopoda: Scutigerida; *Allothereua lesueuri* Lucas [Waldock, 1996].

Hexapoda; Collembola (springtails): Poduridae: Entombryiidae: *Lepidocyrtus* sp. associated with human faeces –Tz (Lowry, 1980).

Insecta; Apterygota: Thysanura: Nicoletiidae: Nicoletinae; *Trinemura novaehollandiae* Silvestri (silverfish) –Tz (Moulds, 2007).

Blattodea (cockroaches): Blattellidae: Blattellinae; *Neotemnopteryx douglasi* [Princis, 1963] (Hamilton-Smith, 1967) (Moulds, 2007).

Coleoptera (beetles): Carabidae: Harpalinae; *Lecanomerus flavocintus* Blackburn - was found in abundance in the dark transitional zone and was well established through the entire Stockyard System (Carabid beetle) (Lowry, 1980) (Foulds, 1996). Pterostichinae; *Pseudoceneus sollicitus* extremely abundant establishment throughout all zones in the Stockyard System with an unidentified larval sp. found at the commencement of the Dz. Histeridae: unidentified sp. collected as larvae under freshly regurgitated owl pellet –Tz. Staphylinidae spp. caught in pit trap –Tz. Anobiidae; *Ptinus exulans* Erichson – a cosmopolitan species, most common in the Twilight Zone and the commencement of the Dark Zone, associated here with old human faeces (Lowry, 1980).

Diptera (flies): Sciaridae: *Sciara* sp.1 (*Bradysia* sp.?) found in all zones seemingly nocturnal, an unidentified sp.2 larvae was found in flood debris 300 m into the caves Dz. Phoridae: *Megaselia* sp.1 baited pit traps in all zones (Lowry, 1980).

Lepidoptera: Cosmopterigidae sp.1 on human faeces –Tz. This species is possibly adpted to guano & debris in caves feeding on detritus & invading the Tz of caves to feed on dry material. Noctuidae; *Dasypodia selenophora* Guenée (old lady moth) - common troglophile resting on walls –Tz, often sheltering in caves within its range.

Odonata (dragonflies & damselflies): Lestidae: Corduliidae; *Hemicordulia tau* Selys – accidentals (Lowry, 1980). Moults of dragonfly nymphs have been found attached to walls –Dz (Foulds, 1996).

E-1 = >26 cavernicolous invertebrate species (abbreviation; = >__ inv. spp.).

Bones; *Macroderma gigas* Dobson remains were collected from the side tunnel.

E-2 Stockyard Bridge; represents a significant component contributing to the geomorphic dynamics of the Stockyard Gully Karst System. Water flow is modified by limestone breakdown increasing the localized influence of the hyporheic zone. Frogs often shelter within the bridge and *Hirundo neoxena* 'the welcome swallow' is commonly seen flying through the arch area and makes nests within the cave. The entire 'cave' as an arch landform is effectively considered Twilight Zone.

Arthropoda; Arachnida; Araneae: Theridiidae: *Achaearanea* spp. generally found in sheltered places near entrances –Tz. Lycosidae: *Trochosa* sp. (Lowry, 1980).

Pseudoscorpionidea: Synsphyronidae; *Synsphyronus (Maorigarypus) grayi* [Beier] - separated from leaf litter and swallow guano, collected in bright twilight in the upstream entrance (Lowry, 1980), Cheliferidae; *Protochelifer cavernarum*[7] Beier 1968, swallow guano (Lowry, 1980).

Crustacea (Malacostraca); Isopoda: Philosciidae: *Laevophiloscia yalgoonensis, L. unidentata* Vandel, 1973.

Hexapoda; Collembola: Poduridae: Entombryiidae: *Lepidoseira* sp. accidental (Lowry, 1980).

Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* (Lowry, 1996).

Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus.* Pterostichinae; *Pseudoceneus sollicitus* carying large numbers of an ectoparasitic mite that has not been identified. Pentagonicinae; *Scopodes sigillatus* Germar. Staphylinidae; *Quedius luridipennis* Mackleay & unidentified sp. from pit trap. Anobiidae; *Ptinus exulans,* Lathridiidae; *Corticaria adelaide* Blackburn -caught in pit trap; members of this genus feed on moulds, larger fungi and mycetozoa (Lowry, 1980).

Diptera; Sciaridae; *Sciara* sp.1 & 2 (*Bradysia* sp.?) found in all zones (Lowry, 1980).

Hymenoptera: Apidae; *Apis mellifera* nests. Bethylidae: *Epyris* sp. accidental, captured in baited trap –Tz (genus associated with ants) (Lowry, 1980).

Lepidoptera (moth): Noctuidae; *Dasypodia selenophora.*

Psocoptera (plant hopper): Psyllipsocidae; *Psyllipsocus ramburii* -Tz (Smithers, 1975) (Lowry, 1980). E-2 = >16 invertebrate species.

E-3 Stockyard Cave; Stockyard Cave is important as a bat maternity shelter for *Chalinolobus morio*; ~80 individuals with 27 females: 11 males collected (Hamilton-Smith, 1965)[8]. Despite safety caution signage this cave is frequented by tourists. Ephemeral ponds in the cave are often inhabited by tadpoles (Robinson, 1964). *Hirundo neoxena* nests in the cave entrance. The hydrology of the cave is very significant as a groundwater inflow. Water pH has been measured as 7, average drip time was 90 seconds with an air temperature of 18.5ºC, Relative Humidity; (RH) = 90%, soil Temperature of 15ºC at the passing of anabranch or tributary (Foulds, 1996). Logs are often found deep in towards the caves terminus and provide valuable resources for invertebrates particularly isopods. Towards the terminus before the logjam the temperature recorded is the same but RH has increased to 96% (Foulds, 1996). Many small mammal tracks are evident in the mudbanks deep within the cave these are assumed to be rodents but are unconfirmed, there are also macropod scats found near the cave terminus (pers. comm. P. Hosie; 5 June 2007).

Mollusca; Gastropoda: Pulmonata: Planorbidae: *Physastra* spp. & Succineidae: *Austrosuccinea* sp. aquatic accidentals probably deposited by flooding (Lowry, 1980).

Annelida; Oligochaeta: Microdrillidae –found in fresh bat guano Dz (Lowry, 1980).

Arthropoda; Arachnida; Araneae: Desidae sp., Theridiidae: *Pholcomma* sp. – from log jam area near mud banks and moist floor, *Euryopis* sp. –Tz [Waldock, 1996] (Foulds, 1996), *Achaearanea* spp. -Tz, *Steatoda* sp. on webs built amongst flood debris –Dz. Linyphiidae: *Laetesia* sp. -Tz transitional area (Lowry, 1980). Pisauridae sp. from clay floor and mud banks, multiple species roving over a diversity of habitats Tz-Dz (Lowry, 1980) [Waldock, 1996] (Foulds, 1996). Lycosidae: *Arctosa* sp. roaming through all zones Tz-Dz, *Trochosa* sp. throughout cave, unknown sp. from cast skins –Dz, Uloboridae –Tz (Lowry, 1980).
Arcarina: (mites) Mesostigmata- Spinturnicidae: *Spinturnix psi* (Hamilton-Smith, unpublished data).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum*[7] -debris (Beier, 1968).
Crustacea (Malacostraca); Isopoda: Oniscidea: Stylonscidae; *Styloniscus australiensis australiensis* Vandel -from fresh guano & coarse flood debris –Dz (Lowry, 1980). Philosciidae; *Laevophiloscia dongarrensis* Wahrberg, *L. yalgoonensis, L. unidentata L .richardsae* –troglophile (Vandel, 1973), *L. longarrensis* in moist flood debris (Lowry, 1980). Armadillidae; *Buddelundia bipartite* Budde-Lund -known troglophile with conspicuously unpigmented areas & reduced eyes, observed browsing on lichens & mosses under the lintel line along with *Sphaerillo grossus* Budde-Lund & *Hanoniscus monody* Bowley -which are both epigean varieties (Lowry, 1980).
Hexapoda; Collembola: Poduridae: *Cryptopygus* sp. near *C. albaridae* Selga -found on organic flood debris Dz. Isotomidae; *Isotoma* sp., near *I. tridentifera* Schott. Onychiuridae; *Tullbergia* spp. (#2) separated from moist flood debris & rotting wood –Dz. Entombryiidae: *Lepidocyrtus* sp. mostly in litter & from owl pellets –Tz, *Pseudosinella* sp.2 from flood debris -Dz (Lowry, 1980).
Insecta: Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* (Lowry, 1996). Coleoptera: Caribidae: Scaritinae: *Clivina* sp. caught in a Dz pit trap (this genus burrows into mud on river banks & was possibly washed in. Harpalinae larvae unidentified sp. separated from moist flood debris –Dz, *Lecanomerus flavocintus* was found in abundance (Lowry, 1980). Pterostichinae; *Pseudoceneus sollicitus* –Dz (Hamilton-Smith, unpublished data), *Sarticus iriditinctus* Chandoir –accidental (Lowry, 1980). Lebiinae: Microlestes sp. & Broscinae; *Gnathoxys crassipes* –Tz both collected at the entrance in the evening. Psydrinae; *Mecyclothorax ambiguous* Erichson –Tz. Pentagonicinae; *Scopodes sigillatus* –Tz. Histeridae; unidentified sp. associated with a dead moth –Tz. Cholevidae; *Pseudonemadus australis* Erichson – baited trap & mouldy regurgitated owl pellet –Tz. Staphylinidae: unidentified sp. near *Lathrobium* sp. separated from flood debris –Dz, *Quedius luridipennis* Mackleay - cave entrance. Anobiidae; *Ptinus exulans*. Corylophidae: *Sericoderus* sp. found in a dead moth near the entrance; members of this family feed on spores & fungal hyphae. Lathridiidae: *Corticaria* sp. pit trap-Tz. Dytiscidae; *Homedytes scutellaris* Germar - floor near entrance & in a dried pool -Dz (Lowry, 1980), *Platynectes decempunctatus* Fabricus -predatory water beetle (Hamilton-Smith, 1967).

Diptera: an abundance of tiny midge (Chironomids) congregate within moist locations deeper within the cave (Foulds, 1996). Sciaridae: *Apterous* sp., cf. *Epidapus* sp. separated from rotting wood collected ~300 m into –Dz, *Sciara* sp.1-3 (*Bradysia* sp.?) found in all zones & from baited traps & an unidentified sp.1 larvae was found in bat guano & kangaroo faecal pellet –Dz along with unidentified larvae sp.2 also found with moldy owl pellet –Tz & was found in flood debris 300 m into the caves Dz (Lowry, 1980). Phoridae: *Megaselia* sp.1 & 2 - (Tz) caught in baited pit traps in all zones and a similar specimen with a mouldy owl pellet along with unidentified larvae –Tz. Sphaeroceridae: *Leptocera* sp.1, cf. *L. longisetosa* Dahl –caught in pit trap –Tz. Calliphoridae; *Calliphora nociva* Hardy -adult females & larvae caught in baited traps near entrance. Psyhodidae sp. accidental caught in bait trap –Tz. Dolichopodidae: unidentified sp.1 accidental –Tz. Lauxaniidae: *Homoneura* sp. accidental, caught in baited trap –Tz (Lowry, 1980).
Hemiptera: Homoptera: Aphididae sp. –accidental, near entrance (Lowry, 1980). Hymenoptera: Apidae; *Apis mellifera* bee nests occur above the entrance. Lepidoptera: Teneidae: *Monopis* sp. as larvae separated from flood debris –Dz. *Monopis* sp. is widespread throughout Australia & classed as a trogloxene by Richards (1971), Lowry (1980), classifies it as a troglophile due to the distance larvae have been found into the Dark Zone both here in E-3 & in E-24 (Lowry, 1980). Cosmopterigidae sp.1 abundant on logs & rocks –Tz. Noctuidae; *Agrotis infusa* Boisduval (bogong moth) captured at night –Tz, *Dasypodia selenophora* Guenée - common troglophile, found in the dark transition tone. Geleciodea sp. adult accidental, captured in baited trap near entrance. Notodontidae: *Teara* sp. accidental, dead adult –Tz, possible prey of *Tyto alba* (Lowry, 1980).
Odonata: Lestidae; *Austrolestes annulosus* Selys –accidental, nymphal skin, from mud covered stone in dry river bed –Dz. Corduliidae; *Hemicordulia tau* Selys –accidental, from pools as nymphs & dead adults on mud banks washed in during floods Dz (Lowry, 1980). Orthoptera: Acrididae: *Macrotona* sp.26 –accidental. Psocoptera: Liposcelidae: *Liposcelis* sp. in baited pit trap at entrance, regurgitated owl pellets –Tz & moist flood debris –Dz (Lowry, 1980). Elipsociae; *Propsocus pulchripennis* Perkins, from two samples near the caves entrance; one on a freshly dead grasshopper (Smithers, 1975). E-3 = >62 invertebrate cavernicolous species.
Bones; Sculls found of *Nyctophilus geoffroyi* Leach (lesser long eared bat), *Vespadelus* sp. recorded as *Eptesicus pumilus* Gray (the little bat) (Bridge, 1963b). Harry Butler found the bones of a Thylacine (Tasmanian tiger), *Sarcophilus* (Tasmanian devil) and *Macroderma gigas* (ghost bat) in a nearby cave with some bones embedded in flowstone (Bridge, 1963b).

E-4D Alpha Doline; important geomorphology (Mathews, 1985).
Feral goats (*Capra hircus* Linnaeus) have been using this doline as regular shelter.

E-5D Beta Doline; geomorphologic significance (Mathews, 1985).
Arthropoda; Arachnida: Araneae: Lycosidae sp. found throughout the entire Stockyard System, *Arctosa* sp. *Trochosa* sp. (Lowry, 1980).
Hymenoptera: Apidae; *Apis mellifera* nests (Lowry, 1980).

E-6D Gamma Doline; important geomorphology (Mathews, 1985).
Hymenoptera: Apidae; *Apis mellifera* nests (Lowry, 1980).

E-7D Delta Doline; important geomorphology (Mathews, 1985). A barn owl; (*Tyto alba*) Scopoli, was found roosting in the side cave (Shoosmith, 1973b).
Hymenoptera: Apidae; *Apis mellifera* nests (Lowry, 1980).

E-8D Epsilon Doline; important geomorphology (Mathews, 1985).

E-9 Aiyennu Cave, (ANU); a very significant and important hydrological & geomorphological feature that has distinctly unique characteristics. It has >100 entrances in the cap rock lattice that constitutes its ceiling as the calcarenite has collapsed to leave the kankar peppered with solution pipes. These entrances are of varying sizes that act as pit traps for surface fauna. This makes it a likely site for cave accidentals; snakes (monk snake[12]; *Rhinoplocephalus monachus* Storr), beetles, ticks, frogs (Foulds, 1983) (*Litoria moorei* Copeland -and others such as burrowing varieties[9]) and marsupials (the author has found a live honey possum (in torpor); *Tarsipes rostratus,* within this cave). It has been known to provide habitat for feral vagrant trogloxenes such as *Cherax destructor* Erichson (the eastern 'yabbie'; Crustacea: Decapoda: Parastacidae). The first record was reported as freshwater crayfish; "marron" in March 1989 (Markey, 1990), and was likely to be a yabby (Jasinska *et al*. 1993). It would now appear with further receeding water that even *C. destructor* has been unable to sustain its population in the cave due to the cave drying and reduced fluvial inputs (Susac *et al.* 2007).
A water snail had been reported living in the terminal pool (Hamilton-Smith, 1965), unfortunately there has not been a terminal pool evident in recent years.
Arthropoda; Arachnida: Araneae: -Tz, Opilioida –transitional (Moulds, 2007).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* –Tz (Moulds, 2007).
Crustacea (Malacostraca); Isopoda; Armadillidae –Tz (Moulds, 2007).
Myriapoda; Chilopoda; Scolopendromorpha –Tz (Moulds, 2007).
Insecta; Apterygota: Thysanura: Lepismatidae –Tz (Moulds, 2007).
Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* – Tz (Moulds, 2007).
Coleoptera: Carabidae –Tz, Dermaptera; Anisolabididae accidental –Tz (Moulds, 2007).
Dytiscidae; *Platynectes decempunctatus* (Hamilton-Smith, 1967).
Hemiptera: Reduviidae: Emesinae sp., Harpactorinae sp. (assassin bugs, predators) – transitional zone (Moulds, 2007).
Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).
Psocoptera: Trogiidae –transition (Moulds, 2007). E-9 = >14 invertebrate species.

E-10 Beekeepers Cave,[10](UNIWA Cave); extensive stream passage cave, seasonally inundated, approximately 1.7 km to permanent water. Known to shelter vagrant feral trogloxenes such as *Cherax destructor* (Anderson, 2001). It would now appear with further receeding water that even *C. destructor* has been unable to sustain its continued population in the cave due to a decrease in energy inputs (Susac *et al.* 2007)[11]. In a large tree root festooned chamber (Octogon Chamber) deep into the Dark Zone a depigmented spider with a ~3.5 mm long abdomen was seen in a thin horizontal side fissure with rootlets (RH: 100%) (observation; P. Hosie, 19 May 2007). A silverfish was also observed in this chamber on mud coated rock (S. Miller, 19 May 2007); probably Thysanura: Nicoletiidae: Nicoletiinae *Trinemura* sp..
Troglophiles include Crustacea (see above), frogs, snakes (monk snake; *Rhinoplocephalus monachus*[12]) (Susac, 2007) and insects.

Stygofauna; Crustacea: Copepoda: Cyclopoida: Cyclopiidae: *Australoeucyclops* (sp. currently under description by T. Karanovic) with abundant nepauli, *Australocyclops australis* Sars, [D. Tang] these are epigean species with *A. australis* having a wide distributution. Protozoa: Oligotrich: Siliate: *Halteria* sp. [R. Shiel], from sift netting sample at the terminal watertable expression ~1.7 km into the cave -Dz (Susac, 2007).
Mollusca; Gastropoda: Pulmonata: Camaenidae: *Styloniscus* sp. from damp stream bed –Tz (Lowry, 1980). Planorbidae: *Physastra* spp. accidental -Tz (Lowry, 1980).
Annelida; Oligochaeta: Microdrillidae – (long thin bright red worms) dug from worm castings at the streams edge and vertebrate faeces (rat pellets) –Dz (Lowry, 1980).
Arthropoda; Arachnida: Araneae: Lycosidae: *Arctosa* sp. -Tz, unknown sp. –Tz. Theridiidae: *Achaearanea* spp. –Tz (Lowry, 1980) (Moulds, 2007). Salticidae sp. entrance –Tz (Lowry, 1980).
Acarina (terrestrial) found in terminal pool through sift-netting (Susac, 2007).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* –Tz (Moulds, 2007).
Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia yalgoonensis, L.* sp. –Dz (Lowry, 1980), Copepoda (see stygofauna above).
Myriapoda; Chilopoda: Scolopendromorpha sp. –Tz (Moulds, 2007).
Hexapoda; Collembola: Poduridae: Onychiuridae: *Tullbergia* sp.1 (*krausbaueri* group) moist rodent faecal pellets –Dz (Lowry, 1980).
Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* –Dz on mud.
Coleoptera: Carabidae: Pterostichinae; *Pseudoceneus sollicitus* –Dz, Dytiscidae: *Liodessus* sp. found near *L. biformis* Sharp & *Platynectes decempunctatus* Fabricus, var. *ocularis* Lea – found in pond in permanent stream (it is unknown if these species actively breed as a colony within the cave) –Dz, *Paroster couragei* Watts [B. Knott] from sift netting sample at the terminal watertable expression ~1.7 km into the cave -Dz (Susac, 2007). Cholevidae; *Pseudonemadus australis.* Anobiidae; *Ptinus exulans.* Curculionidae; *Leptopius colossus* Pascoe –dead & fungus covered near base of entrance talus slope (Lowry, 1980). Scaraboidea sp. (Moulds, 2007). Diptera: Phoridae: *Metopina* sp., cf. *M. australis* Borgmeier –Tz.
Hemiptera: Heteroptera: Reduviidae: *Centrogonus* sp. predatory genus –accidental, near entrance (Lowry, 1980).
Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).
Odonata: Lestidae: Corduliidae; *Hemicordulia tau* –epigean washed in accidentally as nymphs –Dz (Lowry, 1980). Orthoptera: Acrididae; *Porraxia nana* Sjöst –accidental.
Lepidoptera: Cosmopterigidae: sp.1 larvae (Lowry, 1980) (caterpillars) (Markey, 1990). Geometridae sp. accidental, larvae near top of entrance talus slope.
Psocoptera: Liposcelidae: *Liposcelis* sp. with rat faecal pellets –Dz (Lowry, 1980).
E-10 = >29 invertebrate cavernicolous species.

E-11 Emu Cave;
Arthropoda; Arachnida; Araneae: Theridiidae; *Achaearanea* spp. –Tz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* associated with a kangaroo carcass (Lowry, 1980).
Insecta: Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* –Dz (Lowry, 1980). = 3 known invertebrate cavernicoles.
Bones; contained the skeletons of three emus (*Dromaius novaehollandae* Latham) chicks, macropods; *Macropus fuliginosus* Desmarest (western grey kangaroo) and other material (Robinson, 1964).

E-12 Facts of Life Cave; so named for the birds and the bees. Swallows nest here and an occasional bat has been reported (Robinson, 1964). Feral goats (*Capra hircus* Linnaeus) are regularly sheltering here as implied by the abundance of fecal pellets.
Arthropoda; Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia* sp. -Tz (Lowry, 1980).
Insecta; Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).

E-13 East /E-14/ West, Little Three Springs Caves; bat guano with much fossil material evident (Robinson, 1964). E-14 is a watershed reserve.
Insecta; Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).

E-15D Delta Half Doline;

E-16 Flatworm Cave; so named as the cave contains many flatworms;
Platyhelminthes: Turbellaria: Planariidae: Tricladida sp. (flatworms).

E-17D Zamia Palm Doline;

E-18E____; hydrological efflux (Mathews, 1985).

