Cavernicole diversity and ecology in Tasmania

By

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This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due acknowledgement is made in the text.

Arthur Kenneth CLARKE

May 31st 2006

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ABSTRACT

The five cave zone regions, ten macro-habitats and 44 micro-habitats for invertebrate species recorded from caves in two adjoining karst areas of southern Tasmania (Hastings and Ida Bay) are described. The information for these two karst areas is a sub-set of the 7,861 cave or karst area invertebrate occurrence records listed in six relationally linked tables together with 309 database queries or tabulations (contained in a Microsoft Access database) that documents collections and observations of 1,292 species from 749 occurrence sites in karst and non-karst cave areas of Tasmania. The cave related data and its content including a comprehensive micro-habitat site analysis and species taxonomy detail in a relational database is unique, making it the only cave fauna database of its kind in the world.

The database provides a historical account dating back to the early 1840s when glow-worms were first reported from caves in Tasmania; these are recorded along with accounts of the first cave spider and cave beetle species described in Australia. Together with anecdotal accounts from some of the early entomologists and naturalists who studied Tasmania's cave fauna, the significant role of modern day cave biologists is commended along with their contributions that have vastly expanded our knowledge base. The history of the study of cave biology is discussed, together with the development of cave fauna related ecological terms and theories or explanations for the colonisation of caves and evolution of troglomorphic characters in aquatic and terrestrial hypogean obligates. Following a brief introduction of geomorphic processes, the term "karst bio-space" is introduced to encompass the total living space for all hypogean species in the saturated or unsaturated karst and karst-like cavities, crevices and voids including caves. The concept of cave ecology is expanded to describe the five cave zone regions, ten macro-habitats and the 44 micro-habitats deployed in the detailed analysis of habitat data for species in the Hastings and Ida Bay karst areas. A comprehensive explanation of the database fields is provided, along with guidelines for operating the database and constructing queries to answer questions related to the diversity and ecology of Tasmanian cave species.

Incorporating the most up to date and current taxonomy for cave species in Tasmania, this thesis provides a detailed overview of the diversity of the most common groups of cave dwelling invertebrates and the first records of new species not previously recorded in the speleological or cave biology literature. The major species groups discussed include glow-worms, cave crickets, land snails, springtails, multipedes (centipedes, millipedes, symphylans, pauropods and onychophorans), aquatic and terrestrial amphipods and isopods, bathynellacean and anaspidacean syncarids, aquatic snails, cave beetles and the arachnids (ticks, mites, pseudoscorpions, harvestmen and spiders).

In addition to factors related to cave morphology and hydrological influences (stream recharge or input etc.), the two predominant factors influencing the distribution of invertebrate species are the intensity of karst bio-space development and the input of organic matter, its re-distribution and dilution as it is transported further into the subterranean domain. In most of the wild caves at Ida Bay, this organic material is naturally derived, but at Hastings where tourist caves have been developed, much of the organic matter has been introduced to the cave. The source of organic input in tourist caves is varied and includes the artificial introduction of exotics in the form of tree trunks, rough sawn timber and other plant matter used in the construction of stairs and fern log pathways, plus the litter "inadvertently" placed in caves by natural processes, carried in by humans or dumped as refuse in the course of the continuing development of caves for tourism.

Aside from organic input, the survival and distribution of cave species is dependent on a range of factors including the presence/ or absence of surface disturbance and the impacts of human use of caves or other components of the karst bio-space, including groundwater. Within the karst bio-space itself, there are the complexities of inter-relationships of species and predator-prey relationships within the subterranean food chain, together with the presence of cave bacteria and other micro-organisms found deep within the dark zone of caves; the dependence of cave species on these micro-organisms has not been studied here in Tasmania. A proportion of the cave species are obligates, totally dependent on the cave for survival and some of these species are cave adapted (troglobites or stygobites). The number of cave adapted species in Tasmanian caves generally exceeds the numbers found in most areas of mainland Australia and five caves in the study area at Hastings and Ida Bay are rated as being at world standard in the number of obligate species.

1: Introduction

Ever since the primate ancestors of hominids descended from trees to walk the Earth, modern man has had a fascination with caves. At the beginning of the Pliocene epoch in East Africa around four to five million years ago, our bipedal ancestors of the genus *Australopithecus* needed shelter to survive. Caves were the obvious choice and in fact it is from caves and limestone palaeokarst deposits in South Africa where modern archaeologists exhumed the first bone fossils of *Australopithecus africanus* and *Australopithecus robustus* (O'Neil, 2005).

1.1: The early history of cave fauna discovery and classification

Although the earliest known record for documentation of caves comes from China, dating back around 2200 years ago (Waltham, 1986), the first known reports of cave fauna did not appear till the third and fourth decades of the sixteenth century. On March 5th 1537, Trissino records "*some tiny shrimp-like creatures*" (presumably *Niphargus* amphipods) from the far end of a cave in northern Italy (Shaw, 1992). Four years later, the first description a cave adapted animal was recorded; engraved in stone, this 1541 inscription describes a blind cavefish from eastern Yunnan in southern China (Chen, *et al.*, 2002). A century later, a Ming Dynasty scholar: Xu Xiake produced one of the first accounts on the ecology and biology of caves recording the relationship of bats, snakes and various insects during documentation of over 350 caves in southern China from 1636-1640 (Yang, 1983; Clarke, 2002). In 1689, a Slovenian polyhistorian: Janez Valvasor reported "*dragon's young*" in lake waters of the Lintvern karst spring (Jeannel, 1943; Shaw, 1992; Aljančič, *et al.,* 1993). Valvasor was reporting the blind salamander: *Proteus anguinis* (Figure 1.1) and when described in 1768 by the Austrian naturalist, Joseph Laurenti, it became the first published account of a cave animal (Jeannel, 1943). However, there was doubt regarding Laurenti's collection site, because *Proteus* was initially considered as a lake dwelling animal, rather than a cave species (Aljančič, *et al.,* 1993), though Richards (1962) records that it was collected by Laurenti from a cave in Istria, western Croatia.

Nevertheless, the discovery and description of *Proteus anguinis* was possibly the catalyst for introducing this cavernous region of the Balkan Peninsula to the world, particularly

Western Europe. Subsequently known as the Dinaric karst, this area of the Balkans attracted considerable attention and even more so from a cave biology point of view when in 1831, a Slovenian cave guide discovered an unknown beetle in the dark zone of Postojna Cave. Subsequently named *Leptodirus hochenwarti* by Ferdinand Schmidt, it became the world's first described cave beetle and lead to a spate of cave invertebrate discoveries, bringing fame to Postojna Cave as the birthplace of modern speleobiology (Aljančič, *et al.,* 1993). In the mid 1840s, Schmidt was accompanied by a Danish biologist: J.C. Schiödte, who classified species in Postojna Cave according to biotope in his book *Specimen Faunae Subterreaneae* (1849) which became the foundation stone for biospeleology (Aljančič, *et al.,* 1993). In addition to the cave dwelling glow-worms reported from Tasmania in 1842 (see Chapters 2.1 and 5.2.1), cavernicoles were also discovered in Kentucky (USA) in 1844 and from caves in the l'Ariege region of southern France in 1857 (Jeannel, 1943).

Figure 1.1: Described in 1768, this blind salamander: *Proteus anguinus* was recently collected from a rock pool of the Pivka River in Postonjski Jama (Slovenia), approximately 3.5km into the cave; photographed by the present writer (September 2002). Note the bare discernable tiny vestigial eye structure, approx. 1 cm from anterior end before head broadens out (just beyond tip of the white arrow).

The first system for classification of cave animals was put forward in 1854 by another Austrian naturalist, J. R. Schiner. Introducing the prefix "*troglo*" as an ecological descriptor, Schiner suggested three categories based on ethological observations of cave species: occasional guests, habitual species (as troglophiles) and the exclusive or obligatory troglobites (Jeannel, 1943). Just over 50 years later, Schiner's classification was modified and expanded by a French speleologist, Emil Racovitza (1907) who suggested that the term "trogloxene" should be used instead of "occasional" (Jeannel, 1943). Racovitza's system involved a more strictly ecological approach, with cave species being classified by the degree of their dependence on the subterranean environment. Although subsequently modified (see Section 1.2.1), the Schiner-Racovitza system provides the basis for ecological classification of cave species.

In that same year (1907), Racovitza joined forces with René Jeannel to form "Biospeologica" the world's first organisation dedicated to biospeleology (Shaw, 1992; Juberthie, 2000). Two decades later, Jeannel (1926) proposed the first classification of cave animals based on zones of light penetration and habitat, with a "light" and "dark" region, plus 15 associated faunistic micro-habitats. In 1943, Jeannel published another monograph providing a comprehensive history of cave fauna discoveries, a detailed analysis of cavernicoles and their troglomorphism, plus one of the first descriptive accounts of the global distribution of known aquatic and terrestrial species recorded in caves (Jeannel, 1943). Australian speleologists first learnt about cave animals and their environment, when in 1962, Aola Richards published her introductory paper describing Schiner's classification of cave animals together the cave zones and habitats proposed by Jeannel (Richards, 1962). Two years later, a more detailed and dedicated manuscript was published by Vandel (translated in 1965), listing cave animals from all round the world, classifying species to ecological status based on the Schiner-Racovitza system, but adding an extra fourth ecological category for the "accidentals" (Vandel, 1965).

1.2: Cave fauna and cave biology: what is it and where is it found?

As with any defined ecological group, there are many terms specifically used to describe the fauna: in this case the cave fauna, introduced in this thesis in terms of the overall biology of caves, cave ecosystems and the subterranean environment (see Glossary, Section

8.2). Although the records of cave fauna in Tasmania include species from a wide range of environments including karst surface localities and "non-karst" caves, the focus of this thesis is centred on caves in karst areas with specific reference to two areas of southern Tasmania: Hastings and Ida Bay. The concept of "karst bio-space" is introduced to define the hypogean environment where cave animals live and evolve, with the development of diverse community groups and ecosystems in a variety of aquatic and terrestrial macro- and micro-habitats in different zones of the subterranean realm.

1.2.1. An introduction to the ecology of cave species

In this thesis, cave fauna is simply defined as all those aquatic and terrestrial invertebrate species living in caves, collectively referred to as cave-dwelling species, cavernicoles or troglobionts. The diversity of cavernicoles includes a wide spectrum of aquatic and terrestrial species in many ecological niches, ranging from the essentially adventititious species, epigean or accidental cave visitors, to the opposite extreme, the hypogean obligates, with a range of facultative and habitual species in between. In terms of cavernicole ecology, the obligate hypogean species are described as "troglobites"; many of these are cave adapted with characteristic morphological features described as "troglomorphisms" or "troglo-biomorphosis" (Juberthie and Decu, 1994). Following a subsequent review of the hypogean fauna, the aquatic species were separated and referred to as stygofauna and the aquatic obligates as "stygobionts" or "phreatobites" (Botosaneanu, 1986). The terminology for aquatic fauna was expanded again with cave adapted stygobionts being referred as "stygobites" (Gibert, *et al.,* 1994) and this term is now commonly used to describe all aquatic obligates. Although the term troglobite can still be applied to aquatic species, use of the word is generally restricted to the terrestrial obligates. Species in the ecotone between the two extremes of accidental or epigean to obligate hypogean, are described as trogloxenes or troglophiles, following the Schiner-Racovitza system (Jeannel, 1943; Vandel, 1965).

Amongst the troglophiles commonly seen in Tasmanian caves, some are erroneously referred to as "cave animals", but in fact caves are just one of several cool, dark, moist and sheltered habitats used by these species. Three such troglophiles are the glow-worms *Arachnocampa tasmaniensis* (Figure 1.2), Tasmanian Cave Spider *Hickmania troglodytes*

(Figures 1.3, 2.1 and 5.29) and the so-called "cave crickets" (Family Rhaphidophoridae) shown in Figure 1.4. Although Doran (1991) reference to cave adaptation in the Tasmanian Cave Spider, this species and other troglophiles are not true cave animals, but belong to the suite of invertebrate species commonly found in surface surrounds that can mimic the subterranean environment. Most of the hypogean species in Tasmania are ectothermic and hygrophilous (moisture-loving) creatures, and some terrestrial invertebrates occupy a range of surface habitats with similar ecological attributes to caves, e.g., in and under large or hollow logs and tree stumps in cool, moist and sheltered rainforest settings, in culverts, under old wooden bridges, in abandoned mine workings (often in horizontal adits or gently inclined winzes) and in suburban drains including the Hobart Rivulet!

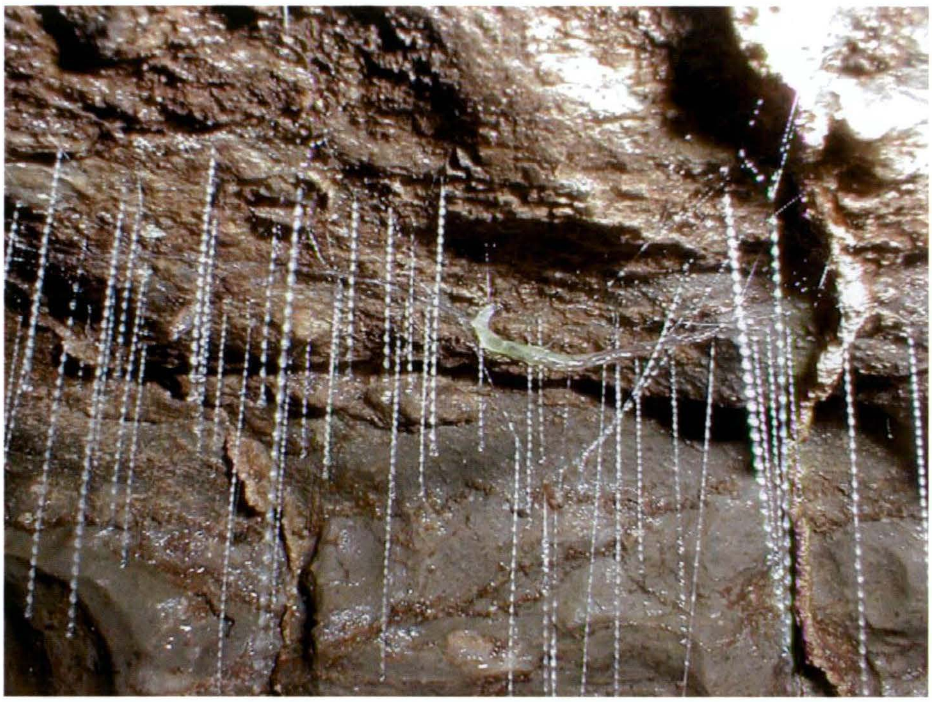


Figure 1.2: Inside its protective tube of mucus suspended in a hammock of horizontal threads the 3cm long larva of the bioluminescent Tasmanian Glow-worm (*Arachnocampa tasmaniensis*) is surrounded by 15-20cm long mucous beaded snare threads, in Mystery Creek Cave at Ida Bay. Note the apparent small item of prey food immediately below the larva, which is probably the pupa of another glow-worm.

The invertebrate cave fauna is just one component – the most studied part – of the even wider spectrum covering the total biology of caves in southern Tasmania. In the very broadest terms, cave biology encompasses a range of aquatic and terrestrial species, comprising micro-organisms such as bacteria and fungi, micro- and macro-invertebrates, occasional vertebrates, plus a range of lichens, ferns and bryophytes.

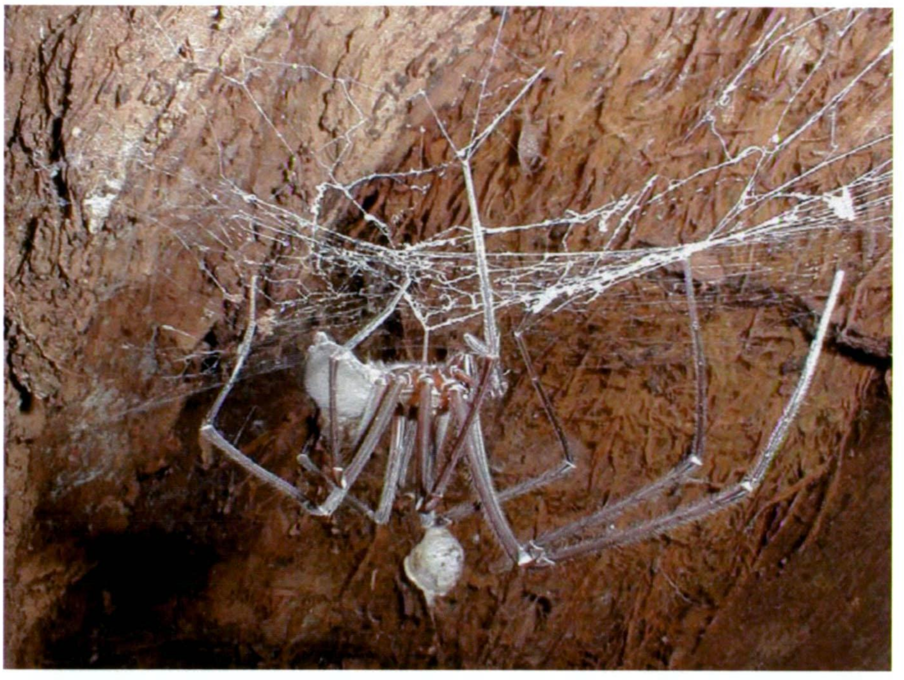


Figure 1.3: Female specimen of the Tasmanian Cave Spider (*Hickmania troglodytes*) with a body length of 2.5-3cm and legs extending 10-12cm, clinging to webbing that often extends over a metre; its egg sac shown in background. Photographed under a rotting log in rainforest at Francistown, near Dover in southern Tasmania.

Figure 1.4: Female rhaphidophorid cave cricket (*Micropathus kiernani*), body length approx. 18-19mm, grazing on dead lichens and mosses on the entrance wall of a sandstone cave, at Francistown near Dover in southern Tasmania.

1.2.2. Cave bacteria

Sometimes referred to as micro-flora (Cacchio *et al.* 2004; Moore and Sullivan, 1997), the bacteria in caves are probably the most fundamental but least known component of cave ecosystems, forming the base of many cave food chains (Chapman, 1993). Microscopic examination of faecal pellets from live hydrobiid snails (collected from the streambed of Western Passage in Exit Cave), revealed a rapid disintegration of the "scats" by unknown micro-organisms (Clarke, 1997a). Ponder (pers. comm., 2004) states that bacteria are likely to be the main food sources for native hydrobiids. Experimental studies show the cave-dwelling amphipod *Niphargus* can subsist and grow in an environment where the sole "food" supply is clay containing iron minerals and iron bacteria (Chapman, 1993).

Heterotrophic and autotrophic bacteria are found in caves. Along with fungi, heterotrophic bacteria essentially scavenge on the dead and decaying organic matter introduced to caves by gravity, streamflow or visiting animals (including humans) and consume the waste matter deposited by cave dwellers. The food webs of cave streams provide an example of the heterotrophic system where aquatic organisms – particularly the stygobionts – are totally dependent on detritus from the surface that "arrives" as particulate organic matter (POM) or dissolved organic matter (DOM), requiring breakdown or transformation by bacteria. In their studies of the trophic structure of bacterially formed epilithic biofilms in cave streams (see Figure 1.5), Simon *et al.* (2003) demonstrated that the abundant carbon and nitrogen immobilised in biofilms had been chiefly extracted from the DOM. Although cave processes obviously drive or direct inorganic precipitation of carbonates, it is difficult to determine whether bacteria are simply colonising the precipitating surfaces, e.g., the epilithic biofilms (Figure 1.5) or whether bacteria are actually contributing to the process of precipitation (Riding, pers. comm., 2006).

Autotrophic bacteria also fuel cave food webs, particularly where there is an abundance of the numerous chemical elements required to support higher living organisms (Sarbu, *et al.*, 1996). Among the autotrophic micro-organisms of particular interest in caves are the chemoautotrophs: specialised bacteria deriving energy from the "digestion" and reduction of minerals (Daoxian, 1989), e.g., the iron, sulphur and calcium compounds in carbonate rocks, cave deposits and calcium saturated cave waters (Northup and Lavoie, 2001). In a study of the lake water chemistry in Weebubbie Cave (Nullarbor Plain), Contos *et al.* (2001) show bacteria playing an active role in precipitation of calcite, controlling the shape and form of crystals in the sub-aqueous calcium carbonate held in suspension and deposited on the lake floor.

Figure 1.5: Possible bacterially formed epilithic biofilms on boulders in the stream of a recently discovered cave in dolomite at Hastings, southern Tasmania. Believed to be an effect related to water borne bacteria (Contos, pers. comm., 2004), the exact cause and explanation for the striated "dot" pattern is unknown. Situated in a natural rainforest setting where logging has not occurred in the catchment, the cave has been "closed" to maintain it as a scientific monitoring site for gathering baseline data. For additional discussion on epilithic biofilms, see McLean *et al.* (2000), Riding (2000) and Simon, *et al.*, (2003).

A common sight on walls and ceilings of many Tasmanian caves are the highly reflective white to silvery-grey, sometimes brown pigmented condensation-like droplets of water and the thin mat-like biolithic films; the pigment is produced by cave Actinomycetes, a mould-like filamentous bacteria (Moore and Sullivan, 1997). As chemoautotrophs, Actinomycetes and hyphal bacteria assist in the biogenesis of complex cave mineral deposits, e.g., in Lechuguilla Cave, New Mexico (Northup and Mallory, 1998), including the amorphous "cheese-like" masses known as moonmilk seen on cave ceilings or walls and clay dirt substrates (Williams, 1959; Danielli and Edington, 1983; Goede, 1988; Chapman, 1993; Forti, 2001; Cacchio *et al.*, 2004; Van der Kamp, 2004). Some of the bacteria known to be involved with the formation of moonmilk by bio-chemical corrosion of bedrock include *Arthrobacter*, *Flavobacterium* and *Pseudomonas* (Forti, 2001); bacteria such as *Macromonas bipunctata* directly precipitate moonmilk (Moore and Sullivan, 1997). There is evidence to suggest that moonmilk is formed seasonally, particularly in cool temperate or cold latitude karst areas (Lacelle, *et al.*, 2004).

In her recent phylogenetic analysis of the microbial biodiversity in Tasmanian caves, Van der Kamp (2004) examined moonmilk, cave sediments, speleothem surfaces and microbial mats associated with Actinomycetes (Figure 1.6) in Mystery Creek Cave, Exit Cave and Loons Cave at Ida Bay. Van der Kamp recognised a total of 302 isolates from 39 genera and noted a community structure at most sample sites composed of *Archaea* (from saturated sediments), *Nitrospira* (obligate nitrite-oxidising chemolithoautotrophs in sediment from Loons Cave), *Gemmatamonadetes* (aerobic polyphosphate accumulating microbes in sediments), *Verrucomicrobia* (in dry sediment samples), *Firmicutes* (mainly aerobic forms in moonmilk), *Chloroflexi* (green non-sulphur bacteria), *Planctomycetales* (aerobic chemoheterotrophs in moonmilk), CFB (*Cytophaga-Flavobacterium-Bacteroides*) groups (most abundant in moonmilk, with aerobic and heterotrophic genera), *Acidobacteria* (in moonmilk), *Actinobacteria* (in dry sediments, moonmilk and microbial mats), plus the *Proteobacteria* from *Alpha*, *Beta*, *Gamma* and *Delta* subclasses, the most commonly sampled group in all cave samples (Van der Kamp, 2004). Despite their geographic separation in linear distance, calcite moonmilk samples from "The Ballroom" in Exit Cave and Mystery Creek Cave showed remarkable similarities in community structure (Van der Kamp, 2004: Figure 3.19, p. 136). Van der Kamp determined that the isolates from moonmilk belonged to *Actinomycetales*, *Firmicutes*, *Proteobacteria* and the CFB groups. The major Actinomycetes isolates from all her samples belong to Stretomycineae, Pseudonocardineae, Corynebacterineae and Micrococcineae.

The specific role of biogenic speleothem bacteria in the food webs of cave ecosystems is unclear, but as their "end" product (moonmilk) consolidates over time (Goede, 1988), this substance is host to many cavernicoles. In a semi-consolidated form, moonmilk acts as a substrate and nutrient base for the hyphae or mycelia of higher plant organisms such as the Ascomycetes fungus (Figure 1.7), seen in caves at Hastings and Ida Bay, which provide a habitat for many invertebrate cavernicoles including troglobites.

Figure 1.6: Condensation droplets associated with microbial mats on the ceiling of a cave at Ida Bay (near the entrance), with their characteristic silvery-white sheen due to the presence of a thin film of calcareous mineral compounds extracted from the limestone rock by Actinomycetes and other chemoautotrophic bacteria.

1.2.3. Fungi, tree roots and lampenflora

The fungus (Class Ascomycetes) shown in Figure 1.7, first reported from a cave at Ida Bay (Eberhard, 1987a), has a cup-shape structure with apothecia, petal-like soft fleshy lobes that harbour many macro-invertebrates. This fungus is presently known from four caves at Ida Bay and two caves at Hastings, growing on a clay or moonmilk substrate and/ or in the near proximity to tree roots in the twilight, transition and dark zones. Species often associated with these Ascomycetes include troglobitic isopods, springtails, millipedes, symphylans, beetles, pseudoscorpions, plus small spiders. Several forms of filamentous fungi occur in the dark zone of caves, particularly where flood litter and/ or large pieces of organic matter (plant or animal) are brought into caves. Closer to cave entrances, the occasional agaric-like (basidiomycetes) fungus is found growing on logs or other organic matter (Figures 1.9 and 1.18); these fungi with stalked fruiting bodies are home to many small dipteran species.

Figure 1.7: Ascomycetes fungus, approx. 6-7cm wide, with cup-shaped apothecia growing on consolidated moonmilk in the twilight-transition zone of a new recently discovered cave at Ida Bay in southern Tasmania. Obligate cave species including troglobites and other macro-invertebrates are found on/ or in these fungi.

Some fungi are associated with tree roots, which themselves form a habitat for cave species and when penetrating roots grow in cave waters, dense root mats develop, providing a habitat and food supply for aquatic cavernicoles (Jasinska, *et al.*, 1996; Jasinska and Knott, 2000). Aside from penetrating tree roots (Figure 1.5), the occasional germinating seed and fungal growth that develops where flood litter is washed in/ or falls into caves, most living plant matter is located in the outer (or upper) entrance zone regions of horizontal (or vertical) caves, where partial daylight occurs. In developed tourist (show) caves where artificial lighting is installed, "lampenflora" is one of the many less fortunate aspects of tourist development of caves (Huppert, *et. al.*, 1994), forming on speleothems and earthy substrates, where lights are ill-directed (Figure 1.8), high wattage illumination is deployed or the intensity of lighting is too prolonged. Lampenflora growths typically include algae, ferns and bryophytes, especially moss (Figure 1.8), which in total often form a micro-habitat for smaller invertebrates, e.g., springtails, flies and isopods. A "natural" form of lampenflora grows inside cave entrances exposed to regular amounts of sunlight.

Figure 1.8: Lampenflora growths: algae and mosses on a clay bank beside a former illumination source in Newdegate Cave: the commercialised tourist (show) cave at Hastings, southern Tasmania, prior to its removal during installation of a re-designed lighting system in the show cave section. The new system utilises low wattage light sources at strategically positioned sites, combined with other ameliorative factors designed to prevent any future onset of lampenflora.

Figure 1.9: Small 1.3cm long mycetophiloid fly on basidiomycetes fungus attached to limestone wall in the entrance zone of a cave in the North Lune karst area, south of Hastings, in southern Tasmania.

1.2.4. Bone deposits in caves

The non-living organic material in caves is principally the dead or decaying remains of epigean species of flora and fauna that have washed in, fallen in or been carried into caves, plus deceased hypogean species, along with skeletal remains of vertebrates that form the sub-fossil or "fossil" bone deposits in caves (Figures 1.11 and 1.12). The writer has observed the fossilised remains of frog skeletons embedded in flowstone in two caves at Ida Bay: Exit Cave and Bottleneck. Most bone deposits are from extant and extinct mammals, considered as accidental species falling into vertical caves (see Figure 1.10); some vertebrate species are washed in by cave streams or simply enter caves as temporary "visitors" and are unable to exit the cave (Andrews, 1971; Clarke, 1986a, 1987a, 1988a, Andrews and Cook, 1990; Muirhead, 1990). Scratch marks are seen on the walls of some caves near the base of shafts; a legacy of the desperate escape attempt by an animal destined to die of starvation or the injuries suffered in a fall. Mound shaped deposits of small bone fragments found inside cave entrances or at the base of former, now blocked, entrance shafts are often derived from the accumulations of owl pellets: the regurgitated bone, feather and fur matter of small animal prey species consumed by owls (Clarke, 2000a; 2006).

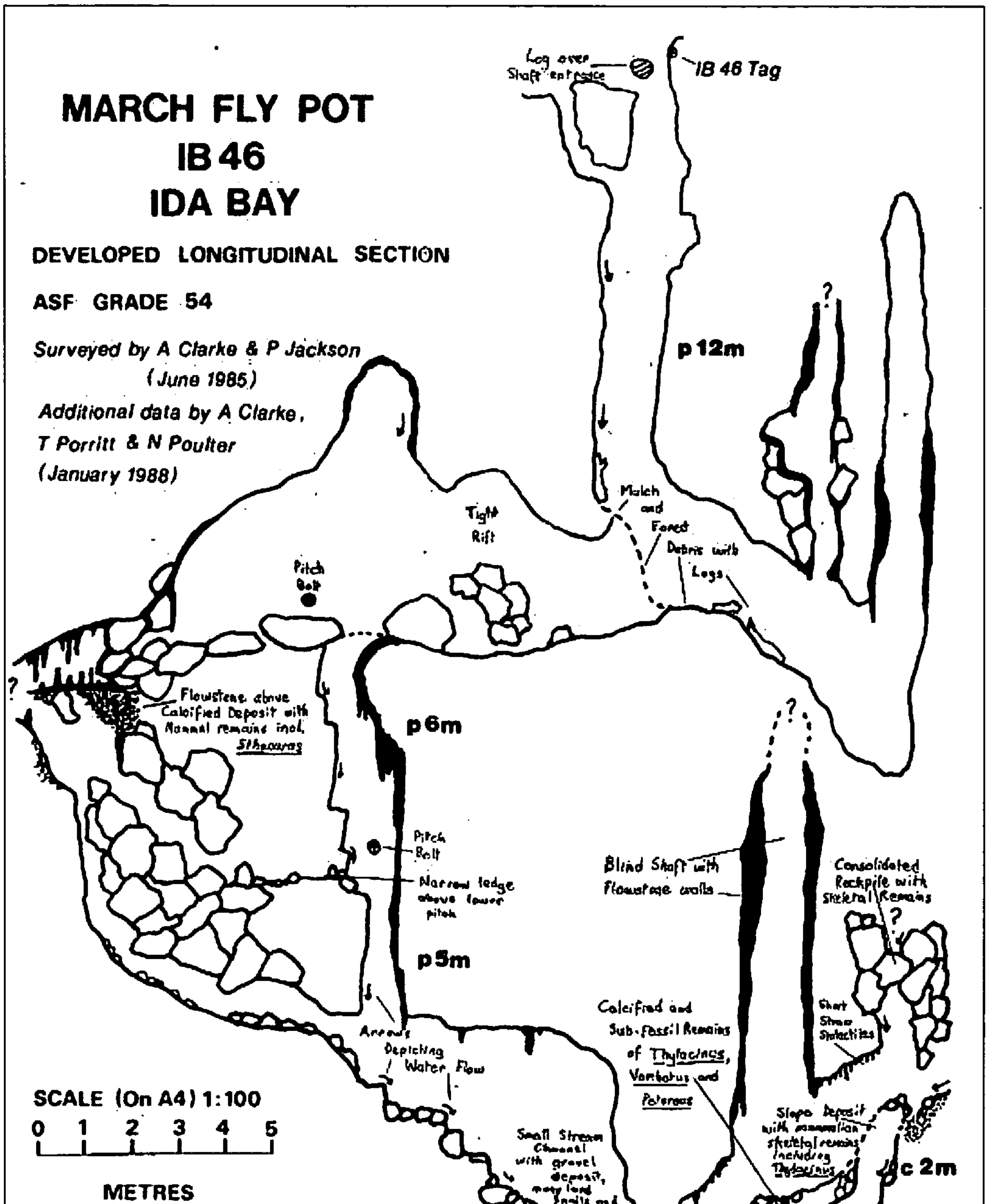


Figure 1.10: Survey (Developed Longitudinal Section) of March Fly Pot, a vertical cave at Ida Bay in southern Tasmania, showing sites of mammalian skeletal remains; (see Clarke 1986a, 1987b, 1988a; Muirhead 1990). Located in forest on a ridge between two high points (which is also a saddle between lowland grass areas), this small vertical cave is an example of a site that has acted as a pitfall or "mammal trap".

Figure 1.11: Jumble of water-washed and muddy macropod bones in terminal fissure of a cave near the Styx River in southern Tasmania (with collecting brush to scale).

Figure 1.12: Skeletal remains of macropods buried and cemented with cave mud on floor of a new cave near the Styx River in southern Tasmania; (5ml McCartney jar for scale).

Due to the prevalence of vertical caves with wide entrance openings, particularly in Tasmania (where there is substantial relief in many carbonate rock karst areas), these "pothole" type caves are sometimes referred to as "mammal traps" (Clarke, 1988a). The mammal bone accumulations at the base of shafts (see cave survey, Figure 1.10) or fissures (Figure 1.11), give the appearance of graveyards with the remains of a mix of small ground dwelling mammals and larger marsupial species including macropods, some of which probably fell down entrances while being chased as prey species by marauding predators. The location of the entrance and size of the opening often govern the type of species found in cave deposits. For example, March Fly Pot at Ida Bay (Figure 1.10) is located on a saddle between adjoining lowland grass areas (and on a ridge between forested highlands). In this cave, the abundance of mammal remains includes a significantly large proportion of predator species and ground dwelling prey species including six thylacines, several Tasmanian devils and numerous brushtail possums, plus extant and extinct macropod species (Clarke, 1986a; 1988a).

Located near the valley floor in the "Potholes" region at Ida Bay another site – aptly named Pseudocheirus Cave – has a 10-12m wide entrance leading down to a 42m deep funnel with an 8-10m high soil cone and bone deposit comprised largely of arboreal mammals (e.g., ringtail possum, pygmy possum and brushtail possum) plus a mix of predator and prey animals including rodents, *Antechinus*, numerous dasyurids, Tasmanian Devil and thylacines (Clarke, 1987a; 1987b). Studies of mammalian skeletal remains, sometimes referred to as "fossil" (bone) deposits in Tasmanian caves (Andrews, 1971; Wakefield, 1972; Muirhead, 1990) have provided information relating the present and past distribution patterns for a number of extant and extinct mammal species, giving additional evidence to past climatic conditions.

Although the primary focus of this thesis relates to invertebrate cavernicoles, it needs to be mentioned that the hypogean fauna of many cave areas includes a range of vertebrates: fish, amphibians, reptiles, birds and mammals (including occasional bats). Some vertebrates will survive in the cave by preying on invertebrates, and then at death, will ultimately become a food supply for other invertebrate species lower down in the food chain. Vertebrates also introduce parasites such as mites and ticks to the cave as well as providing excreta as a nutrient base for micro-organisms and fungi, plus other scavenging arthropods.

1.2.5. Living vertebrate species in caves

Cave dwelling fish, such as the depigmented varieties of the Introduced Trout (*Salmo fario*) described by Scott (1960) or native species such as the Tasmanian Spotted Galaxid (or mountain trout) *Galaxias truttaceus* (Figure 1.13) appear to have reduced vision. Found several kilometres underground in caves at Mole Creek and Ida Bay (Anon, 1974; Jackson, 2000) and at Vanishing Falls (Eberhard, *et al.*, 1992), some of these pale species are probably cave ecotypes; fish that have become obligate cavernicoles, in similarity to the blind cavefish found in China (Figure 1.14). Described as a "white fish", a specimen caught in Exit Cave in January 2000, over 2km from the entrance has been identified as a Spotted Galaxid (*Galaxias truttaceus*); it is suggested that if these fish are in fact part of cave populations, possibly feeding on amphipods and anaspidacean syncarids (Jackson, 2000).

Figure 1.13: Possible cave ecotype of the spotted galaxid (*Galaxias truttaceus*) in slightly tannin coloured stream waters of a side passage with clay-silt floored basement rock in Mystery Creek Cave at Ida Bay; fish is approx.15cm long.

Frogs and snakes are occasionally seen in caves at the base of entrance shafts. In some caves at Ida Bay, the remains of frogs can be seen as "fossils" covered in flowstone at the base of avens or shafts. In the mid-1980s, the writer found the remains of a deceased lyrebird near the base of the 49m pitch in Milk Run (IB-38) at Ida Bay, some 120m below the surface. Lyrebird nests have also been found in two caves at Hastings. Swallows commonly nest on ledges inside cave entrances, near inflow or efflux streams, e.g., Mystery Creek Cave at Ida Bay, Sassafras Cave at Mole Creek and Swallownest Cave at Loongana. Owl roost sites are found in some Tasmanian caves and several cave sites have repositories of owl pellets: regurgitations of small mammal species, some forming as accumulation mounds (Clarke 2000a; 2006). Three mammal species are occasionally seen in Tasmanian caves: wombats, brushtail possums and platypus (Sleinis, 1986; Munks, *et al.*, 2004); sometimes nesting in the darkened transition zone of caves, these mammals are only occasional cave dwellers. Early in 1988, the writer collected scats riddled with bone fragments and teeth from an animal lair in a cave at Bubs Hill in western Tasmania. Reportedly the site of a thylacine lair, subsequent analysis of the hair in these scats and the discovery of claw tips amongst the bone fragments proved it to be the lair or den of a Tasmanian Devil (Clarke, 1988b; Houshold and Clarke, 1988). Although the "fresh" scats of wombats, echidnas, rodents and occasional dasyurids are often found in the outer transition, twilight and entrance zones of caves, these more reclusive mammals are rarely seen by cavers.

In warmer latitudes, cavernicolous species include bats that use the dark zone of caves as hibernacula, maternity sites and summer roosts; such species are described as having an obligate dependence on caves (Culver and Sket, 2002). However, here in cool temperate Tasmania, the writer has postulated that the present day temperature of caves is too cold for bats to survive (Clarke, 1987c). This can be further evidenced from the fact that although most of the known species of bats in Tasmania are tree dwelling species, several of the same species are found in caves of mainland Australia, e.g., in the Nullarbor karst, where there are no trees. There is an unconfirmed report of the recent discovery of bat skeletons in a cave along the Franklin River where the deposit has been dated as late Tertiary during a period when the climate was much warmer than today. Although a few solitary bats are found in Tasmanian caves today, it is rare to find evidence of large numbers or clusters. An exception to this norm was the writer's discovery in April 1985 of the remains of 25 specimens (three species) of bats, all deceased in the far back reaches of an elevated alcove in Judds Cavern (Wargata Mina) (Clarke, 1986b; 1987c; Saava and Taylor, 1986). Four of the specimens (still partially covered in fur) were still attached to a short section of passage wall (< 1.5m wide), clinging in roost positions; the remaining specimens were found on the dirt floor at the base of the wall. As an indication of the importance of cave records, the discovery of the Large Forest Eptescicus (*Eptesicus saggitula*) as one of the bats in Judds Cavern represented the southernmost record for the species (Clarke, 1987c). It was suggested that inclement weather or snowfall in the surrounding forest may have driven the bats underground where they subsequently perished in the cold (Clarke, 1987c).

Figure 1.14: New undescribed species of blind cavefish of the genus *Sinocyclocheilus* (F. Cyprinidae), approx. 7.5cm long, from a recently discovered cave in NW Guangxi Province, southern China. Note the presence of the paired barbels, whisker-like tactile organs, used in a manner similar to the antennae of many cave invertebrate species.

Figure 1.15: Undescribed troglobitic amphinectid cave spider on clay bank below the entrance to King George V Cave at Hastings; body length approx. 2.5cm. (These obligate amaurobioid spiders were previously classified as Family Amaurobiidae.)

1.2.6. A brief mention of Tasmanian cave invertebrates

Adapted to the cool and humid conditions of southern Tasmania, the cave invertebrate communities include many obligate (cave restricted) cavernicoles; some have specialised troglomorphic features enabling species to live in total darkness deep within the climatically stable, but low nutrient hypogean cave environment (Clarke 1997a). Some obligate hypogean species, e.g., spiders (Figure 1.15) and anaspidacean syncarids (Figure 1.16) retain the characteristics of epigean relatives, but are totally dependent on the cave environment; some are described as relicts, without any present day epigean relatives. Together with habitual, facultative, opportunistic or accidental species, obligates form complex cave communities with overlapping food chains, essentially limited by the food supply and presence of mating partners in the zone or region of the cave in which they forage within the overall constraints of the karst bio-space. The characteristic groups of cave invertebrates in Tasmania and examples of their diversity are discussed in Chapter 5.

1.3: Karst bio-space: a subterranean habitat for living organisms

1.3.1. Introduction

In this thesis, the term "*karst bio-space*" is used to describe the subterranean environment of cavernicoles in karstic carbonate rock areas. It is defined as the total diversity of potential or actual habitats in the saturated (water-filled) or unsaturated (air-filled) "spaces" of any karstified area of carbonate rock (Clarke, 1997a; 1997b; 1997c). Karst bio-space can be considered synonymous with the terms "habitat" and "habitat availability" as described by Christman and Culver (2001) in their analysis of the distribution and biodiversity of obligate cavernicoles in eastern North America. In spatial terms, the karst bio-space is represented by the varying sized cracks, crevices, cavities and solution spaces, defined in dimensional terms as microcaverns: <1mm; mesocaverns: 1mm to 15-20cm; and macrocaverns (including spaces large enough to accommodate humans, i.e., caves): >15-20cm (Clarke, 1997c; 1999a). Various researchers have different terminologies and size constraints for these spatial components. For example, Poulson and Lavoie (2000) consider the intermediate size spaces as mesocaverns or mesovoids with dimensions from 10-100cm (maximum) and the smaller microcavern areas are described as interstitial spaces and "microvoids" in the range 1-10mm. In SE Romania, near Movile Cave, the karst bio-space is described as a network of micro and macro-fissures (Tabacaru and Giurginca, 2003). In order to distinguish between the comparatively small sized "macro-fissures" or "macrocaverns" and the larger space that humans can enter, the term "megacavern" has been used for caves (Humphreys, 1993). In ecological terms, this karst bio-space can be defined as the sum-total of the actual or potential habitats and micro-habitats for living species in karstified carbonate rock areas.

1.3.2. Non-karst habitat space

It should also be noted that this sub-division of subterranean habitat space can equally be applied to non-karst rock types, such as the vesicular lavas (including lava tubes), other igneous rock areas and in any rock type that develops microcaverns, mesocaverns, macrocaverns or larger fractures, voids and cave-like structures by tectonic forces or pseudokarst processes. Early reports describing hypogean fauna, referred to troglobites as species from caves (in karst), but amongst more recent studies there are references to the discovery of troglobites in non-karst rocks. Ueno (1977) described the biospeleological importance of fractured substrates as a site for troglobites in non-calcareous rocks and Juberthie (1984) reports the presence of troglobites in the finer voids of what he terms the MSS or "milieu souterrain superficial" (see Glossary) at the top of a rock mass beneath the deep soil layer. Similarly, Iliffe, (1986; 1990) describes a crevicular habitat in the submarine equivalent to the MSS and in a paper relating the distribution of freshwater ostracodes, reference is made to both troglophiles and troglobites found in crevicular spaces (Maddocks and Iliffe, 1993). In addition to lava tubes, the vesicular cavities of basaltic rocks are described as sites for hypogean fauna (Howarth 1972, 1973, 1981, 1986, 1988), and Ashmole (1993) relates the colonisation of mesocaverns in recently cooled lava flows by pre-adapted epigean fauna.