E-19 _____;
Annelida; Oligochaeta: Microdrillidae – inhabiting washed in kangaroo pellets -Tz. Arthropoda; Arachnida; Araneae: Araneidae; *Araneus transmarinus* Keyserling - found in entrance solution pipe –Tz, *Arachnura* sp. entrance Tz, Theridiidae: *Achaearanea* spp. –Tz (Lowry, 1980).
Acarina: Metastigmata: Argasidae; *Ornithodoros (Pavlovskyella)* sp.2 pit trap-Tz.
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* (Lowry, 1980).
Hexapoda; Collembola: Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance (Lowry, 1980).
Insecta; Coleoptera: Scaritinae; *Scaraphites silenus* Westwood & Psydrinae; *Mecyclothorax ambiguous* both accidental –Tz, Staphylinidae; *Quedius luridipennis* cave entrance, Anobiidae; *Ptinus exulans* collected in both 1969 & 1974 near the same dessicated kangaroo carcass along with psuedoscorpion; *P. cavernarum*. Scarabaeidae; *Heteronyx* sp. accidental –Tz. Buprestidea; *Stigmodera (Themognatha) heros* Géhin –accidental found dead -Tz. Tenebrionidae; *Helaeus perforatus* Latreille – Tz – Dz. (Lowry, 1980).
Diptera: Sciaridae: an unidentified sp.1 larvae was found in kangaroo faecal pellet – Tz. Phoridae: *Megaselia* sp.1 baited pit traps in all zones (Lowry, 1980).
Hymenoptera: Ichneumonidae; *Lissopimpla excelsa* Costa –accidental, found dead – Tz (Lowry, 1980). Lepidoptera: Cosmopterigidae sp.1 –Tz. Oecopterigidae sp. accidental, cased larvae – Tz (Lowry, 1980). E-19 = >14 invertebrate species.

E-20 Seismic Cave; contains bats. An owl pellet and bones were collected by P. Bridge (1973).

E-21 _____; solution tube peppered kankar lattice overlaying a low chamber. Flatworms (Tricladida sp.) seen within by P. Bridge in 1966 (Bridge, 1973).

E-22 Arramall Cave; the caves entrances are on private property but the cave system passes beneath the Brand Highway. Development of this cave is attributable to phreatic stream passage outflows that were seasonal and can now be considered episodic. Repeated bifurcation of the streams occurs deeper into the cave (Williamson, 1976). It contains trogloxenes; bats with old guano piles evident from *Macroderma gigas,* but now supplemented by *Chalinolobus morio*[13]. Moonmilk is located in isolated pockets after the darkness transitional zone thermocline[3] and is often accompanied by the intrusion of roots[15]. Average annual temperatures in this area range from; 17.6°C ± 1.1°C at 63 m from the entrance to 18.7°C ± 0.6°C at 125 m from the entrance (Lowry, 1980). A temperature of 23°C; July - recorded at 1170 m from the entrance (Caffyn, 1973). The moonmilk itself often displays marks which are the scrapings of bat claws suggesting some association; possible moisture or mineral dietary supplementation or a microclimatic preference (Susac *et al.* 2007). Upper sections within the cave have areas of preserved phytolithic material and palaeosol breccia. *Hirundo neoxena* nests in the entrance[14] (Susac *et al.* 2007).
Troglophiles; *Litoria moorei,* frogs and recorded troglobites.
Annelida; Oligochaeta: Microdrillidae –found in mouldy flood debris –Dz (Lowry, 1980). Mollusca; accidentals washed in with flooding, -Gastropoda: Pulmonata: Bithyniidae: *Gabbia* sp.*,* Planorbidae: *Physastra* spp., *Gyraulus* sp. & Succineidae: *Austrosuccinea* sp. aquatic accidentals probably deposited by flood. Punctidae: *Paralaoma* sp. (Lowry, 1980).
Arthropoda; Arachnida; Araneae: Amaurobiidae sp.. Araneidae: *Araneus* sp. entrance, Stiphidiida; *Baiami volucripes*[32]*, B. Epimecinus* sp.*, B. Ixeuticus* sp. including a troglomorphic variety, Clubionidae sp. –Dz. Sparassidae sp. found as a cast moult. Theridiidae: *Achaearanea* spp., *Latrodectus mactans* Thorell (black widow) (Lowry, 1980)*, Steatoda* sp. on webs built amongst flood debris -Dz*, Pholcomma* sp.*,* unidentified spp. –Tz. Linyphiidae: *Laetesia* sp. troglomorphic, blind & depigmented. Pisauridae sp. -Dz (Lowry, 1980). Opiliones: Triaenonychidae; *Nunciella aspera* Pocock –cave wall -Tz (Lowry, 1980).
Acarina: Mesostigmata: Ameroseiidae; *Kleemannia plumose* Oudemans –from dipteran pupae cases & bits of dried tissue under a desiccated fox carcass –Tz. Blattisociidae: Blattisocius sp. predator separated from swallow guano & nest debris, collected under the nests near two entrances –Tz. Dermanyssidae: Dermanyssinae: unidentified sp. bird parasites & Oribatei sp. separated from disused nests & guano beneath nests –Tz. Laeleapinae: *Hypoaspis* sp. associated with rodents taken from fungus covered soil & flood debris –Dz. Ichtyostomatogasteridae; *Asternolaelaps australis* Womersley & Domrow from swallow guano collected in Tz. Prostigmata: Stigmaeidae; *Calligonella humilis* Koch predator separated from desiccated tissue & blowfly pupaecases, collected from under a fox (*Vulpes vulpes* Frisch) carcass -Tz. Astigmata: Cryptostigmata: Palaeacari spp. swallow guano, feathers & beneath nest debris (Lowry, 1980).
Pseudoscorpionidea: Chthoniidae; *Austrochthonius australis* Hoff -from flood debris –Dz (Lowry, 1980). Cheliferidae; *Protochelifer cavernarum*[7] swallow guano, human, fox & canine faeces, fox corpse (Lowry, 1980, 1996). Cheiriidae; *Cryptocheiridium australicum* [Beier] soil, debris near entrance & swallow guano (Lowry, 1980). Crustacea (Malacostraca); Isopoda: Philosciidae; *Laevophiloscia yalgoonensis, L. unidentata L. richardsae* (Vandel, 1973), *Tripectenopus unidentata* (Britton, 1974). Armadillidae; *Hybodillo australiensis* Vandel -blind & depigmented associated with rotting branches washed in Dz (Lowry, 1980).

Myriapoda; Chilopoda: Scutigeridae; *Allothereua lesueurii*[16] one twilight species and one very rare variety that is troglomorphic(Lowry, 1980, 1996). Scolopendromorpha spp. one sp. is troglomorphic (Lowry, 1980).
Symphyla: unidentified species, the first recorded Symphyla from Australian mainland caves, associated with decomposed fox/canine scats on moist stream floor – Dz (Lowry, 1980).
Hexapoda; Collembola: Poduridae: *Setanodosa* sp., cf *S. afurcata* Womersley separated from moss growing on the lintel & moist plant debris collected near a roof window along with Isotomidae: *Folsomides* 2 spp., cf *F. sexopthalma* Womersley associated with *F. angularis*, *Isotomodes productus* Axelson – cosmopolitan soil dweller separated from flood debris –Dz. Onychiuridae: *Tullbergia* 2 sp.1 & ? (*krausbaueri* group) soil inhabiting genus separated from coarse flood debris –Dz. Entombryiidae: *Entombrya* sp. from *M. gigas* fossil guano –Dz, *Lepidocyrtoides* sp. litter dwelling found on walls in entrances some also separated from flood debris in Dz, moister material had 3 *Pseudosinella* spp., also from lintel moss (Lowry, 1980).
Diplura: Japygidae spp. –Tz (Hamilton Smith, 1967).
Insecta; Blattodea: Blattellidae: depigmented, troglobite; *Paratemnopteryx* sp. (Roth, 1991), Blattellinae; *Neotemnopteryx douglasi*[17] (Moulds, 2007).
Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus* found in all zones. Lebiinae; *Speotarus lucifugus* Moore found in all zones but more abundant at the commencement of the Dark Zone. Pterostichinae; *Catadromus lacordairei* Boisduval –fragments found on a mound of *M. gigas* guano (prey or wash-in) (Lowry, 1980). Dermestidae sp. (?) larvae, under represented in Australian guanobite communities – Tz (Moulds, 2007). Histeridae: *Saprinus* sp. swallow guano –Tz (Lowry, 1980). Staphylinidae; *Tripectenopus occultus* Britton -blind but pigmented, very rare; not recorded since 1969, *Leptacinus* sp. separated from flood debris –Dz. Pselaphidae spp.. Lathridiidae; *Corticaria adelaide* flood debris & near a roof window –Dz, *Lathridius* sp. separated from swallow guano near roof window (Lowry, 1996). Tenebrionidae: Tenebrioninae; *Anemia caulobioides*[18] Carter (darkling beetle) downstream of a large daylight hole –Tz & from flood debris -Dz (Williamson, 1976) (Moulds, 2007). Pythidae sp. near a dead frog -Tz (Lowry, 1980). Coleopteran accidentals: Dytiscidae; *Cybister tripuntatus* Oliver & *Eretes Australia* Erichson both remains from debris wash in with flooding –Dz, Hydrophilidae; *Berosus australiae* Mulsant, *Hydrous albipes* Castelnau & *Limnoxenus zelandicus* Broun -remains on flood debris washed in, Staphylinidae; *Paederus meyricki* Blackburn collected at the lintel line, Lampyridae: *Luciola* sp. separated from debris under roof window, Coccinellidae; *Coccinella repanda* Thunberg –widespread species –Tz, Tenebrionidae; *Helaeus perforatus* – accidental, Tz – Dz, *Pterohelaeus* sp. –Tz, *Adelium* sp. found under roof window, Mycteridae or Pythidae sp. found dead under roof window (Lowry, 1980).
Diptera: Sciaridae: *Sciara* sp.2 (*Bradysia* sp.?) found in all zones along with a sp. 1 found by A. Richards on the Nullarbor (1971). Phoridae: *Megaselia* spp.1 & 2, sp.1 - particularly abundant in Dz. Sphaeroceridae: *Leptocera* sp.2 –Dz. Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance along with pupae cases taken from a swallow nest, *Chrysomya rufifacies* Macquart & C. *varipes* Macquart – both found as pupae cases near fox carcass & swallow guano under a nest with fox faeces –Tz. Drosophilidae: *Drosophila* sp. accidental, caught in baited trap at entrance (Lowry, 1980).

Hemiptera: Homoptera: Meenoplidae: unidentified sp. unpigmented –Dz, Cydnidae: *Aethus* sp. –accidental associated with run-off, feeds on roots, near a roof window (Lowry, 1980).
Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980). Formicidae: Ponerinae: *Rhytidopoera* sp. collected from swallow guano –Tz. Dolichoderinae: *Tridomyrmex* sp. associated with swallow guano under a disused nest –Tz (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. (*M. crocicapitella*{?} -larvae (Moulds, 2007)) – Tz with swallow guano or nests as larvae separated from guano, as larval cases in guano or under a fox carcass & on wall near nest & as adults with guano under a nest. Noctuidae; *Dasypodia selenophora* is a regular troglophile Tz – Dz, *Persectania dyscrita* Common -wings under swallow nest (Lowry, 1980).
Psocoptera: Liposcelidae; *Liposcelis corrodens* Broadhead –from guano under swallow nest & fox scull in entrance -Tz & very old bat guano –Dz (Smithers, 1975), *L.* sp. from baited pit trap –Tz (Lowry, 1980). Trogiidae: *Lepinotus inquilimus* Heyden -from swallow nests & guano at the entrance (Smithers, 1975). Trogiomorpha: Psyllipsocidae; *Psyllipsocus ramburii* Selys-Longchamps & *P.* sp. associated with frog corpse both –Dz (Lowry, 1980). E-22 = >83 invertebrate species.
Bones; macropods, *Vulpes vulpes* (fox) & bat corpses (Susac *et al.* 2007).

E-23 River Cave; situated on private property near Lake Arramall; River Cave represents an intermittently active inflow (episodic). Etiolated creepers have been found growing within the caves dark zone (Bastian, 1960). A bat has been sighted leaving the cave's inflow passage at dusk (Williamson, 1976) and bats have been heard in the cave's larger sections of passage (personal observation, March, 2007). The cave has a higher degree of surface connectivity allowing for a more even distribution of organic inputs throughout the cave. This connectivity also allows for more rapid desiccation of the fauna as the environment dries significantly during summer and autumn. It attracts troglophiles such as frogs, gastropods, barking geckos[19] (Gekkonidae; *Underwoodisaurus milii* Bory) and snakes.
Annelida; Oligochaeta: Microdrillidae: found in moldy flood debris –Dz (Lowry, 1980). Mollusca; Gastropoda: Pulmonata: Planorbidae: *Physastra* spp. & *Isodorella* sp. aquatic accidentals probably deposited by flooding.
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida; *Baiami volucripes, B. Ixeuticus* sp.. Theridiidae: *Steatoda* sp. on webs built amongst flood debris -Dz, *Pholcomma* sp. on webs against flood debris, unidentified spp. –Dz/Tz (Lowry, 1980). Clubionidae sp., Gnaphosidae -Tz, Pisauridae –Dz (Lowry, 1980). Many harvestman spiders (Opiliones: Triaenonychidae: *Nunciella* sp.) have been sighted in this cave congregating around clusters of moist rootlets that cascade intermittently throughout the cave (personal observation, November 2005). These roots were desiccated and most fauna absent in March 2007. Salticidae sp. entrance Tz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* (Lowry, 1980, 1996).
Crustacea (Malacostraca); Isopoda; *Laevophiloscia yalgoonensis, L. unidentata* –Dz, *L. richardsae* including a troglomorphic variety (Vandel, 1973). Armadillidae; *Hybodillo australiensis* blind & depigmented associated with rotting branches washed in -Dz (Lowry, 1980).
Hexapoda; Collembola: Poduridae: Entombryiidae: *Pseudosinella* sp. from moist flood material –Dz (Lowry, 1980).
Insecta; Blattodea- Blattellidae unidentified troglobite (Lowry, 1980).

Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus* found in all zones, Staphylinidae; *Quedius luridipennis* Mackleay -cave entrance, Anobiidae sp. collected under a roof window (Lowry, 1980). Tenebrionidae sp. (pie dish beetle) –Tz (Susac *et al.* 2007), *Helaeus perforatus* – Tz – Dz, Pythidae sp. flood debris & sand under a sealed solution tube –Dz. Hydrophilidae; *Berosus australiae* –accidental; remains on flood debris. Scarabaeidae; *Heteronyx rudis* Blackburn –under roof window, Sylvanidae sp. accidental; from roof window. Coccinellidae; *Coccinella repanda* Thunberg –widespread species, accidental –Tz, Anthicidae: *Formicomus* sp. & Curculionidae sp. both accidentals, found under roof window (Lowry, 1980). Hemiptera: Hyocephalidae; *Hyocephalus aprugnus* Bergroth –accidental, (rare) from litter near roof window, Pentatomidae; *Dictyotus caenosus* Westwood -accidental collected near roof window (general ground dweller) (Lowry, 1980).
Reduviidae: Harpactorinae sp.3 –Tz (Moulds, 2007).
Hymenoptera: Mutillidae: *Ephutomorpha* sp. found under a roof window (Lowry, 1980). Braconidae sp.1 accidental –Tz (Moulds, 2007).
Psocoptera: Trogiidae sp.2 –transitional (Moulds, 2007).
E-23 = >26 invertebrate cavernicolous species.

E-24 Weelawadji Cave, (Jankara or Woodada Cave); D.C. Lowry (1974) attributes the caves possible formation to the Eneabba Creek. The large doline entrance[20] is situated in a flora reserve and the cave has been used for previous biological studies. Contains trogloxenes, troglophiles and Troglobites. In addition to the common cave bird species; *Hirundo neoxena*[21], nests of the fairy martin; *Hylochelidon ariel* Gould, occur just inside the lintel (Lowry, 1980). An owl roosting site[22] (detemined to be used by a boobook {*Ninox novaeseelandiae*} through numerous shed feathers), was noted on a prominent stalagmite looking over the entrance chamber with an abundance of bones located at the base including many rodents and dasyurids[23] (Susac *et al.* 2007). Feral goats and foxes regularly shelter here as implied by the abundance of their faecal matter found throughout the entance chamber.

Weelawadji Cave is an important bat maternity site; *Chalinolobus morio*[2], *C. gouldii*, and *Vespadelus* sp. recorded as *Eptesicus pumilus* Gray, with large guano mounds and fine roots present (Mathews, 1985). *C. morio* is far more abundant than other species and also approximately half the size of other bats (Capon, 1981). It was noted that fewer bats were present with the onset of winter and the mating season during the subsequent trips from May to June 2007, with only a few present on 3 June 2007, and none apparent on 24 June 2007 (Susac *et al*. 2007). Deeper within the mounds is fossilized guano from *Macroderma gigas*. Deep into the cave on the left hand side passage tiny tree roots exploit cracks in the mud and old guano providing habitat for isopods and silverfish with an associated group of tiny predatory arachnids (Anderson, 2007). Palaeosol horizons containing phytolithic breccia are evident[5].
Annelida; Oligochaeta: Microdrillidae –from dry guano, entrance base (Lowry, 1980).
Mollusca; Gastropoda: Pulmonata: Bulimullidae; *Bothriembryon perobesus* Iredale -Tz, Punctidae: *Paralaoma* sp. Tz (Lowry, 1980).
Arthropoda; Arachnida; Amaurobiidae: Stiphidiida; *Baiami volucripes* including a troglomorphic variety, *B. Ixeuticus* sp. -Tz. Clubionidae sp.. Oecobiidae: *Oecobius* sp. entrance Tz. Theridiidae: *Achaearanea* spp., Mimetidae: *Mimetus* sp. -Tz (Lowry, 1980). Salticidae sp. entrance Tz (Lowry, 1980).

Acarina: Mesostigmata: Ameroseiidae; *Kleemannia plumose* –from bat guano, debris & sand under fox faeces & under a dead bat. Laeleapinae: *Hypoaspis* sp. bat guano collected at the base of the entrance rock slope. Macronyssinae sp. bat parasites taken from guano at the base of a rockpile –Tz. Ichtyostomatogasteridae; *Asternolaelaps australis* Womersley & Domrow -dry floor debris near entrance & bat guano -Tz. Prostigmata: Ereynetidae: *Ereynetes* sp. & Cheyletidae: *Chelacaropsis* sp. & *Chelatonella* sp. all separated from swallow nest material & organic debris close to entrtance in Tz, *Cheyletus* sp., unidentified sp. both separated from dried rumen contents of a feral goat (*Capra hircus* Linnaeus) carcass in the Tz (Lowry, 1980), *Granulocheyletus corpuzrarosae* Fain & Bockov, 2002. Cunaxidae; *Cunaxa setirostris* Herman -debris & Erythraeoidea spp. (& bat carcass -Dz) blowfly pupae cases associated with a goat carcass Tz (Lowry, 1980). Astigmata: Glycyphagidae; *Austrolycyphagus weelawadjiensis* [Fain & Lowry] separated from materials near dead goat in Tz & bat guano Dz (Lowry, 1980). Rosensteiniidae: *Nycteriglyphus* sp. troglophile, separated from bat guano –Dz. Pyroglyphidae; *Weelawadjia australis* [Fain & Lowry] separated from cave floor debris, rich in bat guano, collected close to entrance (Lowry, 1980). Cryptostigmata: Palaeacari spp. swallow guano & cave floor debris, fox faeces, bat guano –Tz- Dz (Lowry, 1980). Trombidiidae sp. (velvet mites) –transitional zone, characteristically an insect parasite (Moulds, 2007).

Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* fox faeces, regurgitated owl pellets & goat carcases (Lowry, 1980, 1996). Cheiriidae; *Cryptocheiridium australicum* –swallow guano; debris near entrance rock slope containing dead bees & other insects, bat & swallow guano, goat faeces, organic debris & feathers, fox faeces, owl pellet, bat carcass, bat guano Tz – Dz (Lowry, 1980).

Crustacea; Isopoda: Philosciidae; *Laevophiloscia Hamiltoni* Vandel, *Laevophiloscia yalgoonensis* in 'the hot room'-Dz, *L. unidentata L. richardsae* (Vandel, 1973) plus undetermined spp.. Armadillidae; *Buddelundia bipartite* Budde-Lund (Lowry, 1980).

Myriapoda; Chilopoda: Scolopendromorpha spp. one is a troglomorphic variety (Lowry, 1980). Cavernicolous millipede (Webb, 1979). The cast moults of many centipedes were found clustered in one place[24] –Tz (observation; Z. Gibbs, 3 June 2007) (Susac *et al*. 2007).

Insects; Hexapoda; Collembola: Poduridae: Isotomidae; *Folsomina yosiii* Lawrence – soil inhabitant separated from fossil guano of *M. gigas* covered with a light sprinkle of recent guano near a drip –Dz. Entombryiidae: *Pseudosinella* sp. 1 & 3 Bat guano -Tz & Dz, *Drepanura* sp.- accidental epigean caught in trap by lintel line (Lowry, 1980).

Insecta; Apterygota: Thysanura: Nicoletiidae: Nicoletiinae *Trinemura* sp. –Dz (troglobitic silverfish) (Moulds, 2007).

Abundant Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi*[25] (Tz)-Dz; common (Lowry, 1996) (Moulds, 2007).

Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus* found in all zones, *Notospeophonus pallidus* Moore -a new extension of previously known Nullarbor range. It has established itself predominately in the Twilight Zone with only fragments found deeper into the cave. Lebiinae; *Anomotarus subterraneus* Moore -previously only known from Riverton Cave, southern Queensland; samples here were associated with bat guano & a goat carcass near entrance, *Speotarus lucifugus* abundantly more established with the commencement of the Dark Zone (Lowry, 1980). Pterostichinae; *Sarticus iriditinctus* Chandoir –accidental caught in pit trap set high on entrance talus slope, Pentagonicinae; *Scopodes sigillatus* -accidental –Tz. Histeridae; *Gnathoncus ripicola* Marseul & *Saprinus* sp.[27] -collected from regurgitated owl pellets & a goat carcass in entrance & bat guano at the base of talus slope where the species was plentiful. Staphylinidae; *Quedius luridipennis* under a stone on bat guano, *Conosoma* sp. near entrance, *Polylobus longulus* Olliff –accidental, from fallen swallow nest material –Tz. Pselaphidae; *Ctenicellus major* Raffray –separated from goat faeces near entrance. Scarabaeidae sp. larvae, *Onthophagus flavoapicalis* Lea –accidental from insect trap at lintel line (unusually small). Anobiidae; *Ptinus exulans* extreme abundance associated with bat guano. Lyctidae; *Lyctus discedens* Blackburn separated from goat faeces –Tz. Cleridae; *Necobia rufipes* De Geer -found in the dried rumen contents of a goat carcass, this cosmopolitan species infests products with high fat content & is associated with corpses. Lathridiidae; *Corticaria adelaide* separated from bat guano –Dz. Tenebrionidae: Tenebrioninae; *Anemia caulobioides* separated from owl pellet & fox faeces –Tz, *Brises acuticornis* Pascoe found in all zones but mainly the Twilight Zone (Lowry, 1980) & *B. acuticornis* sub sp. *duboulayi* –Tz representing a known range extension from more arid regions (Moulds, 2007), *Helaeus* sp. found as larvae near goat carcass, *Pterohelaeus guerini* Breme -abundant in the Twilight Zone particularly the entrance, another member of this family found dead as a larvae under a stone –Tz, Alleculinae sp. larvae separated from goat faecal pellets –Tz along with a representative of either: Mycteridae or Pythidae. Elateridae; *Conoderus* sp. accidental –Dz (Lowry, 1980).

Diptera: Sciaridae: *Sciara* sp.3 (*Bradysia* sp.?) close to the entrance. Phoridae sp. associated with a recently dead bat –Dz. Muscidae: *Musca* sp. found as pupae cases near goat carcass. Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance & adult flies resting on walls –Tz, *C. varifrons* Malloch found as pupae cases associated with swallow nest material –Tz, *Chrysomya rufifacies*–found as pupae cases near goat carcass –Tz (Lowry, 1980).

Hemiptera: Heteroptera: Anthocoridae: *Cardiastethus* sp. predator -separated from cave floor debris, hair, blowfly pupae cases & bits of dried tissue near a goat carcass in the entrance. Lygaeidae: *Pachybrachius* sp. –accidental; seed feeder, common in litter (Lowry, 1980).

Hymenoptera: Apidae; *Apis mellifera* nests found here have been particularly numerous and ferocious but have been less so from May to June 2007 (Susac *et al*. 2007). Formicidae: Ponerinae: *Cerapachys* sp. & an unidentified sp. along with Leptanillinae: *Leptanillae* sp. all captured in baited trap near lintel line (Lowry, 1980).

Lepidoptera: Teneidae: *Monopis* sp. (*M. crocicapitella*{?} (Moulds, 2007)) as larval cases with fresh bat guano, cave-floor debris, hair & dipteran pupal cases near a goat & as pupal skins in the dried rumen contents & as larvae separated from fox scats & owl pellets –Tz & with bat guano both fresh & fungus coated as larvae, & with larval cases on old guano –Dz. Adults were captured in baited traps & seen flying in Dz along with unidentified species, Cosmopterigidae sp. adults resting on a sack & wood –Tz, Noctuidae; *Dasypodia selenophora* –Tz-Dz (Lowry, 1980).
Orthoptera: Acrididae: *Beplessia* sp.3 –accidental (Lowry, 1980).
Psocoptera: Troctomorpha: Liposcelidae sp.. Trogiidae; *Lepinotus inquilimus* & *L.* sp. both associated with a dead goat in the Tz, *Liposcelis corrodens* from under swallow nest material in entrance (Smithers, 1975), *L.* sp. from baited pit trap & regurgitated owl pellets –Tz (Lowry, 1980). Trogiomorpha: Psyllipsocidae; *Psyllipsocus ramburii* (& *P.* sp. both separated from goat rumen contents) –Tz (Lowry, 1980).
Siphonaptera: Pucilidae; *Ctenocephalides* sp. –Tz (Lowry, 1980). = >83 invertebrates.
Bones; calcified bats including *Macroderma gigas* many skulls and fragments in the entrance area and scattered throughout the cave, particularly in proximity to roost sites. This vast array of bones is at risk of being trampled and collection as souvenirs. Skinks as bones & corpses (*Tiliqua occipitalis* Peters, *Tiliqua rugosa*).
The following bones have been found [Identified by B. Johnson, June 2007, DEC]
Dasyuridae
Antechinus sp.,
Dasyurus geoffroii, Gould (western quoll),
Sminthopsis sp.
Peramelidae
Isoodon sp. (bandicoot) (Lowry, 1969).
Potoroidae
Bettongia pencillata, Gray (brush-tailed bettong, woylie)
Macropodidae
Macropus fuliginosus, Desmarest (western grey kangaroo)
Microchiroptera
Macroderma gigas, Dobson (ghost bat),
Muridae
Pseudomys shortridgei, Thomas (heath rat),
Rattus fuscipes, Waterhouse (bush rat)
(Susac, 2007).

E-25 Honey Cave;

E-26 Lake Erindoon Cave;

E-27D____;

E-28H____;

E-30 Drip Cave; reputed 'permanent' small pool of fresh water (Campbell, 1909).
Hexapoda; Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi.* Coleoptera: Anobiidae; *Ptinus exulans* (Lowry, 1980). E-30 = 2 invertebrate species.
Bones; numerous of small animals and birds (Campbell, 1909).

E-31_____; Owls recorded roosting here, minor pellet deposit evident (Lowry, 1969). Insecta; Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).

E-32E Arramall doline; has a hydrologic connection to Arramall Cave as an efflux into the main western passage of E-22, intersecting at ~100 m.
Insects; fleas, ticks (Howeison, 1990).
Bones; Echidna (*Tachyglossus aculeatus* Shaw) (Webb, 1979). Macropod (kangaroo) skeletons (Howeison, 1990).

E-33D, E-34D, E-35H____; dolines and a sinkhole.

E-37D, E-38D, E-39D, E-40D, E-41D_____; dolines.

E-42D, E-43D, E-44D____; degraded dolines.

E-45 Red Brush Cave; contains the mummified remains of a fox (Caffyn, 1972a).

E-46 _____; situated on private property near Lake Arramall; this cave is reported to contain troglophiles and it has been used for a biological study (Mathews, 1985), but no details are available. The first reported trip was by P. Caffyn; 18 Sep1972 (Caffyn, 1972b).

E-47E____; Hydrological efflux; private property (Mathews, 1985).

E-48 Sponge Cave; situated on private property near Lake Arramall, a W.A. endemic freshwater sponge grows on the roof and walls; Porifera: Spongillidae; *Heterorotula multiformis* Weltner -as the cave floods after heavy winter rains (Lowry, 1976).

E-49 Rat Cave; some decoration; surface area used for biological reserve.

E-50E Weelawadji Cave; this efflux is a surface feature between E-24 and E-52.

E-51E Skylight Cave; hydrological efflux.
Arthropoda; Arachnida; Araneae: Theridiidae: *Achaearanea* spp. (Lowry, 1980).
Insecta; Blattodea- Blattellidae; unidentified troglobite (Lowry, 1980).
Lepidoptera: Notodontidae; *Eudesmeola lawsoni* Felder -accidental, -Tz (abdomen eaten by psocids) (Lowry, 1980).
Odonata: Lestidae: Corduliidae; *Hemicordulia tau* –epigean, washed in as nymphs –Dz (Lowry, 1980).
Psocoptera: Troctomorpha: Liposcelidae: *Liposcelis* sp. with dead invertebrates; (moth) in Dz. Trogiomorpha: Psyllipsocidae; *Psyllipsocus ramburii* –Dz (Lowry, 1980). E-51E = >4 invertebrate cavernicolous species.

E-52 Weelawadji West; used in a palaeontological study. The sinkhole entrance claims accidental captives such as snakes (dugite[26]; *Pseudonaja affinis* Günther) and lizards (western bearded dragon[28]; *Pogona minor* Loveridge) (20 May 2007) (Susac, 2007).
Arthropoda; Arachnida: Theridiidae: *Achaearanea* sp., Lycosidae (Moulds, 2007).

Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* (Moulds, 2007). Hymenoptera: Apidae; *Apis mellifera* –although no nests are present in the entrance hole bees are sometimes encountered in the solution pipe seeking moisture.
Coleoptera: Histeridae: *Saprinus* sp.[27] –Tz –transition zone predator associated with bat guano deposits (irridescent emerald green beetle).
Lepidoptera: Teneidae: *Monopis crocicapitella* (Moulds, 2007). E-52 = >5 invrt. spp..
Bones; of *Macroderma gigas* the ghost bat[29] at the caves terminus. Large Macropods.

E-53 Swallow Cave; entrance home to several *Hirundo neoxena* nests.
Arthropoda; Arachnidae: Araneae: Theridiidae sp. (Foulds, 1996).
Bones; *Macropus* sp., 5 x *Tiliqua rugosa* skeletons (Webb, 1979b).

E-54 Syg Cave;

E-55 Fisherman's Pot; located on private property. Contains; speleothems and moonmilk that are desiccated and show signs of significant degradation. Boreholes on this property intersected large voids (6.5m↕) and draft air heavily (Nannink, 1979).

E-56 WAIT Cave; six pothole entrances, with a large chamber and dry stream passage with standing water intermittently occurring after winter rains.
Important for geomorphology (Mathews, 1985).

Gap Assessment

The gap assessment component of this report is to highlight and summarize areas that can be enhanced with further investigation. This is included for each karst area. In order for the information that is presented in this report to be fully useful to managers as a workable reference component, the material should be incorporated in an accessable database. Tasks implemented, can then be recorded in this updatable tool.

Dolines in the Stockyard System that have been assessed as having little in the way of potential leads could be re-assessed using Ground Penetrating Radar (GPR) in conjunction with a visual inspection. This may be valuable as new caves have been found to be opening up at an increasing rate. This phenomenon has been realized further south at Yanchep caves due to the desiccation of the landscape due to reduced rainfall and subsequently the watertable. When this occurs it leaves the soil profile more vulnerable to subsidence if subterranean voids are present below. This is particularly so when an area is exposed subsequently to episodes of heavy rainfall. Some areas may only require the removal of small amount of material (be it soil or rubble) to be accessed. This would allow investigation into areas never seen before. When significant areas are accessed it is important to make an effort to cover a new entrance created with a large stone after exiting so as to provide caves with a degree of protection from lost humidity. Where this is not possible fallen branches or logs will help to achieve this. These investigations require some discretion of their individual values and should be considered in relation to the broader karst system and the proximity of other available entrances. Where there is a likelihood of intersecting an existing accessable cave this sort of exploration should not be undertaken.

These general statements are applicable to karst systems in general and not exclusive to the Eneabba karst area. The importance of this is that the type of organism found in a cave environment is intrinsically linked to the type (or existence) of cave entrance present. This considered; a cave environment that is physically opened may be compromised in some way in regards to its microclimate and should be biologically assessed promptly.

It is evident that there is much more to the karst system servicing Lake Arramall than is currently known and documented. These areas should be further assessed for their biological significance. This would be particularly valuable after the influence of a flood-based pulse event in the area, this is recommended for E-22, 23 and including E-46-48 of which very little is known. This area being under private tenure will require prior liaison with the land holders. A review of caves in the Stockyard System E-1 to E-3 including E-9, 10 & 56 should also take place after a flood event in order to assess the ecological condition of the cave and to better understand the successional dimension of the community.

JURIEN

The karst is of Pleistocene aeolian calcarenite where the fossilized remains of the mollusc *Luinodiscus* are a conspicuous shell fossil (Kendrick, 1965). Calcareous algae and foraminifera are the other main biogenic limestone components with rounded quartz forming the remainder (Lowry, 1974). The dominant surface geological unit is Quaternary Tamala Limestone which overlays Mesozoic sediments (Goh & Begg, 2000). Cockleshell Gully is the main drainage unit for the Bassendean Dunes to the east, conducting flows onto the coastal plain, Munbinea Creek and tributaries of the Hill River flowing south (Baynes, 1979).

Representatives from the families; Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum*, Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx (Shawella) douglasi* {first collected from Jurien caves and associated with guano from *Vespadelus* sp. recorded as *Eptesicus pumilus* Grey, (Princis, 1963)} and Coleoptera: Anobiidae; *Ptinus exulans* are represented in this area as disjunct extensions of previously known ranges (Moulds, 2004).

Borehole sampling of stygofauna has been undertaken in the Jurien area by Biota Environmental Services from 35 bores. Of the 35 bores; 7 yielded stygofauna totalling 96 specimens, of which all were Crustacea with 91 amphipods and 5 copepods found in one borehole (Armstrong & Higgs, 2002). Identifications by Dr Brenton Knott (Department of Zoology UWA, 2002) revealed at least two undescribed species present; one belonging to a family under the super family Crangonyctoidea with a southerly distribution, and a species in the genus *Austrochiltonia* (Family: Ceinidae) from the northern part of the study area (Armstrong & Higgs, 2002) including the stream in J-7 (Foulds, 1994).

J-1 Gooseberry Cave; situated on private property this large cavern is important for its bat population, *Chalinolobus morio* as it is an important maternity site (~400 individuals (Cook, 1962), ~300 (Hamilton-Smith, 1965), ~80 March (Susac *et al.* 2007)) with the guano providing an energy resource for a guanobite and guanophile based invertebrate community. Estimates of population size suggest that numbers of bats have decreased significantly over the last 45 years. A large carpet python (*Morelia spilota imbricate* Smith) has been seen to regularly inhabit the cave (pers. comm. C. Cook, 5 March 2007). The caves expansive interior fosters an extensive and predominately productive Twilight Zone. Large active nests of *Apis mellifera*[6] were treated with pyrethrum laden talc on 7 April 2007 by Joe Tonga (Susac *et al.* 2007).
Arthropoda; Arachnida; Araneae: Theridiidae spp. -Tz.
Acarina: Cunaxidae sp. (orange & red mites) transitional (Moulds, 2007).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* collected from guano -Tz (Hamilton-Smith, 1965) (Susac *et al.* 2007).
Malacostraca; Isopoda: Philosciidae; *Laevophiloscia dongarrensis* ([Vandel], 1973).
Myriapoda; Chilopoda sp. transitional (Moulds, 2007).
Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* –Dz - Tz (Lowry, 1980) (Moulds, 2007).
Coleoptera: Carabidae: Harpalinae; *Notospeophonus pallidus* associated with bat guano (Muir, 1968). A cosmopolitan Coleopteran- Anobiidae; *Ptinus exulans* -Tz (Hamilton-Smith, 1967). Histeridae -unknown sp., Lebiinae; *Speotarus lucifugus* –Tz, the presence of the *Speotarus* sp. greatly expanded the previously known range of this discontinuously represented species in 1965 (Hamilton-Smith, 1965) (Lowry, 1980).
Psocoptera: Trogiidae sp. transition (Moulds, 2007). J-1 = >11 invertebrate species.
Bones; Many bones & corpses are throughout the cave as scattered macropods, bats[30] and lizards; *Tiliqua rugosa,* Gray (bobtail skink). There are also many smaller bones from rodents and much of them are throughout the guano based soil strata and cemented as a bone breccia (Susac *et al.* 2007).

J-2 Drovers Cave; extreme entrance modification by management has decimated the bat population that roosted here (~200 individuals, approximately 50/50 male: female ratio (Hamilton-Smith, 1965)). No bats can now roost here due to the sealed gate that was installed in 1972 and the 2 tonnes of concrete used to seal the solution pipe entrances (Shoosmith, 1972b). This was done at the expense of the caves ecology to tackle the problem of frequent unauthorized access and vandalism. Moonmilk and tree rootlets are prominent in quantity from the roof of the main chamber (Anderson, 2002). The entrance chamber and Twilight Zone was the most biologically active area with an abundance of collembolla and other fauna situated to take best advantage of the modified (reduced) inflows.
Annelida; Oligochaeta: Megadrillidae: from soil, (earthworms) –Tz (Lowry, 1980).
Turbellaria: Planariidae: Tricladida sp. are active after winter rains (Lowry, 1980).
Mollusca; Gastropoda: Pulmonata: Punctidae: *Paralaoma* sp. -Tz & Succineidae: *Austrosuccinea* sp. accidentals both washed in with run-off (Lowry, 1980).
Arthropoda; Arachnida; Araneae: Gnaphosidae from wood debris -Tz [Waldock, 1994], Miturgidae: ctenid –epigean incidental, Opilionida: Triaenonychidae: *Nunciella* sp. –under stones, transitional [Waldock, 1994] (Foulds, 1994). Theridiidae; *Latrodectus hasselti* Thorell (redback spider) -Tz in webs behind the gate in the entrance chamber [31] (Susac *et al.* 2007).
Arcarina: Cunaxidae spp. (mites) (Moulds, 2007). Ixodidae; *Amblyomma triguttatum* (kangaroo ticks) (Lowry, 1980).

Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia yalgoonensis* -collected from bat guano & under wood –Dz (Lowry, 1980).
Myriapoda; Chilopoda sp. transitional (Moulds, 2007).
Hexapoda; Collembola: Entomobrydae sp. from under rocks and of intermitted, high abundance (personal observation) (Moulds, 2007).
Insecta: Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* were collected from bat guano (Hamilton-Smith, 1965) prior to gating & after in transitional zone (Moulds, 2007). Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus* found in all zones (Lowry, 1980).
Hemiptera: Reduviidae: Harpactorinae sp. transitional (Moulds, 2007).
Orthoptera: Rhaphidophoridae: Gen. nov. & sp. nov. –Tz (cricket) (Moulds, 2007). Psochid insects have been noted in the cave (Anderson, 2002). J-1 = >14 invert. spp..
Bones; Calcified in flowstone of possibly *Macroderma gigas* (Webb, 1994) and *Chalinolobus morio* (Anderson, 2002).

J-3 Moorba Cave, (Smithy's Cave); *Macroderma* guano deposits (~2000 tonnes) (Goeczel, 1908) have been extensively mined and are now only supplemented by occasional bats from other species. The deepest piles of guano lie under the largest solution tubes. Tree roots are featured in some upper areas (Anderson, 2001). Significant mineralogy (Mathews, 1985).
Arthropoda; Arachnida; Araneae: Theridiidae spp. –Tz (Moulds, 2007). Araneus sp. entrance (Lowry, 1980). Opilionida sp. transitional (Moulds, 2007). Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* (Moulds, 2007).
Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia yalgoonensis* (Lowry, 1980) & *L*. spp. (Moulds, 2007).
Insecta; Coleoptera: Histeridae: *Saprinus* sp. & Anobiidae; *Ptinus exulans* both associated with swallow guano. Cryptophagidae: *Cryptophagus* sp. caught in a pit trap with abundant swallow guano –Tz, members of this family feed on fungi & mouldy material, Scarabaeidae: *Heteronyx* sp. accidental –Tz. Curculionidae: *Timareta* sp. caught in pit trap –Tz (Lowry, 1980).
Diptera: Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance (Lowry, 1980).
Hymenoptera: Apidae; *Apis mellifera* several very active nests (caution).
Lepidoptera: Teneidae: *Monopis* sp. common as adults flying around guano at the base of the doline (Lowry, 1980). Psocoptera: Liposcelidae: *Liposcelis* sp. associated with moth on swallow guano –Tz (Lowry, 1980). J-3 = >13 invertebrate species.
Bones; *Macroderma gigas*. Many bones of Rodentia, mandibles particularly evident.

J-4 Hastings Cave; an extremely significant palaeoecological site with complex bone material assemblages as a result of predation from owls (*Tyto alba*) producing numerous pellets. As an inclined fissure Cave (Bastian, 1964) the caves wide entrance has taken in large amounts of fluvial sandy sediment. Mammalian Dasyurid predators have also contributed in part to bone remains found in the caves. This has been the subject of a thesis by A. Baynes (1979) and his study has investigated faunal assemblages as an evolving succession throughout the Quaternary period. This has been translated into three principal edaphic zones around the cave for the Holocene period (Baynes, 1982). Based on radiocarbon dating the total duration over the period of bone accumulation could be as much as 17,000 calendar years (Lundelius, 1964), wheras Baynes has put this age extent at 13,000 calendar years (pers. comm. A. Baynes, 1 Aug 2007). Several active nests (23 -counted in 1986, by B. Loveday) of *Apis mellifera* are at the entrance as well as nests from *Hirundo neoxena* providing a rich guano deposit (Lowry, 1976). Snakes have been reported as a visitor hazard in this cave (Mathews, 1985).
Mollusca; Gastropoda: Pulmonata: Punctidae: *Paralaoma* sp. -Tz & Succineidae: *Austrosuccinea* sp. -accidentals, both washed in with run-off (Lowry, 1980).
Arthropoda; Arachnida; Araneae: Theridiidae: *Achaearanea* spp. -Tz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* from swallow guano –Tz (Lowry, 1980).
Insecta; Blattodea: Blattellidae: unidentified –Tz (Lowry, 1980).
Coleoptera: Carabidae: Lebiinae; *Anomotarus minor* Blackburn collected from abundant swallow guano –Tz (widespread but uncommon species), Lebiinae; *Speotarus lucifugus* more established at the darkness transitional zone, Anobiidae; *Ptinus exulans* associated with swallow guano & extremely abundant (Lowry, 1980).
Hymenoptera: Apidae; *Apis mellifera* several active nests.
Lepidoptera: Pyralidae; *Achroia grisella* Don Herbison-Evans (lesser wax moth) this cosmopolitan species is common from swallow guano & organic debris including dead bees and is likely to be associated with bee nests on the lintel (Lowry, 1980).
J-4 = >7 invertebrate cavernicolous species.
Bones; reveal the past presence of *Protemnodon brehus* (Baynes, 1979) (extinct megafauna wallaby). Sub-fossil material assessed by Baynes (1979) based on the surface deposit's fauna; (Baynes, 1982).