1.3.3. Karst Bio-space and groundwater

In karst areas, the subterranean habitats lie within a geomorphic complex or network of interconnected or separated "spaces" in the intermittently or perennially saturated or unsaturated zones of karstic carbonate rock. The multitude of karst bio-space includes miniscule cracks, pipes, vertical channels, tubes, voids or microcaverns, vertical shafts or fissures, horizontal conduits and larger cavities, caverns or chambers that may be inhabited by invertebrates. In between the saturated or unsaturated zones, there is a fluctuating intermediate region characterised by the interstitial zone, e.g., in riparian habitats, where hydration of sediments is dependent on the level of groundwater… itself dependent on the regular input or recharge of meteoric waters. The ecology of habitats in the karst bio-space can be quite convoluted. An example of the habitat complexity of karsts can be found in a recent paper describing the zoning of hypogean fauna from caves in Southeast Alaska, where the aquatic fauna is described from epigean, insurgence, lower, resurgence and upper level aquatic habitats, and the terrestrial fauna in terms of epigean, entrance and cave habitat fauna (Carlson, 1999). Following the acceptance of karst systems and karst wetlands under the auspices of the RAMSAR convention in 1996, there has been an upsurge in study of groundwater ecology and aquatic obligates, generally referred to as stygofauna. Aquifers are now described in terms of their intrinsic value as ecosystems (Humphreys, 2002a; 2006) and the whole range of aquatic and terrestrial fauna in the karst and non-karst bio-space are classified as components of groundwater dependent ecosystems (Humphreys, 2006).

Figure 1.16: Translucent form of the 3.5cm long anaspidacean syncarid (*Anaspides tasmaniae*), with algae in its gut tract, browsing the substrate of a clear water pool upstream from the efflux of Marakoopa Cave at Mole Creek; (see also Figure 5.13).

The study of groundwater ecology in the karst bio-space of Tasmania is lacking. In Western Australia (WA), where groundwater is common in calcrete aquifers (Humphreys, 1999a; 2006; Leys, *et al.*, 2003) or limestone, and includes diverse anchialine systems (Humphreys, 1999b; 2003) often with complex anchialine cave faunas, including relict species from ancient crustacean groups (Boxshall, 2005). Boreholes are used to sample stygofauna in the karst bio-space of aquifers. Depending on the geology and degree of metamorphism of carbonate rock (e.g., limestone or dolomite), the karst bio-space of most areas above and below the water table will comprise of microcaverns and macrocaverns (including caves). In karstified areas that have not been subjected to intense tectonic activity – a process which can lead to structural alteration and metamorphism of carbonate rocks – there will be a significant development of solution formed mesocavern spaces. In these "honeycomb-like" karsts, the medium sized 10-15 or 20mm diameter mesocaverns and small, perhaps fist-sized macro-cavern voids probably represent the major zone of habitat availability for invertebrate cavernicoles, but sampling or collection of specimens from these areas is difficult. At Cape Range and Barrow Island near North West Cape peninsula in WA, the intensely karstified lower Miocene (Tertiary) limestone is honeycombed with cavern spaces, including mesocavern voids and crevices, and bore holes have been drilled to jointly assess resources and subterranean fauna sampling and as part of a regional piezometer array in karst aquifers (Humphreys, 1996; 2002). An examination of down-borehole videos from Cape Range shows a diversity of invertebrates in the saturated mesocaverns below the water table (Humphreys, 1996). Interestingly, no terrestrial fauna was photographed in the humid unsaturated mesocaverns above the water table, yet the same boreholes have been used for trapping in order to sample the terrestrial troglobites (pers. comm., Bill Humphreys, 2005). Using borehole sampling, a mix of terrestrial and groundwater species were collected in the karst bio-space of unconsolidated limestone near Ludlow, north of Busselton in WA (Armstrong and Humphreys, 2003). A similar method of borehole sampling for terrestrial fauna from the karst bio-space of SE Romania is reported by Tabacaru and Giurginca (2003).

Although simplistic, the term karst bio-space can be used as an all embracing term to describe the hypogean fauna from karst areas. The evolution of karst itself also warrants some basic understanding of the processes involved, particularly in regard to the colonisation of these subterranean habitats, subsequent speciation and endemism, plus the development of troglomorphism in the hypogean faunas.

1.4: An overview of the evolution of karst and models for colonisation of subterranean habitats, relict faunas, speciation and troglomorphism

Karst is a term which describes the myriad of landforms that evolve from the solution and erosion of carbonate rocks such as limestone, dolomite and magnesite. Although caves are the most well known form of karst, subterranean structures also occur in many non-karst rock types, e.g., sandstone, mudstone, dolerite and granite. Limestone is the classic example of a sedimentary carbonate rock, typically formed from alternating layers of calcium/ or magnesium carbonate deposits such as lime rich mud, calcareous sand, shell fragments, bone skeletons or corals which may be solitary forms or reefs. Subsequent to deposition on the sea floor, as shoreline reefs or dunes, or bottom of freshwater lakes, the process of diagenesis (compaction, cementation, crystallisation and perhaps mineralogical replacement) leads to lithification or consolidation as rock. Uplift by tectonic activity and/

or lowering of sea levels exposes limestone to the surface where the calcium carbonate is readily, but slowly dissolved over time due to the action of natural solution processes: meteoric (rain) water and acidified soil percolation water, both described as being "aggressive". The solution process leads to the formation of numerous small cracks, voids, fissures, conduits and chambers, which become the karst bio-space for colonisation by species, many of which evolve and speciate further; some become hypogean obligates with the on-going evolution of the karst.

1.4.1. Models for colonisation of subterranean habitats

Theories related to the modes of colonisation in karst bio-space are many and varied; some models even quite convoluted. By comparison, it is relatively simple to comprehend the notions of speciation and evolution of troglobites amongst obligate hypogean species. There are two forms of colonisation: primary and secondary, both of which are dependent on favourability of climatic conditions, availability of nutrient (energy) sources, competition between species and predator/ prey interactions (Stoch, 2003). Primary colonisation is the first time establishment of a species or population of species in an environment that has not been previously colonised by that species or population. For example, as karst bio-space is developing and the miniscule microcavern cracks widen and/ or as the slightly larger mesocaverns develop, epigean organisms can migrate down from the surface and similarly the already hypogean species can move up and laterally across from adjoining areas of karst or lenses of groundwater. A primary colonisation could also occur when a subterranean space becomes available in the aftermath of a natural catastrophic event, e.g., an earthquake, volcanic eruption and lava flow or glaciations and also when a previously geographically isolated location becomes accessible. Secondary colonisation occurs when a species re-colonises a site after the original population of that species has been removed or disappeared, possibly as a result of one of the afore mentioned catastrophes, or for example in the case of Bradley-Chesterman Cave at Ida Bay as the site recovers from a pollution event.

By way of further analysis, biospeleologists describe colonisation in terms of being either active (mechanical or locomotory) or passive (involuntary). Stoch (2003) states that when biospeleologists raised the question of why species colonised the subterranean domain, it reflected the old school of thought that caves were "*...refugia against climatic vicissitudes for the ancestors of troglobites.*" Sometimes referred as the "Pleistocene Effect" and more recently at the "Climatic Relict Hypothesis" (Peck and Finston, 1993), the refugium model was commonly accepted when – on the basis of studies of subterranean diversity in North America (Barr, 1968; Barr and Holsinger, 1985; Culver, 1982) – it appeared that most troglobitic species occurred in cool temperate latitudes near former glacial limits. With the current day knowledge that troglobitic species occur globally, even in seemingly favourable habitats, the refugium model is now considered to be incompatible, especially where there is evidence of contemporary colonisation, e.g., recently formed lava tubes, and since it is now apparent that many hypogean animals are not relicts (Stoch, 2003).

However, the concept of caves acting as refugia still has validity, as possibly indicated by the populations of troglobitic *Olgania* spiders in Tasmanian caves, and as noted by Eberhard *et al.* (1991), the presence of several obligate species related to now extinct ancestors or epigean species that live in colder high altitude locations. This concept is exemplified by the aquatic crustaceans living in the constantly cool to cold low altitude cave environment of Exit Cave at Ida Bay, where the obligate paramelitid amphipods and anaspidacean or bathynellacean syncarids are probable ecotypes of epigean species, typically found in the cold high altitude lakes or tarns (Williams, 1965a; Schminke, 1973; Morimoto, 1978).

Summary models for the colonisation of karst bio-space and speciation have been variously developed to explain the presence of hypogean fauna in groundwater and the origins of terrestrial troglobites, as well as the fauna from non-karst lava tubes in tropical areas. Using aquatic metacrangonyctid amphipods as an example, Coineau and Boutin (1992) developed a complex two-step model to explain two methods for colonisation of inland (continental) groundwater. The first phase involves an active colonisation by limnicoid stygobites which occupied freshwater habitats prior to a vertical transition down to the groundwater and a second phase (as an active or passive colonisation) by thalassoid stygobites in a horizontal transition from the marine littoral interstitial environment to the groundwater during a marine regression (Coineau and Boutin, 1992; Boutin, 1994; Boutin, *et al.*, 1997; Stoch, 2003). Using a different approach, Juberthie (1984) devised a three-step model of "compartments" using the MSS: Mesovoid Shallow Substratum (see glossary and Figure

1.17) or interstitial medium as an ecotone between the epigean and hypogean environment to explain the gradual colonisation of cave habitats by terrestrial species.

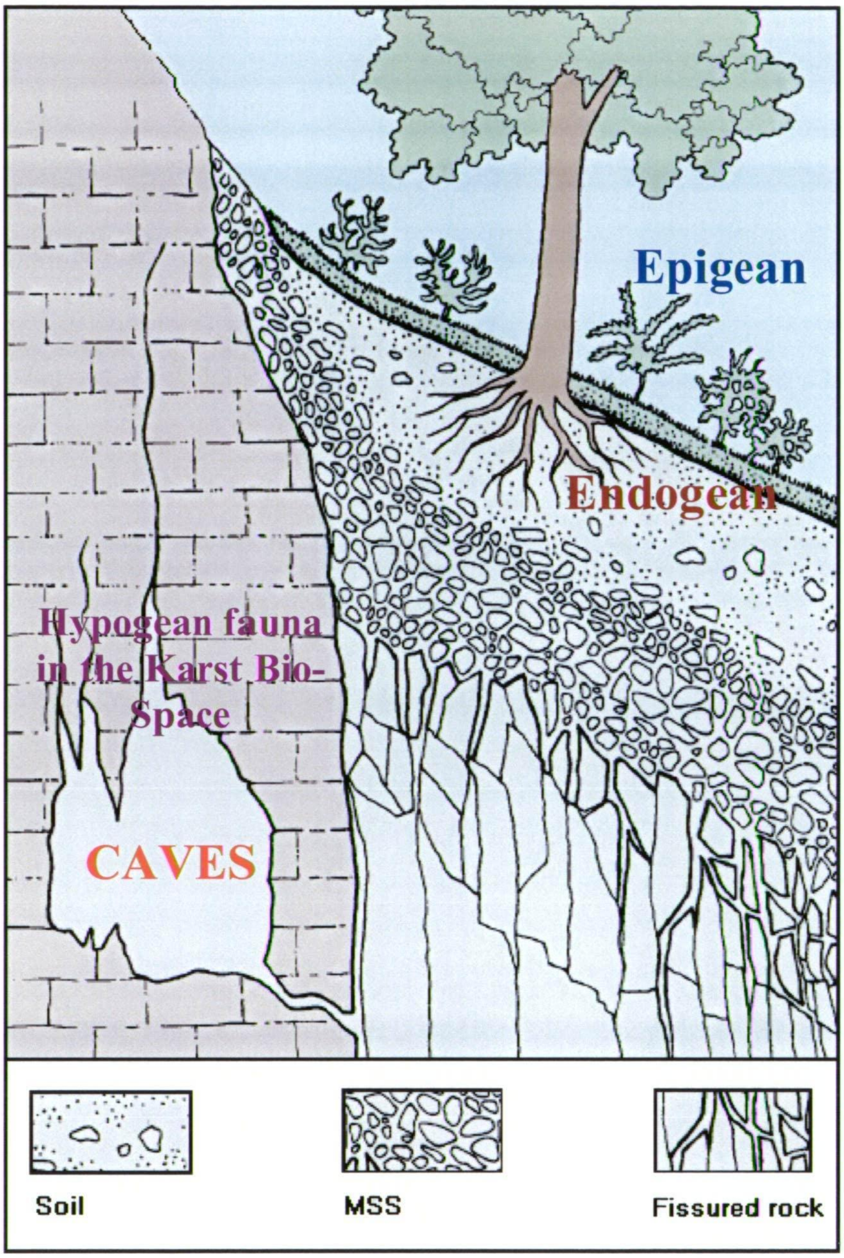


Figure 1.17: Stylised view of hypogean habitats and the karst bio-space for cave species, showing the intermediary MSS layer situated between the endogean soil and humus layers and fractured or fissured rock zone (modified after Stoch, 2002).

In the first step, populations of litter species colonise the deep lower layer of forest soils, becoming pre-adapted to the subterranean environment. In the second stage, colonising populations invade the MSS (Figure 1.17), but still occupy the deep soil layer; then in the final stage, species invade the deep hypogean compartment (Juberthie, 1984). An additional explanation for the evolution of troglobitic species was formulated by Stoch (1995) who proposed the "adaptive zone model" with two alternate methods: firstly a three-step process where surface populations invade subterranean habitats to exploit a new resource, then following colonisation and niche specialisation, speciate by adaptive radiation, or the second two-step method involving multiple colonisation and speciation, but without adaptive radiation. Christiansen (1992) and Holsinger (2000) provide a more complete and comprehensive overview of the models of ecological derivation, colonisation, evolution and speciation, whereas Botosanaenu and Iliffe (1999) provide a more specific hypothesis to explain the stygobitisation of stenetriid isopods that colonised caves from their origins as shallow water marine species.

The evolution of non-relictual troglobites in lava tube caves of tropical areas is described by Howarth (1981; 1986; 1988) who proposes the model of "adaptive shift" in preference to vicariant speciation. This model is further expanded by Ashmole (1993) who defines the differences between ecological colonisation of lava tubes (as soon as the rock is cool) and evolutionary colonisation of mesocaverns in the deep cave zone and saturated region, as pre-adapted epigean species move from one habitat to another that imposes new selection pressures, leading to adaptive divergence and rapid speciation by the colonising population. This view is shared by Hoch (1999) who describes independent evolutionary lines and endemism in allopatric populations of highly troglobitic fulgoroid planthoppers, suggesting a model for rapid subterranean speciation from a common ancestral species that underwent intensive adaptive radiation. Now referred by the acronym "ASH", the Adaptive Shift Hypothesis is gaining wider acceptance, particularly from authors describing the evolution of troglobitic species in the tropics (Rivera, *et al.,* 2002).

1.4.2. Relict faunas

Interestingly, the theory behind the "Pleistocene Effect" has been used as an explanation for the evolution of highly specialised relictual troglobites in tropical areas of northeastern Brazil that were dry arid zones during the glacial periods (Gnaspini, 1999). This model predicts that regions subject to more frequent fluctuations and extremes will present a higher ratio of troglobitic to troglophilic species and dry, arid or semi-arid areas will produce the most specialised troglobites. Gnaspini suggests the species may have colonised the subterranean biotope during the short periods of high humidity, possibly near the interglacial maxima and then became isolated from surface populations during long dry glacial periods. Similarly, DNA analyses of new species of stygobitic water beetles collected from calcrete aquifers in Western Australia has revealed some quite ancient lineages (Cooper, *et al.* 2002), and in further studies on the phylogeny of these dytiscid beetles, Leys, *et al.* (2003) concluded that their origins supported the CRH (Climatic Relict Hypothesis) model, indicating that all evolutionary transitions took place during the Late Miocene and Early Pliocene as a result of aridification.

It well known that the dark and moist deep zone of caves represents a stable environment. Several writers have implied that subterranean ecosystems have been buffered from the vicissitudes of climate over geological time while troglobitic species evolved from pre-adapted surface ancestors (Culver, 1982; Sbordini, 1982; Barr and Holsinger, 1985; Holsinger, 1988; 2000). This evolutionary view is supported by the fact that many cave adapted species have hygrophilous relatives living in cave-like epigean habitats including perhaps in cave entrances (Figure 1.18) and the deep litter of rainforests, e.g., millipedes, symphylans, isopods and springtails. As caves became refugia by constraint (Botosaneanu and Holsinger, 1991) during glaciations or the hotter inter-glacials, the long term isolation and troglogenesis of species has resulted in some old and highly troglobitic cave faunas with a diversity of phyletic or distributional relicts, where the ancestors of species have become extinct or migrated elsewhere (Culver,. 1982; Holsinger, 1988; 2000; Humphreys, 2000). It has been suggested that the present distribution patterns for the seven described species of the genus *Hickmanoxyomma* (e.g., species shown in Figures 1.19, 5.20, 5,21) suggest being due to vicariance, from the extinction of once more widespread surface ancestor (Hunt, 1990; Eberhard, *et al.*, 1991). Although it is difficult to determine how long the karst bio-space or the caves we study have been colonised by species with lost surface ancestors, the age of a cave can sometimes be determined by dating its deposits (speleothems or stratigraphic sequences) on the assumption that the cave will be older than its deposit. Some of the modern techniques deploying molecular data to determine species phylogeny and similar use of micro-satellite analysis of gene fragments for species population analyses may in time provide some estimated time frames or approximation indicating when caves were colonised by particular invertebrate species.

Figure 1.18: Stalked basidiomycetes (agaric) fungi, together with moulds and filamentous species growing on accumulated mulch and forest detritus inside the entrance to Queen of Sheba, a cave at Mole Creek. This environment provides a habitat for many epigean species, some of which are similar to the hypogean species found further inside the cave. Note, the 11mm diameter cavers "Bluewater II" rope (to scale), partially buried in the entrance mulch and twigs.

Similarly, you would expect the cave to be formed well before the fauna occupied it, but given that the development of the karst bio-space is a long, slow but continuous and dynamic process it is highly possible that some species will have already colonised parts of the karst bio-space prior to the formation of the larger human-sized macro-cavern caves. Over time as a land mass is elevated or the erosion base level is lowered (e.g., from a drop in sea level), solutional down-cutting creates further additional bio-space, permitting vertical migration of troglobites already in the older parts of the karst bio-space or cave system.

Coinciding with tectonic activity and climate change, the break up of the southern super-continent Gondwana and subsequent continental drift of smaller land masses has resulted in isolation of species. Gondwana contained most of the landmasses which are the present day southern hemisphere continents: Antarctica, South America, Africa, Madagascar, India, Australia-New Guinea, New Zealand, and New Caledonia. The remaining continents at that time (North America and Europe-Asia) formed a northern supercontinent: Laurasia. The separation of Gondwana began in the late Jurassic (approx. 180 mya) and until the late Cretaceous (approx. 65 mya), Australia and New Zealand were still connected to Antarctica.

Some isolated fauna including Tasmanian cave species are Gondwanan relicts, e.g., aquatic crustaceans: crangonyctoid amphipods, anaspidacean and bathynellid syncarids, janirid isopods, phreatoicids and freshwater crayfish (Clarke, 1997a). Additional cave species in Clarke (*op. cit.*, p. 48) include paludicolan flatworms and hydrobiid gastropods, plus several families of collembolan and spiders including the Tasmanian Cave Spider and species of *Icona*. Apart from caves in southern Australia, *Icona* is only known from surface habitats on sub-Antarctic islands south of New Zealand. Since there are no marine forms of Syncarida, it has been suggested that these may in fact be Pangaean relicts (Boutin and Coineau, 1987). Moore (1972a) states that troglobitic carabid beetles only occur in Tasmania and New Zealand and similarly Hunt (1972) records species of cavernicolous opiliones (harvestmen) of the Family Triaenonychidae in southern Australia as well as southern Africa, Madagascar, New Caledonia, New Zealand and southern South America. Given this isolation from now distant relatives and the on-going evolution of karst bio-space, many of the relict species now found in Tasmanian caves have been potentially evolving as troglobites for several millennia.

Figure 1.19: The cave harvestman, *Hickmanoxyomma cavaticum* (var. 1: IB), on a gloved finger in Mystery Creek Cave at Ida Bay; body length (behind pedipalps) approx. 7mm. Note: the enlarged and thickened spinose pedipalps, attenuated and setose legs, with longer second pair of legs used in a searching and sensory capacity in a manner similar to the antennae of some crustacean and insect species.

1.4.3. Speciation and the evolution of troglobites

In a brief overview of the origins of troglobites and stygobites, Eberhard and Humphreys (2003) describe them evolving from surface ancestors already pre-adapted for life in the hypogean environment. They state that cave species belong to animal groups that are well represented in the moist soil and ground litter of forest floors, or in streambeds, swamps, groundwater and marine crevice habitats (Eberhard and Humphreys, 2003). However, there are numerous other theories for processes that act as the driving force for the evolution and distribution of troglobites, supporting development of ancient relict faunas in karst and non-karst caves. In a more detailed analysis of the origins of hypogean relict faunas, Humphreys (2000) summarises the studies of different cave species or species groups used to demonstrate the evolution of troglobites by allopatric, parapatric, peripatric and sympatric speciation, in addition to the possibility of relicts being derived from regional vicariance. Some alternative theories relate troglogenesis in the hypogean environment in terms of divergent and convergent adaptation (Humphreys, 2000). Other writers discuss the merits of "Punctuated Equilibria", a concept suggesting that troglogenesis in isolated cave species results from concentrated outbursts of rapid speciation, rather than slow, steady and directional transformations (Culver, 1987; Wilkens, 1987). However, in arguing against this concept, Culver (1987) suggests the need to consider "adaptive topographies" to explain the reasons for evolutionary change in colonising species.

The concept of troglogenesis in an adaptive topography or highly specialised environment as proposed by Howarth and other workers in Hawaii (e.g., Howarth, 1986, 1988) has also been applied to sub-tropical regions of Far North Queensland (Howarth and Stone, 1990), where lava tube troglobites have also been described. Implicit in the adaptive shift theory proposed by Howarth (1986; 1988) and Rivera *et al.* (2002), is the notion of the subterranean environment imposing a selection pressure on colonising organisms, assumed as having an epigean origin, even if pre-adapted. In addition to the absence of light and other external influences, most subterranean sites have elevated levels of humidity and a range of other environmental "attributes" that could be considered as harsh and off-putting and likely to impose added selection pressure for any potential coloniser. Bayliss Cave (a lava tube) near Undara, has persistently high levels of carbon dioxide, (sometimes called "bad air"), but contains some of the most highly modified, troglobitic obligate species of any subterranean site in Australia (Howarth and Stone, 1990). Similarly, in Movile Cave (SE Romania), described as a chemoautotrophically based groundwater ecosystem (Sarbu and Popa, 1992; Sarbu, 2000), the presence of sulphuric acid fumes and highly acidic waters make this cave a very harsh environment for humans; however, many new and highly stygobitic and troglobitic species have evolved there (Sarbu, 2000; Tabacaru and Giurginca (2003). In Tasmania, where most karst caves have very limited organic input, it could be deemed that these low nutrient systems are also "harsh" environments that have applied selection pressure on colonising organisms, which may in part explain the high numbers of troglobitic species in our caves. In describing the work of various cave researchers in North America, Culver (1982) states that many cave populations are adapted to scarce food supplies, which he suggests supports the concept of strong selection with modified olfactory sensory organs for food-find ability and locating mates.

The tendency for reduction or loss of eyes and body pigment are amongst some of the major troglomorphisms of troglobitic/ stygobitic species, sometimes described as traits of regressive evolution (Kane and Richardson, 1985; Culver, 1986). As listed in Table 1.0, troglomorphic characters include reduced eyes or lens size (and loss of visual ability) or loss of eyes (see Figures 1.1, 1.14, 1.21, 5.10. 5.11, 5.12, 5.13, 5.25. 5.26, 5.27), reduced body pigmentation or no pigment (Figures 1.1, 1.14, 1.16, 1.21, 5.5, 5.8, 5.11), loss of wings (e.g. carabid beetles), elongation or attenuation of appendages (Figures 1.19, 5.9, 5.25, 5.27), extra sensory structures e.g. elongated antennae (Figures 1.15, 5.6, 5.10, 5.13), longer and greater density spines or setae (Figures 1.15, 1.19, 5.14, 5.24), sometimes modified chelicerae or pedipalps, the grasping organs used to hold prey foods etc (Figures 5.19, 5.22, 5.24) and reduced metabolic rate (Hüppop 1985). In a recent study of obligate cavefish in Mexico, Mejia-Ortiz and Hartnoll (2005) noted these stygobites had shorter eyestalks and reduced integument pigmentation. To compensate for loss of eyes or reduced vision, many troglobitic species have enhanced non-optic sensory structures (Eberhard and Spate 1995a). Examples of non-optic sensory structures include modified antennae, specialised spines and modified walking limbs as in the case of the cave harvestmen (Figure 1.19), whose second pair of legs are longer and used as feelers. In low nutrient ecosystems, cavernicolous species show resistance to starvation (Doran 1991), but conversely, because of their low metabolic rates these cave species cannot tolerate high nutrient inputs (Culver 1982).

Table 1.1: Troglomorphic characteristics of hypogean species, relative to epigean species, based on Christiansen (1992: p. 463) and Culver *et al.*, 1995.

Morphological Characteristics
Specialisation of sensory organs, (touch chemoreceptor, hygroreceptor, thermoreceptor, pressure receptor)
Elongation of appendages
Pseudophysogastry (in Coleoptera)
Reduction of eyes, pigment, wings
Increased egg volume
Unguis elongation (in Collembola)
Foot modification (Collembola, planthoppers)
Scale reduction or loss (in fish)
Cuticle thinning
Physiological and Ethological Characteristics
Slowing metabolism
Relaxation and degeneration of Circadian rhythms
Reduction or adjustment of Circannual rhythms
Lowered fecundity
Increased life span
Starvation resistance
Behavioural Characteristics
Locomotory patterns (in Collembola)
Decreased aggregation (in Collembola)
Reduced alarm substance reaction (in fish)
Enhanced food finding ability (in fish)
Reduced intraspecific aggression
Increased sensitivity to vibration

1.5: An overview of cave ecology, communities, ecosystems and biodiversity, endemicity, cave zones and habitats

1.5.1. Cave ecology

As defined in the glossary (Chapter 7.3.2), cave ecology relates the interaction and relationships between cave organisms and their physical environment, including energy input from the surface and climatic influences, etc.; the latter will be discussed in Chapter 1.4.3. In their analysis of the trophic basis of subsurface ecosystems, Poulson and Lavoie (2000) have grouped cave organisms on the basis of their source of energy. Based on the premise that all organisms are either chemotrophs using chemically bonded energy or phototrophs that utilise radiant energy, these trophic types are sub-divided by use of a prefix "hetero-" or "auto-" to describe how organisms source their carbon: respectively as either organic carbon feeders (heterotrophs) or self-feeders (autotrophs) that use fixation of carbon dioxide. Decomposers such as fungi and bacteria that feed on organic matter are chemoheterotrophs (like all animals and protozoans) and micro-organisms that derive their energy from inorganic sources are chemoautotrophs (Poulson and Lavoie, 2000).

Hypogean systems are typically energy limited systems; the dominant source of energy coming from epigean organic matter. Cavernicole communities are found in different zones with different sources of organic matter and the interactions between species in food chains have been described as competitive, parasitic, predatory or mutualistic (Culver, 1982; 1994). There is often limited food supply in caves for troglobitic species (Moore and Sullivan, 1997) and aquatic species may be seasonally restricted to small pools, trickles and seepages (Culver and Sket, 2002) and heavily dependent on regular flood inputs. Aside from tree roots, airborne microflora (e.g., pollen) or microfauna (e.g., midges and flies) and the faeces or guano from bats or birds and other vertebrates, the principal source of food is derived from organic debris including faunal remains and carcasses washed into caves by streams or percolation seepage (Gillieson, 1996; Poulson and Lavoie, 2000). The derived energy is progressively transferred underground via food chains or transported further by air and water; accession of this energy is critical for the survival of organisms comprising the cave ecology (Gillieson, 1996); see food web diagram for Ida Bay in Figure 1.20.

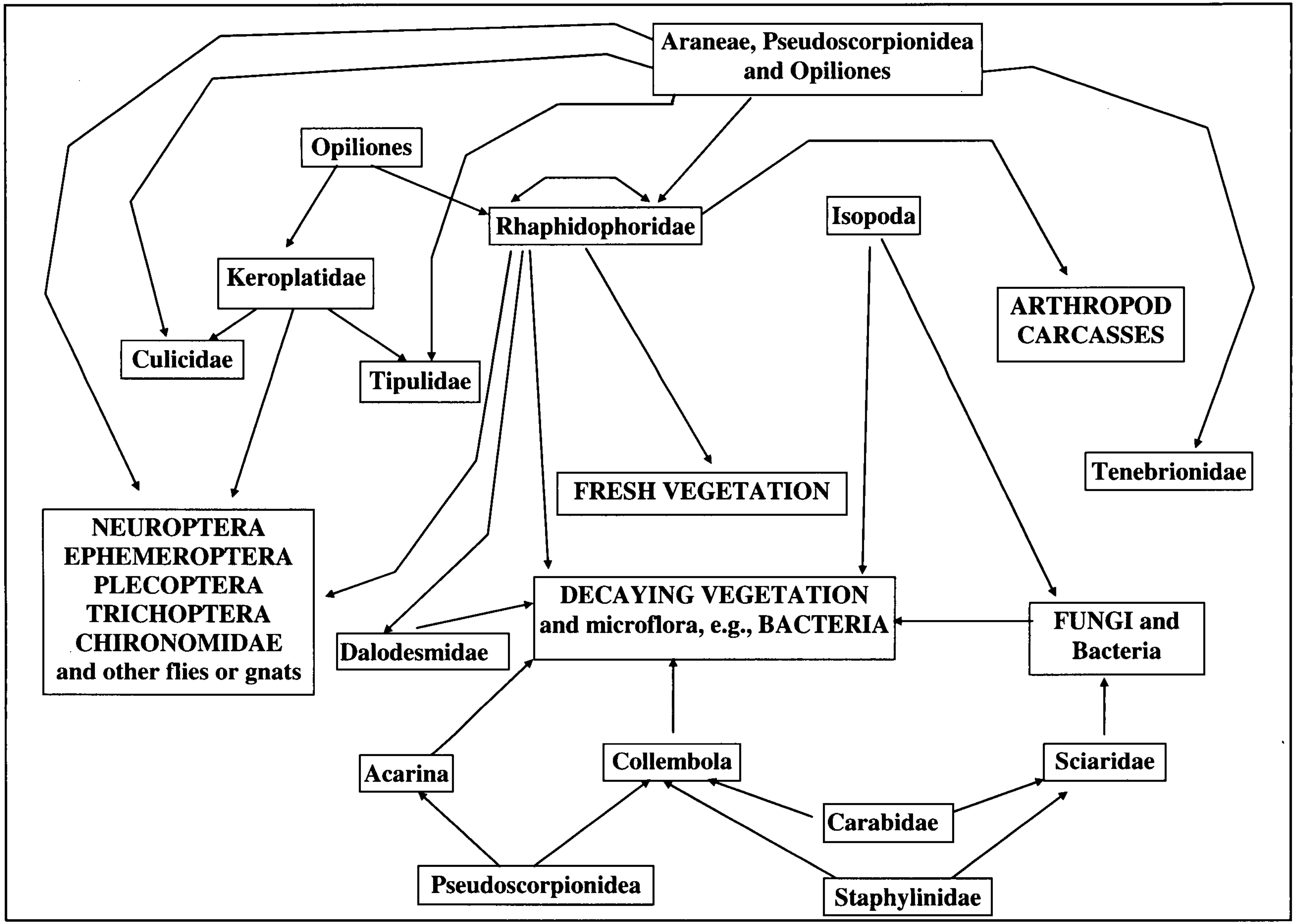


Figure 1.20: Terrestrial species food web in the Ida Bay Caves. Adapted and modified from Richards and Ollier, (1976).

In cave ecology, most of the more numerous primary or first level consumer species are detritivores consuming the dead organic matter or animal faeces, partially broken down by decomposers: micro- or macro-fungi and/ or bacteria. Grazing arthropods, e.g., millipedes, isopods and springtails will preferentially consume the fungi, rather than the detritus (Chapman, 1993). In ecological terms, these fungus eaters can be referred to as fungivores; other examples include some beetle species and mites (Moore and 'Sullivan, 1997). Amongst other detritivores, Chapman (1993) reports that "gulpers" and burrowers, e.g., fly larvae and earthworms, tend to be bacterial eaters. In caves with bats, detritivores that consume the ammonia and nitrogen rich fresh guano deposits are described as guanophiles. Moulds (2004) recently published a checklist of the invertebrate species known or believed to be associated with guano deposits in Australian caves. Chapman (1993) provides an example of a simple guano based food chain from a cave with insectivorous bats in Trinidad, where cockroaches eat the excreted insect remains in fresh guano, removing most remaining protein and fat. The cockroach droppings are rich in chitin which is decomposed by a penicillin fungus and this in turn is grazed by mites and other tiny arthropods which are subsequently consumed by higher order arachnid predators: secondary and tertiary consumers. In Tasmanian caves the primary consumers are likely to be nematodes, isopods, small flies, cave crickets, springtails, mites and beetles e.g., tenebrionids, weevils and lucanids. The secondary consumers include spiders, pseudoscorpions, harvestmen, centipedes and millipedes, bugs and beetles: carabids, pselaphids and possibly stayphylinids. The interactions of cave species and energy flow through food chains within cave ecosystems can be demonstrated as a food web, as shown in Figure 1.20 on previous page; (a diagram adapted and modified from Figure 11 in Richards and Ollier, 1976).

In the dark zone of caves where transported nutrient input is low, herbivorous invertebrates require high quality, nutritious plant matter free of foreign substances such as silt particles, charcoal or inorganic compounds. Much of this transported organic matter is partially or completely decomposed by micro-organisms (Culver 1982; Holsinger 1988) or entrance dwelling detritivores (detritus-feeding invertebrates) prior to ingestion by detritus feeding troglobites. Micro-organisms including microfungi constitute an important component of the food source for cave obligates (Eberhard 1987a; Holsinger, 1988; Chapman, 1993). Aquatic species are usually either surface feeders, suspension feeders or bottom feeders relying on clean water and unadulterated food particles, free of floating debris or flocculant and settling clay particles (Hynes 1970; Lewis 1982). Many of the cave-dwelling terrestrial obligates are carnivorous species, often performing the role of predator or hunters in the cave ecosystem. For example, arachnids are known to ambush prey species on moist cave walls or mudbanks in riparian zones, grasping and manipulating captured species with their modified pedipalps or chelicerae, e.g., the chelate pedipalps of troglobitic pseudoscorpions (Figure 5.19), the interlocking teeth-like pedipalpous spines of the Ida Bay cave harvestman (Figures 1.19 and 5.22), or the enlarged chelicerae of cave spiders (shown in Figure 5.24).

Figure 1.21: A new undescribed phreatoicid species (sub-family Paraphreatoicinae), shown here in copula, these blind aquatic isopods are bottom feeders, seen here grazing a sandy grit floored pool with moonmilk in Lake Passage of Marakoopa II at Mole Creek. (See photomicroscopy image with scale bar in Figure 5.10)

1.5.2. Cave communities, ecosystems and biodiversity

In broad terms, communities of terrestrial species are typically found on the cave roof (ceiling), wall and floor (Chapman, 1993; Gillieson, 1996); e.g., flood litter deposits shown in Figure 1.22. Aquatic species are found in wall and floor seepages of vertical or horizontal caves, in pools or ponds (Figure 1.21) and within the water column of streams, in riffles and in association with various aquatic substrates (see Chapter 1.4.3.). Each cave community has a restricted and disjunct distribution pattern that is not repeated and often varies between different cave systems of a single karst region (Eberhard *et al.*, 1991; Eberhard 1992). Although the communities of cavernicoles are normally described as part of cave ecosystems, they may be defined in terms of their distribution within a cave, e.g., as entrance zone, twilight zone or dark zone species (Culver and Sket, 2002) or as communities within the ecotone between zones (Prous, *et al.,* 2004). The topic of cave ecosystems together with their biodiversity is one of the most widely written (and often highly debated) aspects of subterranean biology. Bio-inventories of cavernicoles are used globally as measures to determine the biodiversity of cave ecosystems and distribution of species in the aquatic and/ or terrestrial components of karst bio-space. Sometimes referred to as biodiversity mapping (Schneider and Culver, 2004), these cave fauna bio-inventories are described as being essential measures of species richness to determine our understanding of subterranean ecosystems.

Culver (2004) outlines some the problems of scale, method and uniformity in studies to measure subterranean biodiversity and whether analyses should be limited to cave-limited obligate species. However, the results of several surveys have been used to define "hotspots" for troglobionts, particularly for surveys of stygofauna (Culver and Holsinger, 1992; Clarke, 2000b; Culver and Sket, 2000; 2002; Thurgate, *et al.,* 2001; Culver, *et al.*, 2003; 2004; Humphreys, 2003) and predictive models have been devised to locate hotspots and/ or to determine biodiversity indicators (Stoch, 2004). In their analysis of the hypogean biodiversity hotspot eco-regions in North America, Culver and Holsinger (1992) suggested there could be up to 1000 troglobitic species within the Ozark plateau area alone; however, barely 100 of these cave adapted species had been described (Culver and Hobbs III, 2000). In recent years, there has been an upsurge of interest in defining the biodiversity of stygofauna in Europe, following the establishment of PASCALIS: Protocols for the Assessment and Conservation of Aquatic Life In the Subsurface (Gibert, 2001; 2004; Stoch, 2001; Culver, 2004; Deharveng, 2004). The biodiversity of species is also described as a measure of species richness. Christman and Culver (2001) used an analysis of biodiversity studies in North America to determine if species richness was dependent on habitat availability, based on the number of known caves.

1.5.3. Endemicity in cave faunas

Due to their regional separation and isolation, caves themselves and/ or the broader karst area have been described as "islands" (Culver, 1970; 1982). Together with this regional isolation, sub-surface isolation has contributed to the large numbers of relict species found in karst areas. Following on... a further characteristic of cave faunas is their very restricted ranges particularly amongst the troglobitic or stygobitic species (Christman and Culver, 2001). Some aquatic species may be confined to one groundwater aquifer or a single cave hydrological system (Clarke, 1997a; Harvey, 2002; Cooper, *et al.* 2002; Humphreys, 2006) and terrestrial species may be limited to a single karst area or a particular cave system within that karst area. For example, all the troglobitic species of the carabid cave beetle: *Idacarabus* – endemic to Tasmania – are confined to one specific karst area, exemplified by *Idacarabus troglodytes* at Ida Bay and *Idacarabus cordicollis* at Hastings. Similarly, the blind *Goedetrechus mendumae* is only known from the Exit Cave system at Ida Bay. Further to the notions of karst areas as islands, Holsinger (1988) describes the very limited geographic ranges of troglobitic species as being "island-like" and Harvey (2002) discusses the SREs (short range endemics) found in non-marine environments.

1.5.4. Cave zones and cave habitats

In similarity with forest environments, there will be numerous physiochemical factors that affect or control the distribution of invertebrate species in cave entrance habitats and to some extent a considerable distance further into caves. For example, carabid beetles and collembola are two epigean ground dwelling species commonly found in Tasmanian caves, extending from the entrance zone to the dark zone. Ecological studies – demonstrating the range of physiochemical factors that influence the distribution of carabids and collembola – indicate a range of inter-related and/ or separate controls (Baker, 1999). In brief, the factors related to cave environments could include external vegetation types, plus more specific factors such as litter: leaf, bark and twig type, chemistry and litter depth; soil: origin of rock type, texture, density and pore space, depth, moisture, humidity, organic content, acidity and chemistry; air gas concentrations, temperature and relative humidity; presence of light; food supply and the presence of other predator and/ or prey species (Baker, 1999, 2000). Some factors – particularly those related to epigean sources - will have less influence on the distribution of species located further into the cave, further distant from epigean influences.

Figure 1.22: Flood litter deposit in Hatwalk Passage of Exit Cave, prior to the major flood event on February 2nd 2005; previously the habitat for an undescribed species of *Lomanella* harvestman and a possibly cave-adapted form of centipede.

Jeannel (1926) was the first cave biologist to clearly define cave zones and faunal habitats in his classification of cave-dwelling animal types. Linking the association of cave community habitats within caves to climatic factors and their relationship/ distance from external influences, Jeannel proposed too broad zones for cave species: the light zone and dark zone. In the light zone fauna, he nominated seven types of faunal associations: parietal (around cave entrance and cave walls), under stones, in soil, among moss and lichen, parasites and scavengers, troglobites attracted to the light zone for food and aquatic species. In the dark zone, Jeannel suggested eight types of fauna associations: in and around guano, on stalagmites, under stones, in vegetable debris, in clay beds, in zones periodically flooded by subterranean waters, terrestrial crevice animals and aquatic species (Jeannel, 1926).

Most current studies described the fauna of caves from three or four ecological regions: daylight, entrance, transition and dark or deep zones, based on the degree of light penetration or the lateral/ vertical extent that surface factors influence the subterranean environment. There may be some overlap between the aspects of light penetration and surface influence, depending on the internal morphology of any individual cave site. This is particularly applicable in the case of inflow (and some outflow) stream caves, where constrictions in the structural shape of a cave or siphons may create a dark zone effect quite close to the surface entrance in a region still under the realm of epigean influences. In such cases, this would be considered to be a transition zone, even though there may be some dark zone species present.

In their descriptions of cave fauna from tropical regions, particularly from lava tube caves, Howarth and Stone (1990) have devised a classification of cave fauna based on five cave zones: entrance, twilight, transition, deep zone and stagnant air zone. In their deep zone area, synonymous with the dark zone, the air is relatively cool and the temperature remains stable, but there is still some restricted circulation. Conversely, in the stagnant air zone, considered as a region further beyond the deep zone, there is little or no air movement, very high humidity and/ or often high carbon dioxide levels (Howarth and Stone, 1990). In discussion of cave fauna habitats in lava cave areas, Howarth relates the importance of mesocaverns: the small spaces and cracks in rock, where tree roots penetrate. Mesocaverns greatly increase availability of underground habitat sites and it is suggested that the majority of hypogean species live in this region.

In a discussion on cave fauna habitats, Chapman (1993) distinguishes between the interstitial (microcaverns) and meso- or macrocavern habitats on the basis of their substantially distinct and different biota. Although there are also obvious differences in the morphology and habitat of aquatic and terrestrial species, Chapman points out that the distinction is not so clear cut. For example, some air-filled mesocaverns and macrocaverns are permanently saturated with water vapour, i.e., having 100% humidity, so terrestrial arthropods need an adaptive morphology that enables them to express excess fluid in a similar manner to aquatic species (Chapman, 1993). In his analysis of "limestone uplands" (regions above seal level), Chapman defines 15 "cave" habitats associated with structural features, geomorphology and the development of karst bio-space, in several zones ranging from doline entrance faunas to the water-filled meso- or macrocavern habitats in the "phreas" or saturated zone.

Broadly speaking, cave zones depend on cave morphology, humidity (and temperature to a lesser extent) and the extent or reach of internal "downstream" effects of epigean influences such as airborne dust (Salmon, *et al.*, 1994), lint (Jablonsky, 1992; Jablonsky, *et al.*, 1993) and microflora. Cave zones have also been defined in terms of the distribution of species and community structures within cave passages (Prous, *et al.*, 2004), climatic changes at cave entrances (Huppert, *et al.*, 1994) or within the cave environment (Yong-Gun, 2005), thermoclines (Reddell, 1965), relative humidity and cryptoclimatology (Michie, 1997), plus distribution of airborne dust particles (Michie, 1998, 2002). Some researchers have based their studies of the cave zones for terrestrial species in terms of habitats, e.g., Sket (2004) describes the " hygropetric" wet zone of caves in the Dinaric karst, where cave walls are often saturated with thin films of water, moving down in mostly laminar flow.