Dasyuridae
- *Antechinus flavipes,* Waterhouse (yellow-footed antechinus),
- *Dasycercus cristicauda,* Krefft (mulgara),
- *Dasyurus geoffroii,* Gould (western quoll),
- *Parantechinus apicalis,* Gray (dibbler),
- *Sminthopsis granulipes* Troughton (white-tailed dunnart)
- *Sminthopsis* sp. indt. (dunnart),

Peramelidae
- *Isoodon obesulus,* Shaw & Nodder (southern brown bandicoot),

Potoroidae
- *Bettongia pencillata,* Gray (brush-tailed bettong, woylie),

Macropodidae
- *Macropus fuliginosus,* Desmarest (western grey kangaroo),
- *Macropus irma,* Jourdan (western brush-wallaby)

Microchiroptera
- *Macroderma gigas,* Dobson (ghost bat),
- *Nyctophilus geoffroyi,* Gould (lesser long-eared bat)

Muridae

Mus musculus, Linnaeus (house mouse),
Notomys sp. (hopping mouse),
Pseudomys albocierieus, Gould (ash-grey mouse),
Pseudomys fieldi, Waite (Shark Bay mouse),
Pseudomys occidentalis, Tate (western mouse),
Pseudomys shortridgei, Thomas (heath rat),
Rattus fuscipes, Waterhouse (bush rat),
Rattus tunneyi, Thomas (pale field-rat)

Canidae

Canis familiaris, Meyer (dog).

J-5 Kjeldahl Cave; moonmilk present and samples collected (Shoosmith, 1972a).
Arthropoda; Arachnida; Araneae: Theridiidae: *Achaearanea* spp. –Tz (Lowry, 1980).
Hexapoda: Insecta: Lepidoptera: Teneidae: *Monopis* sp. (Lowry, 1980). =2 invrt. spp..
Bones;

J-6 Mystery Cave; moonmilk deposits present.
Turbellaria: Planariidae: Tricladida sp. are active after winter rains (Lowry, 1980).
Bones; Thylacine bones {(*Thylacinus cynocephalus*; 2 individual) jaw found; P. Adamson, August 1986 [L. Hatcher, 1986] & remaining skeleton plus second incomplete skeleton; M. Simpson & L. Hatcher, October 1986 [L. Hatcher, conf.; A. Baynes]} have been recorded from this cave (Hatcher, Unpublished records).

J-7 Old River Cave; contains excellent moonmilk deposits (Bridge, 1973) and a flowing stream which has been used to monitor flow rates over an extended duration. Flow rates are typically quite slow for example; ~15.5 cm per minute. There does not appear to be any significant variance from this rate of flow and stream depth has retained a consistant depth between 368-378 mm over the last 5 years (Susac *et al.* 2007). Stygobite amphipods of the genus *Austrochiltonia* have been recorded there (Foulds, 1994). Rotifers are also a ubiquitous inhabitant (Susac *et al.* 2007). An active *Apis mellifera* nests in the tight entrance has prevented human access in recent years. Incidentally trapped creatures such as lizards and snakes are occasionally encountered at the base of the entrance pitch and beyond. Access to the streamway requires the rigging of a 15 m internal, overhanging pitch in a flowstone area.
Arthropoda; Arachnida; Araneae: Linyphiidae sp. [Waldock, 1998] -under rock beneath entrance pipe near webs, Zodariidae sp. (Foulds, 1998). Theridiidae; *Latrodectus hasselti* (Susac *et al.* 2007).
Acarina: Cunaxidae sp. –transitional (Moulds, 2007).
Crustacea (Malacostraca); Amphipoda: Crangonyctoidea: Ceinidae: *Austrochiltonia* sp. (Foulds, 1994). Isopoda: within moist leaf litter under a small solution pipe in the entrance chamber and columnar roots spanning the height of the chamber (Foulds, 1998) Oniscidea: Philosciidae; *Laevophiloscia* spp. (Moulds, 2007).
Myriapoda; Chilopoda: Scutigerimorph (Van Ballegooyen, 1994) (Susac *et al.* 2007).
Hexapoda; Collembolans.
Insecta; Coleoptera: Carabidae (Foulds, 1998).
Lepidoptera –resting on rock below main entrance pipe (Foulds, 1998). J-7 = >11 inv.
Orthoptera: Rhaphidophoridae: Gen. nov. & sp. nov. –Tz (cricket) (Moulds, 2007).

Bones; many *Dasyurus* (chuditch) skeletons in the entrance chamber and on the streambed (Bridge, 1973). *Sarcophilus harrisii* (Tasmanian devil) skeleton found (subsequently minus skull); {P. Adamson, August 1986 [C. Bialakowski, 1986], 2 part jaws & damaged skull with 2 part maxillae & 2 molars, post cranial material; August 1991 [L. Hatcher, 1991]} (Hatcher, Unpublished records).

J-8 Green Head Road Cave; surface used for a reserve.
Arthropoda; Arachnida; Aranaea: Linyphiidae; *Laetesia mollita* ([Gray], 1973).
Insecta; Hymenoptera: Apidae; *Apis mellifera* (pers. com. R. Foulds, March 2007).

J-9 Retreat Cave;
Insecta; Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).
Bones; owl pellets.

J-10 Tumbled-In Cave (Pussy Cat Cave);
Arthropoda; Arachnida; Amaurobiidae: Stiphidiida: *Baiami* sp. (Foulds, 1996), Theridiidae: *Achaearanea* spp. -Tz, Linyphiidae; *Laetesia mollita* (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum.*
Crustacea (Malacostraca); Isopoda: Armadillidae sp. (Lowry, 1980).
Insecta; Coleoptera: Carabidae: Harpalinae; *Lecanomerus flavocintus* found in all zones. Histeridae: *Saprinus* sp. associated with a goat carcass & dead kid in the entrance that had attacted the species –Tz. Staphylinidae; *Creophilus erythrocephalus* Fabricus –Dz below a rock-choked entrance, insect predator (Lowry, 1980). =>8 spp..

J-11 Rifle Cave;
Pseudoscorpionida: Cheliferidae; *Protochelifer cavernarum.*
Insecta; Neuroptera: Ascalaphidae unidentified sp. found as larvae in moist debris under a partly closed solution pipe –Tz -larvae of this group wander amoungst sheltered debris (Lowry, 1980). J-11 = 2 known invertebrate cavernicolous species.

J-12D, J-13D, J-14, J-15, J-16, J-17D, J-18D, J-19H_____;

Gap Assessment
The caves of Jurien require some further assessment and continued monitoring on a periodic basis to evaluate the influence of seasonality. As recommended by Moulds (2007) the continued sampling of J-1 should be undertaken to better understand the dynamics of ecological succession in this primarily guano driven ecosystem. Very little is known about J-11 to J-19H and these features are likely to contain more of significance than has been recorded. Considering the valuable palaeontological material that has been examined at J-4 it is concievable that similar insightful results could be used to verify and expand on this knowledge from caves such as J-1 (pending liaison) and J-3 which both contain very significant and extensive sub-fossil assemblages. Stygofauna sampling in J-7 yielded little from the (pungent cheese) baited trap considering some previous interesting records (Foulds, 1994). Future efforts would be better served using sift nets along the streamway and/or left *in situ* over the stream inflow.

SOUTH HILL

South Hill River is a coastally aligned area of late Pleistocene-Holocene Aeolian Calcarenite that is predominately located within land reserved as national park. The area around the Nambung River is the predominate area of karst development. It is only around 24 km long but is complex in its drainage patterns. During the winter months it is fed by swampy flatlands to the east. Lakes are then filled in sequence to overflow into the next basin where they drain into the karst system. Only when the northern lakes overflow does the final lake adjoining Nambung Cave begin to fill before release into that insurgence (Shoosmith, 1973). The salinity of the Namung River has been measured at its lowest downstream when the water reaches the Tamala Limestone of the karst system as tributaries of lower salinity dilute its concentration (Kern, 1988). Given enough rainfall there are two parallel distributaries flowing towards the last lake north of Green Hill and two chains of widely staggered inflows (Foulds, 1994). The karst system of the Nambung River Basin is susceptible to introducing contaminants that can be washed into groundwater reserves during flooding episodes. In a broader context the southern portion of this catchment is centrally located in proximity to the Perth Basin.

The tendency for caves of the South Hill area to possess smaller entrances provides more consistency within the internal environment to provide for troglobitic fauna. Arachnida: Theridiidae fauna found within caves in the Nambung River region are nationally significant as representative of the oldest of cavernicoles with some specimens showing a complete loss of eyes (Gray, 1973). The meeneopolid plant hopper *Phaconeura pluto* is only one of two such troglobitic species found in Western Australia (Hoch, 1993) and is considered congeneric with species from Cape Range, Barrow Island, the Kimberley and Chillagoe; Qld. (Hamilton-Smith & Eberhard, 2000). In general the spider genera are found to be diverse in representation and habitat preferences; for example the genus *Baiami* is found through all cave zones.

The Pinnacles at Nambung National Park may be an extreme example of solution pipe coalescence of closely spaced solution pipes in a calcrete band (Lowry, 1973). Grimes (2006) suggested that their formation may also involve focused cementation. The upper portion of the calcrete band is composed of hardened pedogenic calcrete where the primary depositional structures have been destroyed; this gradually reverts to less consolidated, friable dune sand with rhizoliths where the dune bedding is still evident (Grimes, 2006). This phytolithic material (rhizoliths) is primarily buried in the dune sand but fragments can be found where aeolian processes expose them. Pinnacles extend southward from the Painted Desert through coastal heathland.

The South Hill area includes the Nambung Defense Training Area which is known to provide habitat for the following arthropod fauna;
(Ecoscape & HLA Envirosciences, 2001);

Stygofauna;

- Bathynellacea (Syncarida),
- Amphipoda,
- Ostracoda: Podocopida,
- Cyclopoidea (Copepoda).

Troglobitic fauna;

- Oniscidea (Crustacea: Isopoda),
- Japygidae (Diplura),

Blattodea (eyeless cockroach),
Arachnida: Araneae: Theridiidae: *Pholcomma* sp., Forsterina: *Desidae* sp.,
Hemiptera: Fulgoroidea: Meenoplidae: *Phaconeura pluto* Fennah,

Regional stygofauna sampling from boreholes produced more specimens from areas of anchialine habitat nearer to the coast where the salt wedge intrudes below fresh groundwater. Although few specimens were obtained from other bores this may be attributable to the limited sampling area provided by bores considering spatial aspects of distribution and the specimens collected from SH-21 located ~9 km inland (Ecoscape & HLA Envirosciences, 2001). The superficial groundwaters in this area discharge into the ocean above the saltwater interface (Nidagal, 1994). During times of high eustatic sea-level variation karst may have provided marine organisms conduits for groundwater colonization.

SH-1 Super Cave; named for its extensive guano, estimated to be 1780 tons in 1908 (Goeczel, 1908) and subsequently disturbed by mining. Accumulation of accidentals occurs under the entrance shaft. *Hirundo neoxena* nest at each entrance. The first entrance ambient temperature is 20.5ºC and 14.2ºC floor temperature, the third entrance was 14.9ºC and 13.9ºC respectively, recorded in September (Foulds, 1998).
Arthropoda; Arachnida; Araneae: Araneidae: *Araneus* sp. –from vertical dripline in the entrance [Waldock, 1998] (Foulds, 1998). Amaurobiidae: Stiphidiida; *Baiami volucripes*[32], Theridiidae: [Waldock, 1994] (Foulds, 1994), *Achaearanea* spp. –from a misty web array near floor in Dz [Waldock, 1998] (Foulds, 1998) *Argyrodes* sp., (Lowry, 1980). Linyphiidae; *Laetesia mollita* ([Gray], 1973). Theridiosomatidae: *Baalzelbub* sp.. Uloboridae (Foulds, 1998). Forsterina: Desidae sp. with reduced eyes, from mud banks next to stream water and chamber floor in the Dz [Waldock, 1994] (Foulds, 1994). Mysmenidae sp.[Waldock, 1998] (Foulds, 1998).
Acarina: sp.–under rock in Dz (mite) Ichtyostomatogasteridae; *Asternolaelaps australis* disused swallow nests, guano & dried rumen contents of a sheep carcass lying under a roof window. Prostigmata: Cunaxidae; *Cunaxa setirostris* sheep carcass-Tz (Lowry, 1980). Astigmata: Cryptostigmata: Palaeacari: spp. dipteran pupae cases & cave floor flood debris near a sheep carcass (Lowry, 1980).
Opiliones: Triaenonychidae; *Nunciella aspera* Pocock -wall Tz (Lowry, 1980).
Scorpionida: Scorpionidae; *Urodacus novaeholandiae* Peters, dead near roof window –Tz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* found 12 m into the cave next to a dead beetle on rocky surface [Harvey, 1994] (Foulds, 1994, 1998), swallow guano, frog & scorpion corpses –Tz (Lowry, 1980).
Crustacea (Malacostraca); Isopoda: Oniscidea, Armadillidae; *Buddelundia bipartita* found under mud flakes in the stream way Dz [Waldock, 1994] (Foulds, 1994), *Sphaerillo grossus* Budde-Lund -epigean near roof window Tz (Lowry, 1980).
Myriapoda; Chilopoda: Scolopendrida: Cryptopedae: Cryptopid: *Allothereua* sp. (centipede). Diplopoda: Paradoxosomatidae: Antichiropus sp.2 accidental found dead beneath cardboard under a roof window (Lowry, 1980).

Insecta; Blattodea: Blattellidae: unidentified –Tz (Lowry, 1980) (Foulds, 1994). Coleoptera: Lebiinae; *Speotarus lucifugus*. Broscinae; *Gnathoxys crassipes* Sloane – accidental, found dead –Tz. Harpalinae: *Amblystomus* sp. accidental collected under roof window. Psydrinae; *Mecyclothorax ambiguous* –Tz. Staphylinidae: *Conosoma* sp. near entrance associated with two dead mice. Pselaphidae spp. associated with a frog corpse found near roof window. Scarabaeidae: Melonthine sp. –accidental found dead under roof window. Tenebrionidae; *Helaeus perforatus* – accidental, Tz – Dz, *Saragus* sp. found dead –Tz (Lowry, 1980).
Diptera: Muscidae: *Musca* sp. found as pupae cases near sheep carcass. Calliphoridae; *Calliphora varifrons* found as pupae cases associated with a sheep carcass under a roof window –Tz, *Chrysomya rufifacies* & C. *varipes* both found as pupae cases near sheep carcass –Tz. Dolichopodidae: *Chrysotus* sp. accidental, found dead –Dz (Lowry, 1980).
Hemipteran nymph found on wet mud flakes on the stream way floor in the Dz [Harvey, 1994] (Foulds, 1994).
Hymenoptera: Diapriidae sp. (*Xenotoma* group) common on walls & roof in darkness transitional zone, this group is often found in dark cool places. Mutillidae sp. accidental found in a spider's web -Tz (Lowry, 1980).
Isoptera: Rhinoptermidae; *Schedorhinotermes reticulatus* Froggatt –accidental collected from wood –Dz (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. pupae skins with dipteran pupae cases near sheep carcass. Noctuidae; *Dasypodia selenophora* –Tz. Cosmopterigidae spp. accidental dead adults of 2 species –Tz, Pyralidae: *Hednota* sp. accidental, dead adult –Tz. Notodontidae: *Teara* sp. accidental, larvae from under roof window (Lowry, 1980).
Neuroptera: Myrmeleontidae; *Austrogymnocnemia* sp. collected from spiders web on cave wall –Dz (adults of this family usually rest in dark places during the day (Lowry, 1980).
Orthoptera: Acrididae: *Cedarina* sp. –accidental collected under roof widow, *Goniaoidea* spp.; 9 & *Porraxia nana* –accidental, from under roof window. Phasmatodea: Phasmatidae; *Hyrtacus tuberculatus* Stål –collected from a spider web near entrance (Lowry, 1980). SH-1 = >36 invertebrate cavernicolous species.
Bones; *Macropus gigas* & *Dasyurus geoffroii* Gould (western quoll/chuditch) remains (Bridge, 1963a), skulls of *Macroderma gigas* embedded in flowstone (Bridge, 1968). Small Dasyurids.

SH-2 Weston Cave; extensive guano that has had small amounts mined (Shoosmith, 1973). Relative humidity was 81% and floor temperature 14ºC in June (Foulds, 1994).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida; *Baiami volucripes*[32] found in the Tz [Waldock, 1994]. Theridiidae: *Achaearanea* spp. -Tz, *Latrodectus hasselti* (redback spiders) (Foulds, 1994), *Steatoda* sp. Dz -Tz (Lowry, 1980). Acarina: Trombidiidae sp. (velvet mites) insect parasite, -Tz (Moulds, 2007).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* –Tz (Lowry, 1996).
Myriapoda; Chilopoda: Scolopendrida: Cryptopedae: Cryptopid: *Allothereua* sp. (Susac *et al.* 2007).
Insecta; Blattodea: Blattellidae: unidentified troglobite.
Diptera: Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance and near a dead fox (Lowry, 1980) & mosquitoes (Foulds, 1996). Sciaridae sp. (?) (Moulds, 2007).
Hymenoptera: Diapriidae sp. (*Xenotoma* group) Tz-Dz (Lowry, 1980).

Isoptera: Rhinopternidae; *Schedorhinotermes reticulatus* from timber –Tz (Lowry, 1980). Lepidoptera: Noctuidae; *Dasypodia selenophora* resting on walls-Tz (Lowry, 1980), Teneidae; *Monopis crocicapitella* transitional zone (Moulds, 2007). = >15 inv.. Bones; rabbit corpse & skulls, macropods & skinks; *Tiliqua rugosa* (Susac *et al.* 2007). Minerals; (Mathews, 1985).

SH-3H_____;

SH-4 Reptation Cave; is a dry cave. Psocoptera were found in deep litter in the light zone of entrance collapse [Humphreys, 1996] (Foulds, 1996). Other unnamed insects are reported within the cave (Mathews, 1985).

SH-5 Specios Cave; diverse in its energy resources from guano, detritus, tree roots and accidental entrapment (Foulds, 1994). Native minnows (galaxiid) (Foulds, 1995).
Arthropoda; Arachnida; abundant- Troglophile; Araneae: Amaurobiidae: Stiphidiida *Baiami volucripes* Gray, 1981 [Harvey, 1994] (Foulds, 1994). A small troglomorphic (eye reduction) variety feeding on abundant mites (Acarina) was found to be Forsterina: Desidae from mud banks next to stream water and chamber floor in the Dz [Waldock, 1994]. Theridiosomatidae: *Baalzelbub* sp. Tz [Waldock, 1994] (Foulds, 1994). Theridiidae from horizontal web [Waldock, 1995] (Foulds, 1995), *Pholcomma* sp. lacking eye pigment from a rock off from the floor [Harvey, 1994] (Foulds, 1994), *Steatoda* sp.. Linyphiidae; *Laetesia mollita* –Dz. Lycosidae: *Arctosa* sp. –Tz, unknown sp. captured in pit trap (Lowry, 1980). Mysmenid (Foulds, 1996).
Crustacea (Malacostraca); troglomorphic isopods: Oniscoidea, found on and mostly under the convex mud flakes in the Dz (Foulds, 1994, 1995), Philosciidae; *Laevophiloscia hamiltoni* troglophile, *Laevophiloscia yalgoonensis* (Lowry, 1980).
Myriapoda; Cryptopidae: (centipede) Chilopoda: Scolopendrida: Cryptopedae.
Hexapoda: abundant collembolans are found in the Dz [Waldock, 1994] (Foulds, 1994). Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance (Lowry, 1980) (collembolans) are also found in the Tz.
Diplura: Japygidae was found under rocks (Foulds, 1994).
Insecta; Blattodea: Blattellidae: unidentified –Tz (Lowry, 1980).
Coleoptera: Carabidae (Foulds, 1995). Tenebrionidae; *Helaeus perforatus* – accidental, Tz – Dz (Lowry, 1980).
Dermaptera (earwig): Labiduridae; *Notolabis occidentalis* Kirby -captured in a pit trap at entrance (Lowry, 1980)
Diptera: Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance, Sphaeroceridae; *Bentrovata regalis* Richards –accidental, caught in baited trap at entrance, Mucidae: *Helina* sp. accidental –Tz (Lowry, 1980).
Abundant hemipterans with troglomorphic features were found in the Dz after flooding (Foulds, 1994). Hemipteran nymph found on wet mud flakes on the stream way floor [Harvey, 1994], (Foulds, 1994, 1996).
Hymenoptera: Diapriidae sp. (*Xenotoma* group) Tz-Dz (Lowry, 1980).
Isoptera (termites) (Foulds, 1983). SH-5 = >22 invertebrate cavernicolous species.
Bones;

SH-6 Wyip Pool Inflow; fed by nearby lakes (Foulds, 1996) this wet silted cave is hydrologically significant. Rhodamine B tracing has linked this cave with Nambung spring on the coast opposite Buller Island SH-30R (Shoosmith, 1972c, 1972d).

SH-7 Thousand Man Cave; tree roots enter the cave through a solution tube (Foulds, 1998). The first sand floored-chamber had a 23.9ºC temperature in September and at the top of the rock pile the temperature was 18ºC with a RH of 91%. The end of the rock pile was 19ºC with a RH of 92%. There is a down slope breeze of 10 m/sec in the unlocked section and active formation with a temperature of 14ºC (Foulds, 1998), 18ºC at 14:30 on the 3 June 2007 (Susac *et al.* 2007). Two barking geckos[19] (Gekkonidae; *Underwoodisaurus milii* Bory) were seen sheltering in a moonmilk roof hollow –Tz (observation; E. Taylor, 3 June 2007). This same trip, a scutigerimorph was observed (J. Anderson) under rock in a cooler area -Tz. The modification of the entrance through the installation of the gate has reduced the available organic inputs and would probably influence resident invertebrate populations (Moulds, 2007).
Arthropoda; Arachnida; Araneae: Araneidae; *Araneus eburnus* [Waldock, 1995]. Amaurobiidae: Stiphidiida; *Baiami volucripes* found with the cave at 91% RH, Forsterina sp. Mysmenidae [Harvey, 1995]. Theridiidae: *Pholcomma* sp. – Dz (Foulds, 1995). Symphytognathidae; *Symphytognatha fouldsi* –transitional zone, from over a water runnel on a diagonal web strand [Harvey, 1998] (Foulds, 1998).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* – from under a rock on the floor (Foulds, 1996).
Crustacea (Malacostraca); Isopoda: Philosciidae: *Laevophiloscia* sp. –Tz. Armadillidae sp. (Moulds, 2007).
Hexapoda; Collembola sp. (Foulds, 1996).
Insecta; Coleoptera (Foulds, 1998), Elatridae sp. –Tz (Moulds, 2007).
Diptera: Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance & with run-off debris in entrance (Lowry, 1980).
Hymenoptera: Formicidae sp. -Tz. Lepidoptera sp. -Tz (Moulds, 2007). =>15 invt. sp.
Bones; contains a significant quantity of fossil and sub-fossil material, including large bones imbedded in flowstone (Shoosmith, 1972a). Paul Devine; 3 June 2007, determined that bones found there were those of bettong, antechinous, bandicoot & small murid (Susac *et al.* 2007).

SH-8H____;

SH-9 Pretty Cave (Nambung River); a damp cave; biologically and mineralogically important (Mathews, 1985). *Hirundo neoxena* nests (Foulds, 1994). R. Foulds recorded a RH: 95% ~noon 8 m in from the entrance 3 June 2007, ambient air temperature was 20.8ºC May (Shoosmith, 1972b), 21.1ºC June (Susac *et al.* 2007).
Gastropoda; Pulmonata sp. (shell only) –Tz (Moulds, 2007).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida; *Baiami volucripes* found at 96% relative humidity, (Foulds, 1994), Gnaphosidae [Waldock, 1997].
Myriapoda; Chilopoda: two centipedes noted on soil cones; *Allothereua* sp. (Shoosmith, 1973), Scutigerid (Foulds, 1996).
Hexapoda; Collembola (Foulds, 1996).
Insecta; Blattodea (Foulds, 1996): Blattellidae: Blattellinae; *Neotemnopteryx* sp. cf. *'douglasi'* –Dz, troglobitic cockroaches found in the cave are completely blind and are likely to represent an undescribed species (Moulds, 2007).
Termite like constructions suggests Isopterian habitation (Brooks, 1994). =>7 invt. sp.
Bones; *Macroderma gigas, Thylacinus cynocephalus* (found; R. Howlett, 19-23 Feb 1961) remains (Bridge, 1963a). Paul Devine; 3 June 2007, determined that bones of the bettong and other macropods were present such as *Macropus fuliginosus* in addition to other marsupials no longer found in the area (Susac *et al.* 2007).

SH-10 Nambung Cave (Sleepy Frog hollow); inflow located on the west bank, water from Nambung River flows in and chokes with rubble, silt and logs. Important for hydrology linked with Nambung Spring SH-30R situated at the coast (Shoosmith, 1972d).

SH-11 Army Cave; dusty cave with extensive guano.
Insects;
Bones; *Trichosurus* sp. (possum).

SH-12 Quandong Cave; *Santalum acuminatum* trees grow near the cave entrance which has *Hirundo neoxena* nests within it. It has been used for a biological study, relative humidity (RH): 93% and temperature of 17.7ºC in September (Foulds, 1998). Much of the roof near the entrance is covered with thick spongy moonmilk and the sandy floor is rich in layers of humus against the north-east wall from fluvial sedimentation (Williamson, 1974). Many tree roots intersect the cave (Foulds, 1994).
Mollusca; Gastropoda: *Gyraulus* sp. caught up in swallow nest building mud –Tz & Succineidae: *Austrosuccinea* sp. both aquatic accidentals probably deposited by flooding (Lowry, 1980).
Annelida; Oligochaeta: Microdrillidae –inhabiting swallow guano (Lowry, 1980).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida: *Baiami* sp. in entrance at 91% relative humidity, (Foulds, 1994). Theridiidae: *Steatoda* sp. (Gray, 1973), *Pholcomma* spp. [Harvey, 1994], *Icona ausrotheridon* gen. nov. -hanging under webs –Dz [Harvey, 1997], *Archaearanea* sp.. on web in Tz [Waldock, 1994] (Foulds, 1994, 1996), *Enoplognatha* sp. under wood –Dz (Lowry, 1980), *Desis* sp. (Foulds, 1998). Acarina: Mesostigmata: Ameroseiidae sp. & Laeleapinae: *Hypoaspis* sp. both species separated from nest material & guano, collected under a nest containing young birds near entrance. Ichtyostomatogasteridae; *Asternolaelaps australis* disused swallow nests & guano. Prostigmata: Tydeidae sp. separated from guano & swallows nest material collected from beneath a nest with young birds –Tz (Lowry, 1980). Pseudoscorpionidea: Chthoniidae; *Austrochthonius australis* Hoff -separated from nest material & guano, collected beneath a swallows nest in the entrance (Lowry, 1980). Cheliferidae; *Protochelifer cavernarum* swallow guano (Lowry, 1980).
Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia hamiltoni* troglophile in little sand hollows, *L. yalgoonensis* & *L.* sp. Tz (Lowry, 1980) (Anderson, 2001).
Hexapoda; Collembola: Entombryiidae: *Entombrya* sp. on tree rootlets [Waldock, 1994] (Foulds, 1994, 1996 & 1998).
Insecta; Blattodea –troglomorphic; no wings & pale eyes-found on fresh rootlet on sand in the Dz [Waldock, 1994, 1998].
Coleoptera: Pselaphidae spp. separated from fresh swallow guano collected under a nest –Tz. Tenebrionidae: *Heleinae* sp. (pie dish beetle).
Diptera: Culicidae; *Anopheles annulipes* Walker –Tz, Muscidae: *Musca* sp. resting on wall –Tz (Lowry, 1980).
Hemiptera: Homoptera: Fulgoridae: Meenoplidae; *Phaconeura pluto* Fennah –troglomorphic & known only from Nambung N.P., males (Lowry, 1980).
Hymenoptera (accidentals): Chalcididae: *Brachymeria* sp., Myrmecinae: *Pheidole* sp. from near entrance –both Tz (Lowry, 1980). Formicidae: Myrmeciinae; *Aphaenogaster barbigula*, Wheeler –collected from swallow guano –Tz (Lowry, 1980) (brown ants) (Foulds, 1998).

Isoptera: Rhinoteridae; *Heterotermes occiduus* Hill -accidental, associated with wood at the entrance.
Lepidoptera: Teneidae: *Monopis* sp. larvae & larval cases separated from fresh guano. Noctuidae; *Dasypodia selenophora* resting on wall, light transition zone (Lowry, 1980). SH-12 = >27 invertebrate cavernicolous species.
Bones and minerals; (Mathews, 1985).

SH-13 Green Island Cave, entrance located within a biological refuge. On the north side of South Island the cave has been reported as a nesting site by the western silvereye (*Zosterops gouldi*), a nest with 3 addled eggs was attached to small solution tubes at the back of the cave (Ford, 1962); *Hirundo neoxena* were also nesting within the cave.

SH-14 Wedges Cave; located on private property Mimegarra. The following species list was compiled by Lundelius (1960) through a dig undertaken in 1954-55.
Insecta; Hymenoptera: Apidae; *Apis mellifera* nests; (feral bees) (Bridge, 1963a).
Bones; important palaeontology cave (Mathews, 1985). *Thylacinus* molar tooth (Bridge, 1963a). This is the species list identified by Lundelius (1960);
Dasyuridae
Antechinus flavipes, Waterhouse (yellow-footed antechinus),
Dasycercus cristicauda, Krefft (mulgara),
Dasyurus geoffroii, Gould (western quoll),
Parantechinus apicalis, Gray (dibbler),
Phascogale calura, Gould (red-tailed phascogale),
Phascogale tapaotafa, Meyer (brush-tailed phascogale),
Sarcophilus harrisii, Boitard (Tasmanian devil),
Sminthopsis spp. (dunnarts).
Peramelidae
Isoodon obesulus, Shaw & Nodder (southern brown bandicoot),
Macrotis lagotis, Reid (bilby),
Phalangeridae
Trichosurus vulpecula, Kerr (brush-tailed possum),
Potoroidae
Bettongia pencillata, Gray (brush-tailed bettong, woylie),
Bettongia lesueur, Quoy & Gaimard (burrowing bettong/boodie),
Potorous platyops, Gould (broad-faced potoroo),
Macropodidae
Macropus eugenii, Desmarest (tammar wallaby)
Macropus fuliginosus, Desmarest (western grey kangaroo),
Lagorchestes hirsutus, Gould (rufous hare-wallaby),
Macropus irma, Jourdan (western brush wallaby),
Petrogale lateralis, Gould (black-footed rock-wallaby),
Burramyidae
Cercartetus concinnus, Gould (western pygmy-possum).
Pseudocheiridae
Pseudocheirus occidentalis, Thomas (western ring-tailed possum).
Microchiroptera
Macroderma gigas, Dobson (ghost bat),
Nyctinomus australis, Gray (white-striped mastiff-bat),
Muridae

Notomys sp. (hopping-mouse),
Pseudomys albocinereus, Gould (ash-grey mouse),
Pseudomys nanus, Gould (western chestnut mouse),
Pseudomys occidentalis, Tate (western mouse),
Pseudomys shortridgei, Thomas (heath rat),
Rattus fuscipes, Waterhouse (bush rat),

SH-15 Taranakite Cave; extensive guano and mineral deposits; previously mined.

SH-16____; private property.

SH-17 Brown Bone Cave; stream cave with significant hydrology. Bone material radiocarbon dated in brown bone cave was around 1000 years old (Shoosmith, 1973). Episodic events conduct large quantities of water through the cave some of which backs up. This expands the potential for vadose karst development. Formations found within the cave display evidence of varying levels of cave fill. Bats have been roosting in the cave (most likely *Chalinolobus morio*) along with *Tyto alba* and a large black skink has been seen in deep in the Tz. It was apparent that the bats were being impacted by the presence of bee colonies (pers. comm. Joe Tonga, 27 March 2007). On the 4 June 2007 the cave was visited and the bees had been poisoned with pyrethrum talc and the nests removed. Water temperature was 18ºC in July (Shoosmith, 1972c) and RH was 94% (Shoosmith, 1972) this was confirmed at 94.5% near the beginning of the water body with an atmospheric temperature of 18.8ºC; June (Susac, 2007). *Hirundo neoxena* nests in the entrance along with *Litoria moorei* found in the stream way (Anderson, 2000).
Arthropoda; Arachnida: Araneidae: Theridiidae cf. *Archaearanea* [Waldock, 1996]. Amaurobiidae: Stiphidiida: *Baiami* sp.. Uloboridae (Foulds, 1996).
Crustacea (Malacostraca); Isopoda – troglobite; Oniscidea: Philosciidae: *Laevophiloscia* sp. [Taiti, 1998] -Dz (Moulds, 2007). Gammaridae; Talitridae as accidental epigean vagrants (Lowry, 1980).
Stygofauna; Amphipoda: Crangonyctoidea: Paramelitidae: *hurleya* sp. ([Bradbury], 1998). Neoniphargidae; *Wesniphargus* nr *yanchepensis*[33] (Bradbury & Williams 1997, 1999) (♂ specimen, reduced eyes present) distinguished from *hurleya* sp. (Straškraba, 1966) [Id.; J. Mc Rae] (Susac, 2007). The presence of this species here is an extention of its known range (Bradbury & Williams 1997). A much larger (15-30mm abdomen), pale stygobiont animal was observed swimming away into the roof sniff area (G. Stuart; 4 June 2007) (Susac, 2007).
Myriapoda; Chilopoda: Scutigeridae; *Allothereua lesueurii*–Tz (Moulds, 2007).
Insecta; Depigmented Blattodea- Blattellidae: unidentified troglobite (Lowry, 1980) (Foulds, 1996), Blattellinae; *Neotemnopteryx douglasi* –Dz (Moulds, 2007).
Diptera: Nycteribiidae; *Basilia troughtoni* (Hamilton-Smith, unpublished data), Sciaridae sp. –Dz (Moulds, 2007).
Hymenoptera: Apidae; *Apis mellifera* nests removed; feral bees (see above). Diapriidae sp. (*Xenotoma* group) Tz-Dz (Lowry, 1980). SH-17 = >17 invert. species.
Trogloxenes; Lepidoptera: large brown and small white moths (Foulds, 1996).
Bones; owl pellet deposits and bones have been washed down stream from the doline.
Hirundo neoxena (welcome swallow) corpse in entrance,
Isoodon sp., *I. obesulus* [B. Johnson] (southern brown bandicoot),
Macropus fuliginosus, (western grey kangaroo),
Bettongia lesueur, B. penicillata (bettongs).

SH-18 Cadda Cave; contains extensive guano {estimated at 2000 tons (Goeczel, 1908) (Poulter, 1973)}, and is important for biology. This inclined fissure cave receives significant amounts of debris from runoff during winter and consequently re-solution of speleothems has occurred in lower areas (Foulds, 1983). In the sediment floor of the lower area many termite tunnel constructions can be seen traversing the area (personal observation; 2 June 2007). Tree rootlets are plentiful along with active dripping areas in the uppermost areas of the cave (Anderson, 2000). Humidity has been measured at 88% July (Shoosmith, 1972c), 91% March (Shoosmith, 1973) and 92% with a temperature of 17ºC in September (Foulds, 1998). The cave has an abundance of moonmilk (Foulds, 1998).
Annelida; Oligochaeta: Microdrillidae –found under carcasses (Lowry, 1980).
Mollusca; Gastropoda: *Gyraulus* sp. aquatic accidental probably deposited by flood & caught up in swallow nest building mud (Lowry, 1980).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida; *Baiami volucripes*[34] ([Gray], 1981). Theridiidae: *Achaearanea* spp. –Dz (Lowry, 1980), *Pholcomma* sp., *Steatoda* sp.. Theridiosomatidae sp. (Lowry, 1980). Gnaphosidae sp. –Tz. Mysmenidae (Foulds, 1998).
Acarina: Parasitidae: 4 unidentified spp. separated from a disused swallow nest –Tz. Eupodidae: *Protereuntes* sp. mycovorious genus, Prostigmata: Cunaxidae; *Cunaxa setirostris*. Astigmata: Cryptostigmata: Palaeacari spp. & Oribatei spp. all separated from disused swallow nest collected at the entrance (Lowry, 1980). Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* swallow guano. Cheiriidae; *Cryptocheiridium australicum* moist sand and organic debris washed in (Lowry, 1980).
Malacostraca; Isopoda: Oniscidea: Philosciidae: *Laevophiloscia* sp. (Moulds, 2007).
Myriapoda; Chilopoda: Scutigeridae: *Allothereua lesueurii* –Tz (Moulds, 2007). Diplopoda: (millipedes) (Foulds, 1998).
Hexapoda; Collembola: Poduridae: Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance (Foulds, 1998). Onychiuridae: *Tullbergia* sp. (*krausbaueri* group) with a dead frog –Dz (Lowry, 1980).
Insecta; Blattodea: Blattellidae: unidentified troglobite (Lowry, 1980) Blattellinae; *Neotemnopteryx douglasi*[35] –Dz (Moulds, 2007).
Coleoptera: Chrysomelidae larvae (Foulds, 1998), Tenebrionidae: Tenebrioninae; *Anemia caulobioides* –Dz, *Alphitobius diaperinus* Panzer –accidental, separated from swallow nest –Tz. Scarabaeidae: *Ataenius* sp. debris -Dz (Lowry, 1980). Carabidae sp. –Tz (Moulds, 2007).
Diptera: Calliphoridae; *Calliphora nociva* pupae cases with run-off debris –Dz & adults resting on walls –Tz, *C. varifrons* pupae cases with charcoal run-off debris –Dz. Desiccated larvae were apparent in abundance on a large moist stalagmite –Dz (personal observation; 4 June, 2007). Tachinidae: *Actia* sp. accidental –Tz (Lowry, 1980).
Hemiptera: Homoptera: Fulgoridae: Meenoplidae; *Phaconeura pluto* nymphs found throughout cave, short range endemic. Lygaeidae: *Pachybrachius* sp. –accidental seed feeder, common in litter (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. as larval cases & pupae skins in a nest. Lyonetiidae; *Opogona omoscopa*, Meyr -adults from swallow guano & nest material near entrance (Lowry, 1980). SH-18 = >34 invertebrate species.
Psocoptera: Liposcelidae: *Liposcelis* sp. with a swallow nest (Lowry, 1980).
Bones; (small rodents) some embedded in flowstone. Minerals (Mathews, 1985).

SH-19E _____; hardened moonmilk is broken up by patches of fine rootlets.
Arthropoda; Arachnida; Araneae: Stiphidiida: *Baiami* sp. and other species some depigmented, Theridiidae; *Latrodectus hasselti* (redbacks) (Foulds, 1994).
Crustacea; (Malacostraca) Isopoda: Oniscoidea.
Insecta; Formicidae (light brown ants) (Foulds, 1994). SH-19E = >3 invert. species.

SH-20 Tick Cave; important cave for biology (Mathews, 1985). Ticks are commonly found at the entrance. This cave takes surface runoff during winter and receives significant litter with sediments. Roots and rootlets are common in the upper areas (Anderson, 2000), with some of these displaying mycorrhizal fungi attachments and moonmilk (Foulds, 1998). The ambient temperature was 20.5ºC in May (Shoosmith, 1972b), 21.5ºC with a RH of 88%; substrate temperature was 20ºC in September (Foulds, 1998).
Platyhelminthes; Turbellaria: Planariidae: Tricladida sp. (flatworms).
Arthropoda; Arachnida; Troglophile; Araneae troglomorphic: Tetragnathidae: Metinae –sand floor near roots Tz (Foulds, 1998). Amaurobiidae: Stiphidiida; *Baiami tegenaroides,* Simon (Lowry, 1980), *B. volucripes* ([Gray], 1981), on roof -Dz [Waldock, 1994], *Desidae* spp.. Theridiidae: *Pholcomma sp.* with no eye pigment found hanging under its web inside the Dz [Harvey, 1994], (Foulds, 1994), *Steatoda* sp. (Lowry, 1980). Sparassidae: *Isopoda* sp. accidental epigean (Lowry, 1980). Opilionida: Triaenonychidae: *Nunciella* sp. & unidentified sp. dead Tz (harvestman).
Crustacea (Malacostraca); Isopoda: Oniscoidea: troglomorphic, pink eyed or eyeless (Foulds, 1995), Philosciidae: *Laevophiloscia* sp. under solution pipe entrance (Lowry, 1980). Armadillidae sp. –Dz (Moulds, 2007).
Myriapoda; Chilopoda: Scutigeridae: *Allothereua* sp. –from roof moonmilk (Foulds, 1994, 1998) (Lowry, 1980).
Hexapoda; Collembola: Poduridae: Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance on the roof at the edge of the daylight 7m into the cave & *Pseudosinella* sp.2 (Lowry, 1980).
Diplura: Japygidae – on a network of roots (Lowry, 1980) –Dz (Moulds, 2007).
Insecta; troglomorphic Blattiidae found at 91% RH -Dz (Foulds, 1994, 1995).
Coleoptera: Carabidae: sp. transition, *Lecanomerous* sp. –Dz (Moulds, 2007). Tenebrionidae: *Heleinae* (pie dish beetle).
Diptera: Culicidae; *Aedes notoscriptus*, SK. –Tz, Phoridae: *Megaselia* sp.1 baited pit traps in all zones. Dolichopodidae: unidentified spp.1 & 2 accidentals –Tz. Tachinidae: *Actia* sp. accidental –Tz (Lowry, 1980).
Hemiptera: Homoptera: Fulgoridae: Meenoplidae; *Phaconeura pluto* associated with tree roots transition into Dz (sap-sucking insect) –on sandy roots. Curculionidae: *Imaliodes* sp. –Dz (Lowry, 1980). Isoptera: (termites) (Foulds, 1995, 1996). Orthoptera: Acrididae: *Beplessia* sp.3 –accidental (Lowry, 1980).
Lepidoptera sp. found as pupae cases delicately constructed from fine pieces of root & attached to tree roots hanging from the roof (Lowry, 1980). =>23 invertebrate species.

SH-21 Tombstone Cave (Woolka Woolka Well Cave); located on private property and fitted with a windmill this important hydrology cave has perennial standing freshwater. Requiring SCUBA diving gear for exploration. Tree roots are featured in several of the chambers as suspended mats dangling into the water and serve as a food source for cavernicolous fauna (Hosie, 2001). The tube worm found in these waters is amoungst the first phallodriline fauna representatives of inland Australian freshwater (Pinder *et al*, 2006).
Annelida; Oligochaeta: Megadrillidae (earthworm), Clitellata: Tubificidae: Phallodrilinae; *Actedrilus podeilema* Pinder -collected from sand & fine black silt with organic material in clear deep fresh water ([Pinder] *et al*, 2006).
Arthropoda; Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae troglomorphic-with reduced eyes (Hosie, 2001).
Stygofauna; Amphipoda (Malacostaca): Crangonyctoidea: *hurleya* sp. [Bradbury, 1998], Ostracoda: Podocopida, Copepoda: Cyclopoida.
Insecta; Coleoptera (Pinder, 1998). SH-21 = >7 invertebrate species.

SH-22H_____;

SH-23 Princes Cave; extensive guano and an important palaeontological cave located on private property (Shoosmith, 1973).
Bones; *Dasyurus* sp. (chuditch)?

? *Perameles* sp. (long nosed bandicoot) –On the Swan Coastal Plain *Perameles* sp. is not normally recorded from deposits younger than mid-Holocene in age (pers. comm. A. Baynes, 1 Aug 2007).

Macropus irma (brush tailed wallaby).

SH-24D____; private property.

SH-25 Scoop Spring; located on private property within a clay pan this reputedly perennially submerged deep fresh water requires SCUBA diving gear for exploration. This is more irregular now in depth and seems to not fit into any known hydrological pattern (Shoosmith, 1973). Long necked tortoises (*Chelodina oblonga* Gray) -have been recorded living in the surrounding reeds.

SH-26_____; Bones; (Shoosmith, 1973).

SH-27_____;

SH-28 _____; on the bank of Moore River. Contains bats (Shoosmith, 1973).