Figure 1.23: Assorted streambed gravels and grit of a natural intermittent stream in the dark zone of Newdegate Cave at Hastings, beyond the developed tourist section.

The transition from the epigean to hypogean environment in caves is characterised by diminishing levels of light penetration from daylight to total darkness, an increasing tendency to constant temperature and high humidity, a gradual decrease in other external or surface influences along with the variable constraints of available physical space: i.e., subterranean morphology, clastic fills or rockfall and talus deposits. In the cool temperate higher latitudes such as Tasmania, where there is a negligible input from bat or bird guano and limited input of flood debris, the epigean-hypogean transition is also characterised by the gradual or rapid decline of nutrient or energy sources. Many of the factors affecting the presence and biodiversity of cavernicolous invertebrates are similar to the habitat constraints that control the presence and biodiversity of epigean species: organic matter (as food supply or habitat space), moisture level, temperature, soil or substrate characteristics (density or interstitial pore space, chemistry and pH) and invertebrate population dynamics (population size and predator/ prey abundance).

The diversity of species in caves, where the microcavern and mesocavern spaces intersect cave walls, was demonstrated by Prous *et al.* (2004) during their meticulous examination of 2m long sections of cave passage in the ecotone of two caves in the Minas Gerais state of Brazil. Using brush and tweezers to sample invertebrate species, Prous and others found up to 180 species in an 80m section of cave passage (pers. comm., Xavier Prous, 2005) and have devised a technique for delimiting the ecotone zone between epigean and hypogean environments, using a similarity matrix between the inner and outer sectors of each cave. Species migration patterns, differential environmental barriers and determination of accidental species versus trogloxenes/ troglophiles species are topics that are primarily approached by establishing ecotone zones in caves. The delimited zones are effectively a linear component derived from an analysis of the richness (abundance) and diversity of species within the ecotone, taking into consideration the species from both the epigean and hypogean environments to effectively measure the area of overlap between the two zones (Prous *et al.* (2004). Most of our knowledge of the hypogean invertebrate faunas of different caves and karsts in Tasmania (and elsewhere) results from specimens collected in the larger macrocavern spaces, which we generally refer to as "caves" or megacaverns (Humphreys, 1993).

Figure 1.24: Cavers in wet and muddy overalls resting in a section of rockfall chamber passage in Mystery Creek Cave at Ida Bay. Note contrast between the predominantly horizontal or gently sloping surfaces muddied or impacted by cave visitors' footwear and the almost pristine vertical wall surfaces with a thin layer of whitish moonmilk.

In addition to the subterranean ecological zones, the cave (or karst bio-space) habitat factors are many and varied. In the very broadest terms, this thesis focuses on two study areas: the past and present tourist caves at Hastings and caves connected with the *Exit Cave* hydrology and neighbouring systems at Ida Bay. As shown in Figure 1.23, there are "natural" regions of *Newdegate Cave* beyond the section developed for tourism and similarly, Figure 1.24 gives an example of the "unnatural" or altered parts of caves of a cave where sediment banks, speleothem deposits and stream habitats that have been impacted by cave visitors in the course of tourism, exploration or research. *Newdegate Cave* should be considered as an example of a cave that is predominantly an un-natural (artificial or disturbed) site where the introduction of exotic substances (Figure 1.25) now over-rides the effectiveness of any natural habitat attributes.

Figure 1.25: Rusted galvanised iron support for handrail bolted to flowstone with rimstone (gour) pools along the tourist path to Titanias Palace (in Newdegate Cave, Hastings). In addition to the rust stains, note the flecks of dirt and detritus with accumulated "foreign" matter in gour pools derived from tourist visitors' footwear; exotic species of aquatic tubificid oligochaet worms were presently colonising these pools.

1.6: Aims of this study

This study has two components: firstly updating and correcting the database of records for occurrences (collections or observations) of cave species in Tasmania and secondly, where possible to use the habitat data from collectors' records or other sources to determine the factors affecting the distribution and biodiversity of Tasmanian cave species. Considering the vast number of records and the paucity of consistent or detailed habitat data, the second component was downsized to a study of two neighbouring karst areas in southern Tasmania: at Hastings and Ida Bay, where it was also possible to compare the differences (if any) between caves developed for tourism or "showing" and "wild" cave sites that were essentially devoid of tourist infrastructure and regular visitation. This database is accessible by contacting the writer in the School of Zoology, University of Tasmania, in Hobart.

In conjunction with the first component, there were a number of secondary aims, including:

- Endeavouring to establish a historical record of all the cave fauna collections in Tasmania;
- Maintaining the database to reflect the collection style of previous cave biologists, which include the records for species collected from surface karst sites in the vicinity of cave entrances;
- Re-checking and validating the records in earlier databases and reports, e.g., Eberhard *et al.* (1991) and Clarke (1997a);
- Verifying the existence of specimens purported to be collected by cave biologists, by checking museum records and published or unpublished records of species descriptions (see Clarke, 2000c);
- Augmenting the existing database of records by locating obscure museum lodgements and/ or museum records that have not been data based electronically;
- Endeavouring to collate a better understanding of the morphology of a wider range of cave species, including taking of digital photo-microscopy images;
- Updating the database with further information relating the troglomorphic or ecological status of species;
- Updating the database with identification and taxonomy of collected cave species;
- If time permitted, doing a comparative study of the cool temperate fauna of Tasmania with the warm temperate and sub-tropical fauna of southern China;
- Run queries from database to answer some of the aims above.

In regard to the second component, additional aims include updating the database with further distribution records, on a Tasmanian state-wide basis with particular preference to the Hastings and Ida Bay areas, with intention to re-visit known collection sites which had been poorly or inadequately sampled. In order to record the fauna from as many and varied habitats and locations in caves, the fieldwork component aimed was aimed at obtaining an analysis of cave fauna habitat sites and/ or surveying caves in order to plot the location of important collection and/ or cave community habitat sites to incorporate in the database. Specific database queries would be developed to analyse the data tables in order to compare species groups, species numbers, ecological status, cave types, habitats, aquatic and terrestrial species and other aspects as required.

1.6.1. Possible questions to answer

Why are some caves richer in cave fauna than others? Is it due to sampling frequency or are there other habitat factors affecting the distribution and biodiversity of cave species? Questions to answer:

- What role does organic input play?
- Is cave size or the physical nature (morphology) of caves a factor?
- Are stream caves likely to be richer in diversity? Stream caves will certainly have a range of aquatic species that adds to the count in number of species.
- Do high energy stream cave systems have less cave species? Do we have any high energy systems, e.g., Growling Swallet?
- Are multiple entrance caves with vertical shafts likely to contain more species?
- Is species diversity related to the number of habitats?
- What effect does frequent visitation have on cave fauna or the ability to locate cave fauna? Compare tourist caves with heavily visited wild caves. Does cave disturbance enrich or inhibit the food chain?
- What is the difference in populations of species or species types in caves with percolation (seepage drip) water versus throughflow waters?
- Are water borne species bacterial species (Figure 1.5) and moonmilk-forming bacteria (Figure 1.26) including significant in cave ecosystems?
- Are our caves dominated by any particular species type, e.g., detritivores or fungivores and/ or dominated by any species group e.g., spiders and beetles.

1.6.2. Thesis question and possible answers

What factors appear to best provide for biodiversity in a subterranean karst bio-space fauna? Factors that may affect the distribution and biodiversity of invertebrate cavernicoles include:

(a) Cave morphology. A consideration of cave passage/ chamber shape and morphology, distance of light penetration, presence of other entrances (shafts, side passages etc.) and noting and abandoned or upper level relict karst passage or chambers.

(b) Nutrient (energy) supply, as introduced organic matter including tree roots (Figure 1.5), with possible consideration of low energy and high energy systems.

(c) Streamflow conditions: possible recording of turbulence, water mass and prevalence of flooding/ desiccation.

(d) Aquifer/ subterranean streamway contamination.

Figure 1.26: Moonmilk deposits associated with tree roots and speleothems in Ross Walker Cave II in the Junee-Florentine karst area of southern Tasmania; a habitat for isopods, springtails, hemiptera, beetles and spiders.

(e) Human activity derived impacts or artificial impacts: examining karst surface or catchment impacts, physical impacts underground within caves, artificial introduction of habitat matter and artificial habitats created by introduction or disposal of organic matter in caves (Clarke, 1997c, 1999a).

(f) Cave habitat factors: examination of species population dynamics, habitat niche partitioning and species co-existence.

(g) Environmental adaptation by obligate species.

Although many of these factors have not been considered in detail before, some early records relate the occurrence of cave species in Tasmania in regard to cave morphology and degree of light penetration and as described in the following chapter dealing with the history of cave fauna, a number of the more recent studies include more precise detail of cave habitats.

2. Collection records for cave fauna in Tasmania

In just under a hundred years since Lea described Australia's first cave adapted beetle, a mere handful of cave biologists have been principally responsible for the collection of additional Tasmanian cave species. Many of these species remain undescribed. The "fossil" bone remains of many extant vertebrate species (and a few extinct species) have been found in Tasmanian caves, along with occasional sightings of live mammals and cavefish. A newspaper report relating some paler specimens caught in Exit Cave in late June, 1974 prompted biologists to consider there might be subterranean forms of surface trout (Anon, 1974). As history and our knowledge of cave collections shows, the vast majority of our cavernicolous fauna are invertebrates with a range of species from aquatic and terrestrial animal groups. Noteworthy amongst these aquatic species, are crustaceans (syncarids and crangonyctoid amphipods), gastropods (hydrobiid snails) and paludicolan flatworms, plus many terrestrial species: arachnids (spiders, harvestmen, mites and pseudoscorpions), insects (including beetles, springtails, cave crickets and glow-worms) and "multipedes" (especially millipedes and symphylans).

2.1: Early records of cave invertebrate biology in Tasmania

Some of the earliest records for cave fauna relate to troglophiles, including species commonly found in dark and moist epigean habitats.

2.1.1. The early history of cave biology in Tasmania

The records for invertebrate species from caves in Tasmania date back to early 1840s, when glow-worm larvae were first recognised at Wet Cave near Chudleigh. First documented in January 1840 - by an unknown "juvenile authoress" – the cave was reported as "The Oak-den Caverns", but without mention of the glow-worms (Anon. 1840). [In 1836, Philip Oakden – a Launceston businessman - had built a "mansion" on lands adjoining the estate of Henry Reed at Wesleydale. Located just eight miles away from Wet Cave, this mansion was the nearest dwelling to the caves.] Two-and-a-half years later in the spring of 1842, Lieutenant William Breton visited some "*...singular caves... in the limestone formation... the only caves of any extent hitherto discovered in the island...*" during an overland "excursion" to the so-called "Western Ranges" (Western Tiers). Describing the cave as being "*...10 or 12 miles...*" west of Quamby Bluff, Breton gave the first detailed description of glow-worms in a presentation to the Royal Society of Tasmania at Government House on the evening of July 5th 1843 (Breton 1846). In a newspaper report of his presentation, Breton states that: "*On the vertical wall of one lofty cave were a number of glow-worms... shining with great brilliancy with a pale greenish light... they were of a whitish colour, very slender, and half an inch long...*" (Breton 1843). Almost a decade later, a similar (less biological) description is provided by John West who reports that "*...in the Western Mountains, are situated the great caves...if the visitor extinguish his* [sic] *torch, myriads of glow-worms are seen to cover the roof and walls, emitting a faint blue light...*" (West, 1852).

Another similar description of glow-worms is given by Robert Johnston, who details his visit to the Ilfracombe Caves at West Tamar near Beaconsfield in 1871. These caves are more commonly known today as the Flowery Gully Caves. In his report, Johnston states that "*...extinction of the candlelights or their concealment under a ledge of the stalagmitic floor discloses the pale blue glow-worms in clusters along roof and walls, as at Chudleigh...*" (Johnston 1888).

One of the first accounts of the ecology of cave dwelling animals in Tasmania was inadvertently provided by Julian Tenison-Woods, who detailed the "web-like structures" associated with keroplatid (glow-worm) larvae in the Chudleigh Caves. Following his observation of the "*...small streaks and spots of phosphorescent light...*" on the cave roof, Tenison-Woods relates their source as "*...a long, slender, almost transparent worm, surrounded by a kind of web...*[which]*... may have had nothing to do with the worm...* [and]*...may be a place where it crept for support*". He obviously did not recognise the "worms" as dipteran fly larvae – let alone as glow-worms - or the webbing with fine vertically hanging snare threads as larval structures. Reverend J.E. Tenison-Woods was a naturalist and although he was a quite prolific writer on a range of subjects including exploration, geography, history, ichthyology, malacology and general biology, it is evident that he was not an entomologist or had not read earlier accounts which described the cave-dwelling glow-worms. Continuing to speculate on the origin of these web-like structures,

Figure 2.1: Tasmanian Cave Spider (*Hickmania troglodytes*) hanging beneath its web on a cave wall in Sassafras Cave at Mole Creek; body length is 3cm. This cave site is located approximately 200-250m from Baldocks Cave, which is believed to be the type locality for this spider, originally described in 1883 by Higgins and Petterd as *Theridion troglodytes* (Clarke 1999b).

Tenison-Woods suggests that these might be the "*...mycelium or rooting portion of some cave fungus, for I need hardly point out that spiders would not build webs where there were no flies*" (Tenison-Woods 1879). He describes the "*worm*" as being "*...luminous at intervals along the whole course of its thread-like body...*" adding that "*...it is easy to see why the worm is luminous in such a dark place; not so easy to say what brings it there, what it lives on, or how it got upon the roof of the cave...*" (Tenison-Woods, 1879).

Caves were not primarily considered as a location for invertebrate species, until the late 1800s/ early 1900s when the sporadic collection of cave fauna commenced. From the mid-1800s and into the early part of the last century, caves were primarily viewed as being important sites for bone deposits (mammalian skeletal remains), where extinct and extant species might be located. To some extent, this still applies today in modern studies of zooarchaeology, where for example Cosgrove (2002) states that "*...over the past 35 years limestone cave sites with exceptionally rich faunal records covering the last 35,000 years have been found in various parts of...southwest Tasmania...*". In 1842, during an address to the Royal Society of Tasmania, relating the instructions for an "Antarctic Expedition", it was suggested that all explorers should "*...examine material from the bottom of caves for bones*" (Anon., 1843). In 1867, S.H. Whintle reported the discovery of some mammalian bones in a cave near Glenorchy and suggested that samples of these bone remains be sent to Professor Owen in England for subsequent study (Whintle 1867). Locally known as the "Bone Cave" the site became an immediate focus of attention with the exhumation and collection of extinct and extant native animals made by several eminent scientists and geologists (e.g., Allport 1868; Krefft 1868). Sporadic collections continued over the next 20 years and in total several bag loads of bone material were presented to the Royal Society of Tasmania (Calder 1876; Anon. 1884). An amount of "*...bones of recent Marsupial Animals, etc., from a calcareous deposit in the Kent's Group, Bass Strait...*" were also collected by William Tarleton from the base of a 50feet deep cavity and presented to the Royal Society at their April 1881 meeting (Anon.,1882). In his treatise on the geology of Tasmania, Johnston makes several mentions of the bone deposits in caves, relating the "*...ossiferous deposits found upon or intimately associated with stalagmitic floors...*" and talks about the "*...cave deposits, with bone breccias under stalagmitic floor at Chudleigh...*" (Johnston 1888). There can be little doubt that the presence of these bone deposits in a recently discovered cave near Chudleigh provided the impetus for the description of the first Tasmanian cave invertebrate species.

Early in 1883, Frederick Henry from Launceston collected some mammalian remains, along with two spiders and one of their egg sacs from "*a recently discovered cave in the Chudleigh district*" (near Mole Creek). Henry passed the specimens (bone material and spiders) to Dr. Edmund Higgins and William Petterd: two eminent geologists with interests in the natural sciences and both aligned with the Tasmanian Museum. In their report to the Royal Society of Tasmania on July 10th 1883, Higgins and Petterd provided a simple description of this "*new cave-inhabiting spider*" referred to as a species of "*Arachnidae*". Named *Theridion troglodytes* (Figure 2.1), these geologists made brief mention of the spider's egg sac (see Figure 1.3) describing it as a "*...nest, which was about the size of* *pigeon's egg, and contained a large number of young...*" (Higgins and Petterd, 1884). Together with a collection of bones taken from this unknown cave, the egg sac and both spider specimens (a male and female) – one of which was mutilated – were presented to the museum as Types. This species has since become known as the "Tasmanian Cave Spider".

Previously referred to as "Bone Cave" in the Chudleigh District (Higgins and Petterd 1884), this site has now been determined as Baldocks Cave (Clarke 1999b), located near *Sassafras Creek* at South Mole Creek. Nearly 40 years later, the respective curators of the Launceston Museum and Tasmanian Museum, Herbert Scott and Clive Lord presented a paper to the Royal Society of Tasmania on June 13th 1921 which gave a more detailed account of the mammalian remains found in the caves at Mole Creek including a report on the bones found in 1917 by Mr. Henwood from some caves on Flinders Island (Scott and Lord 1922). .

One of the very few early non-zoological records relating to the botany of caves or cave entrances in Tasmania is contained in the *Papers and Proceedings of the Royal Society of Tasmania, 1890* [published in 1891]. Listed amongst the presentations made at the June 1890 meeting of the Royal Society of Tasmania, Mr. Alexander Morton "*...submitted specimens of ferns connected with limestone formations taken from the Chudleigh Caves*" (Anon. 1891a).

Eight years after the description of our first cave-dwelling species from Mole Creek, the attention on cave fauna reverted back to glow-worms, reportedly found in abundance in another new cave system in southern Tasmania. In late May 1891, there were two identical newspaper reports – a week apart - describing a Hobart Tour Party, who chartered the *S.S. Huon* on a voyage to Tylers Wharf at Ida Bay and walked six miles overland to some "*fine marble cliffs*" and the new cave system nominated to be named "The Queen's Caves" (Anon. 1891b). Led by the museum curator Alexander Morton, who collected numerous stalactite specimens for the museum, he described the second cave chamber where "*...clustering around roof and sides were millions of glowworms.*" In an address to the scientific community at a meeting of the Royal Society on June 9th 1891, Morton spoke more glamorously about the caves at Ida Bay, near Southport. In response to a query from the Governor about the new "Southport Caves" Morton stated that "*...on extinguishing the* *lights carried by the party, the ceiling and sides of the caves seemed studded with diamonds, millions of glow-worms hanging to the sides of the walls and from the ceilings causing this phenomenon..*" and goes on to say that "*...the only life met with in the caves were the glow worms...*" (Morton 1892). Morton's report to the Royal Society was subsequently reiterated in *Scientific American,* in an article titled "*The Glow Worm Caves of Tasmania*" reporting the presence of millions of glow-worms in new caves near Ida Bay in southern Tasmania (Anon., 1895). Chartered voyages from Hobart to Ida Bay, taking excursionists to the new glow-worm caves became quite a novelty and Clarke (2005a) refers to another newspaper report giving a graphic account of the glow-worms during a candlelight tour in February 1892.

At the turn of the century Tasmanian caves became the focus of some more serious study, following the appointment of Arthur M. Lea in 1899 as the Government Entomologist for the Tasmanian Department of Agriculture (Musgrave, 1932). In January 1901, Lea collected three species of cave dwelling invertebrates from Baldocks Cave at Mole Creek: a cave harvestman, eight spiders and over two dozen cave crickets (Clarke, 2000c). Most of Lea's collected specimens from Tasmanian caves were ultimately lodged in the South Australian Museum (SAM) in Adelaide, but in September 1997, during an examination of their collections of species known or purported to be lodged at SAM, the writer discovered the harvestman and eight spiders collected from Baldocks Cave in their original spirit collecting jar, but still not formally identified (Clarke, 2000c).

On July 27th 1901, J.C. (Voss) Wiburd – a visiting expert from Jenolan Caves in NSW – inspected some of the new caves near Sassafras Creek including Baldocks Cave (AOT: 1999) where he collected another female of the Tasmanian Cave Spider (Clarke, 2004). In 1904, William Rainbow re-described the new "cave-dwelling" spider, assigning it to the genus "*Ectatostica*" Simon because "*...it fits the generic diagnosis...*" commenting that the original description by Higgins and Petterd was "*...so brief as to be little better than useless...*" (Rainbow, 1904). Stating that the new species from Mole Creek had not been "*...listed in the Zoological Record...*", Rainbow suggests this would explain why in 1902, Eugene Simon (a European arachnologist) had erected the genus name *Ectatosticta* in his description of a new species (*E. australis*) collected in Tasmania, which Rainbow suggests is undoubtedly "*...synonymous with the species described by Higgins and Petterd...*".

[Note: it may be a typographical error by Rainbow, but the genus name erected by Simon was spelt as "*Ectatosticta*", not as "*Ectatostica*".] In also providing a much more detailed description of "*Ectatostica*" *troglodytes* and probably examining a number of other specimens, Rainbow also re-classified the species to the family Hypochilidae (Rainbow 1904). It is highly probable that the Tasmanian Cave Spider specimens from Baldocks Cave, independently collected in 1901 by both Lea and Wiburd were amongst those examined by Rainbow. Both collections were lodged in the Australian Museum; the Wiburd specimen is in the museum's collection of Types, assigned as a paralectotype of *Theridion troglodytes* [Registration KS: 08842] (Clarke, 2004).

In December 1909, eight invertebrate species were collected from caves in two areas: at Ida Bay and Mole Creek (Clarke 2000c; 2004). Lea collected six species of cave fauna and recorded another five species from the "Ida Bay Caves" (Mystery Creek Cave) and one of his associates: R.A. Black, an amateur naturalist collected cave crickets and a cave beetle from Scotts Cave, another recently discovered cave at Mole Creek. On March 10th 1910, Lea provided a summary of these cave studies and invertebrate collections to the Tasmanian Field Naturalists Club during "*...an instructive address on Entomology, illustrated by numerous lantern slides...*" (Anon. 1910). Effectively the first public lecture on cave fauna, the ecology of cave species and cave "zones" to a Tasmanian audience, most of Lea's presentation was published in *The Tasmanian Naturalist.* In this paper, Lea describes the different types of species found in the "*dark parts*" or "*black parts*" of caves and those in the "*twilight portions*", relating the occurrence of similar species such as spiders and crickets found in caves of N.S.W., such as Jenolan Caves (Lea 1910). Lea collected cave crickets which "*...have very long antennae and legs...*" as well as adult glow-worm flies and a cave harvestman from Mystery Creek Cave (Clarke 2004). He also reported on the insects commonly found in the twilight portions of all caves recording the presence of "*...mosquitoes, daddy-long-leg flies* [crane flies], *moths, ants, caddis flies, etc.*" suggesting that they "*...appear to be purely chance visitors...*" Lea records the fact that there are numerous spiders in Australian caves, with species occurring in dark parts and in the twilight parts, referring to one species being abundant in the twilight parts of "Gunns Plains Caves" and two in the twilight parts of caves at Ida Bay and also at Mole Creek, where "*...at least one of these commonly feeds on the crickets.*" Although Lea also says that there is "*...one true species of cave spider which feeds on the glow-worms...*" in the dark zone of Mystery Creek Cave (Lea 1910), he is referring to the cave harvestman, because in the subsequent description of the glow-worm flies collected from this cave, Ferguson (1925) quotes Lea as saying that the glow-worm larvae "*...are eaten by a spider-like creature and by the Idacarabus...*" (Figure 2.2). In his paper to *The Tasmanian Naturalist*, Lea (1910) informs the readers that the glow-worms seen in majority of Tasmanian caves are in fact "*...the larvae of a very peculiar fly...a true cave fly...*"

Figure 2.2: Cave beetle (*Idacarabus troglodytes*) on clay-earth above rock slab in Mystery Creek Cave at Ida Bay; body length is approx. 6.5-7.0mm.

Commenting on the known occurrence of beetles including blind species from caves in Europe, Arthur Lea describes his fruitless search for cave-dwelling beetles here in Australia while examining cave sites in S.W. Western Australia, New South Wales and northern Tasmania (Lea 1910). Although he reports with "pleasure" on the new finds at Ida Bay, Lea states that "*...our cave beetles are not blind but as one species certainly, and the other probably, feed on glow-worms, eyes are of use to them...*" First published in *The Tasmanian Naturalist* (then in the *Proceedings of the Royal Society of Victoria*), Lea provided descriptions of the three Ida Bay beetle species collected in December 1909:

Idacarabus troglodytes (described from seven specimens), *Idacarabus flavipes* (from one female) [later re-described as *Tasmanorites flavipes* (Moore 1972b)] and *Cyphon doctus* (described from one living and numerous dead species). His papers also provide a description of the beetle (seven specimens) collected by R.A. Black from Scotts Cave at Mole Creek, which he names as *Cryptophagus troglodytes* (Lea 1910; 1914). Interestingly, this species has never been re-located since and the holotype and paratypes that were once lodged at SAM (E. Hamilton-Smith, pers. comm.) were not found there in September 1997 (Clarke 2000c). The carabid beetle described by Lea as *Idacarabus troglodytes* was the first true cavernicolous obligate to be recorded from a cave in Tasmania and Goede and Goede (1973a) state that for "...*nearly half a century*...[it]...*remained the only truly cave adapted animal known from Australia*".

Following Lea's brief but relatively comprehensive encounter with Tasmanian cave fauna, there was a "drought" of about 15 years until 1924, when Dr. Robert Pulleine - a consultant physician and naturalist from Adelaide, with a keen interest in life sciences (particularly Arachnology) – collected a number of spiders from Baldocks Cave at Mole Creek (Pulleine, 1924). Pulleine's cave spider specimens were lodged at SAM in Adelaide and in September 1997 the writer observed two vials of spiders in the spirit collection containing a total of five males and three females: all recorded as *Ectatostica troglodytes* (Clarke 2000c). However, another jar with eight smaller spiders – probably 2-3 species – was observed in the spirit collection at SAM and like the specimens collected by Lea from this same cave in 1901, Pulleine's collection had still not been determined or identified (Clarke 2000c).

In 1925, the glow-worm flies, collected by Lea from Mystery Creek Cave in 1909, were described by Eustace Ferguson. Although primarily engaged as a bacteriologist for the Department of Health in Sydney, Ferguson was also active as an entomological taxonomist (Musgrave 1932). Arthur Lea had collected three adult glow-worm flies "...*a pair in copula and a single male*..." and recognising them as species of the same genus found in caves at Waitomo in New Zealand, Ferguson (1925) described the Ida Bay glow-worms as *Arachnocampa tasmaniensis* in a paper read to the Linnean Society of NSW on November 25th 1925. In his description, Ferguson adds some further ecological detail of the Ida Bay glow-worms provided by Lea who he quotes as saying "...*the larvae construct a hanging* *affair for themselves, along which they pass…*" (Ferguson 1925).

Two years later in 1927, during a series of presentations on Tasmanian spiders to the Royal Society of Tasmania, Vernon Hickman provided another even more detailed description of the Tasmanian Cave Spider. Still recording it as *Ectatostica troglodytes* (Family Hypochilidae), Hickman quotes Dr. Robert Pulleine who reportedly described the cave spider as "*Tasmania's most aristocratic spider*" (Hickman 1928). In his lecture to the Royal Society, Hickman provided additional information on the structure of the spider's web based on observations of webbing in a cave at Mole Creek; from the brief site description which records a narrow passage fissure entrance, it is probably Baldocks Cave, the type locality for the species. In the published paper, Hickman (1928) records the spider's distribution in caves throughout Tasmania, along with several epigean sites.

In the late 1920s/ early 1930s the reports of Tasmanian cave animals had captured the imagination of several entomologists, including Keith Collingwood McKeown. A copious author, writing books on Australian insects and spiders, McKeown was an entomologist working for the NSW Govt. and obviously spent time inspecting habitats and collecting species in Tasmania for various museum collections (McKeown, 1935; 1936; 1942; 1944). Some of his remarks make interesting reading as he reports on glow-worms from Gunns Plains Caves and Mole Creek, as well as the "*…spiny-legged, blind Cave Crickets …* [that]*… form a brown tapestry over the rough rock walls, a tapestry which breaks up and scatters in all directions if disturbed; the individual crickets form the mass leap away into the most inaccessible positions …*" which he believes are food supply for *Hickmania troglodytes*. Reporting anecdotally on the latter, McKeown says "*A wonderful example of these cave dwelling spiders is to be found in Tasmania, where a large brown or blackish species, with long sprawling legs, lives in the depths of caves at Mole Creek in the north of the island. It affixes an irregular snare of tangled threads of a curiously glistening silk among stalactites which hang from the roof of the grotto.*" (McKeown, 1936: p. 9).

Continuing in an anecdotal vein, McKeown states "*An amusing incident occurred during the writer's visit to the Mole Creek Caves. To secure a near view of one particularly large spider which was clinging to her precious nursery, it was necessary to crawl along a somewhat narrow "chimney." The illumination was provided by the guide who extended a* *guttering candle at arm's length along the tunnel above my back; a not particularly comfortable arrangement, since bristling stalactites and stalagmites intruded their sharp points into every conceivable part of my anatomy, while the hot grease from the candle found its way with uncanny precision down the back of my neck. It was while in this very restricted position that I evinced a desire to secure the spider as a specimen for the Museum, but was completely rebuffed by the youthful guide, who exclaimed heatedly,* "Don't touch 'im! E's been 'ere for forty year!" *I doubted the age of the spider – but did not get my specimen.*" (McKeown, 1936: p. 10).

From the 1930s onwards, there were sporadic collections of cave invertebrates from Ida Bay and Mole Creek, plus Flinders Island, Junee-Florentine and Hastings. Noteworthy amongst the records for this period are:

- New species of cave crickets collected in January 1930 from Ranga Cave on Flinders Island by the South Australian mammalogist, Hedley Finlayson;
- Collections from tourist caves by K. Martin (c. 1932-1938) a local cave guide at Mole Creek;
- A specimen of the Tasmanian Cave Spider collected from Junee Cave in mid-April 1938 by Leonard Rodway;
- The first record of an aquatic species from caves: an anaspidacean syncarid from *Marakoopa Cave* at Mole Creek collected in late April 1938 by A. Rafferty;
- A cave cricket collected by R. Boswell from "Hastings Caves" (Newdegate Cave) in December 1938, prior to the cave being opened for commercial tourism; and
- Harvestman collected from "Ida Bay Caves" by Vernon Hickman in November 1939 (Clarke 2004). One of these Hickman specimens became the holotype male for the first cave harvestman to be described from Tasmania: *Monoxyomma cavaticum* (Hickman 1958), subsequently re-described by Hunt (1990) as *Hickmanoxyomma cavaticum.*

2.1.2. Early reports of the surface occurrence of "cave species"

When William Breton reported glow-worms in the cave west of Quamby Bluff during his excursion to the Western Ranges in 1842, he also stated that "*...they are not uncommon in the forests far to the westward...*" (Breton 1843). Although it could be construed that Breton is reporting glow-worms in forests of the "Western Ranges" (Western Tiers), it is likely he is probably referring to the account of glow-worms in the Acheron Valley reported during Governor Franklin's overland journey to Macquarie Harbour in April 1842. Re-counting the historical reports by David Burn (1843) and James Calder (1849) of Sir John and Lady Franklin's journey to Macquarie Harbour, Kathleen Fitzpatrick (1949) relates their passage through the Acheron Valley and their encampment, where glow-worms were seen in the rainforest on the night of April 10-11th 1842. Some of Calder's convict assistants who accompanied the Franklins on this expedition referred to this Acheron Valley site as the "*Glow-worm Forest*" (Burn 1843; Calder 1849; Fitzpatrick 1949). The reports of glow-worms in the Acheron Valley gave credence to rumours of caves or cave entrances, which were subsequently proven by Hydro-Electric Commission surveys (Paterson, *et al.*, 1983) and cave fauna studies (Eberhard, 1988). In Arthur Lea's early account of the cave-dwelling species at Ida Bay, he refers to the glow-worms seen in abandoned mine workings and underneath logs in wet gullies (Lea 1910). Following description of the glow-worms in Ida Bay Caves as *Arachnocampa tasmaniensis*, Ferguson (1925) records that "*...the identity of the luminous larvae found in gullies and old mines is more doubtful...*" suggesting these may in fact be species of another genus, "*Ceroplatus*".

Similarly, when Rainbow (1904) re-described the Tasmanian Cave Spider as *Ectatostica troglodytes*, he records a letter from William Petterd who states that the spider "*...is fairly common in shallow sandstone caves along the banks of the Pieman River.*" Hickman records that *E. troglodytes* is widely distributed throughout Tasmania, not just in caves, but in many surface sites e.g., "*...under a log on Mt. Arthur, near Lilydale...in the vicinity of the Forth Falls, near Sheffield...in forest debris at Lenah Valley in the foothills of Mt. Wellington...* [and]*...from old mining shafts in the Zeehan area...*" (Hickman, 1928). In recognition of Hickman's contribution to the study of Tasmanian arachnids including spiders, the Tasmanian Cave Spider was re-described again by Willis Gertsch (1958) and re-designated as *Hickmania troglodytes*.

2.2: Recent collections by cave biologists and taxonomists

With the advent of organised caving in Tasmania and increasing interest in caves locally and nationally, cave biology studies gradually developed as an adjunct to cave exploration, documentation and survey mapping of subterranean passages or chambers.

2.2.1. The development of organised caving and cave biology in Tasmania

In September 1946, Sam Carey – recently appointed as Professor of Geology at the University of Tasmania – founded the first caving club in Australia: Tasmanian Caverneering Club (TCC). In January 1947 members of TCC collected aquatic amphipods from Mystery Creek Cave at Ida Bay, essentially representing the start of a new era when the majority of invertebrate species in caves were collected by caving club members, primarily dedicated cave biologists. Amongst the active cavers or biologists involved with the study of Tasmanian cave species are: Elery Hamilton-Smith, Albert and Therese Goede, Bob Cockerill, Aleks Terauds, Stefan Eberhard and Arthur Clarke. It is perhaps worthy to note for historical purposes that in early days of organised caving in Tasmania, the rhaphidophorid cave crickets were referred to as "*cave grasshoppers*" (TCC, 1949).

2.2.2. The first Tasmanian speleo-biologists and their different systems for classification of cave fauna

Although there were minor occasional collections - often in selected karst areas - by Cockerill, Kiernan, Middleton and Terauds, the first two serious collectors of cave fauna in Tasmania were Elery Hamilton-Smith and Albert Goede. As speleologists with different background approaches to cave fauna, both men considered the classification of species from alternate perspectives: biological and geographical.

The original ecological classification of cave animals based on the Schiner-Racovitza model had several shortcomings. Some categories of fauna such as species living in the twilight zone, micro-organisms or parasites could not be readily assigned to a category. Similarly, there appeared to be an anomaly relating to troglophiles: defined as species that spend their life cycle within caves, but do not show the morphological adaptation of troglobites. However, there are several facultative epigean species such as isopods, millipedes and symphylans that appear to be pre-adapted to caves, but still living in surface habitats. To classify cavernicoles as troglobites, speleologists need to rely on the determinations and statements of specialists involved in the study and anatomy of species in the various taxa. Two revised systems of classification were proposed in the early 1970s.

The first new system for classification of cave fauna proposed by Hamilton-Smith (1971) was a modified or revised version of the Schiner-Racovitza model. The system of classification devised by Hamilton-Smith was designed in order to resolve some of the above-mentioned problems or anomalies in methods classifying cavernicoles. Hamilton-Smith included eight categories in his revised system:

• Accidental visitors, as proposed by Vandel (1965).

• Twilight zone dwellers, including birds such as swallows, moths and invertebrates using the cool entrances as shelters.

• Trogloxenes, as per original model.

• Parasites, including mites, tapeworms and blood parasites brought into caves by mammals.

• First Level Troglophiles - species recorded from surface habitats.

• Second Level Troglophiles - species that may be similar to surface dwelling forms, but are only found in caves and do not exhibit the troglomorphic adaptive features that are commonly used to distinguish troglobites (Table 1.1), e.g., attenuation of appendages and the so-called "regressive" features such as depigmentation or anophthalmy.

• Troglobites – as per original model. (Cavernicoles confined to the cave habitat and adapted to the cave environment.)

• Micro-organisms: aerobic and anaerobic bacteria in caves feeding on organic matter or inorganic sources, i.e., deriving their energy from the oxidation of iron and sulphur rich compounds. (Some of these bacteria are likely to be responsible for a proportion of the carbon dioxide gas found in caves.)

The second classification by Goede (1970, 1972) was based on a geographical approach relating to the known distribution characteristics of cavernicolous invertebrates in Tasmania. As an island state, with many isolated areas of karst in carbonate rock, Goede claimed that the distribution patterns of cave species in Tasmania provided an ideal application for his classification.

In his system, Geode (1970; 1972), classified Tasmanian cave species into six groups:

• Regular visitors with state-wide distribution; species found in caves and on the surface throughout Tasmania wherever favourable conditions occur. Examples - Tasmanian Cave Spider and the Tasmanian glow worm.

• Regular visitors with regional distribution; species found in various parts of Tasmania and in more than one karst area. Two genera of cave crickets of the family Rhaphidophoridae occur on the Tasmanian mainland, each with species in different areas.

• Distinct but closely related species in separate limestone karst areas, in areas where limestones are close together or quite distant, but separated by non-carbonate rocks there is a suggestion that cave species have a common ancestor no longer present on the surface. Goede quotes the examples of two species of the carabid beetle of genus *Idacarabus* at Ida Bay and Hastings. Similarly two different spider species of the genus *Icona* have been located at Ida Bay and Precipitous Bluff. There are also three different species of the isopod crustacean of the genus *Styloniscus* at Ida Bay, Precipitous Bluff and Mole Creek.

• Species occurring in only one limestone area (and without close relatives in other areas). Goede gives two examples: a phreatoicid of the possible genus *Crenoicus* at Mole Creek and millipedes of the family Dalodesmidae at Ida Bay. Recently a possible new genus of the spider family Theridiidae was discovered at Ida Bay and the tiny troglobitic *Olgania* spiders could be considered as another example.

• Species occurring in only one cave or system of related caves (within a limestone area). Examples include an eyeless form of the fresh water shrimp *Anaspides tasmaniae* found in Wolf Hole at Hastings, aquatic gastropods of the family Hydrobiidae in Skyhook Pot and Mystery Creek Cave (two caves in the Exit Cave system) and the blind carabid *Goedetrechus mendumae* known from three caves in the Exit Cave system.

• Accidental visitors in only one cave or system of related caves, not usually regarded as significant to the biospeleologist, although several new species not previously recorded have been found in caves.

The problem of relying on statements of specialists relating to troglobitic determinations and the question of whether a species fits into classes (5) and (6) of Goede's system assumes that there is an adequate knowledge of the taxonomy, variation and distribution of individual species and that a particular cave site or karst area has been adequately studied and sampled. Both the Hamilton-Smith and Goede classification systems and the original Schiner-Racovitza model fail to completely cover all aspects of cavernicolous fauna. Although it might be simpler or convenient to relate cave invertebrates as being "troglomorphic", the merits of this early approach to classification of cavernicoles need to be questioned, because the use of adaptive features to categorise cave animals shifts the focus from an ecological basis to an evolutionary one (Eberhard, 1988). There is also the problem of using troglomorphy as a determining character because a number of epigean or endogean invertebrates living in deep litter or sub-soil regions also have seemingly troglomorphic features; these species are often described as being pre-adapted to cave life. In several of his reports on the status of species in Tasmanian World Heritage areas, Eberhard (1988, 1989, 1992a) adopted a quite detailed ecological habitat approach, e.g., recording fossorial (burrowing) koonungid syncarids and describing aquatic species from discrete habitats such as the hyporheos (saturated sediment) or from hygropetric (rock surface) sections of a stream and recording riparian species as ripicoles; (see Glossary, Section 8). This writer has attempted to classify cave fauna in more direct ecological terms in a similar manner to Eberhard (1988), describing species as adventitious, facultative, habitual and obligatory cavernicoles on the basis of their relationship to micro-habitat and cave ecology, but also considering factors such as cave morphology, the separation distance from epigean influences and nutrient (or energy) sources.

Adventitious cavernicoles include accidentals and trogloxenes are those species which normally have no interest in caves and merely "arrive" there by chance. Facultative species have a preference to certain habitats based on their faculties, i.e., they may be hygroscopic species that prefer dark or wet places and are capable of living in caves. These species could be thought of as being opportunistic, being able to adapt to caves as they would elsewhere in rain forest or mine adit etc. Facultative species would include first level troglophiles. Habitual cavernicoles are species that develop the habit of living in caves and may show some degree of apparent morphological adaptation to cave conditions e.g., they may be blind, but can exist outside caves in similar dark and moist habitats, e.g., in deep litter and under logs. Eberhard (1987b, 1987c) lists species of the following groups as being habitual cavernicoles in Tasmanian caves: Hydrobiidae, Symphyla, Diplopoda, Paramelitidae (Crangonyctoidea), Janiridae, Acarina, Collembola, Pseudoscorpionida, Syncarida and Tricladida. Obligatory cavernicoles are those species that must live in caves and are unable to exist outside. In terms of the Hamilton-Smith classification they include second level troglophiles and troglobites. Many aquatic obligates will be troglobitic. Obligatory are typically endemic to a particular region, karst area or particular cave and are possibly best exemplified by the aquatic species (stygofauna) confined to a particular individual karst hydrological system.

2.2.3. More recent collections, principally by Eberhard and Clarke

Following the early cave fauna collections by "P.J. Darlington and son", Hamilton-Smith, Goede, Cockerill and Terauds dating from 1957, most of the recent studies over the past two decades have been undertaken by Stefan Eberhard and the present writer (Figure 2.4). The bar graphs in Figures 2.3 and 2.4 (overleaf) show analyses of the numbers of cave fauna occurrence records (collections and observations) for two 25 year periods, for the 50 years from 1957 to 2006. (Note, this is a slightly skewed result because 2006 and has only just begun and much of the writer's cave material from mid-2004 to the present has not been sorted, analysed, documented or databased during this period of thesis writing.)

The high collection point in Figure 2.3 represents the year (1968) when Albert and Therese Goede commenced a regular programme of cave fauna studies, rigorously documenting the collection of specimens, forwarded to museum and university based taxonomists, e.g., Alan Dartnall, Ray Forster, Alison Green, Peter Johns, Barry Moore and Aola Richards. A "Filter Sort" on the surname "Goede" in the "Collector" field of the database "Records" Table (see Section 4) shows that 693 collections or observations are recorded for Albert or Therese Goede. In Figure 2.4, the three high years (1988-1990) represent the period when, in addition to the collections of cave fauna associated with cave exploration in the Ida Bay and Junee-Florentine karsts, Eberhard and Clarke were involved, together and independently, with cave fauna studies in several karst areas of western and southern Tasmania. For example, during 1988-1989, Eberhard and Clarke both conducted studies at Bubs Hill, Hastings, North Lune and Precipitous Bluff and in addition, during the three year period from 1987-1989, Eberhard undertook a number of ground-breaking cave fauna investigations in some very remote areas of the southwest and western Tasmanian World Heritage Area; a few of these western Tasmania study sites are listed in Table 3.1 (Section 3.2.1). In the database, Stefan Eberhard is recorded for 2,243 cave species occurrences and Arthur Clarke for 1,629 occurrences. Cave fauna collection studies in the period from 1957-2006 are recorded by Clarke (1987b, 1987c, 1987d, 1987e, 1988b, 1988c, 1989a, 1990); Eberhard (1987c, 1988, 1989, 1990b, 1991, 1992a, 1994, 1999a); Eberhard, *et al.* (1991); Eberhard, *et al.*, (1992), Eberhard and Spate (1994), Goede (1967, 1970, 1972); Goede and Goede (1973a, 1973b, 1974a, 1974b); Gray and Heap (1996); Houshold and Clarke (1988); Hume and Clarke (1989); Richards and Ollier (1976); Spate, *et al.*, (1991).