SH-29 Ranger Cave; important cave for biology. Active formations with the fastest drip occurring ~ every 3 seconds (Foulds, 1998). Ambient air temperature recorded as 22.4ºC and a substrate temperature of 12.4ºC in September (Foulds, 1998).
Mollusca; Gastropoda: Pulmonata: Punctidae: *Paralaoma* sp. –Tz & Succineidae: *Austrosuccinea* sp. both accidentals washed in with run-off (Lowry, 1980).
Arthropoda; Arachnida; Aranae: Stiphidiidae: *Forsterina* sp. Theridiidae: (Foulds, 1995), *Achaearanea* spp. -Tz [Waldock, 1998] (Foulds, 1998) – a web contained *Argyrodes* sp., *Latrodectus mactans*. Dipluridae; *Dekana diversicolor* Hogg – close to entrance; accidental, epigean (Lowry, 1980).

Acarina: mesostigmata 2 species from run-off debris covered with dusty spiders web Tz. Astigmata: Cryptostigmata; Palaeacari; spp. spider webs & cave floor debris Tz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* dusty cave floor debris.
Malacostraca; Isopoda: Armadillidae; *Buddelundia bipartite* (Lowry, 1980).
Myriapoda; Chilopoda: Scolopendromorpha sp. Diplopoda; Polydesmida (millipede).
Hexapoda; Collembola: Poduridae sp. (Foulds, 1995).
Insecta; Blattidae sp.. Coleoptera: Staphylinidae sp. (Foulds, 1998). Harpalinae; *Acupalpus vestigialis*, Erichson –accidental separated from organic debris & spider web –Tz. Broscinae; *Gnathoxys crassipes* –accidental found dead –Tz. Scarabaeidae; *Onthophagus ferox* Harold –accidental, dead near transitional area into –Dz. Coccinellidae; *Coccinella repanda* widespread species, accidental –Tz. Curculionidae: *Mandalotus* sp. near entrance & unidentified spp. -separated from moist organic debris & spider web –Tz (Lowry, 1980).
Diptera: Culicidae: *Aedes (Ochterotatus)* sp. –Tz, *Culex pipiens australicus* Dobrotworsky & Drummond –Tz. Calliphoridae; *Calliphora nociva* adults resting on walls –Tz. Dolichopodidae: *chrysotimus* sp. accidental –Tz. Chironomidae: *Chironomus* sp. (midge) –Tz (Lowry, 1980).
Hemiptera: Lygaeidae; *Nysius vinitor* Bergroth –widely dispersed seed feeder, accidental from organic debris–Tz (Lowry, 1980). Hymenoptera: Diapriidae sp. (*Xenotoma* group) Tz-Dz (Lowry, 1980) (wasp) (Foulds, 1995).
Lepidoptera: Teneidae: *Monopis* sp. larval cases on the wall near a nest. Gelechiidae sp. accidental, dead adult –Tz. Geometridae sp. pupa accidental under entrance -Tz (Lowry, 1980) & unidentified larvae (Foulds, 1998).
Orthoptera: Acrididae: *Pespulia* sp. –accidental. SH-29 = >22 invertebrate species.

SH-30R Nambung Spring; coastal resurgence opposite Buller Island used for a hydrology study. Partial outlet and efflux for the Nambung River; downstream outlet for both SH-6 and SH-10 (Shoosmith, 1972, 1973).

SH-31M Lake Thetis; (DEC Reserve # 35819) salt lake in a Holocene limestone collapse. Reputed to rise and fall with the tides; 300 m x 400 m water body fed by underground flow. R. Shoosmith (1973) noted that laminated calcareous algal mats have formed two atolls ~ 0.5 m Ø (Shoosmith, 1973), these stromatolitic microbialites represent the earliest record of life on earth and there is in fact a 5 m wide marginal terrace surrounding the lake covered in both relict and living stromatolites and a benthos covered in a red-purple microbial mat (Tello *et al*. 2004). The complex sedimentation sequences reveal the various stages of stromatolite formation from early submersion through later emergence and erosion through exposure (Tello *et al*. 2004). These fossilized structures are unique in morphology and have been radiocarbon dated at 3370 ± 260 years old (Grey *et al*. 1990). The lake's waters are typically alkaline and nutrient poor (DCLM, 1998). As planned (DCLM, 1998); Lake Thetis's tenure is now incorporated into Nambung National Park (as of; July, 2006).

SH-32S____; stream sink; important seasonal hydrological inflow (Shoosmith, 1973).

SH-33R____; efflux rising during flood periods of the Nambung River, hydologically significant.

SH-34______;

SH-35 Verandah Post Cave; this sea cave has been destroyed (Mathews, 1985).

SH-36 ______; inclined fissure with tree roots present. 90% RH recorded in twilight and 96% recorded at the rear of the cave with a consistent 21ºC temperature during September (Foulds, 1998).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiidae: *Baiami* sp..
Myriapoda; Chilopoda; Scutigeridae; *Allothereua* sp. (large & yellow) (Foulds, 1996).
Hexapoda; Collembola: Poduridae (Foulds, 1994).
Insecta; Diptera: Chironomid midges (Foulds, 1998). SH-36 = >4 invertebrate spp..

SH-37D______; doline containing saline water and reeds similar to SH-48D & 49D all located within 1 km of one another (Shoosmith, 1972a, 1973).

SH-38 Pulchella Cave; (*Pulchellus*: small and pretty) solution hole opened on 12 Aug 1972 by R. Shoosmith *et al.* Damp; 95% RH. (Shoosmith, 1972c). Temperatures throughout the cave ranged from 20.1ºC - 20.6ºC, early June and there were several root mats encased in stalagmites (Anderson, 2007). This cave has the important status of being a 'benchmark cave' meaning no access is granted unless there is a particular scientific or management reason given based on using data collected from the cave for benchmark comparisons.
Gastropoda; Pulmonata sp. (Moulds, 2007).
Turbellaria; Planariidae (flat worms): Tricladida sp. –Tz moist wall at the base of the solution pipe (Anderson, 2007).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiidae: *Baiami* sp.transitional zone, in addition to *Baiami* sp. at least six other spider (Araneae) species were found to inhabit this cave –Tz-Dz (Moulds, 2007). Acarina spp. –Dz (Anderson, 2007).
Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae: *Laevophiloscia* sp. –Dz, Armadillidae sp. –Tz (Moulds, 2007).
Myriapoda; Chilopoda: Scutigeridae: *Allothereua lesueurii* –Tz transition zone. Diplopoda: Polydesmida sp. (millipede) transition zone (Moulds, 2007).
Insecta; Blattodea: Blattellidae: Blattellinae; *Neotemnopteryx douglasi* –Dz.
Coleoptera: Carabidae transition zone, Anobiidae; *Ptinus exulans* - transition zone.
Hemiptera: Reduviidae: Harpactorinae sp. –Dz (assassin bugs, predators) troglomorphic; likely to be an undiscribed species. Homoptera: Meenoplidae –Dz, troglobite -both hemipterans were captured in association with moist root masses growing from dripping stalagmites[36] & the floor of the main chamber (Moulds, 2007).
Hymenoptera: Formicidae sp. –Tz base of solution pipe on floor (Moulds, 2007).
Lepidoptera: Noctuidae; *Dasypodia selenophora* (Lowry, 1980). = >14 invt. species.

SH-39_____;

SH-40 Kinenabbra Cave; extensive guano and Turbellaria; Planariidae (flat worms) Tricladida sp. in damp warm soil found in a moonmilk hollow formation in a state of aestivation (Lowry, 1980); living in the solution pipe, moss coated entrance (Shoosmith, 1972a).
Significant for its geomorphology and mineralogy (Mathews, 1985).
Arthropoda; Arachnida; Araneae: Amaurobiidae: *Baiami Epimecinus* sp. (Lowry, 1980). Acarina: Metastigmata: Ixodidae: *Amblyomma* sp. pit trap in entrance.
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum.*

Hexapoda; Collembola: Poduridae: Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance (Lowry, 1980).
Insecta; Apterygota: Thysanura: Nicoletiidae; *Trinemura novaehollandiae* Silvestri – vegetarian found near a wall in Dz (Lowry, 1980).
Coleoptera: Phalacridae sp. collected from detritus associated with aestivating flatworms in a moonmilk hollow –Tz (Lowry, 1980). SH-40 = >7 invert. species.
Diptera: Psyhodidae: *Phlebotomus* sp. accidental –Tz (Lowry, 1980).
Bones; *Tiliqua rugosa* just inside entrance (Lowry, 1980).

SH-41_____; small and significant only in that it is the furtherest south-western cave of the Nambung karst area (Shoosmith, 1972a).

SH-42 Strathmore Cave; likely to be hydrologically linked to the inflow at SH-52 which is only ~350 m distant as observed aerially by R. Shoosmith (1974). Considered to have by far the best representation of helictites north of Perth the cave is also considered to be dangerously unstable by all previous visitors (Shoosmith, 1973). Temperature was measured at 16.7ºC in May (Shoosmith, 1972b).

SH-43_____;

SH-44 Ardak Cave; important for biology, damp environment. Surface ticks; many were in the cave, March (Shoosmith, 1972b). Moonmilk in the cave has been observed as a resource provision for invertebrate fauna along with large tree roots and cave coral (Foulds, 1995).
Arthropoda; Arachnida; Aranaea: Salticidae, *Desis* sp., Amaurobiidae: Stiphidiida: *Forsterina* -Tz [Harvey, 1995], *Baiami* sp., Theridiidae: *Pholcomma* sp..
Opilionida: Triaenonychidae: *Nunciella* sp. (harvestman) (Foulds, 1995, 1996).
Acarina sp. (mites) [Waldock, 1996] (Foulds, 1996).
Crustacea (Malacostraca); Isopoda: Oniscoidea (Foulds, 1996).
Myriapoda; Chilopoda: Scutigeridae: *Allothereua* sp. (Shoosmith, 1972b) (Foulds, 1995). Hexapoda; collembola (Foulds, 1995). SH-44 = >9 invertebrate species.

SH-45 Scallop Cave; insect life and an occasional drafting breeze (Shoosmith, 1973).
Bones; large deposit of small bones, mainly murids and dasyurids (Shoosmith, 1973).

SH-47_____;

SH-48D____; 4 m Ø doline that contains 2 m deep saline water (Shoosmith, 1972, 1973), reputedly permanent.

SH-49D____; doline that contains reeds and shallow saline water (Shoosmith, 1972).

SH-50 Horse Cave; solution pipe, low sandy chamber pit trap (Shoosmith, 1972).

SH-51 Echidna Cave; so named as it contained a large number of echidna quills. The upper area serves as a carnivore lair, probably a fox or dingo. RH: 94% (Shoosmith, 1972c). Important for biology (Mathews, 1985), with many surface ticks.
Arthropoda; Arachnida; Troglophile: Araneae: Amaurobiidae: Stiphidiida; *Baiami volucripes* (Gray, 1981), *B. tegenaroides* –Dz many moults and webs in Tz up to the entrance, *B. Epimecinus* sp. (Lowry, 1980). Salticidae sp. entrance Tz (Lowry, 1980).

Acarina: Metastigmata: Argasidae: *Ornithodoros (Pavlovskyella)* sp.2 pit traps Tz-Dz. Ixodidae; *Amblyomma albolimbatum* Neumann -is a common ectoparasite parasite of *Tiliqua rugosa* & found near such a skeleton on sandy floor in Dz along with an unidentified species from this family (Lowry, 1980).
Coleoptera: Cholevidae; *Pseudonemadus australis* found on the moldy bones of *T. rugosa* Dz (Lowry, 1980).
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* fox scats (Lowry, 1980).
Hexapoda; Collembola: Poduridae: Entombryiidae: *Lepidocyrtoides* sp. from walls in entrance (Lowry, 1980).
Insecta; Diptera: Calliphoridae; *Calliphora nociva* dead adults collected near a skeleton of *T. rugosa* –Dz (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. larval cases in canid & possum scats with an adult –Dz & unidentified sp. found as pupae cases containing larvae delicately constructed from fine pieces of root & attached to tree roots hanging from the roof where moonmilk formation was encroaching onto the pupae cases. Geometridae: unidentified Oenochromatinae sp. accidental, adult -Dz (Lowry, 1980). =>13 invt. sp..
Bones; rich in bone material (Shoosmith, 1972c) such as the Echidna (Trachyglossidae; *Tachyglossus aculeatus*) and skinks; *Tiliqua rugosa* (Lowry, 1980).

SH-52 Skitzoid Inflow; Likely to be hydrologically linked with SH-42 and is located at the edge of a freshwater lake (Shoosmith, 1974).

SH-53, SH-54_____; both caves located on private property.

SH-55 Abrasion Inflow; a snake was reported to have been living in this cave (Shoosmith, 1973).

SH-56 Kabarda Maya; aboriginal name meaning 'death adder camp', requires a biological assessment; reputedly humid, with active formations and many roots.

Gap Assessment
The caves of the South Hill area that are situated on private land are consequently less well known in terms of biological diversity, although some interesting discoveries have been recorded. Of particular mention and importance of these caves is SH-21; Tombstone Cave which is predominately inundated by water in its extensive passages. A closer examination of the ecology based around the rootmats found deeper into the cave including the interstitial sediments could provide some new species and/or range extensions of fauna found further south at Yanchep NP. Several caves within the Nambung NP would also provide beneficial information if further assessed including one cave recently rediscovered for which there is no available information (Kabarda Maya, SH-56) by R. Foulds 2 June 2007, reputed to be rich in habitat niches and of active formations (last recorded vist -no details; R. Bourne, 1979).

Trapping fauna (both passive & active) for collection may be valuable in various caves throughout the NAR as suggested by Moulds (2007) as a more comprehensive biological community assessment tool. This would be of particular value in the South Hill karst where there was a higher representation of fauna through the Dark Zone. This has the advantage of being able to obtain a cross section of fauna with an emphasis on roaming fauna which tend to be predatory in nature and consequently more indicative of overall ecological condition. This also means that the time visitors need to be in the cave is reduced and thus the potential impacts on the cave are lessened. This may produce specimens from inaccessible areas of the cave. This would involve the use of pitfall traps, litter traps and Tullgren funnels on soil and miniature inverted cone traps in water (such as in SH-17 where a significant diversity has been revealed). Fauna sampling in Lake Thetis (SH-31M) would also be valuable in the epilimnion, halocline profile and benthic portions of the lake in order to see what faunal linkages may be present within the surrounding karst.

EAST MOORE

East Moore caves are formed in late Pleistocene aeolian calcarenite. Known collectively as the Gingin or Bidamina Caves. Caves at Bidamina have been mined for guano in 1922 in excess of 475 tons with some deposits being completely exhausted (de Burgh, 1986). Bones at 'Stalactite Cave', Cowalla Road are recorded at the W.A. Museum as *Pseudocheirus* (the ring-tailed possum). R. Roe (1971) recorded the results of an excavation from a small cave just north of Poison Hill at the north branch of Wallering Brook and 500 m ~SE of 'Koorian' homestead, resulting in the following bones from the surface Layer 1; (Roe, 1971) sheep, rabbits, lizard bones and native mammals;

Dasyuridae: *Antechinus flavipes,* Waterhouse (yellow-footed antechinus),
Sminthopsis sp. indt. (dunnart),
Phalangeridae: *Pseudocheirus peregrinus* Boddaert (ring-tailed possum),
Trichosurus vulpecula, Kerr (brush-tailed possum),
Potoroidae: *Bettongia lesueur,* Quoy & Gaimard (burrowing bettong/ boodie),
Muridae: *Pseudomys albocierieus,* Gould (ash-grey mouse),
Pseudomys shortridgei, Thomas (heath rat)
Rattus sp.

Bone in Layer 2 yeilded; *Pseudocheirus peregrinus* as above with similar dasyurids & murids plus;
Peramelidae: *Isoodon obesulus,* Shaw & Nodder (southern brown bandicoot).
(Roe, 1971)

EM-1 ____; Contains bones (Mathews, 1985).

EM-2, EM-3, EM-4, EM-5H, EM-6_____;

EM-7 ____;
Arthropoda; Arachnida; Araneae: Lycosidae (accidental): *Lycosa* sp..
Insecta; Orthoptera: Acrididae; *Coryphistes ruricola* Burm –accidental, found dead.
Coleoptera: Scaritinae; *Scaraphites silenus* Westwood accidental –Tz (Lowry, 1980), Broscinae; *Gnathoxys crassipes* -accidental found dead –Tz (Lowry, 1980).
Contains bones (Mathews, 1985).

EM-8, EM-9H, EM-10, EM-11______;

EM-12H, EM-13H, EM-14H, EM-15H_____; sinkholes.

EM-16____; Contains extensive guano & bones (Mathews, 1985).

EM-17 Caladenia Cave; (Swan Location 4413) named after orchids growing near the entrance (Bridge, 1972) which contains a large bee nests (*Apis mellifera*) and *Hirundo neoxena* nest within. Contains protruding root matter from grass trees (*Xanthorrhoea preissii* Endl) (Foulds, 1994). Inside relative humidity is 79% -temperature 21.5ºC, outside temperature 31.5ºC; 14 Jan (Foulds, 1994).
Arthropoda; Arachnida; Araneae: Amaurobiidae: Stiphidiida: *Baiami* sp., Salticidae sp. & Theridiidae sp..
Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* found in Tz.
Crustacea (Malacostraca); Isopoda.
Insecta; Blattellidae, ants and midge (Foulds, 1994). EM-17 = >8 invertebrate species.
Important cave for palaeontology, bones present (Mathews, 1985).

EM-18____; South facing cave with bone material collected by E. de Burgh for the WA Museum (Bridge, 1972).

EM-19____; North facing small doline contains moonmilk deposits, large speleothems and bats (Bridge, 1963, 1972, 1973).

Gap Assessment
The East Moore area has the least amount of information known about its karst system and associated biodiversity in the NAR. This is attributable to the area being predominately freehold in land tenure and some general lack of endeavor in the past as speleological research focussed in other regional areas. A systematic assessment of the caves here is long overdue in collaboration with relevant land owners and stakeholders. In particular the cave EM-19, where bats have been recorded to roost. This could provide important habitat information as bats no longer shelter in the caves to the south at Yanchep National Park. The only other Western Australian cave to the south known to be used for regular shelter by bats is several hundred kilometres away at Quininup Lake Cave in Cape Leeuwin Naturaliste National Park. Access to this important cave is prohibited during the late spring -summer bat maternity cycle. This highlights the significance of bat roosts found in the East Moore area.

MOORA

These caves are collectively known as the 'Caves of Coorow'. The geologic Moora Group is located to the east of the Darling Fault and is comprised of sedimentary, vulcaniclastic and volcanic rocks. More specifically, the karstic area is within the Noondine Chert (Appleyard, 2002) and consists mainly of chert converted from partially silicified dolomitic limestone. The caves occur where this conversion is incomplete (Bastian, 1959). Due to a lack of metamorphism or structural deformation, the sedimentary structure is well preserved with relict dolomitic rhombs and oolitic textures (Appleyard, 2002). Fossilized alga that has deposited calcium carbonate is evident in the limestone as the remnants of Proterozoic stromatolites of the genus *Collenia*. The three forms recognized in the formation are *Collenia undosa, C. columnaris* and *Cryptozoon frequens* (Playford *et al.* 1976) These features would have grown when the area was inundated by the sea and now appear as wavy laminations or short stalks that mushroomed out into a consolidated mass (Bastian, 1959).

Öpik & Tomlinson (1955) identified a 'fossilum problematicum'; a tabulate coral, possibly belonging to the genus *Tetradium* or a stromatoporoid of the family Labechiidae (Playford *et al.* 1976). Some conjecture as to the organic origin of these fossils has arisen from inconsistency with the known Ordovician age of the suggested genus (Playford *et al*. 1976). Appleyard (2002) suggests that this may be attributable to the sequencing of several extensive episodes of karstification continuing on until much of the carbonate rock had succumbed to silicification. This could explain the intensive brecciation as a result of later karst development as opposed to exclusively, or in conjunction with slumping from weak consolidation as suggested by Playford *et al*. (1976). Dolerite dykes intruded the Noondine Chert in several places during the late Proterozoic causing the metasomatic alteration of dolomite near some of these intrusions to create talc deposits such as the Three Springs Deposit (Appleyard, 2002).

Evidence obtained from drilling for water abstraction indicates that the Noondine Chert is extensively fractured and contains large voids as a likely result of residual carbonate dissolution within the chert matrix (Appleyard, 2002). Accelerated groundwater flow rates in zones of highly brecciated chert reveal a high degree of hydraulic connectivity between high relief rubble outcrops of chert and low lying shallow bores. This cavernous and highly fractured aquifer is therefore at a higher risk of potential contamination from agricultural land use (Appleyard, 2002). The landscape undulates gently with intergrated drainage patterns. Current erosion patterns show no relation to producing these caves of variable morphology (Lowry, 1980).

Boreholes 13 km north of the Moora townsite have been sampled for stygofauna by Knott & Goater (2005) for proponents of a quartzite mine. The pH range for bores found with stygofauna was as low as 4.22 where three Syncarida: Bathynellacea: Parabathynellida were recorded, another family of the order Bathynellacea: Bathynellida was also represented (the Western Australian forms have not been studied in taxonomic detail). Other stygofauna included Oligochaeta, predominately Naidae where an upper pH range of 6.27 was recorded. Aquatic mites and nematodes were also recorded. Of these stygofauna it is the syncarids that are considered of most importance as a new genus to science (Knott & Goater, 2005). The presence of syncarids coincided with surface water tributaries, which may have provided an increased potential for energy inputs (Knott & Goater, 2005).

M-1 Coorow Cave; 550 m of joint plane development structure and strike-oriented maze passages. Extensive guano and bat roosting colonies evident in the upper areas of inclined tunnels (Bastian, 1962). A 'deep pool' of water was encountered at the end of the cave in August (Raison, 1999), but is ephemeral in nature and based on rainfall. The current bat denizens are *Chalinolobus morio* but guano has been found to be from *Macroderma gigas*. A *Tiliqua rugosa* (bob-tail) was sighted in the cave by Shoosmith (1973). Echidna (*Tachyglossus aculeatus* Shaw) scats have been found well into the dark zone of this cave but this does not appear to have reoccurred since the surrounding area has been cleared for agriculture.

Arthropoda; Arachnida; Amaurobiidae: Stiphidiida; *Baiami Ixeuticus* sp. skins found in Dz (Lowry, 1980). Theridiidae; *Latrodectus mactans* (Lowry, 1980), *L. hasselti* (redbacks) many are encountered in the entrance area (Loveday, 1979). Oecobiidae: *Oecobius* sp. entrance Tz (Lowry, 1980). Oxyopidae: *Oxyopes* sp. accidental, -close to entrance Tz (Lowry, 1980).
Insecta; Blattodea: Blattellidae: unidentified sp. (Lowry, 1980). Just within the entrance are cockroaches and small beetles. Cockroach egg sacks were found lying on the guano within the cave (Scott, 1973).
Colleoptera: Chaeniinae; *Chlaenius greyanus* White –near entrance. Coccinellidae; *Coccinella repanda* widespread species, accidental –Tz. Tenebrionidae: *Helaeus* sp. –accidental -Tz (Lowry, 1980).
Diptera: Nematocera found as larvae –Tz. Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. & Pyralidae sp. as larval cases with a sheep corpse –Tz (Lowry, 1980).
Psocoptera: Liposcelidae: *Liposcelis* sp. –Tz (Lowry, 1980). M-1 = >11 invert. spp..
Bones; *Macroderma gigas*, *Dasyurus* sp. (chuditch). Corpses of rats, kangaroos, rabbits & small wallabies remain in a mummified state due to the dry, stable environment (Bridge, 1963a).

M-2 to M-5D; small caves and shallow depressions, little description (Bridge, 1972).

M-6 Jingemia Cave; this cave is of quartzite-based limestone (silicified dolomites) overlying granite. Contains owl pellets; *Tyto alba* (?) pair roosting. Guano deposits including rock phosphate and copper phosphates have been mined (Bridge, 1973a) to a depth of 5 m (Loveday, 1979). This is an aboriginal place name meaning a haunted place and applying to an extinct volcano crater ~20 m depth (Landgate, 2007).
Arthropoda; Arachnida; Oecobiidae: *Oecobius* sp. entrance Tz (Lowry, 1980). Crustacea (Malacostraca); Isopoda: Armadillidae; *Buddelundia sabinermis* Budde-Lund, (sub sp.) found in a dusty alcove used as an animal lair (Lowry, 1980).
Insecta; Blattodea: Blattellidae unidentified sp. –Tz (Lowry, 1980).
Coleoptera: Psydrinae; *Mecyclothorax ambiguous* accidental –Tz. Helluoninae; *Gigadema bostocki* Castelnau –accidental, collected dead from the centre of this large shallow cave (Lowry, 1980). Staphylinidae spp. (WAM unpublished records).
Diptera: Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance (Lowry, 1980).
Lepidoptera: Teneidae: *Monopis* sp. as larval cases under a damp sack (Lowry, 1980).
Psocoptera: Psyllipsocidae; *Psyllipsocus ramburii* -Tz (Smithers, 1975). =>7 invt. sp..
Bones; bats, mummified animals- rabbits & small wallabies. Evidence of echidnas (Bridge, 1963a).

M-7 Bishop's Hole, Devil's Hole; located at Bishop Hill, Shire of Three Springs; a 31m deep shaft leading to a single large chamber (Scott, 1976). Guano mined prior to 1916 (Bridge, 1973). A bat population of 50 to 100 individual *Chalinolobus morio* roost here with naked young present (date not supplied; end of the year? {1975}). Many small spiders, adult and nymph cockroaches, a large centipede and several mummified bats have been collected for the W.A. Museum (Scott, 1976).
Mollusca; Gastropoda: Pupillidae; *Pupilla (Omegapilla)* sp. washed in accidental.

Arthropoda; Arachnida; Araneae: Araneidae: *Araneus* sp. -Tz, unidentified sp. -Tz. Oecobiidae: *Oecobius* sp. entrance Tz (Lowry, 1980). Lycosidae (all accidental); *Lycosa godeffroyi* found as fragments, entrance -Tz, *L. leuckarti* entrance -Tz & *L.* sp. Gnaphosidae -Tz (Lowry, 1980).
Crustacea (Malacostraca); Isopoda: Oniscidea: Philosciidae; *Laevophiloscia yalgoonensis* (Lowry, 1980).
Insecta; Blattodea: Blattellidae; *Paratemnopteryx couloniana* (Saussure) –Dz & unidentified spp. associated with bat guano -Tz (Lowry, 1980).
Coleoptera: Carabinae; *Calosoma schayeri* Erichson & Harpalinae; *Gnathaphanus melbournesis* Castelnau –both accidental collected near entrance (Lowry, 1980). Staphylinidae spp. (WAM unpublished records). Scarabaeidae; *Liparetrus opacicollis* Macleay, dead –Tz. Coccinellidae; *Coccinella repanda* widespread species, accidental –Tz. Tenebrionidae; *Helaeus lubricus* Blackburn –Tz, *Pterohelaeus disperses* Macleay –Tz (Lowry, 1980).
Diptera: Phoridae: unidentified sp. larvae associated with dead insects under entrance, Calliphoridae; *Calliphora nociva* adult females & larvae caught in baited traps near entrance (Lowry, 1980).
Orthoptera; Acrididae; *Austracris gluttosa* Walk –accidental, dead (Lowry, 1980).
Psocoptera: Liposcelidae: *Liposcelis* sp. –Tz (Lowry, 1980). M-7 = >10 invt. spp..

M-8 Campbell Cave; this fissure contains algal fossils in the roof (Bastian, 1959). Campbell (1909) described these as thin sheets or filaments of chalcedony deposited in festoon-shaped order between vertical walls of the same material. This may represent an example of Öpik & Tomlinson's (1955) 'fossilum problematicum' as mentioned above in the Moora introduction.
Arthropoda; Arachnida; Araneae: Araneidae; *Araneus dae* sp. accidental, found as dead larvae caught in spiders web –Tz (Lowry, 1980).
Insecta; Hymenoptera: Apidae; *Apis mellifera* nests in entrance (Lowry, 1980).

Gap Assessment
The caves of the Noondyne Chert offer a particularly different insight into our biological record that represents a more direct link into older geologic sequences and paths of habitat refuge. Of the eight features recorded in the area only half of these have any information recorded about them, their biology or processes and none of it has been recorded in recent years. The presence of Blattellidae; *Paratemnopteryx couloniana* at M-7 and Minnie's Grotto at Yanchep NP (Lowry, 1980) warrants further investigation due to inconsistencies in the species W.A. representation.

Borehole information produced by Knott & Goater (2005) revealed deficiencies in the taxonomic knowledge of syncarids found in the groundwater. Knowledge of stygal ecology which may be used to assess groundwater quality would be enhanced with further sampling in areas of the Noondine Chert. This important research should be continued along with a survey of the terrestrial fauna and bat populations.

The most obvious gap in information revealed in this report is the lack of taxonomic classification of organisms to species level of identification. This is a problem revealed throughout the entire NAR and is a major limitation for ecologists and consequently environmental managers. For some taxonomic goups it is clear that further morphological and molecular work would be of particular value. These groups as identified by Moulds (2007) include; the psuedoscorpion *Protochelifer cavernarum*, the spider *Baiami*, the isopod genus *Laevophiloscia* and the meenopolid species. Specialist verification of bat species would be desireable at maternity sites.

Palaeontology and Palynology of the Northern Perth Basin

The interdisciplinary earth sciences of palaeontology (the study of fossilized fauna & flora) and palynology (the study of contemporary and fossilized palynomrphs; pollen, spores, dinoflagellate cysts, acritarchs, chitinozoans, scolecodonts, kerogan and particulate organic matter) reveal insights into palaeoecology, biostratigraphy, geochronology and taxonomy. This information is primarily derived from borehole analysis and in the NAR this is focused around the northern portion of the Perth basin. In general Permian sequences found in Western Australia display affinity with biota found in India, Pakistan, the Himalayas and Timor making them easier to correlate with classic Ural sequences (Skwarko, 1993). In the NAR this correlation is more specific to the Himalayas or the general area northwest of the Bramahputra Bend (Veevers *et al*. 1975) as a Laurasian connection with ancient Gondwana and Tethyan Sea biogeographic linkages. The relevance of these anchient associations is evident in current investigations into biogeography and phylogenetic research. The Perth Basin is a faulted trough containing thick Phanerozoic sedimentary sequences that may exceed a depth of 15 000m at its deepest point in the Dandaragan Trough (Playford *et al*. 1976). Of particular note in the Northern Perth Basin are extensive Permian fossil records from the glacigene Nangetty Formation followed in consecutive stratigraphic sequence by the Holmwood Shale; comprised of the Beckett Member, Woolaga Limestone Member and Fossil Cliff Member. Overlaying this is the High Cliff Sandstone which is in sequence overlain by the Irwin River Coal Measures, Carynginia Formation, Wagina Sandstone and then the shallow marine deposit of the Mingenew Formation (Playford *et al*. 1976). These sequences continue through various regions of the Perth Basin within the NAR and beyond with the basin floor identified now as the Cattamarra Coal Measures (Mory, 1994) (previously the Cockleshell Gully Formation {Playford & Low 1972}) which is then overlain by the Yarragadee Formation and so on as detailed by Playford *et al*. (1976). For comprehensive lists of Permian, Jurassic and Cretaceous fossils from the Perth Basin sediments refer to Playford *et al.* (1976), Skwarko (1993) and Backhouse (1988).

Discussion of Management Implications

With even a cursory view of the information presented above it is clearly evident that there are significant areas that are lacking representation. In museum collections and published records these areas are not necessarily depauporate biologically, they have just not been adequately investigated. In terms of a comprehensive examination of the existing material that can be readily sourced for interpretation, there is a significant limitation on the amount of baseline data that is currently available. Various inferences can be made of the available information to give some insight into the condition and significance of subterranean ecosystems in the NAR. ~90% of the taxa that has been presented here was identified long ago and should be considered in relation to the identification reliability and its contemporary taxonomic status.

Just as water availability is the foundation of life in the epigean world, so it is in the hypogean realm. Water is the main driver of karst geomorphology and the server of biological processes. Its presence or absence is therefore intrinsically linked to the biotic potential that can be sustained. The success of foraging trogloxenes will be linked to the abundance of water. This prompts a response from invertebrate prey, which is in turn linked with primary production. With this context in mind it is imperative to determine the composition of faunal assemblages before and after the pulse of winter rains. Just as critically endangered root mat communities further south ebb and wane in a flux based on seasonality they are also inter-governed by succession between flora, fungi and fauna. It is readily conceivable that endemic root mat communities of similar composition to those found within Yanchep National Park may be represented in locations within the NAR. Of particular note in relation to such speculation is SH-21, which has floral representation from *E. gomphocephala* and a little known but significant stygofauna assemblage.

Recent dry years now widely attributed to anthropogenically induced climate change have taken their toll on the superficial water-table in many areas of temperate Australia. The NAR is no exception, with many of it's previously identified 'permanent' cave streams and pools now experiencing complete depletion. This increases the importance of quantifying aquatic based community structure and emphasizes the potential harm that can occur from altered hydrological regimes. Alterations to the catchment area servicing Stockyard Gully occurred in 1984 with a ~10km trench dug from a nearby farm into the blasted tunnel entry. An unnatural increase in unregulated flow caused the pulse based flush of water to be increased in magnitude carrying tons of sediment into the system. This sedimentation clogs up interstitial spaces and smothers existing habitat. This results in a reduction in streamway heterogeneity and has closed smaller conduits. This can compromise the ability for some fauna to obtain suitable refuge during the flood episode. This also results in less time for water to infuse laterally into the hyporheic zone to allow for more even groundwater recharge and was also particularly destructive to some upstream ripairian vegetation (pers. comm. R. Webb; 6 June 2007). This major alteration may have also contributed to colonization of both E-9 and E-10 by *Cherax destructor* from eastern farmland (Jasinska *et al*. 1993). The presence of this feral organism can have major implications to the ecology (Horwitz, 1990). This should be considered in relation to current population dynamics that have altered in response to the lowered watertable and diminishing resource inputs.

The Nambung River is an area of dynamic change during episodic flooding. Certain areas of the river should be considered as extremely dangerous to the unwary due to various insugences where the river sinks into the earth to resurgences on the other side of hills. Colloquial names (now titles unlinked to specific features) such as 'Nightmare Inflow' and 'Mantrap Hole' are terms for various features certain to produce fatalities if the hapless are swept in during episodic rainfall events. For a more detailed description of the Nambung River in flood in relation to the karst system refer to *TWC;* R. Shoosmith (1974).

Just as caves can provide a biological refuge for native biota, they can also provide a foothold for feral species. In the above literature review it is apparent that there are areas where *Apis mellifera* (feral bees) are competing for space with native fauna. The continued monitoring of significant cave sites to determine the extent of these impacts should be investigated. Subsequent control measures should involve a contractor that is familiar with techniques and equipment that considers the sensitivities of cave ecology in order to minimize the influence of broader contamination. Currently the DEC is working on a Feral Bee Control Strategy that will address the sensitivities of sites such as caves by implementing bait stations in remote areas (Contact; Jacqueline.hay@dec.wa.gov.au ph: 9334 0103). Naturally, this sort of control method needs to be considered in conjunction with aparists who are normally working in areas such as Beekeepers Nature Reserve. Likewise; cave entrance areas (particularly dolines) are potentially exploited by weed species. Similarly, the monitoring and sensitivities suggested for bees also apply to vegetation control in order to minimize the risk associated with deleterious contaminants from chemicals introduced into these groundwater entry points.

The protection of groundwater resources is fundamental to stygal ecology and the protection of public health. The Noondine Chert has been identified as an aquifer vulnerable to contamination (Appleyard, 2002) and consequently requires control measures implemented to ensure its continued viability as a sustainable resource. The investigation and monitoring of stygofauna diversity in this area could be used as a key indicator for the assessment of groundwater impacts and environmental health. On the coastal plain and Dandaragan Plateau within the NAR, Hirschberg (1993) identified several groundwater pollutant point sources of the Perth Basin aquifers. Of particular concern is when these sources are located in a close or easterly proximity to karst. The most significant pollutants were considered non-point contaminants such as fertilizer, herbicides and pesticides from agricultural applications (Hirschberg, 1993).

Ecological resilience can be improved by increasing areas of landscape connectivity. This is generally provided by ensuring nature corridors are considered in management plans and reducing the compromising influence of edge effects with strategic placement of access roads. Caves occurring as palaeodrainage conduits provide important subterranean linkages between areas for genetic dispersal of primarily seeds and invertebrates. In this sense it is important to maintain these hydrological conduits as healthy, vital landscape components.

Cave access need not require vehicle tracks and where possible such access should be avoided. This should also be considered in relation to beaten walk trails that lead to cave openings and the unnecessary clearing of vegetation in the vicinity of caves. The gating of caves deemed vulnerable to visitation pressures should be considered in consultation with speleologists for an assessment of the energy input and fauna requirements of the cave's ecosystem. Current best practice in gating materials (rust for example is deleterious to ecosystems) and design should be sourced as several gates in the NAR are deficient in this regard. Speleologists have long recommended that the gate and track to Drovers Cave (J-2) be altered for these reasons.

Guanophile and guanobite communities in the NAR are primarily driven by the input of bat guano with some minor supplementation from *Hirundo neoxena,* (the welcome swallow), raptors and incidental mammals and reptiles. The temperate climate influences the energy input process through the seasonal variation patterns of occupancy by microchiroptera. This roosting cycle adds a temporal component to resource availability. This can directly influence the atmospheric conditions of the cave causing increased temperatures, relative humidity, CO_2 and ammonia (Moulds, 2004). This fluctuation invariably influences the guano community composition and is connected to rainfall patterns as previously mentioned. This energy fluxing aspect bolsters the requirement for post rainfall monitoring and sampling surveys in order to fully encompass the successional dimension of the community structure.

The significance of guano deposits in cave ecology merits the protection of this resource input both in-situ and as its source; being epigean invertebrates. It is possible that bats hunting for insects over agricultural land may be exposed to contaminants as invertebrate 'pests' can be targeted by indiscriminant fumigation. This could result in bats taking a larger proportion of prey compromised by toxins that will invariably end up as a residual deleterious factor in guano based communities. Other negative effects from ingesting contaminated prey could manifest through the bioaccumulation of toxins in predatory organisms. Areas where this issue could occur in the NAR are where development is encroaching or agriculture already exists. This situation occurs at (J-1) in Jurien, the Stockyard System (E-1-3) and the caves of Moora (M-1 to M-7). Another area would be the East Moore region which has had very little investigation. However, bats were reported there at EM-19 by P. Bridge (1963). This area is surrounded by a mosaic of rural uses such as intensive and hobby agriculture, grazing and mixed woodlands.

Natural resource inventory is a means to understand the values inherent in our natural assets. In a sense this has been happening with each reported cave visit. This information can become a valuable as a tool for management if the recorded information is systemic in its observation of significant features and compiled in a way that is relevant and accessable for reference and updates. The comprehensiveness of such information is largely based on available time and resources versus the perceived significance that the feature. This is addressed as a Medium Priority (5.3) in the current management plan (DCLM, 1998) for Nambung NP, Wanagarren, Nilgen and Beekeepers Nature Reserves.

This plan recommends a cave classification system along with access policies for caves and karst features in consultation with speleological groups. This should be addressed in a manner based on a feature by feature basis that considers all relevant stakeholders with the supporting evidence of the complete resource inventory. It is a primary role of the DEC to conserve and protect the environmental attributes of areas that are considered sensitive to anthropogenically induced impacts. In this sense it is important that caves are recognized as important as areas of biological refuge, as areas of interpretation and as features that provide environmental services relating to drainage and landscape connectivity.

Each karst area has its own inherent qualities, values and management issues that require thorough understanding. The multifaceted nature of complex ecological functions and processes inherent to karst environments coupled with the DEC service aspects of maintenance, public and private liaison, administration, risk assessment, education and research suggests that there should be consideration towards the permanent employment of a regional karst officer specifically for the NAR, to protect and promote the values of its karst areas (see; Appendix I).

Of all the caves visited during the 'Hidden Treasures' project 2007, it is Weelawadji Cave (E-24) that stands out most significantly as a natural resource located on DEC managed land that is representative of the highest overall natural values. This is not to suggest that other caves do not possess higher environmental values for individual characteristics. E-24 is already on maps and is regularly visited, as is evident by its visitor's book located on a rock in the central portion of the main entrance chamber. The gate that is currently installed in the cave, although essential for the protection of some of the regions finest diplays of karst development, is possibly not adequately 'bat friendly' in design and the cave's deep Dark Zone ecology has been intrinsically compromised for this reason. When installed, a bat gap was left in the gate and it appears that this gap is able to be aerially negotiated by bats (Webb, 1979c). However, the bars and single horizontal slot that are in the gate simply do not leave enough room to encourage aerial entry by bats which have long inhabited this cave as large guano mounds deeper within such as the aptly named 'Mt Pooji' are a testament to. Shortly after (2 weeks) the gate was installed; 'a fair amount' of fresh guano was found on either side of the gate (Webb, 1979c), suggesting an impediment to flight at that point. No fresh guano has now been found past the gated section and there are no recent reported sightings of bats in this area since G. Howeison saw 'a few' Jan (1990). Gate design should be reviewed and corrections incorporated in consultation with a bat biologist and speleologist here in E-24, as with J-2 mentioned previously.

Bat habitation is the dominant driver of ecological processes found within E-24 and bats are very sensitive to disturbance within the cave. During times when bats nurse altrical pups and are gathered at a maternity site, this sensitivity becomes heightened to the point that any minor disturbance (such as human visitation) can cause abandonment of the vulnerable young (Buecher, 2006). It is for this reason that a period of prohibited access be considered during maternity phases; this would be in the months of November to January (this is a standard international protocol for bat protection). This is a problematic issue for the management of E-24 due to the high degree of unauthorized access and the caves remote location. Consequently, it is suggested that interpretive signage be incorporated at the surface 'car park'. This would be valuable on several levels for management. Firstly, the sign can impart the significance of the feature before them and the importance and fragility of its ecology and its physical features such as guano mounds, speleothems and bone deposits. Secondly, the sign can warn against visitation during prohibited times and provide further contact information for managers and speleological groups. Finally, the sign can provide safety information for any potential visitors regarding cave risk issues and appropriate lighting. Such interpretive signage is invaluable in fostering positive public relations particularly in accompaniment with access restrictions and is also becoming an ever increasing necessity in addressing public liability. Signage would also be valuable at E-3 which is also subjected to many unauthorized visits, has roosting bats and which predominately features slippery mud coating limestone.

Analyzing mitochondrial DNA sequences makes it possible to reconstruct the phylogenetic relationship between species, thus allowing insights into dispersal and localised endemism. Molecular taxonomic study into phylogeny is performed through allozyme electrophoresis. This has resolved some of the grey areas of knowledge in biogeographic speleology. It has also been used to investigate incongruity between morphological variation and molecular markers for the determination of true species status (Playford, 2001; Finston *et al.* 2004). Phylogenetic work undertaken on fauna such as the pseudoscorpion genus *Protochelifer* incorporating representatives found in the NAR enables a clearer understanding of patterns of distribution and endemism. This work has established *Protochelifer cavernarum* as phylogenetically multiple species (Moulds *et al.* 2007). Mark Harvey of the Western Australian Museum is currently researching this from specimens obtained from the NAR and other regions.

Work that will proceed using allozyme electrophoresis is a project to study the phylogeny of the family Pyroglyphidae (best known as the house dust mites), undertaken by Professor Barry O'Connor (bmoc@umich.edu); Curator of the Museum of Zoology at Michigan University. He is particularly interested in the species *Weelawadjia australis* of that family, which has been collected by J. Lowry from E-24. Another project that will be occurring around the Nambung River area in October 2007 is some karst catchment mapping and geomorphological interpretation by Slovenian PhD candidate Matej Lipar (matej.lipar@gmail.com). His work will expand and reinterpret information which has been collated on the Nambung Karst in a way that is compatible for GIS applications.