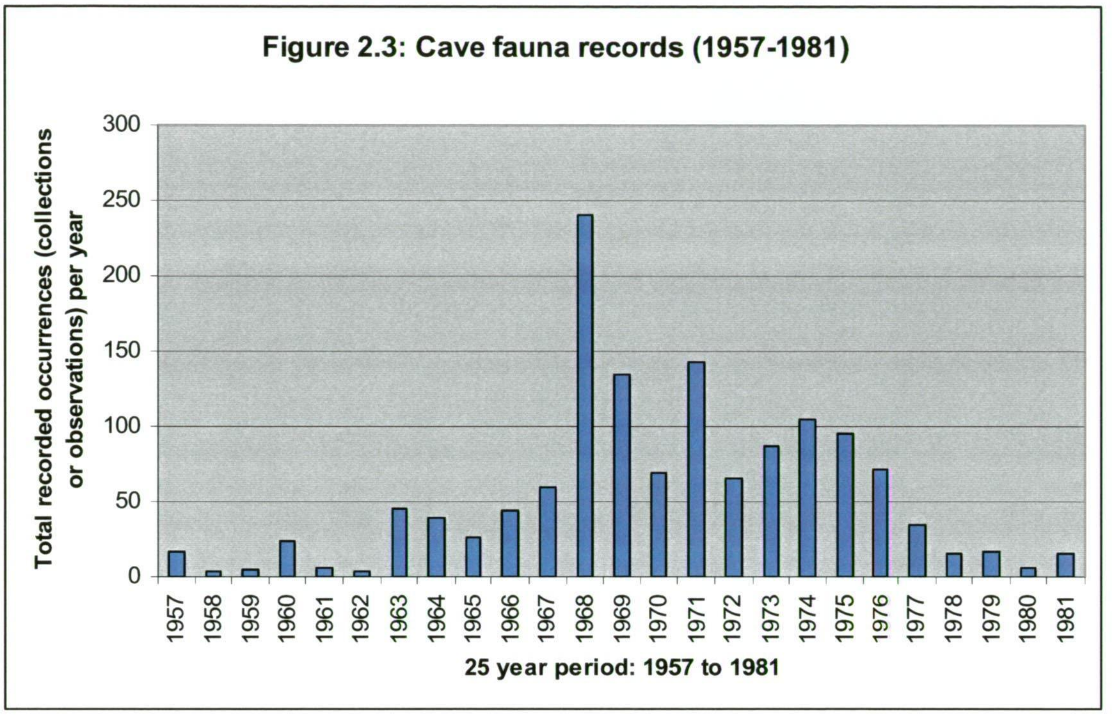


Figure 2.3: Tasmanian cave fauna occurrence records (collections and observations) over a 25 year period from 1957 - 1981. Based on database query titled: "THESIS FIGURE - Collectors and collection YEAR Query_Crosstab"

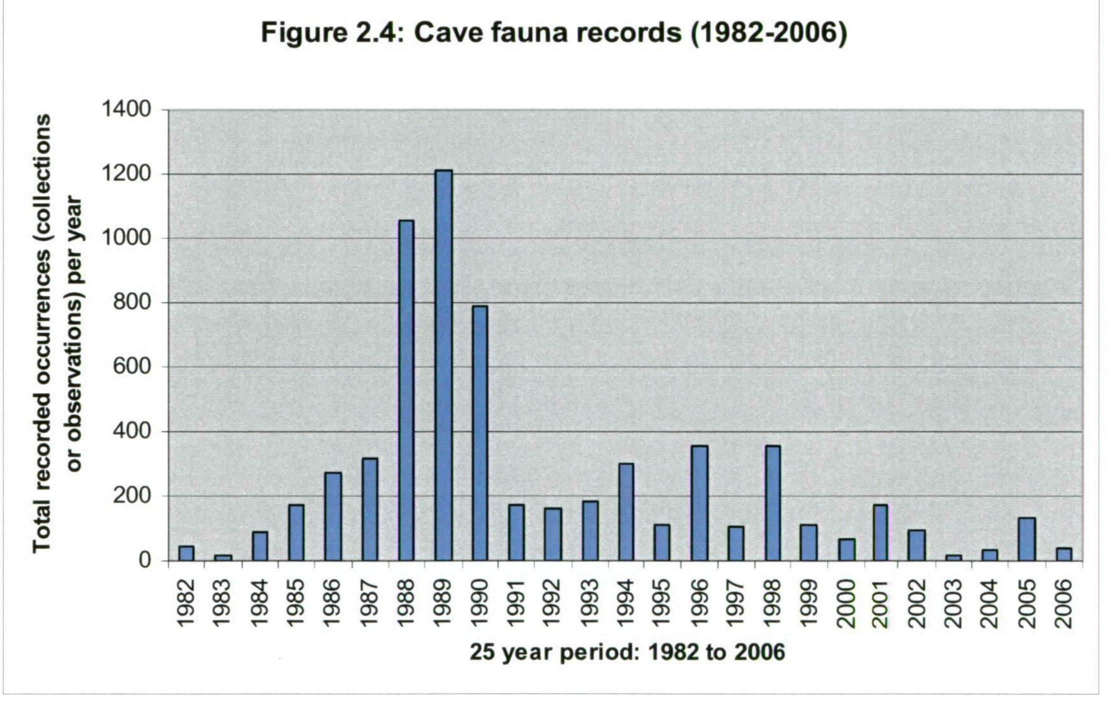


Figure 2.4: Tasmanian cave fauna occurrence records (collections and observations) over a 25 year period from 1982 - 2006. Based on database query titled: "THESIS FIGURE - Collectors and collection YEAR Query_Crosstab"

3. Methodology

3.1: Introduction

Aside from the fieldwork for this study and sourcing of references related to the biodiversity and distribution of cavernicoles, the major component of this thesis has centred on the compilation of a relational database in MsAccess with tables of defined, queries and tabulations (referred to as Cross-Tab queries in Ms Access). Designed as a bio-inventory to systematically catalogue and record the occurrences (observations and collections) of invertebrate species from Tasmanian caves and karst areas, the database is an on-going project that will serve as a basis for future research. In addition to providing a historical and comprehensive record of the occurrences of invertebrate cavernicoles in Tasmania, the database will also provide information to answer questions related to species biodiversity and the role of micro-habitats within caves as distribution determinants.

3.1.1. The accompanying database

The original RFA database contained 4,665 records, covering 643 species from 492 caves sites in 50 karst areas and 18 non-karst areas (Clarke, 1997a). The presently updated and expanded database contains 7,861 records for 1292 species from 749 occurrence sites, which now include 71 karst surface sites, incorporating the surface collection records by previous cave biologists (e.g., Goede and Eberhard). These additional surface records from sites near cave entrances include the collections made by museum based taxonomists, e.g., Mike Gray and Glenn Hunt, accompanying Stefan Eberhard and Arthur Clarke. However, unlike the Goede records, the present database does not record the occurrences of so-called cave species from artificial or man-made sites in non-karst areas. Goede collected species from a number of artificial sites, for example: the *Micropathus* "cave crickets" and two spiders (*Hickmania troglodytes* and *Tupua bisetosa*) are amongst the species for Goede reference numbers 84-87 collected from the twilight zone of Sandfly Colliery at Kaoota; similarly Goede collection nos. 227-230 are species from convict ruins at Port Arthur and nos. 285-291 are surface sites underneath the Tahune Bridge beside the Huon River.

In addition to listing species occurrences from caves in karst and non-karst areas, the database includes species recorded from surface sites in karst areas; most of these sites are near the entrances of known caves. The reasoning behind this is based on the concept of the connectivity of karst bio-space within any given area of karstified carbonate rock and the inter-relationship of karst surfaces, including covering soil mantles, with subterranean processes and ecology. An analysis of species from karst surfaces and hypogean sites can be used to determine whether surface species are entering caves and conversely whether so-called cave species are migrating into surface habitats. The late Dr. Glenn Hunt encouraged cave biologists such as Goede, Eberhard and Clarke to search for triaenonychid harvestmen in surface litter near cave entrances in order to determine whether some cave species were found in epigean habitats or vice versa. Discussed briefly in Chapter 5 (section: 5.2.5), the Blind Velvet Worm (*Tasmanipatus anophthalmus*) is possibly an example of colonisation of surface habitats by a cave species. Considered as possibly a former cave dwelling species (Fig. 5.7), this peripatus is known from a broad area of surface habitats, in karst and non-karst areas of northeastern Tasmania (Mesibov, 1987; Eberhard and Eberhard, 1989).

Encompassing many of the published or unpublished records of Cockerill, Eberhard, Goede and Hamilton-Smith, the first RFA database provided a summary overview and preliminary collation of the range of known invertebrate species in Tasmanian caves. However, the RFA database contained a number of inherent inaccuracies and inadequacies that needed to be redressed in order to deliver more constructive outcomes for this thesis.

3.2: Addressing inadequacies inherited from the previous RFA database

One example of the inadequacies or problems with the original relational database in Clarke (1997a) related to data analysis, where for example records could not be sorted chronologically by date. In order to show the month component of a collection date in Roman numerals, all the dates had been recorded as text format. Amongst other inherent problems there were duplication of records, incomplete field data sets, inconsistent terminology in the same field and a general lack of taxonomic resolution for many species groups. Although the original database was quite comprehensive and informative, when queries were devised to analyse certain aspects of the data, the results were skewed and/ or produced an unnaturally fragmented glimpse of the desired outcome. The conversion of text dates into real "dd-mmm-yyyy" dates is detailed in Section 9.5.1 in the Appendix.

3.2.1. Ambiguity and inadequacies of information from previous RFA database and other record sources

Examples of the ambiguity with cave site collection records include inadequate detail of specimen location site, insufficient information on the accompanying specimen label and/ or incorrectly recorded information in museum records. For example, at the commencement of research for this thesis, the writer conducted an inspection of the Tasmanian cave invertebrate fauna held in the "spirit" collection of the South Australian Museum (SAM). Amongst the vials held at SAM, there was a container of unidentified arachnids collected a century ago by Arthur Lea from an un-named cave in Tasmania. Containing a harvestman and several spiders, the vial has a label in Lea's handwriting that simply reads as "Mole Creek Caves January 1901" (Clarke, 2000c).

Based on some historical research (Clarke, 1999b), it has been deduced that Lea's 1901 collection site at Mole Creek was in fact Baldocks Cave, determined as the Type Locality for the Tasmanian Cave Spider described by Higgins and Petterd (1884). For the period covering the late 1800s/ early 1900s, the so-called "new" dry caves at South Mole Creek (Sassafras Cave, Cyclops Cave and Baldocks Cave) were known solely or collectively as the "Mole Creek Caves" and the "old" wet caves near Chudleigh (Wet Cave and Honeycomb) as "Chudleigh Caves" (Clarke, 1999b). As detailed in Clarke, following the description of the Tasmanian Cave Spider based on specimens collected from Baldocks Cave, this cave was visited on a regular basis by specialists and museum staff, prior to the discovery of Scotts Cave and Byards (Marakoopa) Cave.

In the late 1980s, a series of collections were made from caves and karst surface sites in the western Tasmania World Heritage Area (Eberhard, 1987c; 1988; 1989). The relevant collection data from these surveys was recorded in an unpublished database and together with updated taxonomic determinations for collected species the results were published by Eberhard, *et al.* (1991) together with other known records of Tasmanian cave fauna. In 1988 and 1989, two similar areas of western Tasmania were visited, almost exactly 12 months apart and as shown in Table 3.1, it appears that the collection dates in museum records have become confused, with some 1988 collections recorded with a 1989 year date.

Table 3.1: A date ordered list of thesis database record sources (including museum lodgements), showing variable range of confused dates in 1988 and 1989 and number of records listed for species collected by Stefan Eberhard from caves and karst surface sites in the western Tasmania WHA. (The original and correct Eberhard collection dates, sourced from Stefan's unpublished database, are shown in bold).

Record Info Source	Date	Recorded Collector/s	Recorded Collection Site	records
SE database	22-Mar-88	S. Eberhard	Lower Andrew River caves	35
QVM arthropods	22-Mar-88	S. Eberhard	Lower Andrew River caves	9
AUSMUS arachnids	22-Mar-88	MR Gray & S Eberhard	Andrew River Caves area	55
AUSMUS arachnids	22-Mar-88	M Gray & S Eberhard	Kutikina Cave (F34) Franklin River	1
AUSMUS arachnids	23-Mar-88	S. Eberhard	Andrew River Caves area	1
SE database	23-Mar-88	S. Eberhard	Kutikina Cave (Fraser Cave)	24
QVM arthropods	23-Mar-88	S. Eberhard	Kutikina Cave	7
AUSMUS arachnids	23-Mar-88	S. Eberhard	Kutikina Cave (Fraser Cave)	6
AUSMUS arachnids	23-Mar-88	MR Gray & S Eberhard	Kutikina Cave (Fraser Cave)	1
SE database	24-Mar-88	S. Eberhard	Acheron River caves	29
QVM arthropods	24-Mar-88	S. Eberhard	Acheron River caves	8
AUSMUS arachnids	24-Mar-88	MR Gray & S Eberhard	Acheron River Caves area	4
SE database	25-Mar-88	S. Eberhard	Nelson River caves	18
QVM arthropods	25-Mar-88	S. Eberhard	Nelson River caves	3
AUSMUS arachnids	25-Mar-88	MR Gray & S Eberhard	Nelson River area	3
AUSMUS arachnids	25-Mar-88	MR Gray	Nelson River	4
SE database	01-Nov-88	S. Eberhard	Bubs Hill (Thylacine Lair BH-203)	7
QVM arthropods	01-Nov-88	S. Eberhard	Bubs Hill (Thylacine Lair BH-203)	2
AUSMUS arachnids	01-Nov-88	S. Eberhard	Bubs Hill (Thylacine Lair BH-203)	1
AUSMUS arachnids	13-Mar-89	S Eberhard	Proina Cave F51 Franklin River	1
AUSMUS arachnids	19-Mar-89	S Eberhard	Proina Cave F51 Franklin River	8
SE database	19-Mar-89	S Eberhard	Proina Cave (Lowe Cave)	31
QVM arthropods	19-Mar-89	S Eberhard	Proina Cave	14
AUSMUS arachnids	20-Mar-89	S Eberhard	Gahnia Cave F74 Franklin River	9
SE database	20-Mar-89	S Eberhard	Gahnia Cave	26
QVM arthropods	20-Mar-89	S Eberhard	Gahnia Cave	11
AUSMUS arachnids	21-Mar-89	S Eberhard	Kutikina Cave F34 Franklin River	14
SE database	21-Mar-89	S Eberhard	Kutikina Cave (Fraser Cave)	33
QVM arthropods	21-Mar-89	S Eberhard	Kutikina Cave	13
AUSMUS arachnids	22-Mar-89	MR Gray & S Eberhard	Andrew River caves area	43
AUSMUS arachnids	22-Mar-89	S Eberhard	Andrew River Caves	8
SE database	23-Mar-89	S Eberhard	Pengana Cave & other Franklin River caves	9
QVM arthropods	23-Mar-89	S Eberhard	Pengana Cave & other Franklin River caves	9
AUSMUS arachnids	23-Mar-89	MR Gray & S Eberhard	Franklin area near Kutikina cave F34	18
AUSMUS arachnids	23-Mar-89	S Eberhard	Kutikina Cave F34 Franklin R	11
AUSMUS arachnids	23-Mar-89	S Eberhard	Pengana Cave & other Franklin River caves	5
AUSMUS arachnids	24-Mar-89	MR Gray & S Eberhard	Acheron River Caves area	72
AUSMUS arachnids	24-Mar-89	S Eberhard	Cardia Cave	12
AUSMUS arachnids	25-Mar-89	MR Gray & S Eberhard	Nelson River Caves area	45
AUSMUS arachnids	01-Nov-89	S Eberhard	Bubs Hill (Thylacine Lair BH-203)	4

3.2.2. Duplication of database records

Aside from the unreliability of older historical sources for database purposes, some other references to species occurrences from Tasmanian cave sites can also represent less reliable sources of information. For example, in instances where a species from a particular cave or karst area is listed, tabled or referred to in a published paper (e.g., Doran, Richardson and Wood, 2000), if there is no accompanying information relating to collection detail, there will be no way of knowing whether the species reference relates to an observation or a collection and whether it has been sourced elsewhere, e.g., as a museum lodgement record. Similarly, where cave species occurrences are mentioned in texts without precise details of their collection dates etc, e.g., Goede (1967, 1970, 1972), Goede and Goede (1973a, 1973b, 1974a, 1974b), Eberhard, (1999a, 1999b); Eberhard, *et al.*, (1991), Matthews (1985), Richards and Ollier (1976), Sleinis (1986), Terauds (1973), any inclusion of these species in a database may simply be a duplication of the more reliable records from museums or collector's notebooks. In the case of the thesis database, this has been rectified by examining the Records Table, listing the caves in order and checking the species recorded for each cave, eliminating possible duplicates where it is apparent those particular species occurrences have been already listed. Suspect duplicate records can usually be determined easily, simply because they do not have any precise collection details: collector name/s, reference codes and collection date. Records sourced from species lists in articles written by cavers, e.g., many of those quoted above, may also have incorrect taxonomy.

Several further reasons may have lead to duplication of records in the database:

- Sourcing the same record from different sources (published species lists including caving club reports, museum records, collector's records and taxonomists' records);
- Reliance on collector's unpublished records or their published accounts where these may include details related to collections by other persons (but not specifically acknowledged in their records, database or published account). For example, in some unpublished sources (e.g., Eberhard pre-December 1989 database), there are records of species collected by others (e.g., Stefan's "...r" suffix numbers referring to previous reported/ recorded specimens) without detail of the original collection;

- Sources, including published records (e.g., Goede, 1967; Richards and Ollier, 1976; Eberhard *et al.*, 1991; Eberhard, 1992a), which only list species names (or animal types) without essential occurrence detail: collector name, field or reference number and date of collection;
- Recording specimen occurrences from unreliable sources, e.g., the brief mention of cave species in the trip reports of caving club publications and journals, often without a clear indication that the species or specimen was actually collected;
- Duplication of species (same species recorded from different information sources), for example: when species taxonomy is updated in museum records or published records without reference to details of previous specimen collection records.

3.2.3. Inadequacies with species taxonomy in present database

A range of problems may lead to ambiguity or inadequacy in taxonomic determination:

- Museum lodgements where species determination is made by museum staff, rather than a trained taxonomist or specialist;
- Collector's specimens, where a species determination is made by the collector, another student, non-specialist advisor or amateur naturalist, rather than taxonomists;
- Determinations made by other taxonomists who are not specialists in the particular animal species group.

There can be problems related to identification and/ or description due to nature of specimens. For example, taxonomists may not have enough specimens, especially if dissection or DNA work is required prior to finalising a description or determining separation of a species. Taxonomists or museums may be unable to determine the species if for example, there is no male in the collection or the collected specimens are immature or juvenile, so "species" can often only be determined to Family level, e.g., Araneae (spiders).

Problems related to identification and/ or description due to location of specimens:

- Specimens held in private collections and/ or not yet forwarded to institutions for curatorial purposes and/ or determination by specialists;

- Specimens in museums that have become lost or mis-appropriated, resulting from the dispatch of undescribed loan material from museums, sometimes not recorded in loans books (see Clarke, 2000c);
- Specimens that are no longer fit for identification due to age or poor condition;
- Specimens in institutions that have not being properly databased or collated on species lists and are therefore unknown to researchers.

Table 3.2: Lack of formal names amongst known, but undescribed crangonyctoid paramelitid species of the genus Antipodeus, many of which are stygobionts, and only known from single cave sites or karst areas. (See discussion in Section 5.2.8)

Sp. ID	Family	Genus species name	Ecology	Cave or Karst area/s
A-106	Paramelitidae	"Ant bla" (unpublished name)	Sb	Broadsword (GP-63)
A-209	Paramelitidae	? Antipodeus "sp. nov. A"	Sp or Sb?	Khazad-Dum (JF-4)
A-210	Paramelitidae	? Antipodeus "sp. nov. B"	Sb	Skyhook Pot (IB-34)
A-062	Paramelitidae	Antipodeus ?"franklinii"	Sp	Upper Weld, Junee-Florentine
A-107	Paramelitidae	Antipodeus "franklinii" (1)	Acc or Sx?	Loons Cave (IB-2)
A-059	Paramelitidae	Antipodeus "sp. nov. A"	Sp?	BH, C, IB, JF, L
A-060	Paramelitidae	Antipodeus "sp. nov. B"	Sp	Growling Swallet (JF-36)
A-211	Paramelitidae	Antipodeus "sp. nov. C"	Sp or Sb?	Thylacine Lair (BH-203)
A-061	Paramelitidae	Antipodeus "sp. nov. C"	Sp or Sb?	Salisbury River Cave (VF-X2)
A-169	Paramelitidae	Antipodeus "sp. nov. D"	Sx or Sp?	Exit Cave (IB-14 and IB-23)
A-212	Paramelitidae	Antipodeus "sp. nov. E"	Sp or Sb?	Newdegate Cave (H-1)
A-051	Paramelitidae	Antipodeus "stygobiont 1"	Sb	Precipitous Bluff
A-052	Paramelitidae	Antipodeus "stygobiont 2"	Sb	Arrakis (MW-X1)
A-053	Paramelitidae	Antipodeus "stygobiont 2a"	Sb	Little Trimmer Cave (MC-39)
A-239	Paramelitidae	Antipodeus "stygobiont 2b"	Sb	Comet Pot (IB-98)
A-054	Paramelitidae	Antipodeus "stygobiont 3"	Sb	Junee-Florentine
A-055	Paramelitidae	Antipodeus "stygobiont 4"	Sb	Cauldron Pot (JF-2)
A-143	Paramelitidae	Antipodeus "stygobiont 5"	Sb	Wargata Mina (C-1)
A-056	Paramelitidae	Antipodeus "stygobiont" cf: A. wellingtoni	Sb	Junee-Florentine
A-058	Paramelitidae	Antipodeus antipodeus	Sp	Kellys Pot (MC-207)
A-098	Paramelitidae	Antipodeus franklinii	Sp?	Bubs Hill, Nicholls Range
A-067	Paramelitidae	Antipodeus or Gen. nov., sp. nov. (1)	Acc or Sx?	Mole Creek
A-213	Paramelitidae	Antipodeus or Gen. nov., sp. nov. (2)	Sp or Sb?	Ida Bay
A-099	Paramelitidae	Antipodeus sp. or spp.	Sp?	JF, L, MC, RB
A-112	Paramelitidae	Antipodeus sp., cf. ("humungus")	Epigean	Un-named Cave (JF-104)
A-057	Paramelitidae	Antipodeus sp., cf: "A. wellingtoni"	Sp or Sb?	Capricorn Cave (MR-204)
A-191	Paramelitidae	Antipodeus sp., nr. A. franklinii (IB-6)	Sp?	Bradley-Chesterman Cave (IB-4)

There can be problems related to taxonomic resolution due to the number of undescribed species, resulting from changed directions regarding the approach to taxonomy where, for example a number of museums or such like institutions have been placed on a more commercial footing adopting "user pay" systems for identifications of species. There can be problems with specific species groups, where their taxonomy has not been studied in detail and many species remained undescribed. A good example relates to the crangonyctoid paramelitid amphipods recorded in the accompanying database. As shown in Table 3.2, there are 27 possibly different species of *Antipodeus* (Clarke 2004) based on the species "assignations" and information in published records (Eberhard *et al.*, 1991) and the unpublished records or preliminary determinations (and classifications) performed by Alastair Richardson (University of Tasmania) and/ or John Bradbury (University of Adelaide).

3.2.4. Essentials for new data entries in the database

In view of these potential problems, the following procedure was adopted when entering records in the database, during the course of this present study:

- Ensure the occurrence exists, e.g., by sighting the published record or dated entry of an observation or matching a purported collector's record with an actual specimen or museum lodgement record;
- Double check that the new entry is not just a more precise record (a duplicate) of an already existing record;
- Record the source/s of information and published reference for an occurrence, adding additional sources or additional references when the specimen details or taxonomy change;
- List as much relevant data as possible for each new occurrence record;
- Check typing and entry of data to ensure it is correct.

3.2.5. Essentials for maintenance of the database

In order to minimise the risk of losing data and or entering duplicate records, there are several essential prerequisites for maintaining a database:

- Perform regular back-ups of database;
- Take care not to delete important data records or fields of data, e.g., column of data in a table;
- Be careful not to delete any fields, Tables and Queries, especially when there is a possibility that other earlier or subsequent queries are dependent on them;

- Be careful not to change the title names of fields, Tables and Queries, especially where subsequent queries may not function if the linkage lost due to a changed name.

3.3: Database coverage, thesis study area and caves

3.3.1. Database coverage

As discussed in further detail on Chapter 5, the species records have been derived from a "parent" database listing the occurrences of cavernicoles from cave sites and karst areas across Tasmania (see Table 4.1); many of these cave areas are shown in Figure 5.1. The sources for cave site location data are summarised in Appendix 9.2.3 (p. 356). The parent database incorporates a more detailed notation for the species occurrences recorded from caves of two areas in southern Tasmania: Hastings and Ida Bay, with particular comparisons with species in the systems of Newdegate Cave and Exit Cave.

3.3.2. Karst study area, karst development and principal cave study sites

There were numerous reasons for choosing Hastings and Ida Bay karst as study areas for this project. Both areas are similarly situated in terms of climate and both areas have a similar topographic position with a similar elevation/ relief (though Hastings slightly lower); both have elevated catchments, near the limits of past glaciations and former World Heritage Area boundaries. The Hastings and Ida Bay karst areas were probably both glaciated during the Tertiary and possibly early Pleistocene, as evidenced by glacial outwash and till in the Lune River and D'Entrecasteaux River flood plains, where these deposits virtually extend to sea level (Clarke, 1990). The two areas are in close proximity geographically, with the Lune River and its tributaries acting as a distribution/ dispersal barrier (?) between each area. The vegetation/ forest cover in both areas is also very similar with a mix of wet and dry sclerophyll forest and rainforest in sheltered valleys or depressions and alongside stream channels and both areas were former timber logging areas, dating back to the 1890s (selective logging methods). The two karst areas both have large caves with spacious passages, plus deep zones in regions of the caves that are less likely to suffer effects of flooding in their inner reaches. Historically, caves in both areas have had reasonable amount of study, with sampling from within caves and to a lesser extent have also been studied on karst surface outside caves. The sites are also relatively accessible and conveniently located for the present writer.

Amongst the significant differences between the two sites, both are formed in different age rock types: Pre-Cambrian dolomite at Hastings and Ordovician limestone at Ida Bay and consequently have different lithologies (dolomite and limestone). There are altitudinal (elevation) differences, so the karst development in both areas is different: Hastings less vertical relief and fewer vertical cave systems, but some large chambers, compared to Ida Bay, where the cave are more vertical with generally smaller chambers. (It might be construed that elevated karst areas or those limestone areas with greater relief, i.e., more depth of carbonate rock above the regional base level, have had more time to evolve.) Both sites have a different hydrology, with different streamflow and stream energy inputs. A major difference relates to the influence of cave-related human activity between the two sites: the Hastings site includes past and present show cave developments, but at Ida Bay, all the study sites are predominantly wild caves.

The development of karst processes and evolution of the karst bio-space at Hastings and Ida Bay appears to differ, possibly due to the different lithologies, carbonate content and elevation. The development of karst is often cyclic beginning with periods of solution creating the cavities: voids, conduits or passages and chambers, and ending with the in-filling of cavities by sediments derived from fluvial, glacial or mass movement origins. In the next cycle, there maybe subsequent exhumation of filled cavities and/ or further solution, followed by another period of deposition. Often cemented or highly crystallised and mineralised, the "fossil" remnants of former cave chamber fills are referred to as palaeokarst deposits. (These palaeokarst deposits should not be confused with the partially consolidated and often imbricated deposits of cobbles seen as terraces or streambank deposits adjacent to present day stream passages or in upper level passages, such as in Mystery Creek Cave and Exit Cave. These latter deposits are examples of relict karst, where sediments have been deposited during an earlier period within the current cycle of karst development.)

Although less obvious in the Hastings karst, there are significant examples of palaeokarst at Ida Bay, as evidenced within caves such as Loons Cave and Exit Cave, where present day karst development has included exhumation of fossil cave fills. These palaeokarst deposits are also exposed in the two major quarry sites at Ida Bay, where at Benders Quarry the remains of former filled surface dolines are evident, along with cross-section views of cavities and chambers with layered sediments; both features are surrounded by sulphide mineralisation and calcite crystals. Quarrying activity at this latter site exposed an entrance to EMP Pot, a deep vertical cave system without a present day surface opening, where the entrance chamber and shaft walls included deposits of finely laminated clays with disseminated sulphide, formerly lithified by diagenesis but now being exhumed by sub-surface drainage and re-solution with sulphate rich waters (i.e., diluted sulphuric acid). At Blaneys Quarry, adjacent to Mystery Creek Cave, an examination of the sediments in exposed palaeokarst fills led to it being determined as Permian age, with cave development commencing at least 260mya during an earlier cycle of karstification (Clarke, 1995). It is highly probable that some invertebrate species in the Ida Bay karst have been evolving since this time, 250mya.

At both Hastings and Ida Bay, there are several caves with upper level "relict karst" passages (that may be former palaeokarst features). The presence of relict karst features such as "Binney Tunnel" and "Binney Chamber" in Newdegate Cave, "The Ballroom" and "Hammer Passage" in Exit Cave (see Figure 6.4) and the "Skyline Route" in Mystery Creek Cave, suggest that the present cycle of karstification has been on-going, so these cave systems are likely to be quite old and were potentially available for colonisation by cave species over a longer period of time, compared to smaller caves without this evidence. The humidity of relict karst passages or chambers, and hence their suitability as animal habitats, is often maintained by percolation water. The major cave study sites where specimens have been traditionally (historically) collected and more recently collected are listed in Table 3.3 overleaf.

Although palaeokarst is less obvious in the Hastings area, there are other significant examples of karst processes including the development of subjacent karst. A prime example is Wolf Hole, where the main cliff-walled entrance feature has formed as a result of collapse of several tens of metres of the overlying Permian mudstone sequence. Wolf Hole is also unique in having two of the largest known underground cave lakes in Tasmania, both formed and partially dammed by finely chipped fragments of mudstone that appear to be the remnants of a mass movement periglacial deposit.

Table 3.3: The major cave study sites and their physical attributes (at Hastings and Ida Bay). Species occurrence records in these caves were analysed to determine the habitat factors controlling distribution and diversity of cavernicoles in Tasmania.

Karst Area	Cave Name	Main development	Dominant hydrology	Palaeokarst	Relict karst	Cave use and visitation
Hastings	*Newdegate Cave*	Vertical and horizontal	Throughflow	possibly	yes	Present show cave
Hastings	*King George V Cave*	Horizontal	Throughflow	possibly	possibly	Former show cave
Hastings	*Beattie Cave*	Horizontal	Percolation seepage	no	possibly	Former show cave
Hastings	*Wolf Hole*	Vertical and horizontal	Percolation seepage?	possibly	yes	Wild cave
Ida Bay	*Exit Cave*	Vertical and horizontal	Throughflow	yes	yes	Wild cave
Ida Bay	*Mystery Creek Cave*	Vertical and horizontal	Throughflow	yes	yes	Frequently visited wild cave
Ida Bay	*Bradley-Chesterman Cave*	Horizontal	Throughflow	possibly	possibly	Wild cave
Ida Bay	*Loons Cave*	Vertical and horizontal	Throughflow?	yes	yes	Frequently visited wild cave
Ida Bay	*Arthurs Folly*	Horizontal	Percolation seepage	no	possibly	Wild cave

As shown in Table 3.3, in addition to their main trend of cave passage/ chamber development by karst processes, most caves have a dominant hydrology which involves a predominantly horizontal or vertical passage of throughflow or percolation seepage cave waters. In caves such as Exit Cave where throughflow water is dominant, the subterranean streams and their tributaries are fed by surface waters that enter horizontal caves, e.g., Mystery Creek Cave or karst surface swallets e.g., National Gallery, draining into horizontally or vertically aligned conduit or crevice systems. However, it should be noted that percolation seepage still occurs in throughflow cave systems. In the few caves not dominated by throughflow drainage systems, stream waters are entirely recharged by percolation seepage.

3.4: Study Methods

3.4.1. An overview and summary of thesis study methods

- Reviewing previous data collated for Tasmanian RFA cave fauna database and re-checking/ sourcing museum records and literature related to cave fauna descriptions.
- Collecting additional data (specimens) from caves, chiefly in the Hastings and Ida Bay areas and following microscopic examination (including possible photo microscopy) endeavouring to identify species or arrange to get specimens identified by dispatching them in a vial for identification (together with label and pencil written detail). Following the format of collection records by other cave biologists (e.g., Eberhard, Goede and Hamilton-Smith), this has included collections from selected karst surface sites near known cave entrances.
- Mapping of caves or cave passages/ chambers where specimens were collected, in order to incorporate collection locations on cave maps and show the effect if any that cave morphology might have on the distribution of cave species.
- Sourcing additional data from cave biologist records or private collections (chiefly from Cockerill, Eberhard, Goede and Hamilton-Smith), various museum records and published species descriptions, then where possible, matching collector records with museum and/ or description records. (The term "museum" is used loosely to include the range of institutions such as ANIC, New Town (DPIWE) laboratory museum, various University institutions or laboratories and overseas establishments where cave fauna specimens are located. Although some museum records have been received as printouts on paper, most of the museum records are derived electronically as Ms Excel spreadsheets, in email replies or occasionally as tab separated text files, all of which have to be converted into Ms Access database format. Some data was sourced by going directly to museums to examine their card index files and/ or the specimens in their wet store (alcohol) or dry (pinned) collections, e.g., Tasmanian cave fauna in the South Australian Museum (Clarke, 2000c).

- Updating RFA database/ collating relational database, refining exiting tables and dealing with problems related to how dates are stored in a database.
- Devising codes for the aquatic ("A-") and terrestrial ("T-") species and checking various authoritative sources for correct spelling of species (taxon) names and higher order taxonomy, e.g., online versions of "Platnick's World Spider Catalog" or the ABRS biodiversity website.
- Defining (and coding) the ecological status of species (or degree of dependence on the cave) for:
  1) Terrestrial species as Epigean, Accidental = "Acc", Trogloxenes = "Tx", Troglophiles = "Tp" and Troglobites = "Tb", plus questionable status with added "?".
  2) Similarly for stygofauna (aquatic fauna): Accidentals, Stygoxenes as "Sx", Stygophiles as "Sp" and Stygobites as "Sb". In some instances this requires the writer making a subjective decision based on factors such as:
     a. Location in the cave where a species is found, e.g., in relation to the morphology of the cave - particularly the distance from the cave entrance – and whether the specimen was collected from the outer, middle or inner parts of the cave;
     b. cave biologist's knowledge of the species and number of specimens seen or known from that particular micro-habitat or other habitats in that cave or other caves;
     c. knowledge of the animal group that the species belongs to;
     d. knowledge of the invertebrate species on the basis of its morphology and the observable troglomorphic structures when examined under a microscope;
     e. By consultation with a recognised specialist or taxonomist, preferably the person who examined or identified the specimen.
- Addition of further database tables, e.g., cave zones, macro-habitats and micro-habitats and assigning information for records related to collections from Hastings and Ida Bay. Habitat data primarily sourced from collector's records (or memories) and museum records based on information on labels or other data accompanying the lodgement of specimens.

- For the sake of consistency and effective operation of database (in order to analyse data and derive meaningful results), ensuring entries into each field are complete and in same sort of format or style to avoid a slewed and/ or meaningless result. Where the ecological niche is not adequately defined, species are only shown as possibly being troglobites ("Tb?") or stygobites ("Sb?").
- Designing/ devising Database Queries to analyse the data in Tables and other queries (see Section 4.4) in order to answer questions related collection sites, taxonomy and occurrence records, including analyses of habitat data (see selected habitat categories in Chapter 4.1).

3.4.2. Accessing museum records of cave fauna lodgements

As described by Clarke (2000c) invertebrate specimens collected from cave sites in Tasmania have been lodged in various museums or institutions around Australia and overseas in Europe and North America. In earlier times, collected specimens were invariably dispatched to particular taxonomists at different institutions where there was some resident expertise or specialist working with a particular species group or an ecological group of species collected from the same or similar habitat (Clarke, 2000c).

Museum records are variable and often difficult to locate, even by museum staff. Some museums and other institutions still rely on a card index system, where hand-written records have been kept and there maybe different indexes for specimens in their wet (spirit) collection and in their dry (pinned) collection. Similarly, some institutions have separate card indexes for separate species groups: arthropods, mollusc and lower invertebrates with arthropod groups sometimes divided into indexes for Crustacea, Arachnida and Entomology. Until recent years, some museums, e.g., the South Australian Museum did not have any system of recording their collection apart from searching their systematic housing of species groups. Fortunately, many museums have now developed electronic spreadsheet format databases, using "Platypus" and other proprietary or self-developed cataloguing systems, but specimens of different species groups are still often recorded in separate databases.

The reasoning behind this separation of species groups is unclear, but it could be the result of several factors such as a convenience due to the enormity of collections housed at the institution; the result of different collections or species groups being curated or managed by different sections/ different taxonomists within the same institution; or simply a reflection that institution's desire to maintain a systematic taxonomy of species databased within different species groups.

Some specimen lodgements are not registered or accessioned immediately, often being kept aside until examined by a specialist and determined to Family level or genus and species. However, this practice of not recording or registering specimens may lead to some records of species becoming "lost" in the system. This may in fact explain the reason why two lots of cave spider specimens housed in the wet collection of the South Australian Museum had not been determined when their collections were examined in 1997. These particular spiders had been collected from Baldocks Cave at Mole Creek by Arthur Lea in 1901 and Robert Pulleine in 1924 (Clarke 2000c).

Not all lodged museum specimens are registered. Some institutions, e.g., staff in the Arachnology section of Australian Museum, are now adopting a policy of only registering those specimens that can be positively identified, so for example juvenile spiders which may be determined at Family level but are virtually impossible to determine at genus and species level are not being registered (Graham Milledge, pers. comm., 2004). In the Western Australia Museum in Perth, Mark Harvey (pers. comm., 2004) reports that cave pseudoscorpion specimens presumed to be new species or not yet positively identified have not been databased. Similarly, Harvey reports that a number of other arachnid species collected from caves have not been registered, because they have not been formally identified to a named Genus and/ or species.

In order to confirm that a collection has occurred, it is desirable to know where the specimen is located, so this may necessitate enquiries to a museum. Museum specimen records often include the accompanying records or notes from collectors that may provide habitat-based data, rather than taxon based information. However, some specimens held in museums have not been databased or recorded. This may be indicative of a number of factors, such as the fact that the museum may still only have its specimen lodgements recorded on card indexes. If included in museum collections, their only record exists in the form of an index card for specimens in their wet (spirit) or dry (pin mounted) collections that are probably catalogued by Family or Genus name, rather than environmental site or location. Specimens may be privately held by museum researchers reluctant to hand over responsibility of their collections to museums or may be awaiting description and/ or identification prior to being catalogued with a museum number and/ or simply on loan to/ from other institutions.

It can be a very large/ long or tedious task to search and notate the records from a card index catalogue. (I speak from experience here, since I have already personally searched the card indexes at the South Australian Museum in Adelaide and TMAG in Hobart.) Different museums or institutions have different and varying ways of cataloguing or housing their collections. For example, in the Australian Museum, their specimens are listed according to various letter prefix codes and housed in separate collections: malacology, entomology, Arachnology and marine invertebrates. The latter group includes a number of cave species including many non-marine freshwater species such as anaspidacean syncarids, crangonyctoid amphipods, phreatoicids, janirid isopods and possibly some terrestrials including styloniscid isopods, annelids, planarians, millipedes, centipedes and perhaps symphylans.

Recorded museum lodgements are usually given a chronologically ordered registration number or accession number, often recorded together with a date of acquisition, registration or presentation (if donated). These registration numbers may be prefixed with a letter or number code (see Appendix 9.3).

4. Database analysis of Tasmanian cave fauna

In addition to fieldwork, laboratory work and photomicroscopy of collected cave species, the major component of this study has centred on compilation and refinement of the relational database that forms the basis for much of this thesis (Clarke, 2001a). Along with the addition of several thousand new occurrence records, updating revisions in taxonomy and incorporating new occurrence sites, considerable time has been devoted to selecting the necessary fields and devising appropriate queries to provide answers to thesis questions and ensure the database maintains a dynamic structure for future research. The answers to questions related to the habitat factors that control or influence the distribution and biodiversity of invertebrate cavernicoles in the Hastings and Ida Bay cave areas (Chapter 6) represent just a subset of the information contained in this "parent" database.

The database is not included as an accompaniment to this thesis for several reasons, including confidentiality of information sources (e.g., copyright on museum records), other requirements for protection of intellectual property, conservation concerns regarding cave site locations and a desire to protect rare cave species and because the database is not complete; (data is missing from particular fields). However, selected information from the database can be sourced through the author or by contacting the School of Zoology at the University of Tasmania in Hobart.

Although by no means complete, this parent database includes a large majority of all the known and recorded occurrences of Tasmanian cave fauna dating from 1842 (see Section 2.1). Based on an earlier database compiled by the present writer as an accompaniment to a technical report for the Tasmanian Regional Forest Agreement (RFA) process (Clarke, 1997a; 2001a), this parent database has been updated, expanded and appended with additional records including occurrences and habitat data collated during fieldwork for this thesis. Amongst the incorporated data, there are a range of new museum records e.g., Clarke (2000c), additional identifications from specialists and species observation or collection records extracted from caving club journals, recently published works, compiled reports or personal correspondence with numerous taxonomists. With the inclusion of cave region, ecological and habitat related data, this thesis compilation appears to be one of the most comprehensive regional cave fauna databases of its kind in the world. The only other known and similarly constructed database is described at the end of Section 4.1.

4.1: Regional cave fauna checklists, surveys and databases

The regional distribution of cave fauna has been recorded as checklists or surveys in several parts of the world. Some of the early checklists include the cave invertebrates of Texas and Central America (Reddell, 1965; 1981), the arthropods in Australian caves (Hamilton-Smith, 1967) and the spiders from Australian caves (Gray, 1973). Regional distributions have been defined in ecological studies, e.g., cavernicoles from the Nullarbor Plain (Richards, 1971c) and surveys of specific ecological groups, e.g., the stygofauna diversity of Eastern Australia (Thurgate, *et al.*, 2001). Although essentially annotated checklists, two detailed studies of the regional distribution of cave species in different parts of Australia have formed the basis of MSc studies, e.g., the cavernicoles of Western Australia (Lowry, 1980) and the invertebrate cave fauna of Tasmania (Eberhard, 1992a).

In recent years, with computerised technologies, advances in analysis of geo-referenced spatial patterns (geographic information systems), the use of GPS to accurately plot cave locations, plus more concern for conservation of hypogean species, databases are being used to record subterranean biodiversity. Examples include the broad scale regional bio-inventory databases revealing "hotspots" of biodiversity in North American karsts (Culver, *et al.*, 1999; 2000; Culver and Sket, 2000), in Italy and the Balkan Peninsula (Culver and Sket, 2002) and the mix of broad scale ecological and fine scale species group databases associated with the European PASCALIS project (Culver, *et al.*, 2001).