Areas of future endeavor would be well served to focus where more obvious gaps in the biotic record are present. This would suggest areas such as the East Moore region. The record gaps presented here indicate that only one cave (EM-17) has a low to moderate level of information available in regard to it. There also seem to be significant information gaps in areas directly north of Moore River and Lancelin as this area is susceptible to encroaching development. Further investigation in the cave region near Moora and the Coorow area would also be useful as they are more isolated and older systems that certainly posses a different insight into older geologic time. This additional research in conjunction with borehole sampling would provide a baseline comparison for referencing future work on the significance of subterranean ecology in the NAR.

Summary of Conclusions

- Both E-24 (DEC) and E-22 (private) were found to have by far the highest levels of biodiversity (species richness) for cavernicolous fauna in the NAR with each having >83 invertebrate species not including accidentals. Both are large extensive caves that support bat colonies and a significant guanobite community. E-3 with >62 species was found to also have a high conservation value with resident bats and a highly diverse ecological community.
- Both E-24 and E-3 should have interpretive signage and consideration should also be given to prohibiting access to the cave during the nursery phase of the bat maternity cycle from mid October to mid January.

- A re-evaluation of the bat slot in the gate at E-24 should be assessed for its effectiveness. This important site should be protected with management consideration in consultation with a bat biologist and speleologists.
- Species richness was lower at Nambung (SH-1; = >36 invertebrate species) and Jurien (J-2; = >14 species) which has a cave containing significant stygofauna in the only stable watertable stream. This reduced diversity is however reflective of different collection methods and the extent to which they have been carried out and replicated. J-2 should also be re-gated.
- Troglobitic fauna diversity in the Nambung area is very significant with several taxa identified as regionally important; Hemipteran, Reduviid (assassin bug predators) which are a new undiscribed species that live with the planthopper consumers; Meenoplidae: *Phaconeura pluto.* Also a blind cockroach similar to *Neotemnopteryx douglasi* is likely to be an endemic new species to the Nambung Karst (Moulds, 2007). A new record of the amphipod; Neoniphargidae; *Wesniphargus* nr *yanchepensis* (reduced eyes aparent) was found at SH-17 which should be resampled to gain a broader understanding of the stygofauna community.
- Much of the sampled fauna had specimens preserved in 100% alcohol to alow for future molecular study. This should continue where there is no such preserved examples amoungst the voucher specimens.
- Caves at East Moore should be evaluated pending liaison with land holders. It is of particular value where data is not attributable to specific caves and to EM-19 which was reported as habitat for bats this is of particular value considering that there is no other known bat roosting caves in this area.
- The Moora caves are significant as an area for investigation into comparisons with the younger Tamala Limestone for both terrestrial and stygofauna. This area should be assessed for community composition and monitored as an indicator of broader ecological health. This is particularly so in relation to the protection of groundwater quality.
- There should be appointed a Regional Karst Officer in order to implement the various requirements of karst management (see Appendix I for details).
- Liaison should continue with private landholders, speleologists and all relevant stakeholders relating to the significance of karst systems, protection measures and appropriate land management in catchment areas.
- Further karst inventories and surveys should be conducted where information is deemed to be insufficient as is evident throughout this document.
- Any database that is developed for departmental use should avoid location information distribution because this is considered as highly sensitive material.

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Appendix I Regional Karst Conservation Officer

In appointing a DEC employee as a Karst Conservation Officer a number of specialized operational functions for nature conservation can be achieved. Administration of the specific karst conservation duties would then be centralized through the one officer responsible for the caves and karst features enabling a central point for public liaison and providing inter-departmental cohesion.This position would be ideally filled by someone with background knowledge in speleological issues and environmental management. Some of the duties that a karst officer can undertake include;

- Environmental monitoring of karst features; condition, biodiversity and environmental physical parameters.
- Conduct karst environmental inventories and create a list of work prioritization to be implemented.
- Instigate and update record keeping mechanisms for ongoing reference; databases, photo-logs and visitation logs.
- KPI assessment for managing cave impacts and reviewing caving practices in conjunction with external pressures.
- Staff and management liaison for undertaking remedial or infrastructural work operations at current best practice standards.
- Involvement in the development of tour activities with an underlying basis firmly grounded in sustainable natural resource management.
- Liaison with the public and private sector education relating to the significance and sensitivities of karst environments.
- Sourcing and implementing further opportunities for broadening education of the community on the issues of karst related topics.
- Active involvement with the scientific and speleological community in producing helpful research into karst systems.
- Inter-departmental liaison with Water Corp., DPI, EPA and any relevant stakeholders including catchment councils, local and Federal governments.
- Facilitate and undertake Risk Assessments of karst for visitors and potential surface collapse or subsidence.
- Involvement in projects that protect surface karst values; feral species invasions, erosion control, regeneration and restoration of native species.
- Conduct patrols in karst areas to deter deleterious behaviours such as unauthorized access, vandalism, fires and illegal dumping.
- Foster a management presence and spirit of stewardship towards park visitors; including minor first time rule perpetrators.
- Provide periodic reports outlining the ongoing condition of caves and any areas that require further attention.

The ASF has advocated such a role for the last decade on a state wide level and recognizes the contributions that can be made at a regional and local level (Anderson, 2005). This role is enough to fill a permanent position but in keeping with general budget constraints it is foreseeable that these works can be supplemented with other general works such as fire duties where staff levels are depleted. Obviously, the more such a position is supplanted with other duties; the core nature conservation of karst priorities will be comparably compromised.

Appendix II

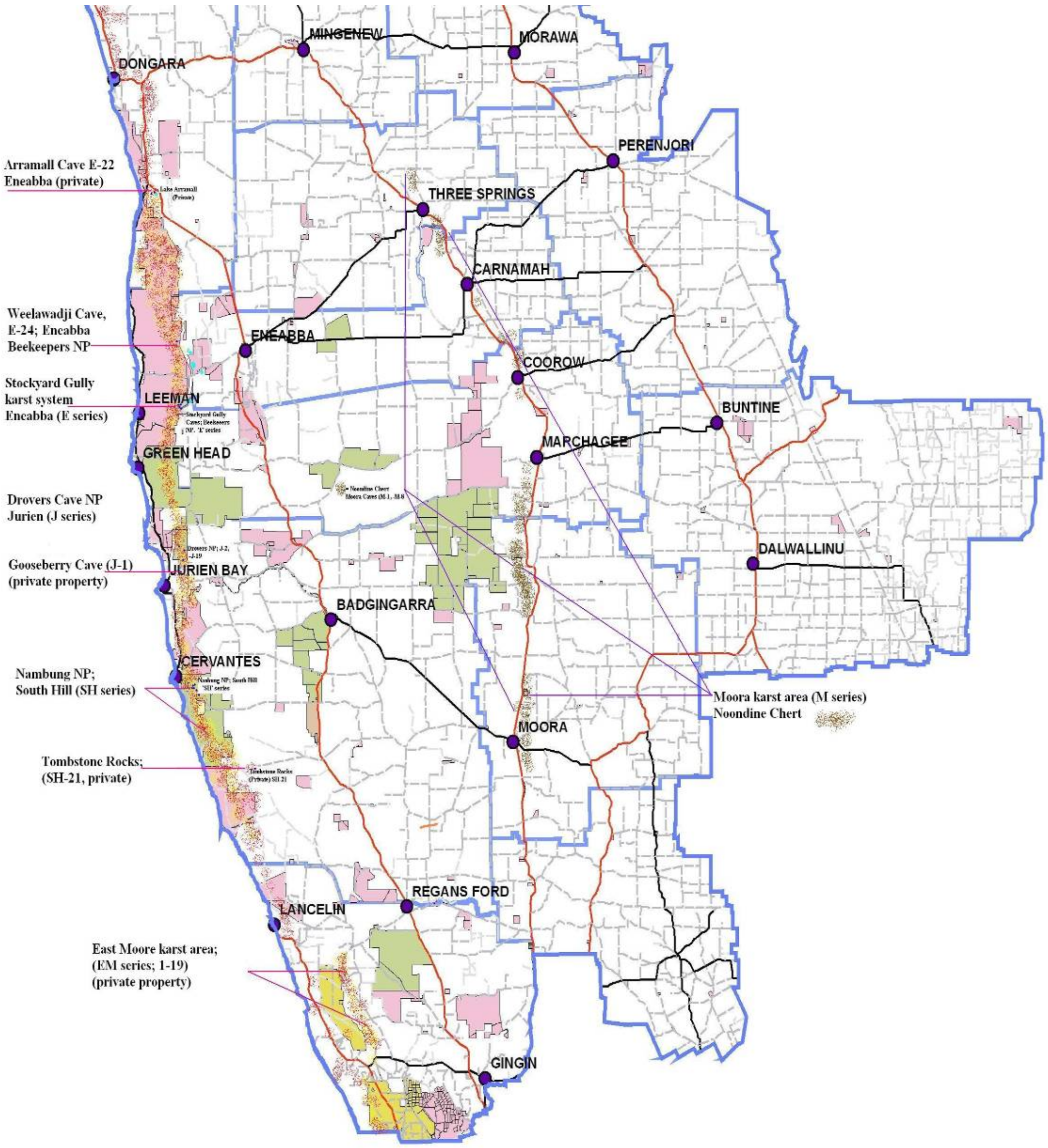


Figure 1; Karst areas found within the Northern Agricultural Region. Note that the coastal karst alignment is of Tamala Limestone and the inland alignment is of older Noondine Chert.

Figure 2; *Chalinolobus morio* Gray 'the chocolate wattled bat'; huddling together on the roof for warmth and protection in 'The Hot Room' –Weelawadji Cave (E-24), Eneabba. Note the presence of the cockroach; Blattellinae; *Neotemnopteryx douglasi* (Princis)[17, 25].

Figure 3; 'Moonmilk' found in Arramall Cave (E-22) Eneabba.

Figure 4; Roots exploiting the moonmilk substrate at Cadda Cave (SH-18); South Hill.

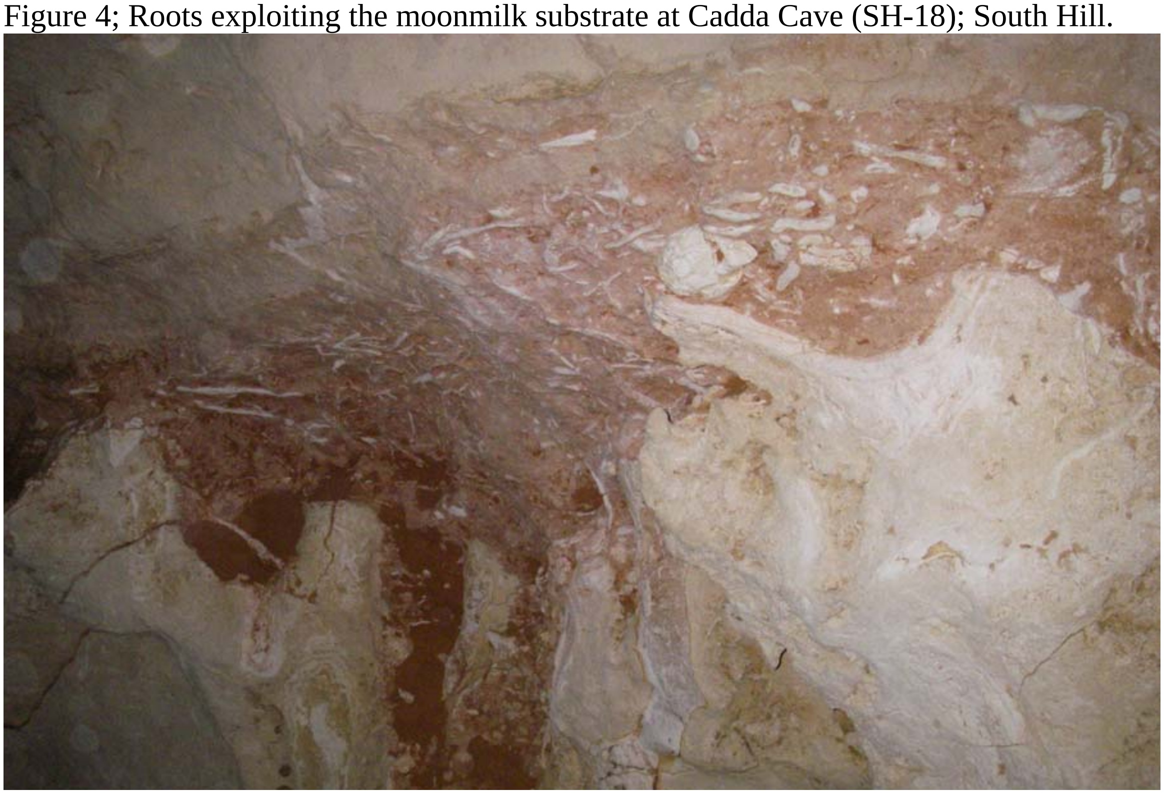


Figure 5; Phytolithic material, rhizoliths evident within a palaeosol horizon (E-24).


Figure 6; Bee nests below the lintel line at Gooseberry Cave (J-1), Jurien (March 2007).


Figure 7; Pseudoscorpionidea: Cheliferidae; *Protochelifer cavernarum* Beier (~10x), a common cavernicole with a dispersal attributable to phoresy (Moulds *et al*. 2007).


Figure 8; *Chalinolobus morio* roosting in Stockyard Cave (E-3), Eneabba.


Figure 9, burrowing frog in Aiyennu Cave (E-9); Eneabba. Photo; Jude Shaw

Figure 10; breakdown at the entrance doline of Beekeepers Cave (E-10), Eneabba. A distinct palaeosol horizon is evident as a red sedimentary band.

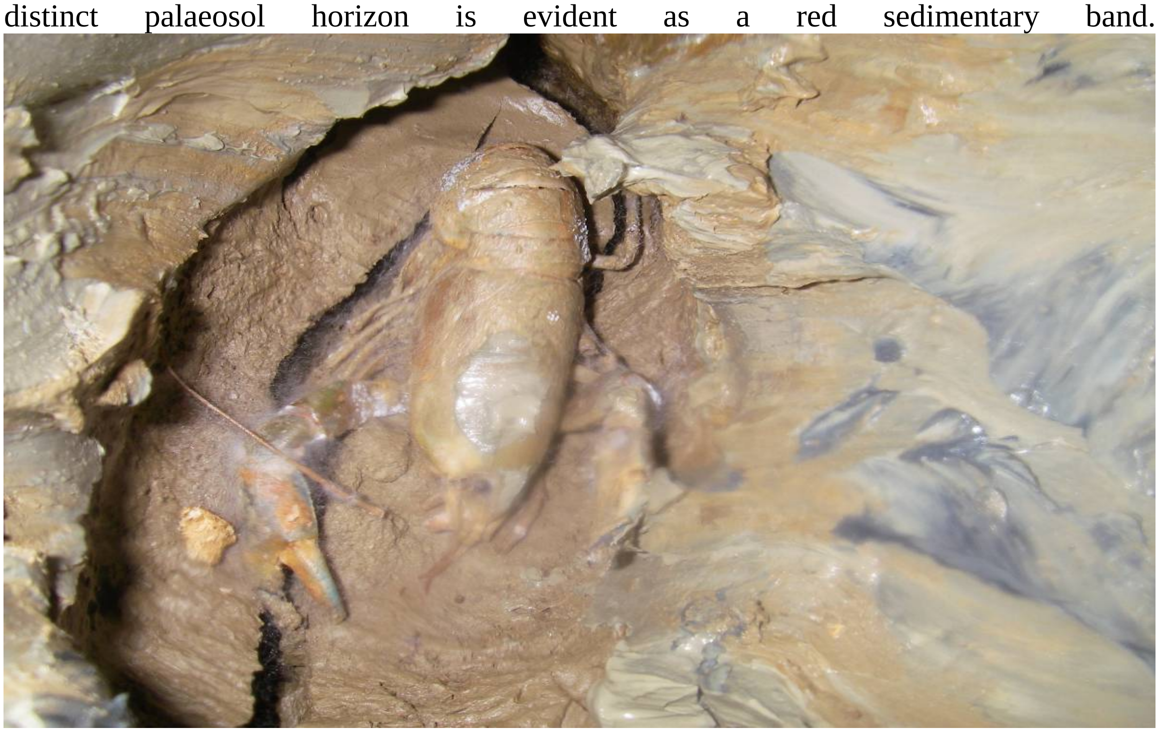


Figure 11; *Cherax destructor* ‘the eastern yabby’; decreasing in population (E-10).

Figure 12; monk snake; *Rhinoplocephalus monachus* only ~12cm long (E-10).

Figure 13; *Chalinolobus morio* (sensitive to disturbances) in Arramall Cave (E-22).

Figure 14; nest of *Hirundo neoxena* Gould   Figure 15; roots, moonmilk in solution pipe.

Figure 16; Scutigeridae; *Allothereua lesueurii* a fast moving predator (Arramall Cave).

Figure 17; troglobitic cockroach; Blattellinae; *Neotemnopteryx douglasi* (Princis).

Figure 18; pie dish beetle; Tenebrioninae; *Anemia caulobioides* (~21mm long), Arramall Cave (E-22).

Figure 19; barking gecko, Gekkonidae; *Underwoodisaurus milii* Bory. Ross Anderson

Figure 20; the large entrance of Weelawadji Cave (E-24). Photo: Candace Williams

Figure 21; *Hirundo neoxena* nest site(E-24). Figure 22; prominent stalagmite roost site.

Figure 23; an abundance of bones from owl/raptor prey accumulate near roost sites.

Figure 24; the cast moults of centipedes in Weelawadji Cave (E-24). Photo; Zoé Gibbs

Figure 25; the cockroach *Neotemnopteryx douglasi* scaling roots deep in the Dz (E-24).

Figure 26; dugite *Pseudonaja affinis* (E-52). Figure 27; Histeridae: *Saprinus* sp. (E-52).

Figure 28; western bearded dragon; *Pogona minor* Loveridge –an accidental found within Weelawadji West (E-52), Eneabba.

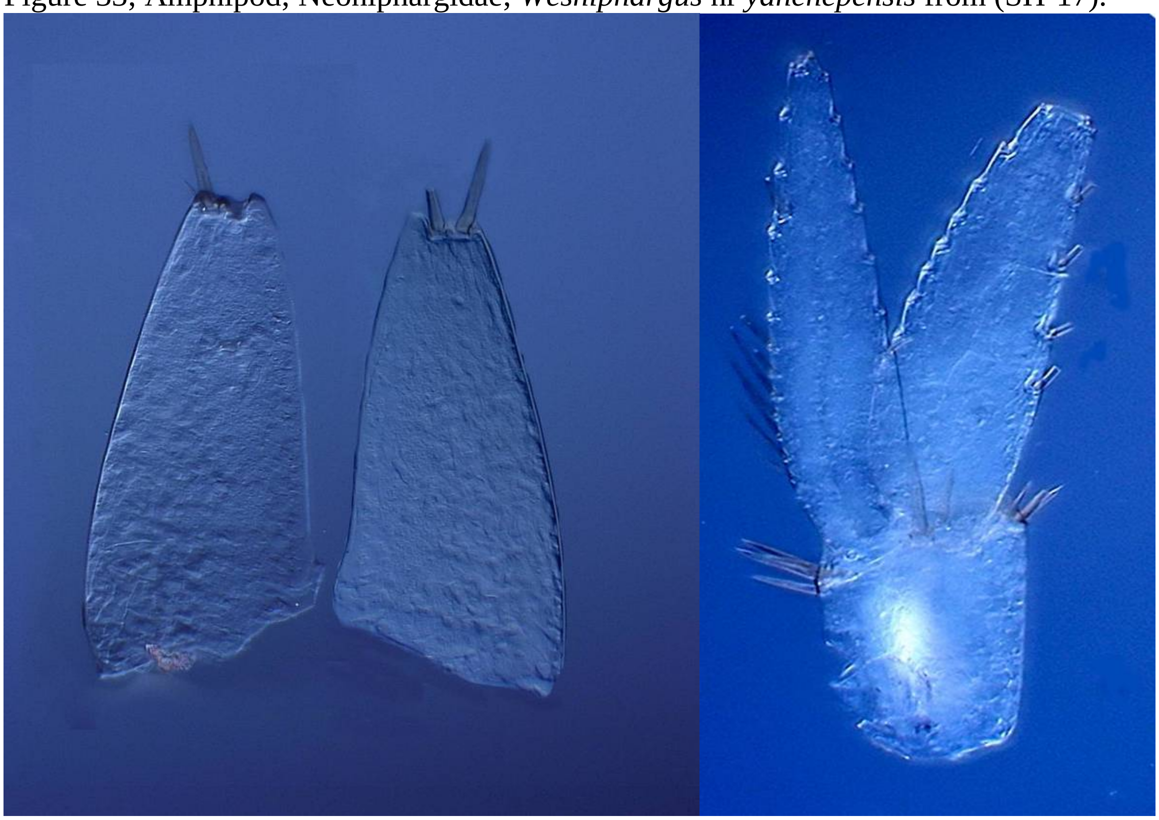

Figure 29; skull & mandible of *Macroderma gigas* the ghost bat at Weelawadji West.

Figure 30; dead bats persisting to hang on walls still attract invertebrates, (J-1).

Figure 31; the occurrence of *Latrodectus hasselti* the redback spider has increased, (J-2).

Figure 32; the spider Stiphidiida; *Baiami volucripes*, Weston Cave (SH-2); South Hill.

Figure 33; Amphipod; Neoniphargidae; *Wesniphargus* nr *yanchepensis* from (SH-17).



Identifying characteristics of *W. yanchepensis*; the telsons (left) & U3 [Jane Mc Ray].

Figure 34; Stiphidiida; *Baiami volucripes*, in Cadda Cave (SH-18), South Hill, Nambung.

Figure 35; Blattellinae; *Neotemnopteryx douglasi*, Cadda Cave (SH-18), South Hill.

Figure 36; root mat engulfed stalagmite providing habitat in Pulchella Cave (SH-38).

Photo Ross Anderson.