The regional databases used in PASCALIS (Protocols for the ASessment and Conservation of Aquatic Life In the Subsurface) generally form part of national databases focused on epigean species. The PASCALIS projects are designed to record the diversity and endemism of stygobiont fauna in groundwater and karst of contiguous countries of southern Europe (Gibert, 2001; 2004; Stoch, 2001; Culver, 2004; Deharveng, 2004). Large databases record the occurrence of subterranean taxa at the broad (European) scale to illustrate groundwater species distribution patterns; smaller regional data sets highlight specific groundwater ecosystems (Gibert, 2001). The distribution of invertebrate cavernicoles in Italy is described by Stoch (2001), who combines CKMAP software with a simple relational database in MS Access, with four tables: taxon (3 fields), species (17 fields), distributional data (13 fields) and references (7 fields). From his study in 2001, Stoch records that 29.3% of the 903 subterranean taxa (from 5,337 species in 250,000 geo-referenced distributional records) are groundwater stygobionts; 35.6% (321 spp.) are terrestrial troglobionts and eutroglophiles; and 35.1% (317 spp.) are recorded from soil litter and the MSS (see glossary and Figure 1.17).

Stoch (pers. comm.) advises the regional cave fauna database for Italy has been significantly updated and an English version has just been published which includes a CD ROM version in MS Access (Ruffo and Stoch, 2005). Stoch reports that 110 people were involved in compiling their database, recording 10,000 terrestrial and inland water species from 530,000 distributional records; the cave fauna component is represented by 864 species: 701 terrestrial and 164 aquatic (stygobiotic) species, plus another 25 endogean species. The different lower numbers compared to the 2001 survey are accounted for by the removal of species synonymies etc. Stoch hastens to add that the spider and millipede fauna have not yet been added to the Italian cave fauna database. Although the Italian database does not specifically record "caves" as a hypogean collection site, Stoch estimates that of the 33,000 known (registered) caves in Italy, less than 3,000, i.e. less than 10% of the caves have one faunistic record for a troglobiont/ stygobiont species, but many caves have additional trogloxenes of troglophiles. The broader large scale European PASCALIS database, produced by Louis Deharveng using 4D software, records all the known stygobionts from Portugal, Spain, Italy, France and Slovenia. Constructed in a manner similar to the present database, the four tables of the Italian database include one-to-many relationships for species-distribution, one-to-many for bibliography/collections-distribution and a further one-to-many relationship between toponyms (geo-referenced) and distribution (Ruffo and Stoch, 2005).

4.2: Structure of the thesis database, its tables, fields and relationships

The primary structure of the database consists of six Tables (shown in Figures 4.1, 4.2 and 4.3), each comprised of varying fields of data relating to that individual table (see named fields in Figure 4.2). Some of these fields are numbers or codes including the six designated fields (one in each table) shown as bold font in Figure 4.2; these are mandatory fields established as primary keys with defined validation rules to maintain integrity of the data, e.g., record (order) number, occurrence date, species ID number and cave number. Five of these primary key fields form relationship links with the Records table, as described below. The database comprises 7,861 occurrence records, each with up to 78 fields of data per record arranged in six related Tables: the three main large tables (Caves, Records and Species Taxonomy) with tool bar shortcuts and the three smaller tables of data for cave region, macro-habitat and micro-habitat; the latter three tables are specifically designed for the analysis of species occurrences at Hastings and Ida Bay.

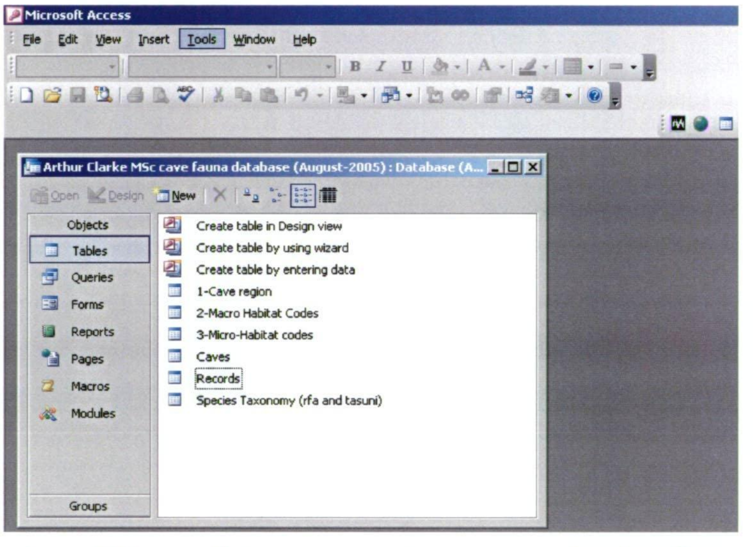


Figure 4.1: Section of Microsoft Access opening screen, showing the smaller window menu for thesis database and at the RHS on lower row of the tool bar: the shortcut icons for the three main tables: “ ” = Caves, “ ” = Records and “ ” = Species Taxonomy.

As shown in Figure 4.2, five tables have defined “one-to-one” or “one-to-many” relationships that maintain connectivity of the data and provide direct access to related field components of each table. Central to the database is the Records table containing 31 fields of data related to species occurrences (observations or collections), specimen numbers, sex and maturity, lodgement, accession numbers, species identification, cave zones, habitat description and photography of specimens. Five of the fields in the records table are entered in the form of codes that are explained and decoded along with related detail in the five ancillary tables in the database: Species Taxonomy (19 fields), Caves (22 fields), Cave region (2 fields), Macro-Habitat (2 fields) and Micro-Habitat (3 fields). The data are normally examined in Table view, where the fields of information for all the records are shown as columns of data. When viewing any of the related ancillary tables, clicking the "+" symbol in the far left hand side of the table, enables access to all the occurrence records related to that code or value. Access to the data in any one or a number of the tables together is also obtained by running "Select Queries" or a "Cross-tab Query" tabulation (see Section 4.4) that provide answers to more specific questions on occurrences, cave or karst areas, taxonomy and habitats. For example, a query can be devised to list all the occurrences of hydrobiid snails recorded from any given cave area, cave, cave zone or any one of 44 micro-habitats within a cave or as shown in Table 4.13 a series of queries can be devised to produce tables listing all the karst and non-karst areas, number of occurrence sites, records and species (Tables 4.13 and 4.14).

All the numerical, date or text format fields in any of the tables or queries can be sorted chronologically or alphabetically by selecting the A-Z or Z-A sort button on the tool bar. Similarly, the data stored in fields of any table or query can be further examined by conducting a filter sort to locate similar parcels of data. For example, to find all the species occurrences recorded on any particular date listed in the Records table, select (highlight) the particular date, right-click the mouse and choose "Filter By Selection" to view the result. To reverse the selection and return to the complete table, right-click again and choose "Remove Filter/Sort".

All the known reports or records relating the occurrence of species from Tasmanian caves or karst surface sites are given a consecutive number and databased to the main "Records" table. Under the validation rule, every record has to have its own unique number so when a new record is added to the database, another consecutively ordered number is allocated. Once a number has been allocated to a record, it remains intact, so for instances where a record is deleted its original number is scrapped. The last currently entered record is number 8,975, but the actual number of records only totals 7,861, which implies that 1,114 records have been deleted. Most deletions relate to duplications, where for example an occurrence record from a reference source without collection information (e.g., Goede and Goede, 1973b, 1974b; Eberhard, *et al.*, 1991) is subsequently found to be identical to another record, e.g., a museum lodgement with detailed collection data.

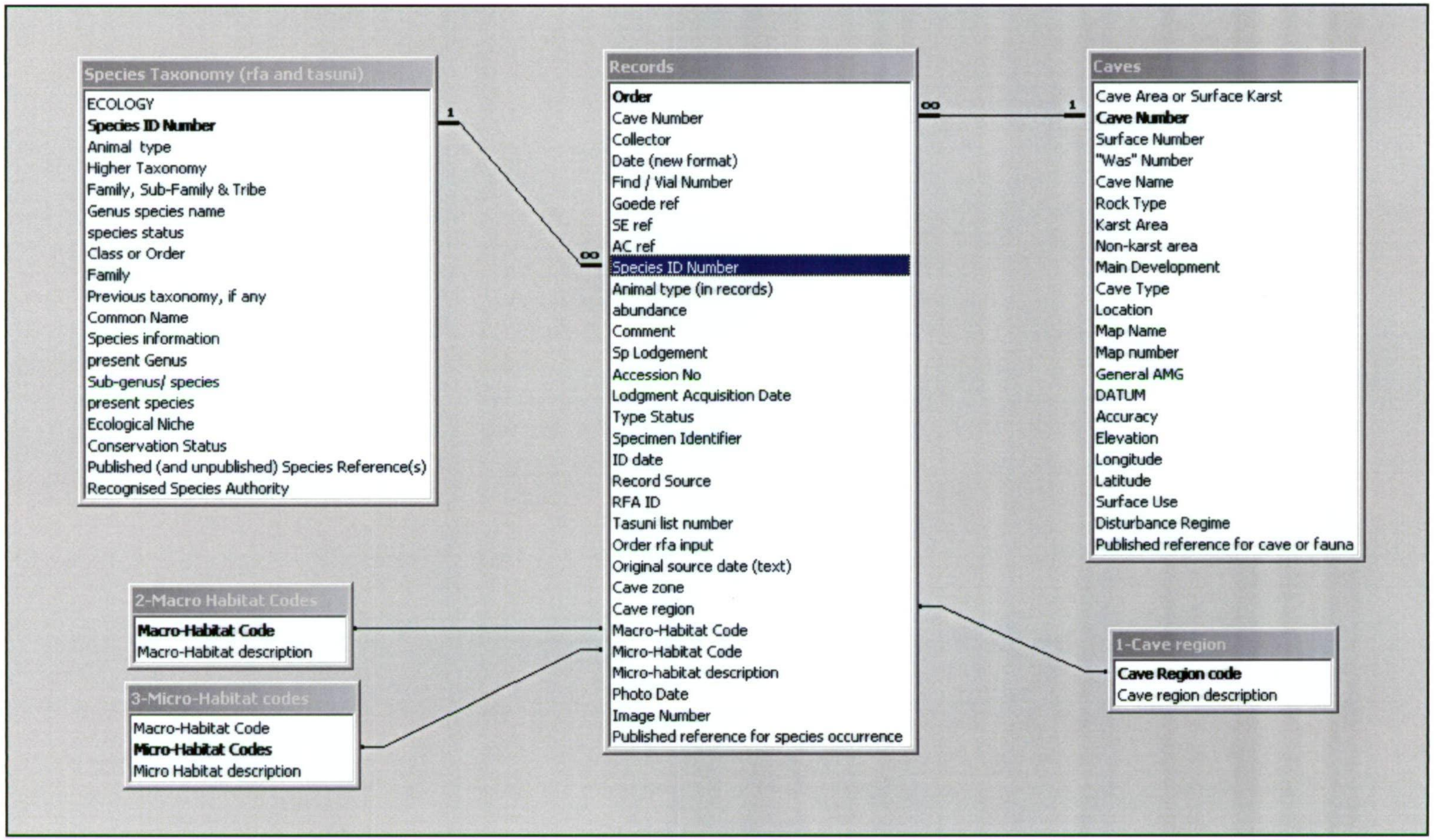


Figure 4.2: Design of the relational database showing the six main Tables and their respective fields; those shown in bold are primary key fields. Note the Records table which acts as a hub and is central to this database, with the "one-to-many" relationships from the surrounding tables, e.g., "Species ID Number" relationship from Taxonomy Table to Records Table. For an abbreviated list of the occurrence sites (from the "caves" table), see Appendix section 9.1.1.

4.2.1. Database tables, selection of fields and explanation of codes.

The Records table comprises the fields of data related to the reported occurrence (in a collection or an observation) of a species or specimen/s. Following the record number (Order), the first three fields list the coded occurrence site (Cave Number), the person accredited with reporting or recording the occurrence (Collector) and the date of observation or collection (Date: new format). The terms "Cave Number" and "Collector" were devised as field names prior to the realisation that the database included records for surface sites close to cave entrances and observations. The critical importance of maintaining selected field names and their precise spelling in regard to database Query design is discussed in Section 4.4.3. The next eight fields relate more specific details of each occurrence: collector's field numbers (Find/ Vial number) or reference codes (see Appendix 9.2.1), species ID code, animal type, number of specimens collected or observed (Abundance) and any comments related to the particular species occurrence (sex, maturity, living status etc). The following six fields are primarily relevant to collected specimens, detailing specimen lodgement or location (see Appendix 9.3.1), accession number, lodgement acquisition date (if known), type status if applicable, name of person providing the identification (ID) and date of the ID (if known).

Accompanying each record there is a field informing the "Record Source" for the occurrence including the author names and publication year of any published reference for the observation or collection, and if obtained from museum records or correspondence, that particular source and date are quoted. Where several information sources are known for the same record and/ or supplementary or additional information becomes available, e.g., additional descriptions of the habitat, an update on lodgement details, revised taxonomy or a publication that includes specific reference of that specimen, all information sources are included, listed in order from the time when they were sourced during data input. Following are three fields included for continuity of data from the original RFA database (Clarke, 1997a), listing the RFA database species code, the RFA record number and the new "tasuni list number", plus another field which records the original source date (stored in text format). Some early cave occurrence records from museum and literature sources have limited associated data; the collection or observation is often simply recorded with only a year or month-year date (see section 3.2.1). This original date is retained for historical purposes, so it can be reproduced in any published or printed report (see Sections 4.3 and 4.4.4).

The following series of fields in the Records table describe aspects of the occurrence site: cave zone (see Section 4.3), codes for cave region, macro-habitat and micro-habitat (detailed in Sections 4.3.2, 4.3.3 and 4.3.4) and a detailed description of the "Micro-Habitat" (if recorded). The next two incomplete fields relate to attempts at photo-microscopy, using a digital camera to photograph particular cave species, or parts of their anatomy to show troglomorphic features. The final field shows any published reference/s relating the occurrence of this record, including the full title and publication detail for any taxonomist author's work listed in the record source.

The "Caves" table provides detail for each of the karst and non-karst cave or karst surface occurrence sites (near cave entrances), listed in the Records table by their respective one or two letter area code prefixes. The codes for the cave areas are listed overleaf in Table 4.1, together with their respective area rock type and number of caves with invertebrate fauna records. It should be noted that although the database includes occurrence records from caves in non-karst areas, it does not record surface species from these areas. The one or two letter code prefix for each cave or karst surface site represents the nationally accepted abbreviated prefix for the area, recorded in the ASF (Australian Speleological Federation) Karst Index database (Clarke, 1999c, 2001a). In the case of cave sites, the letter code is followed by a hyphen then the respective cave number; for surface sites, the word "Surface" follows the hyphen, then the successive surface site number (from 1 to71). The codes for cave sites appear in two forms: with a number directly following the hyphen or with an "X" followed by a number. The number listed caves represent sites that have been physically number tagged, usually with a small metal plate or disc attached to rock near the entrance; if the cave has not been number tagged, it is assigned a temporary "-X" number, e.g., IB-X70 or H-X08, following the accepted principles of cave documentation in Australia (Clarke, 1997a, 1999c). Note, the latter example is actually recorded as "H-X8" in the ASF Karst index, but due to the problem of chronological listing of text-prefixed numbers in Ms Access, H-X8 has been given a preceding zero to read as "H-X08".

Table 4.1: List of karst and non-karst cave areas of Tasmania with invertebrate fauna showing area code, area name, rock type and number of caves with species records.

CODE	KARST AREA	ROCK TYPE	Caves
AI *	Albatross Island	Limestone	1
AR	Acheron River	Dolomite?	2
BH	Bubs Hill	Limestone	22
BY *	Boyer	Limestone	1
C	Cracroft	Limestone	14
CB	Cape Barren Island	Limestone	1
CK *	Claude Creek	Limestone	1
CP	Mount Cripps	Limestone	90
CR	Cheyne Range	Dolomite	1
DB	Dubbil Barril	Limestone	2
DR	Dante Rivulet	Limestone	2
DV	Davey River	Limestone	2
E	Eugenana	Limestone	1
EI	Erith Island (Kent Group)	Limestone	1
F	Franklin (River)	Limestone	10
FB *	Fossil Bluff	Limestone	1
FC	Frenchmans Cap	Dolomite	2
FG	Flowery Gully	Limestone	2
G	Gray	Limestone	4
GP	Gunns Plains	Limestone	52
GS	Gordon-Sprent	Limestone	6
H	Hastings	Dolomite	12
HC *	Hustling Creek	Limestone	5
HS *	Hampshire	Limestone	1
IB	Ida Bay	Limestone	144
IG	Ile du Golfe	Limestone	3
JB	Jubilee Ridge	Limestone	1
JD	Jukes Darwin	Limestone	2
JF	Junee-Florentine	Limestone	52
JR	Julius River	Dolomite	5
KR *	Keith River	Magnesite	6
L	Loongana	Limestone	12
LA	Lower Andrew (River)	Limestone	3
LH *	Lower Huskisson	Limestone	1
LL *	Lake Lea (Vale of Belvoir)	Limestone	4
LM	Lower Maxwell (River)	Dolomite	7
LO	Lorinna	Limestone	1
M *	Moina	Limestone	2
MA	Mount Anne	Dolomite	10
MC	Mole Creek	Limestone	53
MI	Maria Island	Limestone	2
MK	McKays Peak	Dolomite?	2
MR	Mt. Ronald Cross	Dolomite	5
MU	Montagu	Dolomite	2
MW	Mount Weld	Dolomite	2
N	Nelson River	Limestone	4
NC *	Newall Creek	Limestone	1
NL	North Lune	Limestone	6
NR	Nicholls Range	Limestone	4
PB	Precipitous Bluff	Limestone	15
R	Redpa	Limestone/ Dol	6
RA	Ranga	Limestone	2
RB	Risby Basin	Limestone	3
SB	Surprise Bay	Limestone	2
SL *	South Loddon River	Dolomite?	2
SP	Scotts Peak	Dolomite	6
SR	Savage River	Magnesite	1
SX *	Styx River	Limestone	3
T	Trowutta	Dolomite	2
TC *	Timbs Creek	Dolomite?	4
TP	Tasman Peninsula	Limestone?	3
UH *	Upper Huskisson	Limestone	1
UW	Upper Weld (River)	Dolomite	3
VF	Vanishing Falls	Limestone	6
WC *	White (Hawk) Creek	Limestone	2
WM	West Maxwell-Algonkian	Dolomite	3
WL	Wilson River	Limestone	3
WT *	Wilmot River	Limestone	1

Asterisked codes represent additional areas with cave fauna records not in Clarke (1997a).

CODE	NON-KARST AREA	ROCK TYPE	Caves
AM	Mount Amos	Granite	1
BI	Birchs Inlet	Sandstone	1
CI	Craggy Island	Granite	1
CL *	Cradle Link	Glacial till	1
D	Devonport	Basalt?	1
DL *	Donaldsons Landing	Siltstone	2
DW	De Witt Island	Sediments	3
FR	Francistown	Sandstone	2
KG	Kent Group Islands	Granite	4
KI *	King Island	Scheelite	1
LB	Louisa Bay	Schist	2
LF	Liffey Falls	Mudstone	1
LP	Liberty Point	Sandstone	1
MN	Moonlight Creek	Mudstone	1
MO *	Mountain River	Sandstone	1
MQ	Macquarie Island	Dolerite?	1
PR *	Pieman River	Sandstone	1
PS *	Prime Seal Island	Granite	1
RI	Rocky Boat Inlet	Qtz. Schist?	1
RO	Ross	Dolerite	3
S	Southport	Mudstone	1
SD	Scottsdale	Granite	1
SI *	Sisters Beach	Quartzite	1
ST *	Stoodley	Conglomerate	1
UN *	Upper Natone	Granite	1
WA	Western Arthurs	Quartzite	1
WE	Mount Wellington	Dolerite	3

One of the idiosyncrasies of MS Access (and MS Excel) is the manner of sorting and ordering numbers in a field with "text" format, instead of "number" format, where e.g., numbers "17" or "123" are listed before number "2". To maintain the list of numbered cave sites in chronological order in this database, the actual cave number component of the text-prefixed cave numbers is preceded by one or two leading zeroes, in areas where there are more than nine (9) or ninety-nine (99) caves, or the few instances where in some karst areas tagged caves were given high numbers commencing at "201" (Clarke, 1999c).

The first column (field) in the caves table shows the cave or surface karst area name, followed by the coded occurrence site, the surface site number (if applicable), any previous or alternate ("Was" number) assignations, e.g., a former "-X" number and the cave (site) name or alternate name. (To avoid confusion, when an untagged cave is eventually number-tagged, the previously assigned temporary "-X" number is never used again in that particular cave area.) The listing of these previous numbers and alternate cave names is particularly important in order to avoid entering duplicate records, especially when new records are sourced for species occurrences that were recorded under a different assignation. All 749 occurrence sites are listed according to their dominant rock type, respective karst area or non-karst area name, a general location, followed by a field relating the predominant geomorphic development as: Horizontal, Vertical or surface and a field for "Cave Type". The latter field is incomplete, being specifically designed as an adjunct to the discussion on habitats for occurrence sites in the Hastings and Ida Bay areas (section 4.3.1). The next group of fields provide site location information with map sheet details, grid references, datum source, level of site accuracy, elevation, longitude and latitude, plus two incomplete fields that record surface use and disturbance regime. Occurrence site location data is sourced from the writer's research, caving club records (surface survey traverses or GPS readings) or the Commonwealth Department of the Environment and Heritage "GIS Tools" website. The last (incomplete) field in the Caves Table contains detail of published references that describe the occurrence site or the presence of cave fauna at the site.

Most cave occurrence records are sourced from either wet or dry habitat sites corresponding to the saturated or unsaturated zones of the karst bio-space. Similarly, as shown in the taxonomy table: "Species Taxonomy (rfa and tasuni)" the recorded fauna can be classified as aquatic or terrestrial species as listed under "ECOLOGY" in the first field.

The number codes for the 247 aquatic ("A-") and 1,045 terrestrial ("T-") species have also been given one, two or three leading zeroes to maintain their sequential order for sorting purposes. The species have been categorised by animal type in the Taxonomy Table, e.g., as cave cricket or hydrobiid snails and the same animal type name is included along side the species code in the Records table. In an attempt to categorise the animals which are cave species, the word "cave" has been prefixed to some species, e.g., cave spider, cave harvestman, cave isopod etc. (see section 4.2.4).

The next three fields record the tiers of species taxonomy within each classification level, with higher order taxonomy as Class or Order, Sub-Order and Super-Family; Family, sub-family and tribe; and Genus species name as one field (with unpublished names in parenthesis, if species are currently under description or in press). In order to record and show their distributions, some individual species have been distinguished from "lumped" groupings, so the data includes some "non-taxonomic" or invalid name suffixes. The next field shows the species status for these invalid or un-named species, including new undescribed species as given by taxonomists or recorded as "sp. nov." or "n. sp." in cave biology publications (e.g., Eberhard *et al.*, 1991; Eberhard, 2001a; Eberhard and Spate 1995b); undetermined species (sp. indet.) where a species has not been identified (e.g., juvenile specimens) or species with presently unpublished names. Two additional fields record the higher taxonomy as either Class (or Order) and Family names, followed by a field with any previous taxonomy (Family, Genus, unpublished name or taxonomist's code name). The next two fields record any common name given to the species and relevant information for the species. In the following three fields, the genus species name is repeated as separate fields for genus, sub-genus/ species and present species. Two subsequent fields list the ecological niche of species in relation to the cave environment ranging from epigean, accidental, trogloxene (Tx), troglophile (Tp) and troglobite (Tb), plus their aquatic equivalents and their conservation status, e.g., as common, uncommon or rare. The species that are considered or known to be troglobites are generally recorded as being rare or uncommon. The last two fields give detail of published (and unpublished) references for the species and the name of the currently recognised species authority. (Data entry in these two fields is currently incomplete.)

4.2.2: Defining the ecological niche and conservation status for species

The introductory chapters to this thesis provide some general background on the ecology of cave species and the history of their classification in terms of their dependence on the hypogean cave environment and/ or their adaptation to this subterranean realm. Issues related to these classifications are still debated by cave biologists as increasing evidence comes to light regarding the plethora of obligate species in hypogean environments including the so-called "beastly stygofauna" (Humphreys, 2002a) in the threatened groundwater aquifer ecosystems of calcrete aquifers beneath the arid surfaces of Western Australia (Boulton, *et al.*, 2003; Cooper, *et al.*, 2002; Humphreys, 1993; 2002b; 2006; Pain, 2005). The early notions suggesting that cave adapted obligate species were only found as isolated populations in the dark zone of caves or were necessarily blind and depigmented are no longer valid.

As mentioned above (in 4.1.1), the species taxonomy table includes two fields for classifying cave species: ecological niche and conservation status, both of which are essentially related (see below) and important attributes for planners, cave managers, cave biologists and ecologists. In a manner similar to the assignation of cave zones (see sections 4.2.2 and 4.2.3), ascribing the ecological niche for cave species can be a subjective process, requiring input from several informed sources to ensure a satisfactory determination. The precise ecological niche for many species remains unclear, as evidenced by the either-or determinations and the question-mark suffix to ecological codes in the database. In some instances, this doubtful assignation arises from the lumping of several undetermined or unknown species given a single code in the database. With a more precise taxonomic determination or due consideration for their scattered distribution in isolated karst areas, the lumped species could be split into separate species and assigned an ecological niche based on their taxonomy or occurrence location and habitat within the cave.

As detailed in Chapter 1, the aquatic species in caves (and groundwater) are generally accorded with a "stygo" prefix and the cave dwelling terrestrial species have a "troglo" prefix. In addition to the listing of epigean and accidental ("Acc") species in the database, the coded aquatic cave species are recorded as stygoxenes (Sx), stygophiles (Sp) and stygobites (Sb). Similarly the terrestrial cave species are recorded as trogloxenes (Tx), troglophiles (Tp) and troglobites (Tb). The assignation of ecological niche for species in this database (see Query 7B and 7C) is based on:

- Taxonomist advice, regarding species morphology and determinations;
- The accepted previous assignation of ecological niche (e.g., Eberhard *et al.*, 1991);
- Cave biologists' knowledge of the animal type in relation to the hypogean and surface habitats and the number of species/ specimens seen in the cave/s;
- The present writer's own species determination based on observation of specimens or species, microscopic examination of their morphology, e.g., apparent depigmentation, density and length of setae and/ or number of spines or barbs, attenuation of limbs, reduction or loss of eyes/ eye lens pigment etc. (see Table 1, Chapter 1);
- The present writer's knowledge of the geomorphic morphology (structure) of the cave and/ or the distance of species from the nearest known cave entrance or epigean influence (see subsequent discussion on cave zones and cave regions).

The assignation of the conservation status of species is often an on-going process based on observation or monitoring of species, abundances and their distribution. There is no hard and fast principle for determining the conservation status of cave species. Some cave adapted species (troglobites) may only be known from their Type Locality whereas other species are known from several areas within a cave or several different caves that are perhaps connected via the contiguous nature of the karst bio-space. Some species would be considered as rare simply because they have a limited distribution and are not seen throughout the cave, but may occur as abundant populations in localised regions of a cave, e.g., the entrance chamber of King George V Cave at Hastings. In reverse, some species that are apparently common, being distributed in many different parts of the cave or cave system, may in fact be very small populations of less mobile species restricted to particular micro-habitats that are threatened by the impacts of visitation or karst surface/ catchment disturbance (Clarke, 1999a). Following the advice of taxonomists and/ or cave biologists, including the present writer, a number of cave dwelling species have been listed as rare, threatened or vulnerable species under the auspices of the *Threatened Species Protection Act* (of Tasmania) 1995. One species: the Giant Freshwater Crayfish (*Astacopsis gouldi*) found in caves at Gunns Plains in NW Tasmania, is listed as vulnerable under the

Commonwealth of Australia's *Environment Protection and Biodiversity Protection Act*, 1999.

Generally as a rule of thumb, any species that are coded as stygobites or troglobites in the database will be given a conservation status as "Rare" unless otherwise determined from cave biology/ biogeography studies. If species are coded as "Sp or Sb?" and "Tp or Tb?" these will be shown as "Possibly rare" except in the instances where their taxonomy is undetermined these are recorded as having an "Unknown Status".

4.2.3: Duplicate occurrence records in Records Table.

As previously described in Section 3.2.3, the original RFA database contained duplicates where the same occurrence was recorded from different sources. Although approximately 1130 of these duplicates have been removed, there are likely to still be several other missed cases. However, there are some deliberately included duplicates, where for example a particular collection has been split with specimens being forwarded to different lodgement institutions or in the instances where another new species has been described from the original collection. In the latter instance, where a new species has been described, the same collection occurrence may show as different records, e.g., for the holotype, paratype/s, allotypes or other type locality specimens that are variously dispersed and/ or given different lodgement reference (accession) numbers by the same or different institutions.

4.2.4: Ambiguities in the species taxonomy table

Species are listed in the database by animal type according to their taxonomy and also on a basis of their ecological niche and degree of troglomorphism if any. Since the main focus of this thesis has been centred on cave fauna, some obligate species, likely obligates and commonly found cavernicoles are given a "cave" animal name prefix. Examples include the "carabid cave beetle", "cave centipede", "cave cricket", "cave harvestman", "cave isopod", "cave millipede", "cave pseudoscorpion", "cave spider", "cave springtail" and "cave symphylan". The system is a bit ambiguous in some respects because there are other apparent troglobitic or obligate species, e.g., "phreatoicids" that could also be classified as "cave" animal types. This arbitrary method of classifying cave animals can potentially produce a skewed result for analyses, if a species list is devised by animal type alone. To determine a more accurate list of a particular animal type, a query can be devised (see section 4.4.3) using several defined criteria expressions, to extract data from two or more different fields in the species taxonomy table, e.g., "Animal Type", "Higher Taxonomy", "Family" or "Genus species name".

As it stands, the taxonomy table demonstrates the on-going problem related to undescribed or un-named species and the lack of taxonomic resolution. Based on advice from taxonomists, the taxonomy table includes unknown, undetermined or new genera and species from several unknown, undetermined or uncertain family groups. The unknown family groups are listed as "unknown family" and/ or if undetermined, listed as "Family not determined". In the case of doubtful and/ or uncertain family groups, the family name is given a "?" prefix. Aside from the few species with uncertain or unknown taxonomy, recorded as "uncertain taxonomy" or "unknown taxonomy", species of unknown genera have been listed as "undetermined: Gen. and sp.", "undetermined: Gen. and sp. or spp.", "undetermined: Gen. and sp. or spp. indet." or "Gen. undet., sp. indet." Species known to be of new genera are listed as "Gen. nov.", "Gen. nov., sp. nov." or "Gen. nov., sp. or spp. nov." As indicated by totalling the records in the "species status" field column, >70% of the recorded species are unknown, undescribed or new species listed as "sp. indet.", "sp. or spp. indet", "n. sp.", "sp. nov." or "(unpublished name)". The latter relates to the proposed names for new species in as yet unpublished manuscripts, with unpublished names shown in parenthesis, or the *nomen nudum* species that have been "described" in unpublished papers or theses, generally given a coded or abbreviated name by the present writer.

The problem of diminished taxonomic resolution is exaggerated by the increasing number of recorded cave species observations. For example, when caving club journals publish caver's trip reports or cave descriptions that relate observations, e.g., cave spiders or snails, many of these are effectively unknown species that cannot be classified in the database. Although a number of these observations for the two examples quoted may in fact relate to the Tasmanian Cave Spider or the common endemic land snail *Caryodes dufresnii* or its sub-species (Kershaw, 1989), for database purposes they have been coded as T-296 ("undetermined spider") and T-811 ("unknown land snail/s").

4.2.5: Sourcing records from cavers and caving club journals

Published articles or trip reports in several Tasmanian caving club magazines have produced sporadic references to cave fauna collections and observations. The caving club publications used as information sources for the database are included in the additional bibliography (Appendix 9.2.2, p. 345), listing cave site and species occurrence references. Over the last 10-15 years, trip reports in *Speleopod*, the journal for the Burnie based Savage River Caving Club (SRCC) contain frequent mention of "Wetas" (= cave crickets: F. Rhaphidophoridae) in caves at Mt. Cripps and Gunns Plains. Like the spider and land snail examples mentioned previously, these wetas could have been recorded as T-0502 ("undetermined cave cricket"). However, based on previous determinations of cave crickets from caves in both these karst areas, with a different species of *Micropathus* recorded in each area, I have assigned the Mt. Cripps observations as *M. cavernicola* (T-003) and the Gunns Plains species as *M. fuscus* (T-014). The only other "cave cricket" genus recorded from the Tasmanian mainland is *Parvotettix*, predominantly found in epigean locations and although positively identified from a surface site near Gunns Plains Cave (Eberhard, *et al.*, 1991), its reported presence in nearby caves has not been confirmed. In regard to SRCC observation reports from "new" areas, such as the Lower Huskisson karst, where cave cricket specimens have not been collected for ID, the reported species has been recorded as *Micropathus*? *fuscus* (T-508), based on its location and the known geographic distribution range for *M. fuscus* (Richards, 1968; Eberhard, 1992), but this could equally have been recorded as *Micropathus* sp. indet., listed as code "T-0077".

Although recording the presence of un-named or undetermined species, the *Speleopod* journal articles provide precise dates for their observations and these reports have expanded the distribution records for many species including glow-worms and the Tasmanian Cave Spider. Over the last 10-15 years, SRCC members have reported cave fauna from many new karst and non-karst cave areas in northern and NW Tasmania: Claude Creek, Cradle Link Road, Donaldsons Landing, Fossil Bluff, Goat Island, Hampshire, Keith River, Lake Lea (Vale of Belvoir), Lower Huskisson, Moina, Sisters Beach, Upper Huskisson, Upper Natone, White Hawk Creek, Wilmot River and Wilson River. So, in fairness to cavers and caving club journals, it should be acknowledged their reports have substantially added to our knowledge of cave fauna in Tasmania. In this respect alone, I need to once again make special mention of Stefan Eberhard who is solely or jointly responsible for over a third of the collection and observation records in this database; he is an extremely talented and multi-skilled caver who has literally gone to great depths to expand our knowledge of cave fauna in Tasmania.

4.3: Databasing records for the Hastings and Ida Bay study areas

As discussed in Section 3.3.2, the records of species occurrences from caves and karst surface sites in the neighbouring areas of Hastings and Ida Bay have been chosen to provide a detailed analysis of the factors affecting the distribution and biodiversity of cave species. In addition to recording the cave zones for all the species occurrences recorded in this database, the cave and surface sites in these two study areas have been classified as "cave type" in the Caves table and in the Records table, a series of codes have been employed to represent cave zone region, macro-habitat and micro-habitat.

4.3.1: A classification system for the caves at Hastings and Ida Bay

In the Caves table, a cave classification system (Cave Type) is used to reflect the level of actual (present), past or potential disturbance to cave habitats in the main study area: Hastings and Ida Bay, with examples of the cave types as listed in Table 4.3 (section 3.3.2). The caves and karst surface sites in these two areas are shown as either: "wild (rarely visited)", "wild (HEAVILY) visited" or "DEVELOPED".

- Developed cave sites (including formerly developed tourist caves) in the Hastings karst, i.e., Newdegate Cave, King George V Cave, Beattie Cave;
- Heavily visited wild cave sites, i.e., Loons Cave, Mystery Creek Cave;
- Rarely visited wild cave sites, i.e., Arthurs Folly, Bradley-Chesterman Cave, Exit Cave and Wolf Hole.

The distinction is used here to show those caves which have or previously had some impact, due to regular visitation or the introduction of some artificial infrastructure, e.g., stairs, bridges and pathways. In terms of the levels of visitation in wild caves, the distinction relates to wild caves with habitats that are potentially disturbed by a range of impacts, e.g., compaction of sediments or disturbance of stream sites by cave visitors' footwear and instances where the impact may become widespread because cave visitors follow more than one particular route (Clarke, 1997c, 1999a).

4.3.2: Cave zone regions for occurrence sites at Hastings and Ida Bay

As discussed in Section 1.5.4, cave biologists generally follow a method of zoning caves according to the degree of light penetration or distance from entrances and the extent of epigean influences. In this thesis, factors relating to individual cave morphology are also used as cave region determinants. For convenience and simplicity in terms of analysing the relevant faunal habitats and to remove any ambiguity of where species were found or located in relation to the cave entrances, five coded zone regions are used in this database: one surface region and four cave regions:

- (D) Daylight (surface) region: Surface dwelling occurrences (near cave entrances), including epigean fauna sites collected from surface karst sites. Note: some surface collection sites may include a "dark zone", e.g., underneath a large rotting forest log;
- (OS) Entrance Zone: in the immediate entrance to a cave where daylight penetrates;
- (O) Outer region: Entrance / Twilight and Twilight zones of a cave;
- (M) Middle region: Transition Zone, including Twilight/ Transition zone;
- (I) Inner region: Dark (or deep) zone, including the Transition/ Dark Zone region. It should be noted that the term "deep" has two meanings for cave biologists: it relates to vertical depth from the surface and is also used in a "lateral" sense defining distance from the entrance and epigean influences.

Some specific examples of cave zone regions and these can be modified by human activity is given in section 6.1.

4.3.3: Macro-habitats and micro-habitats at Hastings and Ida Bay

There are effectively five levels of analysis for the habitat data associated with occurrence sites in the Hastings and Ida Bay karst areas, based on cave type, cave zone, cave region, macro-habitat and micro-habitat. As shown in Table 4.2, the coded macro-habitats are divided into ten categories including a range of generally broad scale and overlapping aquatic or terrestrial habitats. As indicated by the micro-habitat codes (Tables 4.3 - 4.12), it was initially envisaged that a hierarchical system could be adopted, whereby the 44 micro-habitats were a direct sub-set of each macro-habitat enabling a determination of the number of occurrences of particular aquatic or terrestrial species in a given habitat within a particular region of the cave. There is obvious overlap between macro-habitat site and micro-habitats, where the former might be considered as micro-habitats and some of the micro-habitats could either be raised to macro-habitat status or sub-divided again into a finer scale of more precise habitat definition. In instances where occurrence records relate to collections from pitfall traps and drift nets or by using a light trap etc, an approximation of the natural habitat is given, based on the known habitat for these species and my knowledge of the particular cave.

Amongst the micro-habitat descriptions listed in the Records table, it should be noted that some occurrences are recorded from different zones or habitat sites within a cave and could therefore be assigned to different regions and/ or given multiple micro-habitat codes. In most of these instances, there is no indication of how many specimens were observed or collected from the different sites. Instead of splitting these records and creating further duplicate occurrences, the species have been assigned to the first given zone region or the first mentioned micro-habitat on the grounds of this being the primary cave zone or habitat. Similarly, in the very few instances where species abundance numbers have been recorded for different micro-habitats, the most populated habitat has been coded to represent that particular occurrence record.

Table 4.2: Macro-habitat codes assigned to species occurrences at Hastings and Ida Bay.

2-Macro Habitat Codes	
Macro-Habitat Code	**Macro-Habitat description**
A	Aquatic fauna sites: seepages, streams, pools or lakes
B	Riparian fauna zones beside running water, still water or springs
C	Terrestrial fauna habitats within the confine of caves
D	Living plant matter in caves, incl. ferns, fungi and tree roots
E	Habitats associated with invertebrate and vertebrate animals in caves
F	Particulate organic matter (POM) including litter and dissolved organic matter (DOM)
G	In, under, around or on top of substrate surfaces (rock, cobble, pebble, sand or clay)
H	"Artificial" habitats derived from human use of caves or karst catchments
X	Habitats in upper level "fossil" (or relict karst) passages and chambers of caves
Z	"Accidental" habitats resulting from gravity fall and wash-in, e.g., land snail deposits

Descriptions of the various micro-habitats aligned to the macro-habitats listed in Table 4.2 are tabled in the following pages (Tables 4.3 – 4.12). As mentioned, it has been impractical to adopt a strict hierarchical approach because a number of these micro-habitats are applicable to several macro-habitats including both wet and dry sites, for example, the particulate organic matter (macro-habitat code F) and the various substrate surfaces (Code G) are found in terrestrial habitats, riparian zones or aquatic sites (Table 4.4). Another example relates to the occurrences of hydrobiid snails from caves at Ida Bay with habitats described as, e.g., from "on surface and undersides of cobbles in pools of small stream" which are recorded in this database under macro-habitat "A", but given a micro-habitat code "G2", being the first mentioned component of the micro-habitat description.

Table 4.3: Micro-habitat code A: Aquatic fauna sites: seepages, streams, pools or lakes

A-Micro-Habitat codes: Aquatic fauna sites	
Micro-Habitat Codes	**Micro Habitat description**
A1	Low flow seepages or trickles, e.g., near cave entrances, on vertical shaft walls or cave passage/ chamber floors and walls
A2	Flowing water: tannin coloured throughflow stream water from the surface or connecting cave systems with dissolved organic matter (DOM)
A3	Flowing water: clear stream water derived from subterranean water sources and/ or percolation (seepage) water
A4	Flowing water: riffle zone (and rapids) with riffled surface in a streamway or between pools
A5	Splash zone or plunge pools at base of water-sprayed vertical shafts
A6	Still (flat water) surfaces with laminar flow: small pools between riffle zones, remnant pools (during low recharge), or cave sump pools
A7	Still (flat water) surfaces: larger pools or natural impoundments, as lakes in caves, e.g., Lake Pluto in Wolf Hole
A8	Still or STANDING water, e.g., in gour pools (may be fed by percolation seepage water, rather than running water) and SPRINGS (fed by emerging/ rising water)

In Table 4.3, the micro-habitat codes are primarily designed for cave sites, but the running water habitats and code "A8" for springs have been applied to some surface occurrence sites. In at least three of these aquatic fauna sites (i.e., in streams, pools or lakes), there could be a further sub-division or stratification of micro-habitats looking at water surface, water column, cobbles and pebbles, saturated interstitial substrate (composed of mud, sand or fine/ coarse gravel), plus aspects related to water clarity (versus turbidity), water purity (versus contaminants or pollutants) and micro-habitat components relating the presence of varying grades of particulate organic matter from coarse (CPOM) to fine (FPOM).

As shown in the following Table 4.4, an attempt has been made to indicate the species types whose preferred habitat is located near water and/ or where the substrate and interstitial space are permanently saturated. This is another very broad scale micro-habitat which could be sub-divided into further categories to record the type of substrate, slope angle, distance from water and perhaps either the presence of aquatic organisms or the presence of organic matter in the stream or pool.

Table 4.4: Code B: Riparian fauna zones near running water, still water or springs

B-Micro-Habitat codes: Riparian fauna zones	
Micro-Habitat Codes	**Micro Habitat description**
B1	Riparian habitats beside running water (as distinct from habitats in the vicinity of running water)
B2	Riparian habitats beside still water or springs (as distinct from habitats in the vicinity of standing water or springs)

Where micro-habitat descriptions relate to a cave occurrence, these are coded according to the respective part of the cave or speleothem habitat where species were collected or observed (as listed in Table 4.5 below). Many of the commonly occurring terrestrial species will be coded here including arachnids, beetles, cave crickets, isopods and many of the "multipedes". A few dipterans are also recorded, either from the cave atmosphere or in the case of glow-worm observations, recorded from cave walls.

Table 4.5: Code C: Terrestrial fauna habitats within the confine of caves

C-Micro-Habitat codes: Terrestrial fauna habitats within caves		
Macro-Habitat Code	**Micro-Habitat Codes**	**Micro Habitat description**
C	C1	Flat floor surfaces: base of vertical shafts, cave passage or chamber regions, or other relatively flat surfaces within caves
C	C2	Sloping floor surfaces: semi-saturated or dry sediment stream banks and other slope deposits
C	C3	Wall related surfaces: flat or irregular wall surfaces, overhangs, ledges, crevices etc.
C	C4	Hard crystalline speleothem surfaces: stalactites, stalagmites, columns, shawls, flowstone and gour pool (rimstone pool) surrounds
C	C5	Soft crystalline speleothem surfaces: moonmilk
C	C6	Ceiling surfaces: e.g., glow-worms, crickets, millipedes and some spiders
C	C7	Cave atmosphere: species caught in flight or attracted to light source/s in cave

Once again, it should be noted that some of the cave surfaces could include additional fine scale micro-habitat components related to speleothem type, sediment deposit and/ or their comparative fractional size: silt, clay, mud, sand, gravel, cobbles and boulders, plus other coded habitats, particularly Table 4.8 listing occurrence sites for particulate organic matter.

Many smaller macro-invertebrates are associated with plant matter in caves, particularly near cave entrances or where tree roots are fungi are found in caves (Table 4.6). Although there are relatively few instances of tree roots in water in caves at Hastings and Ida Bay, this is a valid micro-habitat in several other karst areas of Tasmania. Although some micro-flora, pollen and bacteria are known from caves and are probably grazed by several species and therefore another valid micro-habitat, studies of these microscopic organisms are beyond the realm of this thesis where the focus relates to invertebrate cavernicoles. Results of recent studies of bacteria in Mystery Creek Cave at Ida Bay (Van de Kamp, 2004) are described in section 1.2.2.

Table 4.6: Code D: Living plant matter in caves, incl. ferns, fungi and tree roots

D-Micro-Habitat codes: Living plant matter in caves	
Micro-Habitat Codes	**Micro Habitat description**
D1	Living roots from surface trees: as rootlets or root mats in streams, pools or seepages
D2	Living roots from surface trees: on cave surfaces (floor or walls) or hanging in cave atmosphere; and plant seedling stems
D3	Ferns, bryophytes (mosses and liverworts) and lichens on entrance walls or slopes or on cave walls, rock and earth at the base of shafts
D4	Fungi: e.g., Ascomycetes with cup-like apothecia (or fleshy lobes) or stalked basidiomycetes such as agarics (with gill structures)

Table 4.7 records the codes for the invertebrates that occur in association with other dead or living animal species or animal structures in caves. Code E1 includes some of the Acarina (mites and ticks) as well as the Gordian "worms" known to use cave spiders or cave crickets as hosts. Many of the spider occurrences from caves will have been observed in, or collected from webs and all the collected glow-worm larvae are taken from their mucous coated web structures. Glow-worm prey species are sometimes collected from snare threads and occasionally dead land snails are found in spider webs.

Table 4.7: Code E: Habitats associated with invertebrate and vertebrate animals in caves

E-Micro-Habitat codes: habitats associated with animal species	
Micro-Habitat Codes	**Micro Habitat description**
E1	Host animal habitats: vertebrates or invertebrates (with external or internal parasites) or found in other animals' stomachs etc., including owl pellets
E2	Animal faeces: faecal pellets of rodents, wombats, echidna, platypus or possums etc.
E3	Habitats associated with animal structures in caves: spider webs, glow-worm snare threads, possum nests or birds' nests
E4	Dead animal habitats: deceased remains of vertebrates or invertebrates, including skeletal (bone) deposits and snail shells

The particulate organic matter found in natural (wild) caves is probably the singularly most populated habitat for a diverse range of cavernicolous species. The CPOM and MPOM component (F2 and F3 in Table 4.8) are mainly found near cave entrances or at the base of large vertical shafts, but F2 also includes logs washed into caves during floods. As shown in Table 4.8, the size fraction of the FPOM component (code F4) is a coarser scale to that used by freshwater biologists, used here to include the small leaves and twigs in flood litter. The DOM (F5) is represented by dissolved organic matter in streams derived from the gradual downstream breakdown, disintegration and eventual dissolution of organic matter from the catchment or immediate karst surface above, entering cave systems via throughflow streams, swallets or percolation seepage. An approximation of the DOM content can deduced from visual inspection of cave stream waters, noting the tannin-like "colour" seen in Tasmanian streams due to the humic or fulvic acid content. Accurate determinations of DOM require sophisticated equipment or expensive water chemistry analysis to measure organic content and mineral salts, such as nitrates. The present writer gratefully acknowledges the receipt of DPIWE water chemistry analyses for caves at Ida Bay, where the high presence of nitrates, e.g., in Western Passage of Exit Cave is assumed to be derived from nitrogen fixing nodules of surface vegetation. I am assured that the nitrates found in these cave waters have not been derived from dissolution of the limestone (pers. comm., Clive Calver, Mines Dept., Hobart).

Table 4.8: Code F: Particulate organic matter (POM) including coarse fragments (CPOM) and variously sized litter particles (MPOM and FPOM), plus dissolved organic matter (DOM)

F-Micro-Habitat codes: organic matter habitats (FPOM, MPOM and CPOM)	
Micro-Habitat Codes	**Micro Habitat description**
F1	Non-living plant matter in caves, e.g., dead or calcified tree roots
F2	Coarse Particulate Organic Matter (CPOM): logs and tree branches
F3	Medium Particulate Organic Matter (MPOM): twigs and large leaves (often forming as cave entrance litter)
F4	Fine Particulate Organic Matter (FPOM): detritus and mulch; small twigs or leaves and seeds (often found as flood litter)
F5	Dissolved organic matter (DOM), "presumed" or evidenced from cave water chemistry

Many cave species are described as being cryptic, using the various fractionally sized sediment deposits including rock, boulders, cobbles or pebbles to hide or forage. Some species, such as hygropetric hydrobiid snails attached to the side of stream cobbles are probably grazing on the bacteria in epilithic biofilms (McLean *et al.*, 2000; Riding, 2000; Simon, *et al.*, 2003). Listed in Table 4.9 below, these substrate surfaces represent the second most common micro-habitat for cave species.

Table 4.9: Code G: In, under, around or on top of various substrate surfaces (rock, cobble, pebble, sand or clay)

G-Micro-Habitat codes: cave substrate related habitats	
Micro-Habitat Codes	**Micro Habitat description**
G1	Under broken rock, boulders, cobbles or pebbles
G2	On top of, or around the sides of broken rock, boulders, cobbles or pebbles
G3	In or on top of soft sand, clay or mud substrate (including burrows) at base of pools or running streams
G4	Interstitial spaces in sediments of saturated streambed or stream bank sand and gravels
G5	Exposed bedrock surfaces (e.g., at the base of pools or along sections of streamways)

Three caves at Hastings contain the remains of timber structures used in the construction of staircases or bridges and at least two caves at Ida Bay contain inorganic debris derived from surface activity in their catchment or in the vicinity of cave entrances (see Table 4.10). Several tonnes of partially decayed timbers and inorganic refuse have been removed from Newdegate Cave during the course of rehabilitation works. This practice was halted following the present writer's discovery of cavernicoles including troglobites occupying components of the unsightly "refuse". The humid atmosphere has assisted in reducing the rotting timbers to mulch and although an unnatural component of the cave, the decaying timbers and mulch support an immense diversity of cavernicoles with abundant species numbers. Inorganic refuse and the presence of lampenflora (now largely removed) have provided micro-habitats for other cave species. Fragments of timber, abandoned conduit, rusted cans and broken light globes in the lower streamway or its riparian zone have provided additional habitats.

Table 4.10: Code H: "Artificial" habitats derived from human use of caves or karst catchments

H-Micro-Habitat codes: "artificial" habitats due to human use of caves	
Micro-Habitat Codes	**Micro Habitat description**
H1	Tourist cave infrastructure: stairs, bridges, pavements, pathways, gates, fences, containment structures, power boxes, light switches, cable conduit and etc.
H2	Discarded timber debris in caves: rotting wood and mulch from cave structures (e.g., old staircase timbers, pathway or concrete boxing and bridge timbers)
H3	Discarded inorganic waste in caves: light globes, tin cans, glass or plastic containers, plastic or lead cable conduit, rubber gloves etc.
H4	Rubbish and waste from cave visitors: food scraps, lint from clothing and human hair; film containers, match boxes; cardboard and/ or paper wrappers etc.
H5	Lampenflora in cave entrances or near artificial light sources in developed tourist caves; algal blooms in developed warm springs

Many of the caves at Hastings and Ida Bay contain upper level passages and chambers that often represent former drainage channels formed during an earlier cycle in the solution development of the karst bio-space and its caves. These upper level features are described as relict karst: remnants from an earlier stage of carbonate rock dissolution, but still within the current geomorphic karst cycle, when the regional base level of erosion was several tens of metres above the present, possibly during a previous Interglacial when sea levels were much higher than today. The two micro-habitats for relict karst areas listed in Table 4.11 are invariably located in the dark and stable air region of caves, above where organic material is deposited; many of these sites contain an abundance of moonmilk and depend on percolation seepage to maintain humidity and replenish pools of water. Some aquatic species live in these pools and terrestrial fauna may occur on the surface tension or on moist speleothem surfaces and the assemblage of species found in this region often includes animals that are not found elsewhere in the lower reaches of active cave passages.

Table 4.11: Code X: Habitats in upper level "fossil" (or relict karst) passages and chambers of caves

X-Micro-Habitat codes: habitats in "fossil" or relict karst sections of caves	
Micro-Habitat Codes	**Micro Habitat description**
X1	Percolation fed drip pools or ponds in upper level fossil (relict karst) passages
X2	On speleothem deposits (e.g., moonmilk or stalagmites), walls or sediment surfaces in upper level fossil (relict karst) passages

The final category of micro-habitats in Table 4.12 is essentially less of a habitat, but more of a region for accidental species, such as the live and often dead land snails that fall into caves or cave entrances, but could also include the aquatic larvae brought into caves by streams.

Table 4.12: Code Z: "Accidental" habitats in caves, resulting from gravity fall and wash-in, e.g., land snail deposits

Z-Micro-Habitat codes: "Accidental" habitats from gravity fall and wash-in	
Micro-Habitat Codes	**Micro Habitat description**
Z1	Inside cave entrances, at the base of entrance shafts or karst windows, due to direct gravity fall into caves, vertical openings or rift entrances
Z2	Inside cave entrances, at the base of entrance shafts or karst windows, due to being washed into caves, vertical openings or rift entrances

4.4: Operating the database:

This database requires Microsoft Office Access 2000 (or better), operated on a PC platform with 128 MB of RAM or greater. The most recent version of this programme (Access 2003) offers additional features including "Dependencies", enabling the user to view those tables or queries (in section 4.4.3) dependent on the selected item. In order to view and sort occurrence dates chronologically, it is recommended that the "short date" setting under Control Panel: Regional Settings (or Regional and Language Options): Customise: Date be set to a "dd-mmm-yyyy" format, so that short dates appear in a sortable manner as e.g., 07-Apr-2005.

In the smaller database window of the opening screen (Figure 4.3), it shows a panel of objects on the left hand side; four of these objects are deployed in this database: Tables (as selected in Figure 4.3), Queries, Forms and Reports. In the window to the right of this panel, beneath the three default options commencing with the word "Create", are the six tables that form the basis of this database. The main table "Records" is shown with an etched border; selecting the square "table" icon to the left of this name highlights the word "Records" and double-clicking this opens the Table.

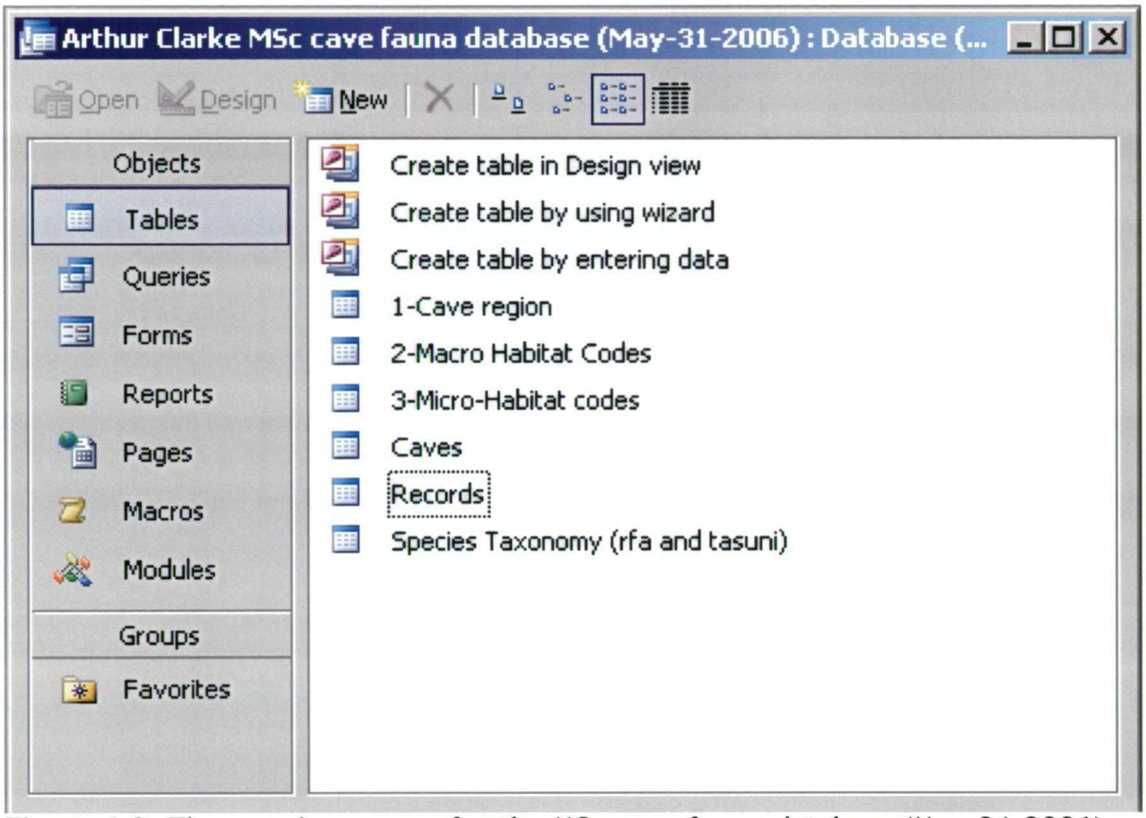
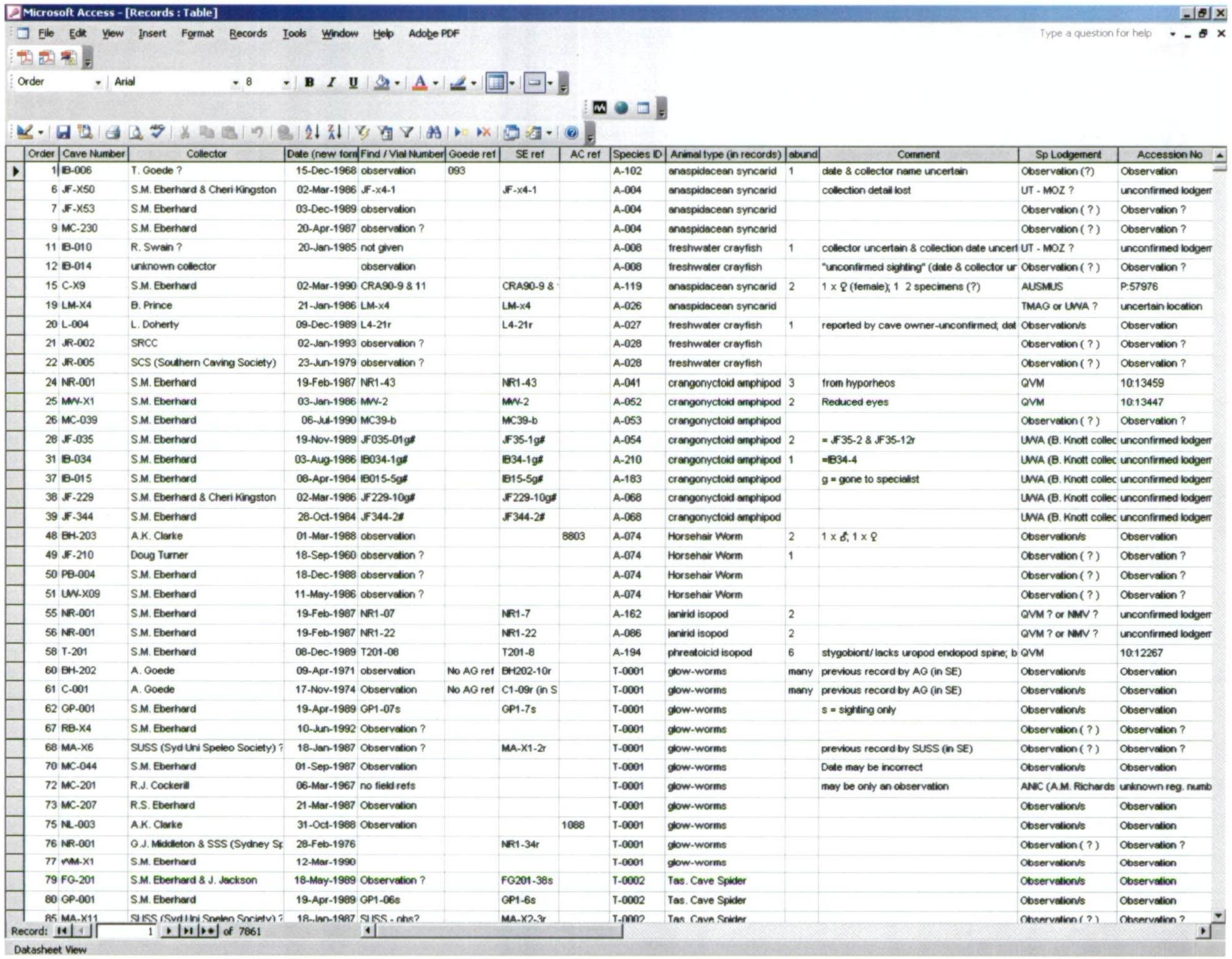


Figure 4.3: The opening screen for the MSc cave fauna database (May-31-2006).

4.4.1: Viewing the Records table and manipulating field columns

As shown in Figure 4.4, the fields in the Records table are presented as columns of data with their respective headings (see section 4.1.1). By default, viewing the table for the first time, it will be ordered by record number (the column headed "Order" on the left hand side). Reading from left to right across a line (row) gives all the information entered for that particular record number in this table. Any record can be highlighted by clicking in the blank box immediately to the left of the record number. Scrolling across the page with the keyboard arrows or the right pointer at bottom right hand side of the monitor screen exposes further columns of data; there are 31 fields in this table. To sort the data by any other field, e.g., "Cave Number", "Date (new format)", "Species ID" or "Animal type (in records)" simply place the mouse cursor in the particular column and select "Sort Ascending" using the right hand mouse button or by selecting that same option from the tool bar button. The data can only be sorted by one field at a time. If blank entries appear at the top of the data column after running a sort in any particular field, the blanks reflect the fact that there are no data entries for that field in that particular record.



Order	Cave Number	Collector	Date (new forn	Find / Vial Number	Goede ref	SE ref	AC ref	Species ID	Animal type (in records)	abund	Comment	Sp Lodgement	Accession No
1	IB-006	T. Goede ?	15-Dec-1968	observation	093			A-102	anaspidacean syncarid	1	date & collector name uncertain	Observation (?)	Observation
6	JF-X50	S.M. Eberhard & Cheri Kingston	02-Mar-1986	JF-x4-1		JF-x4-1		A-004	anaspidacean syncarid		collection detail lost	UT - MOZ ?	unconfirmed lodgem
7	JF-X53	S.M. Eberhard	03-Dec-1989	observation				A-004	anaspidacean syncarid			Observation (?)	Observation ?
9	MC-230	S.M. Eberhard	20-Apr-1987	observation ?				A-004	anaspidacean syncarid			Observation (?)	Observation ?
11	IB-010	R. Swain ?	20-Jan-1985	not given				A-008	freshwater crayfish	1	collector uncertain & collection date uncert	UT - MOZ ?	unconfirmed lodgem
12	IB-014	unknown collector		observation				A-008	freshwater crayfish		"unconfirmed sighting" (date & collector ur	Observation (?)	Observation ?
15	C-X9	S.M. Eberhard	02-Mar-1990	CRA90-9 & 11		CRA90-9 &		A-119	anaspidacean syncarid	2	1 x ♀ (female); 1 2 specimens (?)	AUSMUS	P:57976
19	LM-X4	B. Prince	21-Jan-1986	LM-x4		LM-x4		A-026	anaspidacean syncarid			TMAG or UWA ?	uncertain location
20	L-004	L. Doherty	09-Dec-1989	L4-21r		L4-21r		A-027	freshwater crayfish	1	reported by cave owner-unconfirmed; dat	Observation/s	Observation
21	JR-002	SRCC	02-Jan-1993	observation ?				A-028	freshwater crayfish			Observation (?)	Observation ?
22	JR-005	SCS (Southern Caving Society)	23-Jun-1979	observation ?				A-028	freshwater crayfish			Observation (?)	Observation ?
24	NR-001	S.M. Eberhard	19-Feb-1987	NR1-43		NR1-43		A-041	crangonyctoid amphipod	3	from hyporheos	QVM	10:13459
25	MW-X1	S.M. Eberhard	03-Jan-1986	MW-2		MW-2		A-052	crangonyctoid amphipod	2	Reduced eyes	QVM	10:13447
26	MC-039	S.M. Eberhard	06-Jul-1990	MC39-b		MC39-b		A-053	crangonyctoid amphipod			Observation (?)	Observation ?
28	JF-035	S.M. Eberhard	19-Nov-1989	JF035-01g#		JF35-1g#		A-054	crangonyctoid amphipod	2	= JF35-2 & JF35-12r	UWA (B. Knott collec	unconfirmed lodgem
31	IB-034	S.M. Eberhard	03-Aug-1986	IB034-1g#		IB34-1g#		A-210	crangonyctoid amphipod	1	=IB34-4	UWA (B. Knott collec	unconfirmed lodgem
37	IB-015	S.M. Eberhard	08-Apr-1984	IB015-5g#		IB15-5g#		A-183	crangonyctoid amphipod		g = gone to specialist	UWA (B. Knott collec	unconfirmed lodgem
38	JF-229	S.M. Eberhard & Cheri Kingston	02-Mar-1986	JF229-10g#		JF229-10g#		A-068	crangonyctoid amphipod			UWA (B. Knott collec	unconfirmed lodgem
39	JF-344	S.M. Eberhard	28-Oct-1984	JF344-2#		JF344-2#		A-068	crangonyctoid amphipod			UWA (B. Knott collec	unconfirmed lodgem
48	BH-203	A.K. Clarke	01-Mar-1988	observation			8803	A-074	Horsehair Worm	2	1 x ♂, 1 x ♀	Observation/s	Observation
49	JF-210	Doug Turner	18-Sep-1960	observation ?				A-074	Horsehair Worm	1		Observation (?)	Observation ?
50	PB-004	S.M. Eberhard	18-Dec-1988	observation ?				A-074	Horsehair Worm			Observation (?)	Observation ?
51	UW-X09	S.M. Eberhard	11-May-1986	observation ?				A-074	Horsehair Worm			Observation (?)	Observation ?
55	NR-001	S.M. Eberhard	19-Feb-1987	NR1-07		NR1-7		A-162	janirid isopod	2		QVM ? or NMV ?	unconfirmed lodgem
56	NR-001	S.M. Eberhard	19-Feb-1987	NR1-22		NR1-22		A-086	janirid isopod	2		QVM ? or NMV ?	unconfirmed lodgem
58	T-201	S.M. Eberhard	08-Dec-1989	T201-08		T201-8		A-194	phreatoicid isopod	6	stygobiont/ lacks uropod endopod spine; b	QVM	10:12267
60	BH-202	A. Goede	09-Apr-1971	observation	No AG ref	BH202-10r		T-0001	glow-worms	many	previous record by AG (in SE)	Observation/s	Observation
61	C-001	A. Goede	17-Nov-1974	Observation	No AG ref	C1-09r (in S		T-0001	glow-worms	many	previous record by AG (in SE)	Observation/s	Observation
62	GP-001	S.M. Eberhard	19-Apr-1989	GP1-07s		GP1-7s		T-0001	glow-worms		s = sighting only	Observation/s	Observation
67	RB-X4	S.M. Eberhard	10-Jun-1992	Observation ?				T-0001	glow-worms			Observation (?)	Observation ?
68	MA-X6	SUSS (Syd Uni Speleo Society) ?	18-Jan-1987	Observation ?		MA-X1-2r		T-0001	glow-worms		previous record by SUSS (in SE)	Observation (?)	Observation ?
70	MC-044	S.M. Eberhard	01-Sep-1987	Observation				T-0001	glow-worms		Date may be incorrect	Observation/s	Observation
72	MC-201	R.J. Cockerill	06-Mar-1967	no field refs				T-0001	glow-worms		may be only an observation	ANIC (A.M. Richards	unknown reg. numb
73	MC-207	R.S. Eberhard	21-Mar-1987	Observation				T-0001	glow-worms			Observation/s	Observation
75	NL-003	A.K. Clarke	31-Oct-1988	Observation			1088	T-0001	glow-worms			Observation/s	Observation
76	NR-001	G.J. Middleton & SSS (Sydney Sp	28-Feb-1976			NR1-34r		T-0001	glow-worms			Observation (?)	Observation ?
77	WM-X1	S.M. Eberhard	12-Mar-1990					T-0001	glow-worms			Observation/s	Observation
79	FG-201	S.M. Eberhard & J. Jackson	18-May-1989	Observation ?		FG201-38s		T-0002	Tas. Cave Spider			Observation/s	Observation
80	GP-001	S.M. Eberhard	19-Apr-1989	GP1-06s		GP1-6s		T-0002	Tas. Cave Spider			Observation/s	Observation
85	MA-X11	SUSS (Syd Uni Speleo Society) ?	18-Jan-1987	SUSS - obs?		MA-X2-3r		T-0002	Tas. Cave Spider			Observation (?)	Observation ?

Figure 4.4: Datasheet view of the Microsoft Access Records Table showing data columns of the first 14 fields, with occurrences listed by order of entry; cursor pointing at number 1 of 7,861 records. Note the three shortcut icons in the centre top of tool bar, one for each of the three main database tables; running from left to right, the icons are for Caves, Records and Taxonomy.

If the large number of fields in the Records table seems cumbersome, it should be noted that for ease of management and viewing appearance, any one of a number of fields can be hidden by selecting the column, right-clicking with the mouse and selecting hide. Similarly, to keep track of a particular field of data while searching through other fields, click the mouse in the desired reference field and on right click select "freeze column" and that column will be immediately positioned on the left hand side. Several columns can be hidden or frozen at once, then by right clicking the mouse the columns can be revealed again, and selecting "unfreeze columns" will cancel the freeze, though that column of data will remain on the left hand side. To reset the position of that field or to rearrange the positioning of any of the field columns, highlight the column, then using the mouse drag the column to the desired position; a heavy black vertical line will appear to indicate where the column is being re-positioned in relation to other columns. In the Records database there are five columns or fields of data represented as codes: Cave Number, Species ID, Cave Region, Macro-Habitat and Micro-Habitat, which form the relationship links to other tables, where they are "decoded".

4.4.2: Inspecting the caves, species taxonomy and other tables

Following the order number, the second field column (Cave Number) in the Records table lists the occurrence site, given as a code to represent individual cave or karst surface sites. To inspect the details for any of these sites and examine the respective occurrence records, select the "Caves" Table from the database opening screen (Figure 4.3) to open up the table in datasheet view; (for an example see Figure 4.5). By default the 749 occurrence sites in the Caves table are listed in ascending order from code number "AI-X1" to "WT-001". The 22 fields or columns of data can be sorted and manipulated, hidden or frozen, in the same manner described in the previous section.

Caves : Table

	Cave Area or Surface Karst	Cave Number	Surface Number	"Was" Number	Cave Name	Rock Type	Karst Area	Non-karst area	Location	Main Development	
+	Hastings	H-Surface51	51		un-named surface site nr. Newdegate Cave	Pre-Camb. Dolomite	Hastings		near entrance to Hastings Caves (Newdegate	surface	W
+	Hastings	H-Surface62	62		un-named surface site	Pre-Camb. Dolomite	Hastings		Chestermans Road (east of Wolf Hole) & Adan	surface	W
+	Hastings	H-X03			Bug Hole (= "Cub Hole" ??)	Pre-Camb. Dolomite	Hastings		200 "yards" from Wolf Hole	Vertical	W
+	Hastings	H-X04			Erebus (Waterloo Swallet)	Pre-Camb. Dolomite	Hastings		upslope from Newdegate Cave	Vertical	W
+	Hastings	H-X08			Wolf Hole	Pre-Camb. Dolomite	Hastings		Uphill, from track to KGV	Horizontal	W
+	Hastings	H-X12			The Minerets	Pre-Camb. Dolomite	Hastings		uncertain location	Vertical	W
+	Hastings	H-X31			Two Gum Entrance	Pre-Camb. Dolomite	Hastings		north side of Hastings hill, west of Creekton Br	Vertical	W
+	Ida Bay	IB-001			Revelation Cave	Ord. Limestone	Ida Bay		west of Blaneys Quarry	Vertical	W
+	Ida Bay	IB-002			Loons Cave (efflux)	Ord. Limestone	Ida Bay		South Lune Road	Horizontal	W
+	Ida Bay	IB-002/3			Loons Cave (efflux & vertical entrance)	Ord. Limestone	Ida Bay		South Lune Road	Vertcal	W
+	Ida Bay	IB-004/5			Bradley-Chesterman Cave (efflux)	Ord. Limestone	Ida Bay		Downstream walk-through stream section to k	Horizontal	W
+	Ida Bay	IB-006		= IB-4 in SE	Bradley-Chesterman Cave (upstream cave)	Ord. Limestone	Ida Bay		Upstream section (into dark zone)	Horizontal	W
+	Ida Bay	IB-007			Log Rift	Ord. Limestone	Ida Bay		Near contact, NE of IB-9	Vertical	W
+	Ida Bay	IB-008			Mini Martin	Ord. Limestone	Ida Bay		Vertical connection to IB-14	Vertical	W
+	Ida Bay	IB-009			Big Tree Pot	Ord. Limestone	Ida Bay		Near Kokoda Trail track	Vertical	W
+	Ida Bay	IB-010			Mystery Creek Cave (Ida Bay Caves, Entran	Ord. Limestone	Ida Bay		also called "Constellation Cave"	Horizontal	W
-	Ida Bay	IB-011			Midnight Hole	Ord. Limestone	Ida Bay		Vertical connection to IB-10	Vertical	W

Order	Collector	Date (new forma	Find / Vial Num	Goede ref	SE ref	AC ref	Species ID	Animal type (in records)	abund	Comment	Sp Lodgement	Accession No	Lodgment Acq	Type Status	
1440	A.K. Clarke & M. Flint	23-Sep-1984	Observation			8406	T-0050	cave harvestman			Observation/s	Observation			Arth
2057	R.S. Eberhard	31-May-1987	IB011-2		IB11-2		T-0050	cave harvestman			QVM	13:12077			Gler
3241	S.M. Eberhard	02-Apr-1989	IB011-4		IB11-4		T-0277	Millipede	1	1 x female	QVM	23:12074			Bob
3242	S.M. Eberhard	02-Apr-1989	IB011-3		IB11-3		T-0368	Spider		juv	AUSMUS	KS:29596			Mike
4351	S.M. Eberhard	02-Apr-1989	IB011-1		IB11-1		T-0050	cave harvestman		date unconfirmed	QVM	13:12091			Stei
5214	A.K. Clarke	05-Dec-1998	1298-11			1298-11	T-0239	Spider	1	1 x ♀	AUSMUS	KS:87301			Gra
5850	S.M. Eberhard	02-Apr-1989					T-0277	Millipede	1	1 x ♀; date uncertain	QVM	23:13487			Bob
7375	S.M. Eberhard	02-Apr-1989					T-0050	cave harvestman		adult; date uncertain	QVM	13:12794			Stei
7380	S.M. Eberhard	02-Apr-1989					T-0167	cave cricket		adult; date unconfirmed	QVM	12:13483			Stei
7382	S.M. Eberhard	02-Apr-1989					T-0651	unknown dipteran fly		adult; date unconfirmed	QVM	12:13486			Stei
7383	S.M. Eberhard	02-Apr-1989					T-0566	Acarina (mites)		date unconfirmed	QVM	13:13485			Stei
7384	S.M. Eberhard	02-Apr-1989					T-0161	cave millipede		date unconfirmed	QVM	13:13487			Stei
0															

	Cave Area or Surface Karst	Cave Number	Surface Number	"Was" Number	Cave Name	Rock Type	Karst Area	Non-karst area	Location	Main Development	
+	Ida Bay	IB-012			un-named cave	Ord. Limestone	Ida Bay		Located 20m west of IB-11	Vertical	W
+	Ida Bay	IB-013			Chockstone Pot	Ord. Limestone	Ida Bay		west of Blaneys Quarry	Vertical	W
+	Ida Bay	IB-014			Exit Cave	Ord. Limestone	Ida Bay		DÉntrecasteaux River exit	Horizontal	W
+	Ida Bay	IB-015			Hobbit Hole	Ord. Limestone	Ida Bay		west of Blaneys Quarry	Vertical	W
+	Ida Bay	IB-016			un-named cave	Ord. Limestone	Ida Bay		west of Blaneys Quarry	Vertical	W
+	Ida Bay	IB-018			Western Creek Swallet	Ord. Limestone	Ida Bay		southern side of Marble Hill, en route to IB-120	Vertical	W
+	Ida Bay	IB-020			Thun Junction	Ord. Limestone	Ida Bay		southern side of Marble Hill, en route to IB-120	Vertical	W

Record: 290 of 749

Figure 4.5: Datasheet view of Caves Table, showing sub-set of the 12 occurrence records for "IB-11" (Midnight Hole) at Ida Bay. A single mouse click on the "-" sign button to the right of the cursor point (left of "Ida Bay") will cancel the selected sub-set.

In common with all five of the ancillary tables that are related to the Records table, a column of "+"symbols appear on the far left hand side of the table. As shown in Figure 4.5, by selecting the symbol to the left of the IB-011 (Midnight Hole) row a "-" symbol appears, so the viewer can examine the 12 recorded occurrences for this site. By placing the mouse cursor inside the sub-set window of records for any cave or karst surface site, another internal set of directional pointers appears on the lower right hand side of this window, permitting the viewer to scroll to the right or down the list, where for example, for IB-014 (Exit Cave) there are 287 listed occurrences. Similarly, as shown by the date order sort for Midnight Hole in Figure 4.5, any of the fields of data in the sub-set of records can be sorted in ascending or descending order. These sub-sets provide a list of the occurrence details as recorded in the Records table, including the codes for species taxonomy and the other tables. If required, another sub-set of records can be selected simultaneously. In order to cancel this sub-set view, simply click on the "-"symbol and return to the complete list of occurrence sites.

The Taxonomy table is opened and manipulated in the same manner, and by default the species are shown in ascending order with the 247 aquatic "A-" species codes listed before the 1045 terrestrial "T-" codes. The screen example in Figure 4.6 features a list of the last 12 aquatic species and the first 12 terrestrial species. The occurrence records related to any species can be examined by selecting the "+"symbol and in this case, near the bottom of the screen about a third of the 30 records can be seen, so the viewer needs to scroll downwards.

The three remaining smaller tables (without shortcut icons) provide explanations of codes for cave region (2 fields), macro-habitat (2 fields) and micro-habitat (3 fields) and can be opened and examined in the same manner as the three previously discussed tables. Importantly, it should be noted that these three tables will only provide a list of the occurrence records for caves and karst surface sites in the Hastings and Ida Bay areas.

Species Taxonomy (rfa and tasuni) : Table

ECOLOGY	Species	Animal type	Higher Taxonomy	Family, Sub-Family & Tribe	Genus species name	species status	Class c
Aquatic	A-236	Aquatic flatworm (planarian)	Turbellaria: Tricladida: Paludicola	Planariidae	? Cura sp. (CP)	sp.	Turbellaria
Aquatic	A-237	undetermined aquatic insect 3	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. & sp. Type 3 larva (CP)	sp. indet.	Insecta
Aquatic	A-238	Aquatic mollusc (bivalve pill clam)	Mollusca: Bivalvia: Eulamellibranchia	Sphaeriidae	Pisidium (Euglesa) hallae Kuiper, 1983		Bivalvia
Aquatic	A-239	crangonyctoid amphipod	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 2b" (IB)	"stygobiont 2b"	Amphipoda
Aquatic	A-240	Aquatic mollusc (bivalve pill clam)	Mollusca: Bivalvia: Eulamellibranchia	Sphaeriidae	Pisidium (Euglesa) tasmanicum Tenison-Woods, 1876		Bivalvia
Aquatic	A-241	hydrobiid snails	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela pupiformis Ponder & Clark, 1993		Gastropoda
Aquatic	A-242	hydrobiid snails	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus juliae Clark, Miller and Ponder, 2003		Gastropoda
Aquatic	A-243	hydrobiid snails	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? Pseudotricula, near P. arthurclarkei (PB)	sp.	Gastropoda
Aquatic	A-244	hydrobiid snails	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Beddomeia paludinella levenensis Ponder & Clark, 1993		Gastropoda
Aquatic	A-245	anaspidacean syncarid	Syncarida: Anaspidacea	Anaspididae	Paranaspides sp. (IB)	sp.	Syncarida
Aquatic	A-246	anaspidacean syncarid	Syncarida: Anaspidacea	Anaspididae	Allanaspides sp. (T)	sp.	Syncarida
Aquatic	A-247	marine opossum shrimp	Mysidacea: Mysida	Mysidae: Mysinae: Leptomysini	Mysidetes halope O'Brien 1986		Crustacea
Terrestrial	T-0001	glow-worms	Diptera: Nematocera: Mycetophilodea	Keroplatidae: Arachnocampinae	Arachnocampa (Arachnocampa) tasmaniensis Ferguson, 1925		Diptera
Terrestrial	T-0002	Tas. Cave Spider	Araneae: Araneomorphae: Austrochiloidea	Austrochilidae: Hickmaniinae	Hickmania troglodytes (Higgins & Petterd, 1984)		Araneae
Terrestrial	T-0003	cave cricket	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus cavernicola Richards, 1964		Orthoptera
Terrestrial	T-0004	cave cricket	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus tasmaniensis Richards, 1964		Orthoptera
Terrestrial	T-0005	carabid cave beetle	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus troglodytes Lea, 1910		Coleoptera
Terrestrial	T-0006	Beetle [carabid]	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites flavipes (Lea, 1910)		Coleoptera
Terrestrial	T-0007	Beetle	Coleoptera: Polyphaga: Scirtoidea	Scirtidae	Cyphon doctus Lea, 1910		Coleoptera
Terrestrial	T-0008	Beetle	Coleoptera: Polyphaga: Cucujoidea	Cryptophagidae: Atomarinae	Cryptophagus troglodytes Lea, 1910		Coleoptera
Terrestrial	T-0009	cave cricket	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Tasmanoplectron isolatum Richards, 1971		Orthoptera
Terrestrial	T-0010	cave cricket	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Cavernotettix flinderensis (Chopard, 1944)		Orthoptera
Terrestrial	T-0011	isopod (terrestrial)	Isopoda: Oniscidea: Ligiamorpha: Armadilloidea	Armadillidae: Akermaninae	Echinodillo cavaticus Green, 1963		Isopoda (te
Terrestrial	T-0012	carabid cave beetle	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus cordicollis Moore, 1967 (H)		Coleoptera

Order	Cave Number	Collector	Date (new form	Find / Vial	Goede ref	SE ref	AC ref	Animal type (in records)	abund	Comment	Sp Lodgement	Accession No	Lodgment	Type Status
6597	H-001	Edie Smith & K.S. Tredall	15-Jan-1950					carabid cave beetle		specimen detail unknown	Observation (?)	Observation ?		
628	H-001	E. Hamilton-Smith	13-Nov-1963	BS0434				carabid cave beetle	1	female	SAM (dry collection)	BS0434		ALLOTYPE
627	H-001	E. Hamilton-Smith	13-Nov-1963	BS0433				carabid cave beetle	1	male	SAM (dry collection)	BS0433		HOLOTYPE
634	H-214	E. Hamilton-Smith	14-Nov-1963	BS0435b				carabid cave beetle	1	female	SAM (dry collection)	BS0435b		PARATYPE
635	H-214	E. Hamilton-Smith	14-Nov-1963	BS0436				carabid cave beetle	2	male & juvenile	SAM (dry collection)	BS0436		PARATYPE
633	H-214	E. Hamilton-Smith	14-Nov-1963	BS0435a				carabid cave beetle	2	male & female	B.P. Moore (private coll	BS0435a		PARATYPE
733	H-214	A. Goede	03-Mar-1968	001e	001e			carabid cave beetle	7	7 "dark" specimens (exuvia)	B.P. Moore (private coll	unknown reg.		
779	H-214	A. & T. Goede	21-Apr-1968	022	022			carabid cave beetle	4	4 "pale" specimens	B.P. Moore (private coll	unknown reg.		
780	H-214	A. & T. Goede	21-Apr-1968	023	023			carabid cave beetle	9	9 "dark" spp., given to Dr. Ueno	Dr. Ueno (27-Dec-1974	unknown reg.	-Dec-1974	
781	H-214	A. & T. Goede	21-Apr-1968	038	038			carabid cave beetle		Fragmentary remains	B.P. Moore (private coll	unknown reg.		
807	H-214	A. & T. Goede	23-Jun-1968	046	046			carabid cave beetle	4	4 "pale" specimens	B.P. Moore (private coll	unknown reg.		
826	H-X08	A. Goede & A. Dartnall	10-Aug-1968	062	062	H-X8-5r		carabid cave beetle	1	1 specimen: Tb	B.P. Moore (private coll	unknown reg.	-Jan-1969	
5938	H-206	R.J. Cockerill ?	08-Sep-1968					carabid cave beetle		collection site recorded as "H-206"	ANIC ?	unconfirmed lc		

Record: 1 of 30

Figure 4.6: View from Species Taxonomy table, showing the last 12 aquatic species and first 12 terrestrial species, plus 13 of the 30 records for collections of *Idacarabus cordicollis* from caves at Hastings, listed by collection date order.

The amount of information that can be extracted from the database by viewing these tables is relatively limited, as it is confined to the field list in each table. However, as a relational database with all its tables linked together, a considerable amount of more precise detail can be extracted by devising select queries in Ms Access based on any one or several tables and previously designed queries. The queries provide results in table form, with fields of information that can be ordered or manipulated in the same manner as the database tables. In a query, the coded fields in the Records table can be replaced by the actual cave or genus-species name, then combined with any other relevant fields to produce lists of species by cave or karst area and vice versa, plus micro-habitat or cave region. In addition to the select queries, a Cross-tab Query (tabulation) can be designed to provide a statistical analysis of the data, e.g., counts of the number of occurrences recorded in any given year or the number of specimens/ species collected or observed from any cave or particular micro-habitat.

4.4.3: Use of queries to extract extra information from the database

In the database there are presently 309 queries including "Cross Tab" queries, providing specific information relating to occurrence dates, species collectors (and observers), specimen lodgement, animal types, family groups, cave or surface species, major species groups, selected cave or karst areas and non-karst areas, ecological niche, cave regions and micro-habitats. An example of some of these queries is shown in Figure 4.7. Obviously, the results for any of these queries will only be as good as the data that has been entered. Due to the enormity of this database and this writer's attempt to keep the database up to date with occurrence records and also maintain a focus on the micro-habitat factors acting as determinants for species occurrences in the Hastings and Ida Bay karst areas, a number of data fields are incomplete. Some examples of specific queries and design of them is provided on the page following Figure 4.7.

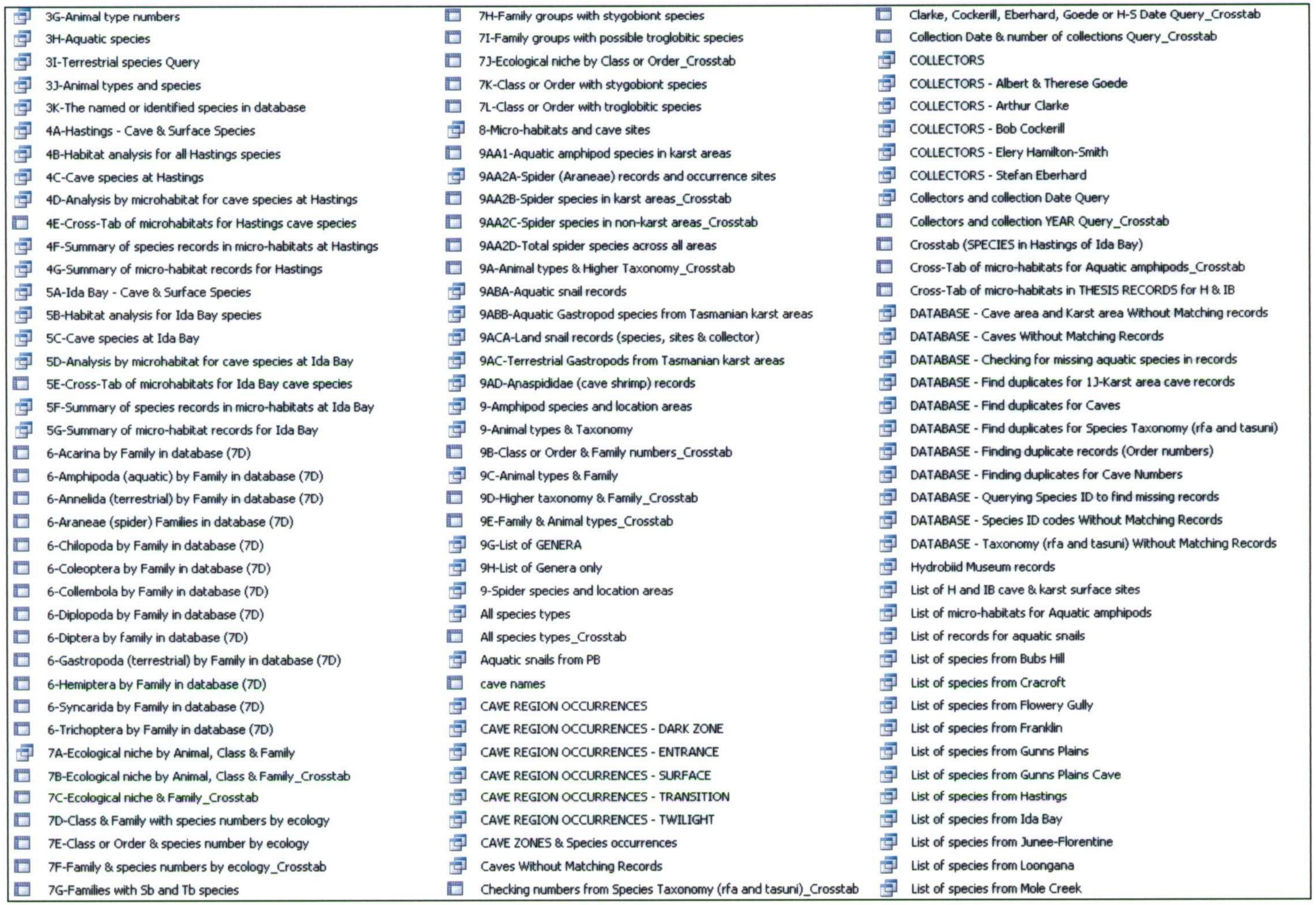
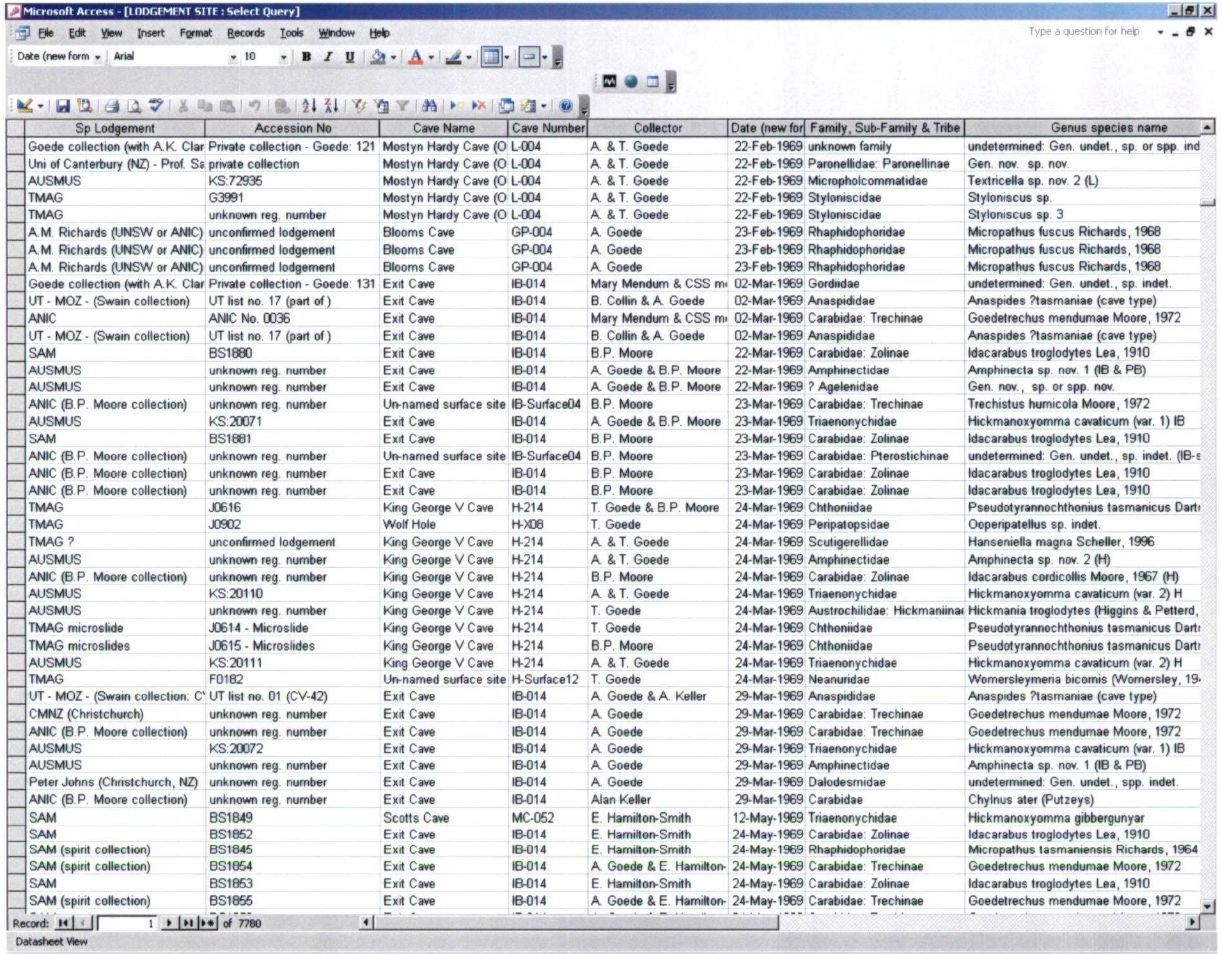


Figure 4.7: Screen dump with a selection of the 309 queries already in the database. The single table icon ("▭") indicates that the query is based on a single table or query; the "⧉" symbol shows that more than one table or query are involved.



Microsoft Access - [LODGEMENT SITE : Select Query]

Sp Lodgement	Accession No	Cave Name	Cave Number	Collector	Date (new for	Family, Sub-Family & Tribe	Genus species name
Goede collection (with A.K. Clar	Private collection - Goede: 121	Mostyn Hardy Cave (O	L-004	A. & T. Goede	22-Feb-1969	unknown family	undetermined: Gen. undet., sp. or spp. ind
Uni of Canterbury (NZ) - Prof. Sa	private collection	Mostyn Hardy Cave (O	L-004	A. & T. Goede	22-Feb-1969	Paronellidae: Paronellinae	Gen. nov. sp. nov.
AUSMUS	KS:72935	Mostyn Hardy Cave (O	L-004	A. & T. Goede	22-Feb-1969	Micropholcommatidae	Textricella sp. nov. 2 (L)
TMAG	G3991	Mostyn Hardy Cave (O	L-004	A. & T. Goede	22-Feb-1969	Styloniscidae	Styloniscus sp.
TMAG	unknown reg. number	Mostyn Hardy Cave (O	L-004	A. & T. Goede	22-Feb-1969	Styloniscidae	Styloniscus sp. 3
A.M. Richards (UNSW or ANIC)	unconfirmed lodgement	Blooms Cave	GP-004	A. Goede	23-Feb-1969	Rhaphidophoridae	Micropathus fuscus Richards, 1968
A.M. Richards (UNSW or ANIC)	unconfirmed lodgement	Blooms Cave	GP-004	A. Goede	23-Feb-1969	Rhaphidophoridae	Micropathus fuscus Richards, 1968
A.M. Richards (UNSW or ANIC)	unconfirmed lodgement	Blooms Cave	GP-004	A. Goede	23-Feb-1969	Rhaphidophoridae	Micropathus fuscus Richards, 1968
Goede collection (with A.K. Clar	Private collection - Goede: 131	Exit Cave	IB-014	Mary Mendum & CSS m	02-Mar-1969	Gordiidae	undetermined: Gen. undet., sp. indet.
UT - MOZ - (Swain collection)	UT list no. 17 (part of)	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
ANIC	ANIC No. 0036	Exit Cave	IB-014	Mary Mendum & CSS m	02-Mar-1969	Carabidae: Trechinae	Goedetrechus mendumae Moore, 1972
UT - MOZ - (Swain collection)	UT list no. 17 (part of)	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
SAM	BS1880	Exit Cave	IB-014	B.P. Moore	22-Mar-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
AUSMUS	unknown reg. number	Exit Cave	IB-014	A. Goede & B.P. Moore	22-Mar-1969	Amphinectidae	Amphinecta sp. nov. 1 (IB & PB)
AUSMUS	unknown reg. number	Exit Cave	IB-014	A. Goede & B.P. Moore	22-Mar-1969	? Agelenidae	Gen. nov., sp. or spp. nov.
ANIC (B.P. Moore collection)	unknown reg. number	Un-named surface site	IB-Surface04	B.P. Moore	23-Mar-1969	Carabidae: Trechinae	Trechistus humicola Moore, 1972
AUSMUS	KS:20071	Exit Cave	IB-014	A. Goede & B.P. Moore	23-Mar-1969	Triaenonychidae	Hickmanoxyomma cavaticum (var. 1) IB
SAM	BS1881	Exit Cave	IB-014	B.P. Moore	23-Mar-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
ANIC (B.P. Moore collection)	unknown reg. number	Un-named surface site	IB-Surface04	B.P. Moore	23-Mar-1969	Carabidae: Pterostichinae	undetermined: Gen. undet., sp. indet. (IB-s
ANIC (B.P. Moore collection)	unknown reg. number	Exit Cave	IB-014	B.P. Moore	23-Mar-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
ANIC (B.P. Moore collection)	unknown reg. number	Exit Cave	IB-014	B.P. Moore	23-Mar-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
TMAG	J0616	King George V Cave	H-214	T. Goede & B.P. Moore	24-Mar-1969	Chthoniidae	Pseudotyrannochthonius tasmanicus Dart
TMAG	J0902	Wolf Hole	H-X08	T. Goede	24-Mar-1969	Peripatopsidae	Ooperipatellus sp. indet.
TMAG ?	unconfirmed lodgement	King George V Cave	H-214	A. & T. Goede	24-Mar-1969	Scutigerellidae	Hanseniella magna Scheller, 1996
AUSMUS	unknown reg. number	King George V Cave	H-214	A. & T. Goede	24-Mar-1969	Amphinectidae	Amphinecta sp. nov. 2 (H)
ANIC (B.P. Moore collection)	unknown reg. number	King George V Cave	H-214	B.P. Moore	24-Mar-1969	Carabidae: Zolinae	Idacarabus cordicollis Moore, 1967 (H)
AUSMUS	KS:20110	King George V Cave	H-214	A. & T. Goede	24-Mar-1969	Triaenonychidae	Hickmanoxyomma cavaticum (var. 2) H
AUSMUS	unknown reg. number	King George V Cave	H-214	T. Goede	24-Mar-1969	Austrochilidae: Hickmaniinae	Hickmania troglodytes (Higgins & Petterd,
TMAG microslide	J0614 - Microslide	King George V Cave	H-214	T. Goede	24-Mar-1969	Chthoniidae	Pseudotyrannochthonius tasmanicus Dart
TMAG microslides	J0615 - Microslides	King George V Cave	H-214	B.P. Moore	24-Mar-1969	Chthoniidae	Pseudotyrannochthonius tasmanicus Dart
AUSMUS	KS:20111	King George V Cave	H-214	A. & T. Goede	24-Mar-1969	Triaenonychidae	Hickmanoxyomma cavaticum (var. 2) H
TMAG	F0182	Un-named surface site	H-Surface12	T. Goede	24-Mar-1969	Neanuridae	Womersleymeria bicornis (Womersley, 19
UT - MOZ - (Swain collection: C	UT list no. 01 (CV-42)	Exit Cave	IB-014	A. Goede & A. Keller	29-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
CMNZ (Christchurch)	unknown reg. number	Exit Cave	IB-014	A. Goede	29-Mar-1969	Carabidae: Trechinae	Goedetrechus mendumae Moore, 1972
ANIC (B.P. Moore collection)	unknown reg. number	Exit Cave	IB-014	A. Goede	29-Mar-1969	Carabidae: Trechinae	Goedetrechus mendumae Moore, 1972
AUSMUS	KS:20072	Exit Cave	IB-014	A. Goede	29-Mar-1969	Triaenonychidae	Hickmanoxyomma cavaticum (var. 1) IB
AUSMUS	unknown reg. number	Exit Cave	IB-014	A. Goede	29-Mar-1969	Amphinectidae	Amphinecta sp. nov. 1 (IB & PB)
Peter Johns (Christchurch, NZ)	unknown reg. number	Exit Cave	IB-014	A. Goede	29-Mar-1969	Dalodesmidae	undetermined: Gen. undet., spp. indet.
ANIC (B.P. Moore collection)	unknown reg. number	Exit Cave	IB-014	Alan Keller	29-Mar-1969	Carabidae	Chylnus ater (Putzeys)
SAM	BS1849	Scotts Cave	MC-052	E. Hamilton-Smith	12-May-1969	Triaenonychidae	Hickmanoxyomma gibbergunyar
SAM	BS1852	Exit Cave	IB-014	E. Hamilton-Smith	24-May-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
SAM (spirit collection)	BS1845	Exit Cave	IB-014	E. Hamilton-Smith	24-May-1969	Rhaphidophoridae	Micropathus tasmaniensis Richards, 1964
SAM (spirit collection)	BS1854	Exit Cave	IB-014	A. Goede & E. Hamilton-	24-May-1969	Carabidae: Trechinae	Goedetrechus mendumae Moore, 1972
SAM	BS1853	Exit Cave	IB-014	E. Hamilton-Smith	24-May-1969	Carabidae: Zolinae	Idacarabus troglodytes Lea, 1910
SAM (spirit collection)	BS1855	Exit Cave	IB-014	A. Goede & E. Hamilton-	24-May-1969	Carabidae: Trechinae	Goedetrechus mendumae Moore, 1972

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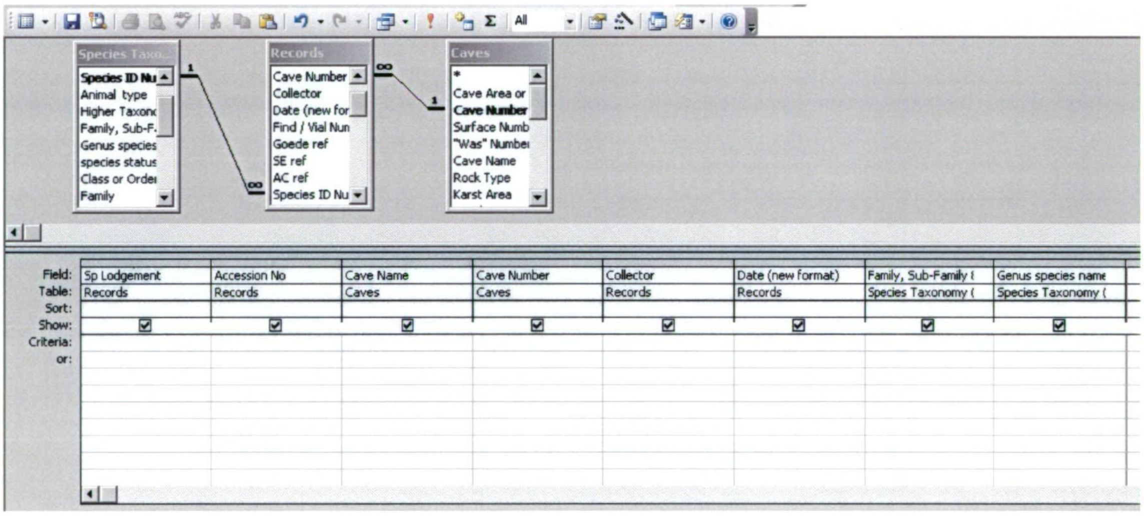
Datasheet View

Figure 4.8: Example of the Query result for LODGEMENT SITE showing a selection of the occurrence records for Feb-May 1969, with lodgement details including collections in "UT - MOZ" (University of Tasmania's Museum of Zoology).

By way of example to view and construct a query, I have chosen an already established query: "LODGEMENT SITE" to search for specimens recorded in the database as being lodged in the School of Zoology at the University of Tasmania, coded as "UT - MOZ" in the "Sp Lodgement" field of the Records Table (see Figure 4.8). From the database opening screen (Figures 4.1 and 4.3) select the "Queries" tab under Objects. Scroll through the queries to find LODGEMENT SITE, select it then double-click to open. If the date column is ordered, a scroll down will to show a result similar to that shown in Figure 4.8, with the lodgement site listed in the first left hand column. To change the design of this table to list the University of Tasmania records, click the design view button on the far left hand side of the tool bar: it has blue triangular symbol with a yellow pencil.



<u>Figure 4.9</u>: Design view for LODGEMENT SITE Query, showing the selected fields sourced from three linked (related) tables: Species Taxonomy, Records and Caves.

Under the small checked square in the left hand column headed Sp Lodgement, beside the row line marked Criteria, type the following "Like" expression: Like *UT - MOZ* with asterisks each side of "UT - MOZ". If the expression has been entered correctly, when you exit that cell, it will show in design view as: Like "*UT - MOZ*" (see Figure 4.10). To run the query after entering the expression, double-click the tool bar "Run" button (with red exclamation mark) to see the result which should appear as a Table of 93 entries, arranged as shown in Figure 4.11. Once the query result has been obtained, you can change from Table View to Design View by double-clicking the button with triangle and pencil icon, or if in Design View double-click the small square "Table" icon instead.

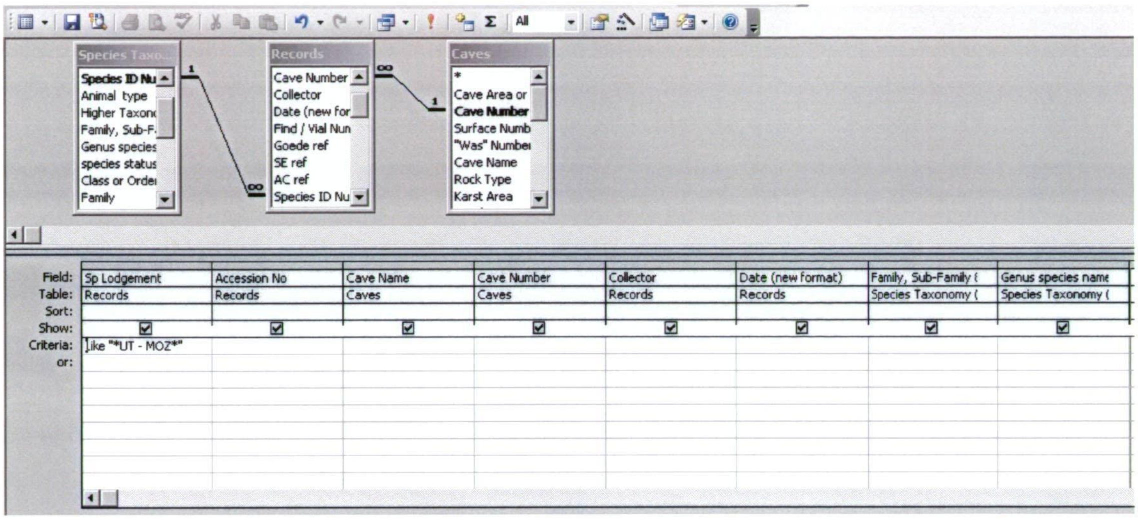
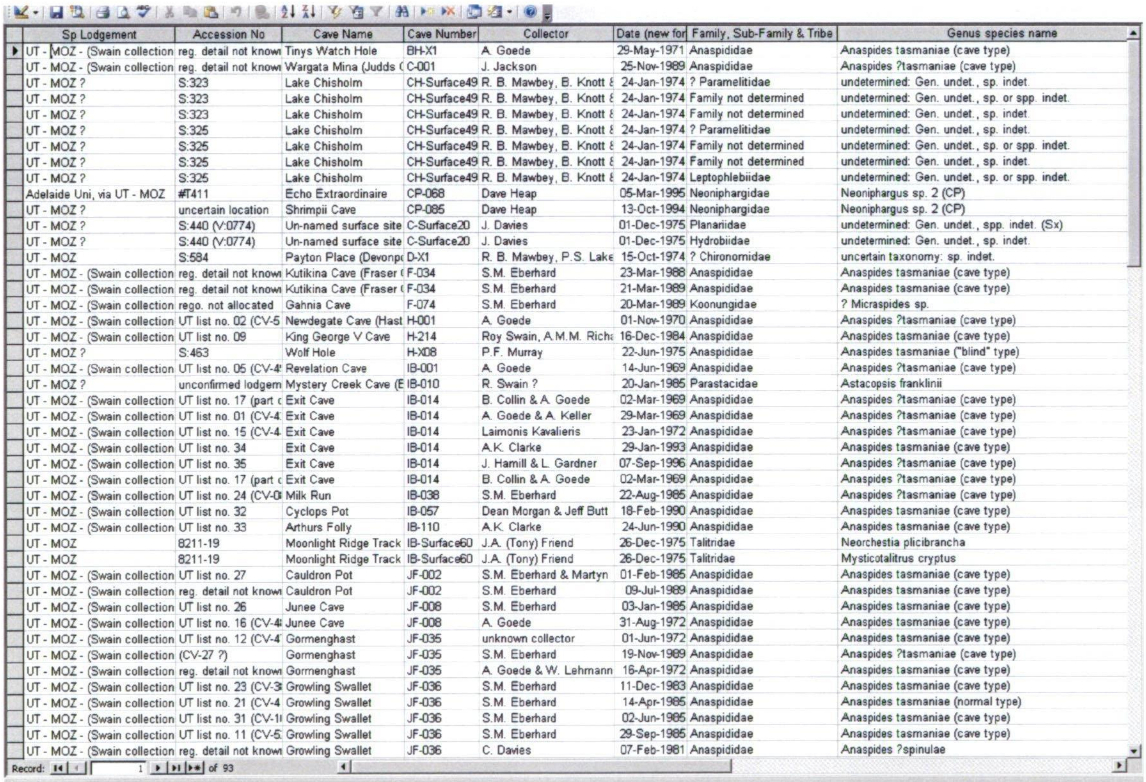


Figure 4.10: Cropped view of a screen dump to show design view of the experimental Query, after entering the expression: Like *UT - MOZ*



Sp Lodgement	Accession No	Cave Name	Cave Number	Collector	Date (new for	Family, Sub-Family & Tribe	Genus species name
UT - MOZ - (Swain collection	reg. detail not know	Tinys Watch Hole	BH-X1	A. Goede	29-May-1971	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	reg. detail not know	Wargata Mina (Judds (	C-001	J. Jackson	25-Nov-1989	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	? Paramelitidae	undetermined: Gen. undet., sp. indet.
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Family not determined	undetermined: Gen. undet., sp. or spp. indet.
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Family not determined	undetermined: Gen. undet., sp. indet.
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	? Paramelitidae	undetermined: Gen. undet., sp. indet.
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Family not determined	undetermined: Gen. undet., sp. or spp. indet.
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Family not determined	undetermined: Gen. undet., sp. indet.
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Leptophlebiidae	undetermined: Gen. undet., sp. or spp. indet.
Adelaide Uni, via UT - MOZ	#T411	Echo Extraordinaire	CP-068	Dave Heap	05-Mar-1995	Neoniphargidae	Neoniphargus sp. 2 (CP)
UT - MOZ ?	uncertain location	Shrimpii Cave	CP-085	Dave Heap	13-Oct-1994	Neoniphargidae	Neoniphargus sp. 2 (CP)
UT - MOZ ?	S:440 (V:0774)	Un-named surface site	C-Surface20	J. Davies	01-Dec-1975	Planariidae	undetermined: Gen. undet., spp. indet. (Sx)
UT - MOZ ?	S:440 (V:0774)	Un-named surface site	C-Surface20	J. Davies	01-Dec-1975	Hydrobiidae	undetermined: Gen. undet., sp. indet.
UT - MOZ	S:584	Payton Place (Devonp	D-X1	R. B. Mawbey, P.S. Lake	15-Oct-1974	? Chironomidae	uncertain taxonomy: sp. indet.
UT - MOZ - (Swain collection	reg. detail not know	Kutikina Cave (Fraser (	F-034	S.M. Eberhard	23-Mar-1988	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	reg. detail not know	Kutikina Cave (Fraser (	F-034	S.M. Eberhard	21-Mar-1989	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	rego. not allocated	Gahnia Cave	F-074	S.M. Eberhard	20-Mar-1989	Koonungidae	? Micraspides sp.
UT - MOZ - (Swain collection	UT list no. 02 (CV-5	Newdegate Cave (Hast	H-001	A. Goede	01-Nov-1970	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 09	King George V Cave	H-214	Roy Swain, A.M.M. Richa	16-Dec-1984	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ ?	S:463	Wolf Hole	H-X08	P.F. Murray	22-Jun-1975	Anaspididae	Anaspides tasmaniae ("blind" type)
UT - MOZ - (Swain collection	UT list no. 05 (CV-4	Revelation Cave	IB-001	A. Goede	14-Jun-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ ?	unconfirmed lodgem	Mystery Creek Cave (E	IB-010	R. Swain ?	20-Jan-1985	Parastacidae	Astacopsis franklinii
UT - MOZ - (Swain collection	UT list no. 17 (part c	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 01 (CV-4	Exit Cave	IB-014	A. Goede & A. Keller	29-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 15 (CV-4	Exit Cave	IB-014	Laimonis Kavalieris	23-Jan-1972	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 34	Exit Cave	IB-014	A.K. Clarke	29-Jan-1993	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 35	Exit Cave	IB-014	J. Hamill & L. Gardner	07-Sep-1996	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 17 (part c	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 24 (CV-0	Milk Run	IB-038	S.M. Eberhard	22-Aug-1985	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 32	Cyclops Pot	IB-057	Dean Morgan & Jeff Butt	18-Feb-1990	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 33	Arthurs Folly	IB-110	A.K. Clarke	24-Jun-1990	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ	8211-19	Moonlight Ridge Track	IB-Surface60	J.A. (Tony) Friend	26-Dec-1975	Talitridae	Neorchestia plicibrancha
UT - MOZ	8211-19	Moonlight Ridge Track	IB-Surface60	J.A. (Tony) Friend	26-Dec-1975	Talitridae	Mysticotalitrus cryptus
UT - MOZ - (Swain collection	UT list no. 27	Cauldron Pot	JF-002	S.M. Eberhard & Martyn	01-Feb-1985	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	reg. detail not know	Cauldron Pot	JF-002	S.M. Eberhard	09-Jul-1989	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 26	Junee Cave	JF-008	S.M. Eberhard	03-Jan-1985	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 16 (CV-4	Junee Cave	JF-008	A. Goede	31-Aug-1972	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 12 (CV-4	Gormenghast	JF-035	unknown collector	01-Jun-1972	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	(CV-27 ?)	Gormenghast	JF-035	S.M. Eberhard	19-Nov-1989	Anaspididae	Anaspides ?tasmaniae (cave type)
UT - MOZ - (Swain collection	reg. detail not know	Gormenghast	JF-035	A. Goede & W. Lehmann	16-Apr-1972	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 23 (CV-3	Growling Swallet	JF-036	S.M. Eberhard	11-Dec-1983	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 21 (CV-4	Growling Swallet	JF-036	S.M. Eberhard	14-Apr-1985	Anaspididae	Anaspides tasmaniae (normal type)
UT - MOZ - (Swain collection	UT list no. 31 (CV-1	Growling Swallet	JF-036	S.M. Eberhard	02-Jun-1985	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	UT list no. 11 (CV-5	Growling Swallet	JF-036	S.M. Eberhard	29-Sep-1985	Anaspididae	Anaspides tasmaniae (cave type)
UT - MOZ - (Swain collection	reg. detail not know	Growling Swallet	JF-036	C. Davies	07-Feb-1981	Anaspididae	Anaspides ?spinulae

Record: 1 of 93

Datasheet View

Figure 4.11: Cropped view of screen dump showing 45 of the 93 records resulting from experimental query for "UT - MOZ" records, modified from the existing Query: "LODGEMENT SITE" in thesis database. Note, that the "?" suffix associated with ten of the results indicates that there is some uncertainty regarding the lodgement, which has been recorded, but not confirmed or sighted in the university collection.

As shown in the example (Figure 4.11) displaying the results for this experimental query, four of the taxa are recorded as "Family not determined; undetermined: Gen. undet., sp. or spp. indet." To find more information about these particular specimens, one or several extra fields can be added to the query. For example, in order to include "Animal type", return to Design View and use the up-down arrows on the RHS of the small blue Species Taxonomy Table to locate Animal Type. Highlight it, and then use the mouse to drag it down into the top cell row of any of the field data columns, either choosing a blank column or by placing it, for example, on top of the Family field, which then moves one column to the right (Figure 4.12). Double-click the run button to view your result as shown in Figure 4.13.

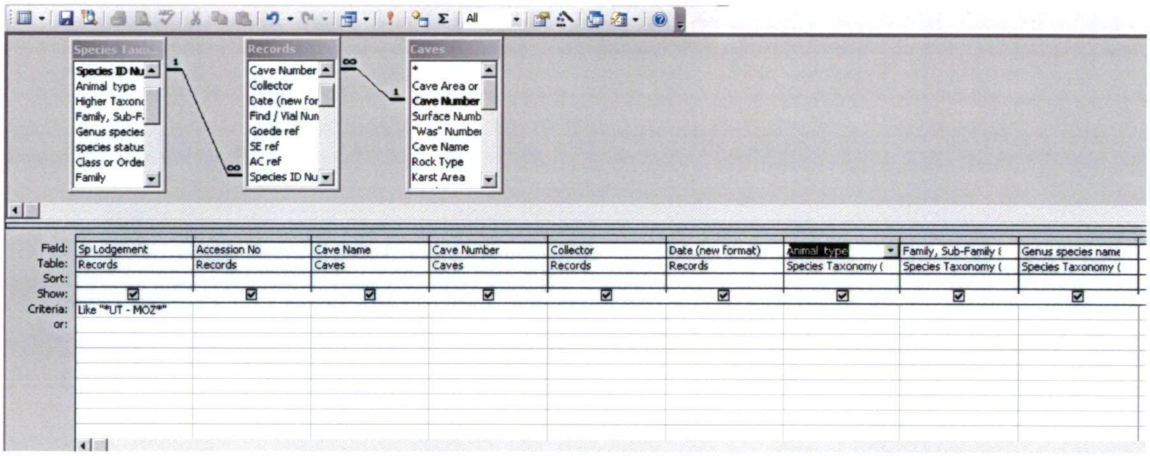


Figure 4.12: Cropped view of screen dump showing "UT - MOZ Lodgement" query in design view with an additional field (Animal type) added to the design

To delete any unwanted field, return to design view and position the mouse near the top of any unwanted data column until a small black arrow appears, single-click the mouse to highlight the column and choose "delete". When the new Table is closed, Access will provide a prompt with an option to name the query, which for example, could be saved as "LODGEMENT SITE – UTAS School of Zoology" or something similar. Choosing a name similar to the original one will ensure that it is saved in sequential order in the list of queries along with similarly named queries for ease of future access.

To design a completely new query using any of the six database tables, choose "Create query in Design view", select the Tables required, then drag the desired fields into the top row of each column, using the "Like * *" expression to select any desired item, then run the table.

Microsoft Access - [LODGEMENT SITE : Select Query]

Sp Lodgement	Accession No	Cave Name	Cave Number	Collector	Date (new forr	Animal type	Family, Sub-Family & Tr	Genus species nar
UT - MOZ - (Swain collection)	unknown reg. number	Tinys Watch Hole	BH-X1	A. Goede	29-May-1971	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	unknown reg. number	Wargata Mina (Judds C	C-001	J. Jackson	25-Nov-1989	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic amphipod	? Paramelitidae	undetermined: Gen. und
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic odonate nym	Family not determined	undetermined: Gen. und
UT - MOZ ?	S:323	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic beetle	Family not determined	undetermined: Gen. und
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic amphipod	? Paramelitidae	undetermined: Gen. und
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic odonate nym	Family not determined	undetermined: Gen. und
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Aquatic beetle	Family not determined	undetermined: Gen. und
UT - MOZ ?	S:325	Lake Chisholm	CH-Surface49	R. B. Mawbey, B. Knott &	24-Jan-1974	Mayfly	Leptophlebiidae	undetermined: Gen. und
Adelaide Uni, via UT - MOZ	#T411	Echo Extraordinaire	CP-068	Dave Heap	05-Mar-1995	Aquatic amphipod	Neoniphargidae	Neoniphargus sp. 2 (CP
UT - MOZ ?	uncertain location	Shrimpii Cave	CP-085	Dave Heap	13-Oct-1994	Aquatic amphipod	Neoniphargidae	Neoniphargus sp. 2 (CP
UT - MOZ ?	S:440 (V:0774)	Un-named surface site,	C-Surface20	J. Davies	01-Dec-1975	Aquatic flatworm (pla	Planariidae	undetermined: Gen. und
UT - MOZ ?	S:440 (V:0774)	Un-named surface site,	C-Surface20	J. Davies	01-Dec-1975	unknown aquatic sna	Hydrobiidae	undetermined: Gen. und
UT - MOZ	S:584	Payton Place (Devonpc	D-X1	R. B. Mawbey, P.S. Lake,	15-Oct-1974	Dipteran midge larvae	? Chironomidae	uncertain taxonomy: sp.
UT - MOZ - (Swain collection)	unknown reg. number	Kutikina Cave (Fraser (	F-034	S.M. Eberhard	23-Mar-1988	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	unknown reg. number	Kutikina Cave (Fraser (	F-034	S.M. Eberhard	21-Mar-1989	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	private collection	Gahnia Cave	F-074	S.M. Eberhard	20-Mar-1989	cave shrimp (koonun(	Koonungidae	? Micraspides sp.
UT - MOZ - (Swain collection: CV-51)	UT list no. 02 (CV-51)	Newdegate Cave (Hasti	H-001	A. Goede	01-Nov-1970	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection)	UT list no. 09	King George V Cave	H-214	Roy Swain, A.M.M. Richar	16-Dec-1984	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ ?	S:463	Wolf Hole	H-X08	P.F. Murray	22-Jun-1975	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae ("
UT - MOZ - (Swain collection: CV-49)	UT list no. 05 (CV-49)	Revelation Cave	IB-001	A. Goede	14-Jun-1969	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ ?	unconfirmed lodgement	Mystery Creek Cave (E	IB-010	R. Swain ?	20-Jan-1985	freshwater crayfish	Parastacidae	Astacopsis franklinii
UT - MOZ - (Swain collection)	UT list no. 17 (part of)	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection: CV-42)	UT list no. 01 (CV-42)	Exit Cave	IB-014	A. Goede & A. Keller	29-Mar-1969	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection: CV-44)	UT list no. 15 (CV-44)	Exit Cave	IB-014	Laimonis Kavalieris	23-Jan-1972	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection)	UT list no. 34	Exit Cave	IB-014	A.K. Clarke	29-Jan-1993	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	UT list no. 35	Exit Cave	IB-014	J. Hamill & L. Gardner	07-Sep-1996	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection)	UT list no. 17 (part of)	Exit Cave	IB-014	B. Collin & A. Goede	02-Mar-1969	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection: CV-08)	UT list no. 24 (CV-08)	Milk Run	IB-038	S.M. Eberhard	22-Aug-1985	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection)	UT list no. 32	Cyclops Pot	IB-057	Dean Morgan & Jeff Butt	18-Feb-1990	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	UT list no. 33	Arthurs Folly	IB-110	A.K. Clarke	24-Jun-1990	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ	8211-19	Moonlight Ridge Track	IB-Surface60	J.A. (Tony) Friend	26-Dec-1975	landhopper (talitrid ar	Talitridae	Neorchestia plicibranch
UT - MOZ	8211-19	Moonlight Ridge Track	IB-Surface60	J.A. (Tony) Friend	26-Dec-1975	landhopper (talitrid ar	Talitridae	Mysticotalitrus cryptus
UT - MOZ - (Swain collection)	UT list no. 27	Cauldron Pot	JF-002	S.M. Eberhard & Martyn C	01-Feb-1985	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	unknown reg. number	Cauldron Pot	JF-002	S.M. Eberhard	09-Jul-1989	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	UT list no. 26	Junee Cave	JF-008	S.M. Eberhard	03-Jan-1985	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-48)	UT list no. 16 (CV-48)	Junee Cave	JF-008	A. Goede	31-Aug-1972	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-47)	UT list no. 12 (CV-47)	Gormenghast	JF-035	unknown collector	01-Jun-1972	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-27 '	(CV-27 ?)	Gormenghast	JF-035	S.M. Eberhard	19-Nov-1989	cave shrimp (anaspid	Anaspididae	Anaspides ?tasmaniae (
UT - MOZ - (Swain collection)	unknown reg. number	Gormenghast	JF-035	A. Goede & W. Lehmann	16-Apr-1972	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-38)	UT list no. 23 (CV-38)	Growling Swallet	JF-036	S.M. Eberhard	11-Dec-1983	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-41)	UT list no. 21 (CV-41)	Growling Swallet	JF-036	S.M. Eberhard	14-Apr-1985	cave shrimp ? (anasp	Anaspididae	Anaspides tasmaniae (n
UT - MOZ - (Swain collection: CV-10)	UT list no. 31 (CV-10)	Growling Swallet	JF-036	S.M. Eberhard	02-Jun-1985	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection: CV-52)	UT list no. 11 (CV-52)	Growling Swallet	JF-036	S.M. Eberhard	29-Sep-1985	cave shrimp (anaspid	Anaspididae	Anaspides tasmaniae (c
UT - MOZ - (Swain collection)	unknown reg. number	Growling Swallet	JF-036	C. Davies	07-Feb-1981	cave shrimp ? (anasp	Anaspididae	Anaspides ?spinulae

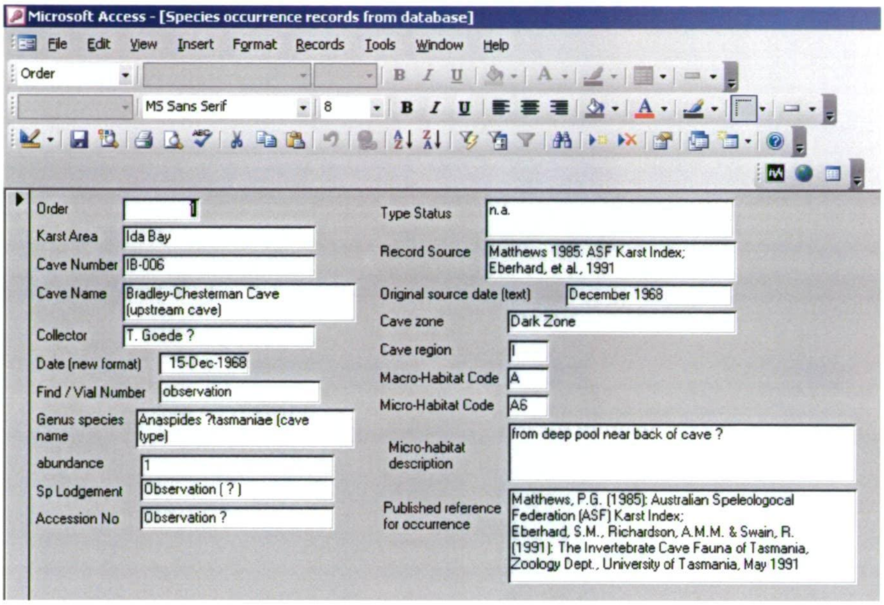
Record: 1 of 93

Datasheet View

Figure 4.13: Screen dump showing table view of the same 45 records in Figure 4.11, with an additional field (Animal type) added to the design.

4.4.4: Obtaining a hardcopy printout of results

A hard copy printout of any table, query or selected field columns can be produced in the normal manner of printing documents. If a printout is required for a particular record from any Query or any of the three main (Caves, Records or Species Taxonomy) tables, this is done as a single page form or a multi-page report if many records are required, shown by the examples in Figures 4.14 and 4.15. These are designed using the "Form" or "Report" objects shown on the LHS of the database window (see section 4.4). In a similar manner to constructing a query, a form or report can be designed with the desired data listed in any required order by selecting particular fields, using one or more tables; in the case of a single page form, the actual layout of the text fields and data boxes can be modified.



<u>Figure 4.14</u>: Example of printed page for a single form showing the layout of field data for one occurrence record: number "1" in the Records table.

1C-Cave Species (without matching surface species)

Animal type	*Family or Sub-Family*	*Genus species name*	*Species ID Number*
Acarina (mites)	Anystidae	Anystis baccarum (Linneaus)	T-0103
Acarina (mites)	Cryzerlidae	Cryzerla sp., (nr. C. australien	T-0099
Acarina (mites)	Erythraeidae	Erythrites (Erythrites) sp. indet.	T-0101
Acarina (mites)	Eupodidae	Linopodes sp.	T-0102
Acarina (mites)	Family not determined	undetermined: Gen. undet., sp.	T-0750
Acarina (mites)	Family not determined	undetermined: Gen. undet., sp.	T-0822
Acarina (mites)	Labidostommatidae	undetermined: Gen. undet., sp.	T-0566
Acarina (mites)	Laelapidae	undetermined: Gen. undet., sp.	T-0559
Acarina (mites)	Macrochelidae	Macrocheles sp. (H)	T-0095
Acarina (mites)	Microtrombidiidae	? Microtrombidium sp. (CP)	T-0553
Acarina (mites)	Ologamasidae	Heydeniella sp.	T-0556
Acarina (mites)	Oppiidae	Lanceoppia sp.	T-0589
Acarina (mites)	Oribotritiidae	Oribotritia contortula	T-0557
Acarina (mites)	Urodinychidae	Uroobovella sp.	T-0588
Acarina (mites)	Uropodidae	undetermined Mesostigmata: s	T-0561
Acarina (mites)	Uropodidae	undetermined Mesostigmata: s	T-0562
Acarina (mites)	Uropodidae	undetermined Mesostigmata: s	T-0564
Acarina (mites: "Beetle" Mite)	Family not determined	undetermined: Gen. undet., sp	T-0684
Acarina (ticks)	Family not determined	undetermined: Gen. undet., sp.	T-0891
Acarina (ticks)	Ixodidae	Aponomma auruginans (Schul	T-0092
Acarina (ticks)	Ixodidae	Ixodes ?antechini, Roberts, 19	T-0554
Acarina (ticks)	Ixodidae	Ixodes ?fecialis Warburton & N	T-0723
Acarina (ticks)	Ixodidae	Ixodes ornithorhynchi Lucas, 1	T-0094
Acarina (ticks)	Ixodidae	Ixodes sp. (H)	T-0560
Acarina (ticks)	Ixodidae	Ixodes tasmani Neumann (L&	T-0555
Acarina (ticks)	Ixodidae	Ixodes trichosuri Roberts, 1960	T-0093
Ant	Formicidae	Chelaner leae (Forel)	T-0437
Aphids	Aphididae	Myzus persicae (Sulzer)	T-0404

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<u>Figure 4.15</u>: First page of a multi-page report on Query 1C in tabulated form; these reports can be produced with a range of heading options for varied presentation purposes.

4.5. A summary of the database records with selected results of filter selection sorts and Query analyses

The "LODGEMENT SITE" Query indicates that the database contains records for 7,861 invertebrate occurrences. A filter sort ("Filter By Selection") on this Query and other related "LODGEMENT" Queries shows a mix of 6,318 collection and 1,543 observation records amongst the databased occurrences. The same result is achieved by adding the expression: Not Like "*Observation/s*" And Not Like "*Observation*" in the Criteria row under "Sp Lodgement" in the "LODGEMENT SITE" query to create another new query titled: "LODGEMENT SITE - All non-observation records". Using the "Not Like" criteria to eliminate unconfirmed lodgements and/ or uncertain location records etc, another query is developed to show the 5,468 lodged records including the present writer's collection of 692 vials in the School of Zoology at the University of Tasmania ("LODGEMENT SITE - All lodged records"); see list of museums, other lodgement institutions and private collections in Appendix 9.3.1. Application of a "filter by selection" sort on this query indicates the lodged material includes 747 items with "unknown registration numbers", 30 "unregistered" and another 166 "not yet registered" specimen/s. This is also shown by one further query in this series devised to eliminate the lodgements that are not formally registered or catalogued (such as this writer's collection), showing a result of 4,525 registered lodgements ("LODGEMENT SITE - All registered lodgements"); however, this figure still incorporates the 322 lots of unregistered material in private collections, e.g., Barry Moore's collection of carabid beetles.

Each of the 7,861 occurrence records has up to 78 fields of data per record. The records cover 1,292 invertebrates: 247 aquatic species and 1,045 terrestrial species, from 749 occurrence sites comprising 678 caves in 68 karst areas (Query 0A) and 27 non-karst areas (Query 0B), plus 71 surface sites (including warm springs) in 34 karst areas (Query 0C). Further analysis of the 1,292 databased species shows the following numbers of epigean and hypogean species:

- 204 species recorded only from karst surface sites: Query 2D.
- 1,088 species recorded from caves or surface sites: Query 1B;
- 207 species recorded in caves and surface sites: Query 2E;
- 881 species recorded only from caves: Query 1C.

Cave sites account for 6,831 of the 7,861 records: with 6,629 occurrences from karst caves (Query 1J) and 202 from non-karst caves (Query 1H); karst surface sites are represented by 1,030 records (Query 2B). Over a quarter of the surface records representing more than a third of the recorded surface species were collated during biological surveys of karst areas (and caves) in the western Tasmanian World Heritage Area (Eberhard, 1987c; 1988; 1989).

The spreadsheet Tables 4.14 and 4.15 provide an overview of the database results, listing the number of occurrence records and species recorded in each of the 97 separate karst or non-karst areas of Tasmania (Figure 2.1; Query 0E) together with the respective number of occurrence sites in each area. Table 4.13 is included to show the 18 specifically designed "Select" queries or "Cross-tab" queries that provide data for the two spreadsheets: Tables 4.13 and 4.14. The karst areas table (4.14) is divided into two sections: cave sites on the LHS and surface sites on the RHS; the second similar table (4.15) is comprised of one section relating the non-karst cave records. It should be noted that the apparent discrepancy in the number of listed karst areas with 68 karst cave areas in Table 4.13 and 70 karst areas recorded in Table 4.14, is explained by the fact that two of the 70 karst areas (Kimberley Springs and Lake Chisholm) are karst spring site areas, not cave areas.

Table 4.13: A list of the database queries used to provide the results tabled under the column headings of two spreadsheet summaries: Tables 4.14 and 4.15.

Position in Table 4.14 or 4.15	Database Query code	Title of Select Query or Cross-tab Query in Database	Column Heading	Resulting number of records
4.14 - LHS	**0A**	Karst cave areas	**Karst Area**	67
4.14 - LHS	**1D**	Karst area caves	**Caves**	633
4.14 - LHS	**1J and 1M**	Number of karst area cave records	**Records**	6554
4.14 - LHS	**1N and 10**	Number of karst area species	**Species**	2336
4.14 - RHS	**0C**	Karst surface areas	**Karst Area**	34
4.14 - RHS	**2A**	Karst surface area sites	**Surface sites**	71
4.14 - RHS	**2B and 2F**	Number of karst surface area records	**Records**	1024
4.14 - RHS	**2G and 2H**	Number of karst surface area species	**Species**	661
4.15	**0B**	Non-karst cave areas	**Non-karst area**	28
4.15	**1E**	Non-karst area caves	**Caves**	40
4.15	**1H and 1R**	Number of non-karst area cave records	**Records**	202
4.15	**1Q and 1P**	Number of non-karst area species	**Species**	124

The spreadsheet results in Tables 4.14 and 4.15 provide a demonstration of the value of query design to give answers for specific questions of the database. A Select Query is based on one or more database Tables and/ or another Query and the Cross-tab Query tabulates the results of a previously designed Query. As shown in Table 4.13, each of the three sections that comprise the two tables (4.14 and 4.15) is the result of six database queries: four separate Select queries and two Cross-tab queries for each section. The Cross-tab queries, identified as the second of the two pairs of queries in each of the three sections of Table 4.13, provide a tabulated result of the first numbered query of each pair. The "column heading" of Table 4.13 relates to the column headings in Tables 4.14 and 4.15.

Table 4.14: Summary overview of the 70 karst areas, number of occurrence sites, records and species in each area, based on the database queries listed in Table 4.13. LHS section relates to karst area cave sites and RHS section for karst surface sites.

Karst Area	Caves	Records	Species	Surface sites	Records	Species
Acheron River	2	36	30	1	78	46
Albatross Island	1	2	1			
Boyer	1	2	1			
Bubs Hill	23	394	178	2	18	15
Cape Barren Island	1	2	2			
Cheyne Range	1	8	8			
Claude Creek	1	3	3			
Cracroft	14	80	43	2	5	5
Dante Rivulet	2	3	1			
Davey River	2	14	7	1	4	1
Dubbil Barril	2	3	3			
Erith Island (Kent Group)	1	5	1			
Eugenana	1	46	31			
Flowery Gully	2	56	37	1	14	13
Fossil Bluff	1	1	1			
Franklin (River)	10	166	86	2	101	64
Frenchmans Cap	2	4	4			
Gordon-Sprent	6	13	7	1	1	1
Gray	4	56	32	1	3	3
Gunns Plains	52	398	144	3	25	15
Hampshire	1	3	3			
Hastings	12	591	152	7	159	92
Hustling Creek	5	19	11	1	3	1
Ida Bay	144	1514	277	7	76	53
Ile du Golfe	3	14	11	1	2	2
Jubilee Ridge	1	2	2			
Jukes Darwin	2	10	5			
Julius River	5	18	10	1	35	14
Junee-Florentine	52	597	194	6	82	55

Karst Area	Caves	Records	Species	Surface sites	Records	Species
Keith River	6	13	3			
Kimberley Springs	0			1	10	5
Lake Chisholm	0			1	9	6
Lake Lea (Vale of Belvoir)	4	7	6	1	2	2
Loongana	12	219	109	3	10	10
Lorinna	1	6	5			
Lower Andrew (River)	3	69	43	1	74	43
Lower Huskisson	1	4	4			
Lower Maxwell (River)	7	26	20			
Maria Island	2	2	1			
McKays Peak	2	4	2			
Moina	2	4	3			
Mole Creek	50	625	195	6	88	57
Montagu	2	36	24	1	14	9
Mount Anne	10	49	26			
Mount Cripps	90	322	78	6	45	32
Mount Weld	2	13	7			
Mt. Ronald Cross	5	88	41	1	3	2
Nelson River	4	31	22	1	47	32
Newall Creek	1	2	2			
Nicholls Range	4	107	71			
North Lune	6	95	51	1	4	4
Precipitous Bluff	15	394	94	4	68	39
Ranga	2	49	11			
Redpa	6	45	22			
Risby Basin	3	37	28	1	6	6
Savage River	1	15	14	1	3	2
Scotts Peak	6	37	22	1	8	7
South Loddon River	2	11	9			
Styx River	3	14	12			
Surprise Bay	2	3	3			
Tasman Peninsula	3	12	7	1	5	5
Timbs Creek	4	10	8			
Trowutta	2	47	38	1	15	13
Upper Huskisson	1	3	3			
Upper Weld (River)	3	21	17			
Vanishing Falls	6	62	34	1	3	3
West Maxwell-Algonkian	3	19	13	1	4	4
White (Hawk) Creek	2	4	1			
Wilmot River	1	2	2			
Wilson River	3	18	8			
70 karst surface and cave areas	**635**	**6558**	**2340**	**71**	**1024**	**661**

Table 4.15: Summary overview of the 27 non-karst areas, number of caves, records and species for each area, based on the database queries listed in Table 4.13.

Non-karst area	Caves	Records	Species
Birchs Inlet, (Port Davey)	1	1	1
Cradle Link	1	1	1
Craggy Island	1	10	1
De Witt island	3	12	10
Devonport	1	10	3
Donaldsons Landing	2	6	6
Francistown	3	37	7
Kent Group Islands	4	6	4
King Island	1	1	1
Liberty Point	1	1	1
Liffey Falls	1	5	4
Louisa Bay (154? in KK, 1988)	2	3	3
Macquarie Island	1	1	1
Moonlight Creek	1	4	2
Mount Amos	1	1	1
Mount Wellington	3	77	53
Mountain River	1	1	1
Pieman River	1	1	1
Prime Seal Island	1	2	2
Rocky Boat Inlet	1	1	1
Ross	1	4	4
Scottsdale	1	5	4
Sisters Beach	1	2	2
Southport	1	2	2
Stoodley	1	1	1
Upper Natone	1	2	2
Western Arthurs (205 in KK, 1988)	1	1	1
27 non-karst cave areas	**38**	**198**	**120**

5. Cave invertebrate biodiversity in Tasmania

Cave biologists discovered a wealth of subterranean biodiversity in the cool temperate regions of North America (Holsinger, 1963; Mohr and Poulson, 1966), and it has been assumed that there would be a similar range of species in temperate Australia. Comparatively little was known on the biodiversity of Tasmanian caves until Goede (1967; 1972) provided an outline of the distribution of species, and subsequently published a series of papers describing selected groups of the known cave biota (Goede and Goede 1973a; 1973b; 1974a; 1974b). Ida Bay was one of the first karst areas in Tasmania to be intensively examined, when Richards and Ollier (1976) conducted their study on the ecology of the Exit Cave system. Fifteen years later, a more comprehensive overview of the invertebrate biodiversity of all Tasmanian caves was described (Eberhard *et al.*, 1991; Eberhard 1992), recording 150 identified taxa from a total of 133 caves in 30 karst areas. In their summary, Eberhard *et al.* (1991) concluded "*...that Tasmania has the richest faunal assemblages in temperate Australia.*" In the database accompanying an RFA report on cave fauna, Clarke (1997a) listed 643 cavernicolous species from 492 caves in 50 karst and 18 non-karst cave areas (see Figure 5.1). A recent overview of the diversity and distribution of stygofauna in Tasmania was compiled by Clarke (2000b) then incorporated in Thurgate, *et al.* (2001) and an even more recent and detailed appraisal of both the aquatic and terrestrial cavernicolous species from Tasmanian karst areas was compiled by Eberhard (2001a).

5.1: An overview of species groups found in Tasmanian caves and karst areas

The accompanying database of 7,861 records relates occurrence details for 1,292 species, found in Tasmanian caves and karst areas, including unresolved taxa lumped together as one species reference code. Analyses of the taxonomy table and database queries show that the 1,292 codes include 954 known species of 426 known and 41 uncertain genera in 219 known and 29 uncertain families from 54 higher taxonomic groups. There are many additional unknown or undescribed species from new or undetermined genera, including 93 taxa from unknown or undetermined family groups and 28 taxa from uncertain family groups. The known taxa include 353 species with published names and another 11 "described" species in various stages of preparation for publication. Species belonging to the major groups are listed in Tables 5.1 to 5.3.

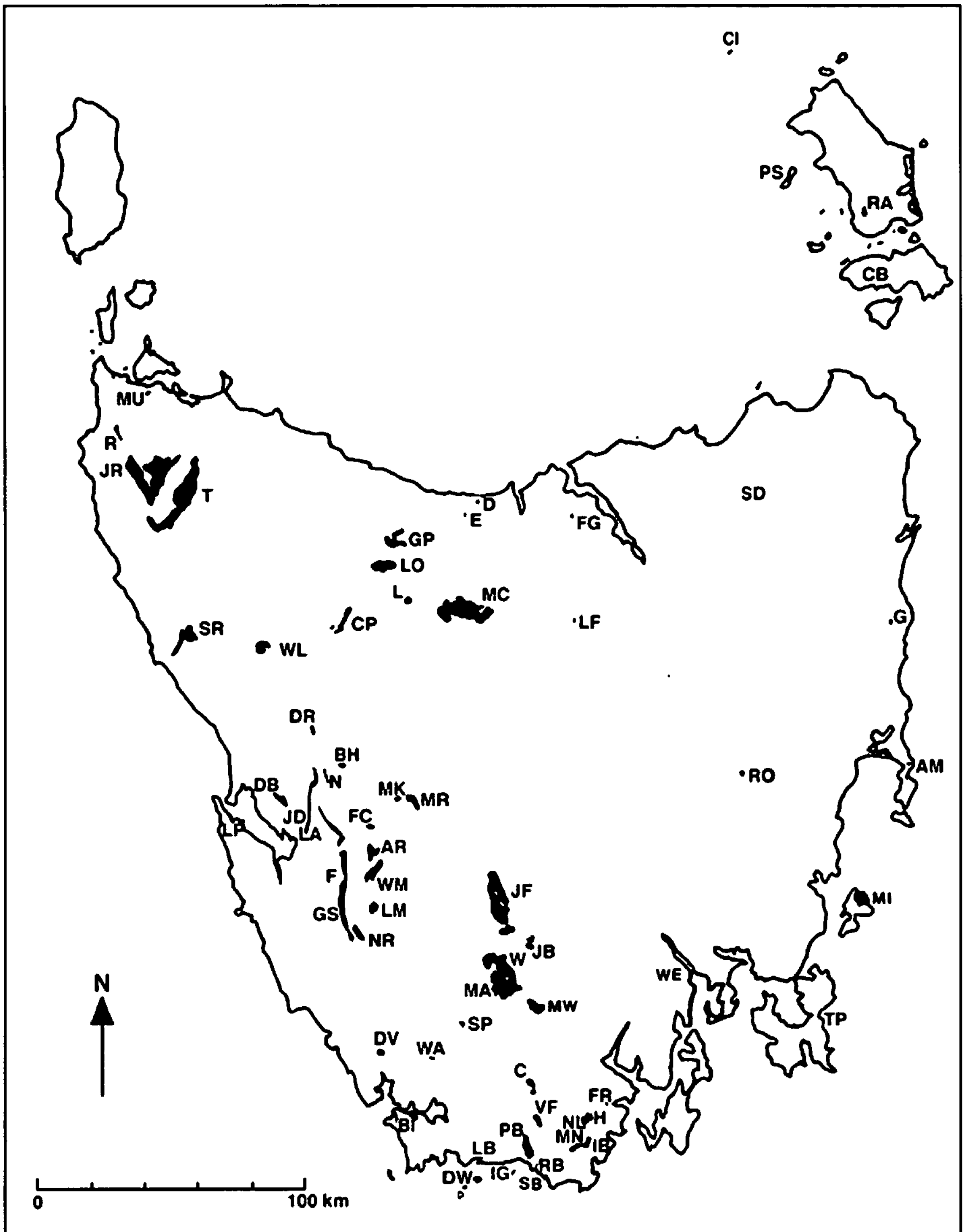

Figure 5.1: Map of Tasmania (Figure 1 in Clarke 1997a, based on the map in Matthews, 1985) showing locations of the 68 karst and non-karst cave areas where occurrences (collections or observations) of invertebrate species were recorded in the RFA database (Clarke, 1997a). Note: another 20 karst and nine non-karst cave areas are included amongst the records covered by this thesis. For detail of coded cave area names, rock types and numbers of caves, see Table 4.1 and database.

Table 5.1 (overleaf), provides a summary of the species abundance and diversity recorded in the database, listing the animal groups with most occurrences and numbers of species. Divided into two sections, the right hand columns in Table 5.1 list the most abundant species of each major group, showing the number of records and number of cave areas where each species is recorded. The 1,824 occurrences for spiders – representing 23% of all database records – show the greatest diversity with 272 species (>21% of the listed species). This diversity is expected to drop slightly during the course of the forthcoming revision of the troglobitic micropholcommatid spiders (pers. comm., M. Rix, 2006), where at present some genera, such as *Micropholcomma*, *Olgania* and *Textricella* have been assigned (or split) into different species on the basis of slight morphological variation and/ or karst area separation. Similarly, at least one of the cave adapted anapid spiders (*Chasmocephalon* sp.) is likely to be re-classified within the Micropholcommatidae (pers. comm., M. Rix, 2006).

The 407 records for the Tasmanian Cave Spider, *Hickmania troglodytes*, indicate this is by far the most frequently documented individual species, with occurrences recorded in over half of the 97 listed cave or karst areas. Similarly, the relatively widespread glow-worm, *Arachnocampa tasmaniensis*, recorded from 33 cave areas and the cave cricket, *Micropathus tasmaniensis*, from 19 areas are the second and third most recorded species. Although often observed in caves, all three of these species are found outside of caves in epigean environments, e.g., old mine adits, under bridges and in some rainforest areas. The sixth most abundant occurring species, the land snail, *Caryodes dufresnii*, recorded from 21 areas, is also an epigean species. Amongst the other most recorded species are two cave troglobites: three varieties of the southern cave harvestman, *Hickmanoxyomma cavaticum*, recorded from Hastings, Ida Bay and North Lune and the carabid cave beetle, *Idacarabus troglodytes*, from Ida Bay. The most abundant occurring aquatic species, *Anaspides tasmaniae*, is recorded from 16 karst areas.

Table 5.1: Overview of the cave and karst invertebrate diversity in Tasmania, listing the most recorded animal groups from database showing their higher taxonomy, number of occurrence records and numbers of species, plus the most abundant occurring cave species of that group with number of records and number of cave areas (sourced from "Major Groups" database Queries)

Group	Higher Taxonomy	Records	Species	Most abundant species	Records	Areas
Spiders	Araneae	1795	273	*Hickmania troglodytes*	407	52
Cave cricket	Orthoptera	706	23	*Micropathus tasmaniensis*	256	19
Harvestman	Opiliones	611	90	*Hickmanoxyomma cavaticum*	174	3
Beetles	Coleoptera	545	128	*Idacarabus troglodytes*	76	1
Land Snail	Pulmonata	520	55	*Caryodes dufresnii*	103	21
Millipede	Diplopoda	475	98	undetermined: spp. indet.	57	15
Hydrobiid snails	Caenogastropoda	442	91	*Nanocochlea* sp., cf .*N. pupoidea*	54	1
Flies (not glow-worms)	Diptera	306	35	uncertain taxonomy	83	33
Glow-worms	Keroplatidae	290	3	*Arachnocampa tasmaniensis*	273	33
Isopod (terrestrial)	Oniscidea	261	26	*Styloniscus* sp. indet.	74	21
Shrimp	Anaspidacea	198	23	*Anaspides tasmaniae*	156	16
Springtail	Collembola	191	62	undetermined: sp. indet.	45	14
Crangonyctoid amphipod	Crangonyctoidea	184	60	? Paramelitidae: sp. indet.	27	13
Oligochaet worm	Oligochaeta	160	34	undetermined: sp. or spp. indet.	52	15
Mites and ticks	Acarina	159	35	undetermined: spp. indet.	31	15
Caddis fly	Trichoptera	97	37	undetermined: spp. indet.	27	11
Pseudoscorpion	Pseudoscorpionida	84	26	*Pseudotyrannochthonius tasmanicus*	14	2
Centipede	Chilopoda	65	17	*Craterostigmus tasmanianus*	16	8

In addition to analyses of cavernicole diversity, studies in biospeleology tend to focus on the ecology of "resident" cavernicoles, describing factors related to the range of physio-chemical attributes of caves and the ecological niche or conservation status of cave invertebrates. Most biospeleological studies relate the presence of cave adapted species: the number of aquatic stygobites and terrestrial troglobites; the results are sometimes used as a measure to show the ecological value or conservation significance of a cave site. Tables 5.2 and 5.3 provide summary lists of the number of confirmed stygobites (Sb) and troglobites (Tb) on the basis of higher order taxonomy and family level classifications; these are shown in bold under their respective column headings along with the possible stygobites/ troglobites and troglophiles (see glossary).

Table 5.2: Families of aquatic groups, listing numbers of confirmed stygobites (Sb) in bold and possible stygobites (Sb?) based on Query 7A, 7H and 7K; Sp = stygophile.

Class or Order	Family	Total	Sb	Sb?	Sp & Sb?	Sp or Sb	Sp or Sb?
	Eusiridae	2					2
	Neoniphargidae	6	**2**				4
	Paramelitidae	28	**16**	1		1	10
	Paramelitidae ?	1					1
	unknown family	2					2
Annelida (aquatic): 1	unknown family	1		1			
Copepoda: 1	Cyclopidae	3	**3**				
Decapoda: 1	Parastacidae	1					1
Gastropoda (aquatic): 38	Hydrobiidae	38	**11**	4	2		21
Isopoda (aquatic): 10	Hypsimetopodidae	1	**1**				
	Janiridae	6	**3**	1			2
	Phreatoicidae	2	**2**				
	Phreatoicidae ?	1	**1**				
Nemertea: 1	unknown family	2		1			1
Ostracoda: 2	Cyprididae	1					1
	Family not determined	1					1
Syncarida: 19	Anaspididae	4	**2**		1		1
	Koonungidae	4	**2**				2
	Parabathynellidae	1	**1**				
	Psammaspididae	10	**9**				1
Turbellaria (aquatic): 2	Planariidae	2	**1**	1			
10 groups: 117 species	**22**	**117**	**54**	**9**	**3**	**1**	**50**

Note that in both tables some of the cave animal species of different family groups are listed as "Sp and/ or Sb" or "Tp and/ or Tb". In most instances, this reflects the lack of taxonomic resolution where similar (but probably different) species, often from different karst areas have been lumped together in one classification, including species that appear to be a stygophile or troglophile in one cave/ karst area and a stygobite or troglobite in another cave or karst area.

Table 5.3: Families of terrestrial groups, listing the numbers of confirmed troglobites (Tb) in bold and possible troglobites (Tb?) based on Query 7A, 7I and 7L; Tp = troglophile.

Class or Order	Family	Total	Tb	Tb?	Tp & Tb	Tp or Tb	Tp or Tb?
Acarina: 2	Family not determined	2				2	
Annelida (terrestrial): 3	Enchytraeidae	2					2
	unknown family	1	**1**				
Araneae: 97	Agelenidae ?	2	**1**				1
	Amaurobiidae	3	**1**	1			1
	Amaurobiidae ?	3	**2**				1
	Amphinectidae	14				3	11
	Amphinectidae ?	1					1
	Anapidae	5	**2**	1			2
	Family not determined	3	**1**				2
	Micropholcommatidae	13	**10**	1			2
	Mysmenidae	5	**4**				1
	Pholcidae	2					2
	Sparassidae	1		1			
	Stiphidiidae	8	**4**			4	
	Stiphidiidae ?	1					1
	Synotaxidae	12	**8**				4
	Tetragnathidae	5				2	3
	Theridiidae	17	**10**		2	2	3
	Theridiosomatidae	2				1	1
Chilopoda: 3	Chilenophilidae	1	**1**				
	Craterostigmidae	1	**1**				
	Craterostigmidae ?	1	**1**				
Coleoptera: 37	Carabidae	35	**26**	6	1		2
	Staphylinidae	2	**1**				1
Collembola: 17	Entomobryidae	2	**2**				
	Family not determined	1	**1**				
	Hypogastruridae	1	**1**				
	Neanuridae	1		1			
	Oncopoduridae	2	**2**				
	Paronellidae	6	**4**				2
	Sminthuridae	4	**2**		1		1
Diplopoda: 24	Dalodesmidae	20	**7**	5			8
	Family not determined	2	**1**	1			
	Haplodesmidae	1	**1**				
	Paradoxosomatidae	1					1

Class or Order	Family	Total	Tb	Tb?	Tp & Tb	Tp or Tb	Tp or Tb?
Diplura: 2	Campodeidae	1					1
	Family not determined	1	**1**				
Hemiptera: 2	Enicocephalidae	1	**1**				
	Fulgoridae ?	1					1
Isopoda (terrestrial): 9	Styloniscidae	9	**4**	1			4
Opiliones: 30	Triaenonychidae	30	**25**	2		2	1
Pauropoda: 1	Family not determined	1					1
Pseudoscorpionida: 18	Chthoniidae	18	**8**	4		3	3
Symphyla: 4	Scutigerellidae	4	**2**				2
Trichoptera: 1	Philopotamidae	1					
15 groups: 250 species	**46**	**250**	**136**	**24**	**4**	**19**	**66**

5.2: Analysis and discussion of cavernicole diversity in Tasmania

In addition to recording cavernicoles on the basis of their ecological dependence and morphological or behavioural adaptation to caves, the diversity of species can be considered simply on the basis of the known taxa in caves. In the following sections, emphasis is placed on those species groups most recently studied and those groups which have the most defined taxonomy or recently described species.

5.2.1. Glow-worms: their phylogeny, genetics and distribution

Glow-worms are one of the species groups currently being studied and although they only have a facultative association with caves, commonly seen in the outer regions, their range extends from the dark zone of caves to epigean rainforest sites exposed to daylight. As described in Section 2.1.1, reports of glow-worms in caves at Mole Creek in the 1840s (Breton 1846) and at Ida Bay in the early 1890s (Anon, 1891b; Morton 1892), represent some of the earliest records of invertebrate cavernicoles in Tasmania. Glow-worms of the genus *Arachnocampa* are the bioluminescent larval form of a dipteran fly (Lloyd, 1971). The larvae construct a mucous tube suspended in a horizontal web of silken threads (Richards 1960; 1964a) and drop snare threads coated with sticky beads or droplets of mucus to ensnare their prey (Lloyd, 1971; Frederikson, 1983; Clarke, 2001b; Baker and Merritt, 2003). The distribution of glow-worms is determined by their sensitivity to desiccation and larvae of *Arachnocampa* rapidly perish when exposed to low relative humidity or excessive air movement; hence they are found only in moist and sheltered habitats such as heavily forested sites in rainforest glades, shaded moist gullies or in caves (Merritt and Baker, 2001; Baker and Merritt, 2003). As shown in Table 5.1, there are 273 records for glow-worms from 33 karst or non-karst areas in Tasmania; these occurrences are all recorded from cave sites (see Query: MAJOR SPECIES OCCURRENCES - Glow-worms). Although an analysis of cave zone region records for Hastings and Ida Bay indicates that some glow-worms are recorded from the inner dark zone regions, most occurrences are restricted to the walls and ceilings in the moist outer regions of caves, adjacent to streamways or in the vicinity of moist airflow.

In a discussion of the New Zealand glow-worm (*Arachnocampa luminosa*) and a review of the known genera and their taxonomy, Pugsley (1983) described the recent proposal for re-classification of *Arachnocampa* by a French entomologist, Loïc Matile, who subsequently transferred the genus from subfamily Keroplatinae (Harrison, 1961; 1966) in Mycetophilidae, to a new sub-family: Arachnocampinae in Keroplatidae, erecting a new super-family Mycetophiloidea (Matile, 1981; 1986; 1989). The re-classification by Matile (1981; 1986; 1990) was made on the basis of larval morphology, the light organ and wing venation in the adults, compared to specimens from the fossil record. Combined with an examination of the biogeographical phylogeny of Keroplatidae in relation to other Diptera (Figure 5.2), Matile (1986; 1990, 1997) was able to show the keroplatids are a relatively ancient and primitive group dating back to the mid-Mesozoic (late Jurassic period). The significance of the monogeneric Arachnocampinae is described by Matile in evolutionary terms, as a species from a predominantly fungivorous (fungus gnat) group evolving to a carnivorous and predaceous species. In discussion of the circum-Tasman distribution of the Arachnocampinae, he describes the "*curious relation of sister groups between Tasmania and New Zealand compared to Australia*". *A. tasmaniensis* and *A. luminosa* are species of sub-genus *Arachnocampa*, both predominantly found in caves; however, on biogeography alone, Matile (1990) shows that *A. tasmaniensis* should be a close relative to the mainland species of the sub-genus *Campara* (Edwards, 1924). To explain the hiatus in a cladogram of Arachnocampinae, Matile proposed that Bass Strait had acted as a dispersal barrier dating back to the Upper Jurassic, before New Zealand and Tasmania became separated from Antarctica and each other during the rupture of Gondwana via the Lord Howe ridge.

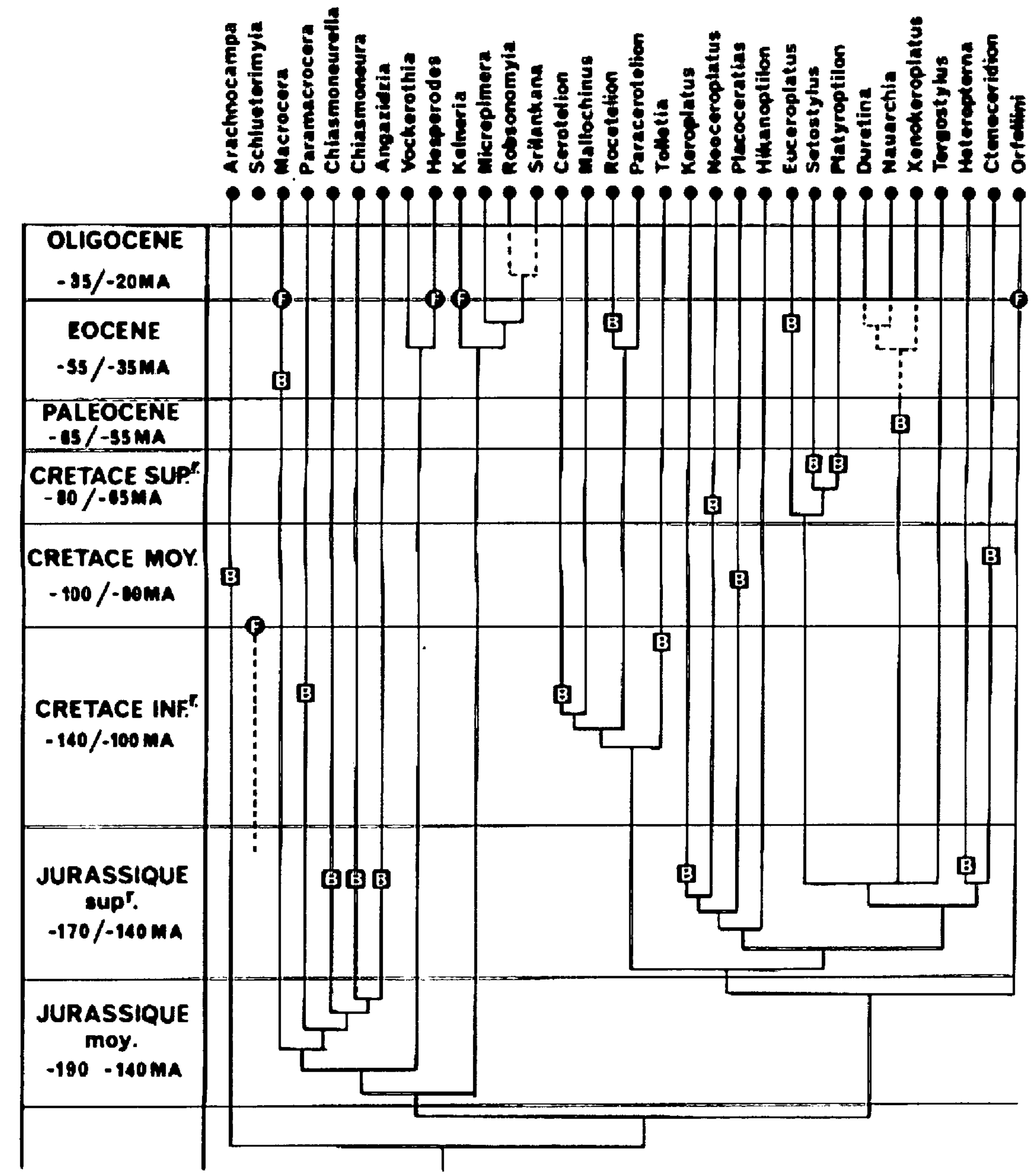

FIG. 1253. — Cladogramme daté des genres de Keroplatidae étudiés. Lettre F dans un cercle : document fossile ; lettre B dans un carré : datation biogéographique.

Figure 5.2: Chronological cladogram from the studies of the genera of Keroplatidae. Letter F in circle: fossil record; letter B in square: biogeographical data from Matile (1990: Figure 1253, p. 602) showing the proposed relationship between Arachnocampa and other genera. Matile proposed that Arachnocampa is the most basal genus within Keroplatidae.

As shown in Figure 5.2, Matile (1990) determined that *Arachnocampa* was basal among the Keroplatidae. Although this determination still stands and is now supported by data from a molecular phylogeny, Matile's assertion that a distribution barrier existed between the Australian mainland and Tasmania has been refuted by the recent discovery of another member of the sub-genus *Arachnocampa* from Mt. Buffalo in northeast Victoria (Baker, 2004). Described as a relict species (D. Merritt, pers. comm., 2005), the "Mt. Buffalo glow-worm" occurs at only one site, in a 300m long granite boulder cave with a permanent stream at an elevation of around 1300m. (It should be noted that there is an unconfirmed report of an isolated population of glow-worms at a slightly lesser elevation in Tasmania, in dolerite caves and/ or near stream trickles underneath boulder fields on Mt. Wellington.)

In addition to re-describing the known species of *Arachnocampa* (including *A. tasmaniensis*) and the sub-genera in Australia, in her molecular phylogeny, Baker (2004) recognised another five regionally isolated groups or clades of *Arachnocampa* from the Australian mainland: one in the wet tropics of northern Queensland, one in northern NSW (*flava* group) and two in Victoria (*richardsae* group), plus the Mt. Buffalo species (see Figure 5.3). Most species are distributed along the flanks of the Great Dividing Range. Phylogenetic analysis of mtDNA gene fragments COII and 16S supported the designated regional clades (Figure 5.3) and the grouping of sub-genus *Arachnocampa* as distinct from and basal to *Campara* (Baker, 2004). Figure 5.3 shows that the two new clades (undescribed 3 and 4) of sub-genus *Campara* (*richardsae* group) in Victoria are geographically closer to Tasmania than the new Mt. Buffalo species (undescribed 5) of sub-genus *Arachnocampa*.

An analysis of the mtDNA gene fragments from cave and rainforest populations in the same region indicates these to be the same species (Baker, 2004). However, there is still some ambiguity and the present writer is assisting in a study to better assess the differences between cave and bush species, collecting specimens in Tasmania for analysis by micro-satellite DNA markers that can reveal population level differences; the technique is frequently used in studies of species migration and gene pool flows (G. Graham and D. Merritt, pers. comm., 2004).

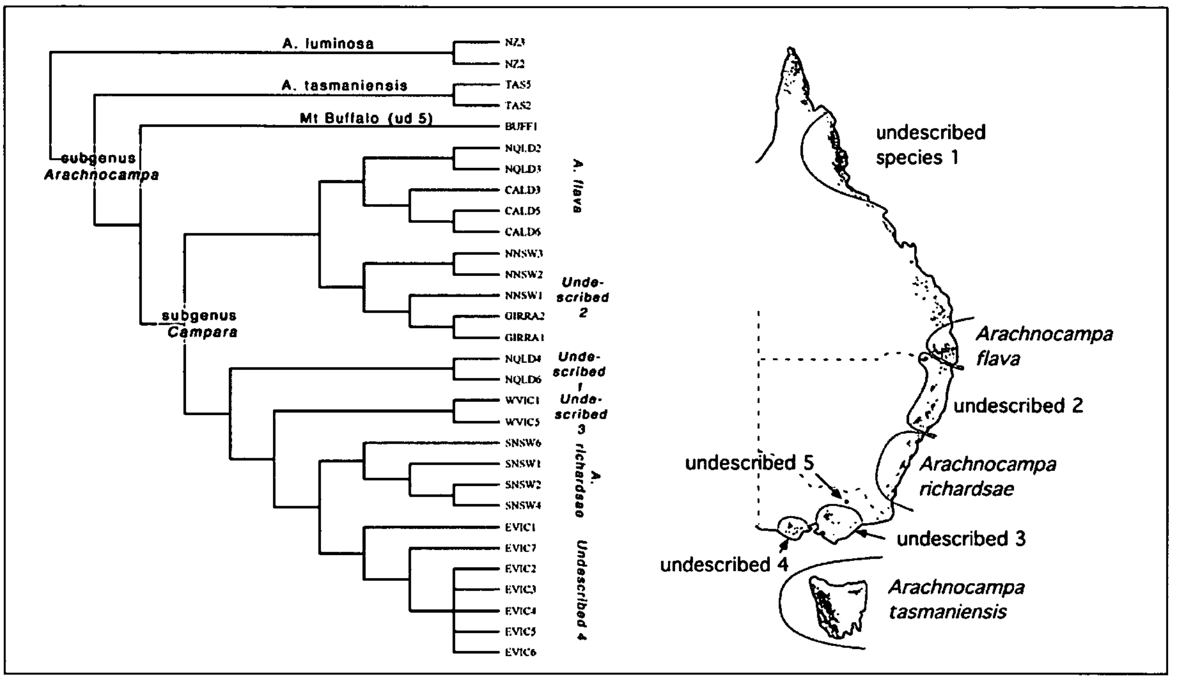

Figure 5.3: Summary of species clades of *Arachnocampa* based on phylogenetic evidence from combined analysis of mitochondrial DNA COII and 16S partial gene fragments, indicating five new undescribed species from mainland Australia (Baker, 2004). Four new species are represented by clades of the *richardsae, flava* and "tropical" groups in the sub-genus *Campara* and one new species ("Mt. Buffalo Glow-worm") in sub-genus *Arachnocampa*; shown in the cladogram, it is closely related to the Tasmanian Glow-worm: *Arachnocampa tasmaniensis*. (Source: Dr. David Merritt, School of Zoology and Entomology, University of Queensland, pers. comm., 2005.)

5.2.2. Cave crickets in Tasmania

The distribution of cave crickets (F. Rhaphidophoridae) in Tasmania has been previously documented by Goede (1972), Eberhard *et al.* (1991) and Eberhard (1992). The four genera in Tasmania are classified as Family Rhaphidophoridae: sub-family Macropathinae: tribe Macropathini. Table 5.1 shows 906 occurrence records for 23 species including several possibly new and undescribed or undetermined species, with *Micropathus tasmaniensis* the most commonly recorded species, occurring in 19 areas of southern and western Tasmania. There are 12 described cave cricket species in Tasmania, and as shown in Table 5.4, *Micropathus tasmaniensis* was one of the first cave-dwelling rhaphidophorids to be described along with *Micropathus cavernicola*, the second most recorded species (Richards, 1964b).

Table 5.4: Alphabetical list by genera of the described species of cave crickets in Tasmania, with species authority, year of publication, Type Locality and number of occurrence records.

Species	Description	Type Locality	Records
Cavernotettix craggiensis	Richards, 1974	Granite Boulder Cave (CI-X1), Craggy Island	10
Cavernotettix flinderensis	Richards, 1967a	Strzelecki Peak Cave (RA-X2), Flinders Island	17
Micropathus cavernicola	Richards, 1964b	Marakoopa Cave (MC-120), Mole Creek	163
Micropathus fuscus	Richards, 1968a	Blooms Cave (GP-4), Gunns Plains	38
Micropathus kiernani	Richards, 1974	Francistown Cave (FR-201), near Dover	18
Micropathus montanus	Richards, 1971a	Virgo Cave (MR-202), Mt. Ronald Cross	23
Micropathus tasmaniensis	Richards, 1964b	Limestone cave (JF-X145), Florentine Valley	256
Parvotettix goedei	Richards, 1968a	Little Trimmer Cave (MC-39), Mole Creek	29
Parvotettix maydenaensis	Richards, 1971a	Rainforest, Nichols Spur, Florentine Valley	11
Parvotettix rangaensis	Richards, 1970	Ranga Cave (RA-X1), Flinders Island	6
Parvotettix whinrayi	Richards, 1974	Main Cave (EI-X1), Erith Island, (Kent Group)	11
Tasmanoplectron isolatum	Richards, 1971b	Un-named sea cave , Tasman Peninsula	2

Fifty years ago, very little was known on cave cricket biology, their distribution or ecological dependence on caves; Aola Richards had just commenced her study on New Zealand species (Renwick, 1958). Within a decade of Renwick's paper, five species had been described from Tasmanian caves (Richards, 1964b; 1967a; 1968a) and other papers detailed aspects of their biology, foraging behaviour and ecology in caves (Hamilton-Smith, 1967; Richards, 1967b; 1968b). Two of these manuscripts lead to an on-going debate regarding the cavernicolous status of rhaphidophorid species, with publication of supporting statements for the notion that cave crickets are trogloxenes (Hamilton-Smith, 1971) countered by Richards (1968b; 1971d) who insisted they were troglophiles, but also records species from epigean habitats and mine adits (Richards, 1970, 1971a). The views of Hamilton-Smith concur with the comments by Mesa (1970), shared by cave biologists such as Hüppop (1985) who studied the metabolic rates of terrestrial cave species, showing that trogloxenes such as cave crickets, have a metabolism similar to epigean species.

In studies of the chromosome cytogenetics, karyology and phylogeny of the Macropathinae from Tasmania, the Australian mainland and New Zealand, Mesa, *et al.*, (1968, 1969) and Mesa (1970) report that most so-called cave species are commonly found at surface sites. In studies of the known Tasmanian species (excepting *Cavernotettix flinderensis*), Mesa *et al.*, (1968; 1969) and Mesa (1970) reported on *Micropathus tasmaniensis, M. cavernicola* and *M. fuscus* collected from caves at Hastings, Mole Creek and Gunns Plains respectively, plus the records for *Parvotettix goedei* taken from a variety of surface sites in forests, widely distributed in the northwest, south and east of Tasmania (Mesa *et al.*, 1969; Mesa, 1970).

Although Mesa (1970) records the presence of cave adapted species from several karst areas in SE Asia, as a result of extensive collecting and examination of cave cricket habitats, he concludes that the Tasmanian macropathines are surface species. From his PhD study, Mesa (1970) states: "*the fact that the earlier entomologists collected species mainly in caves, where they are more conspicuous because of the high density of population, gives the wrong impression that these insects are predominantly cave inhabitants. After six months of fieldwork, both in Australia and New Zealand, I am now convinced that these insects are mainly forest inhabitants, the percentage of the total population living actually in caves being relatively small. Moreover, the caves do not play any role in speciation since their populations are always mixing with the "outside" specimens. They are however conceivably of some role in speciation during glaciation periods when groups of insects could have been isolated for long periods of time inside the caves.*" (Mesa, 1970: p. 121).

5.2.3. Land snails from caves or karst surfaces

Land snails appear to be very common in karst areas, possibly reflecting the availability of calcium. Cave entrances preserve high numbers of dead snails, suggesting the better conditions for preservation in a sheltered and non-acidic site. Several karst surface sites appear to have vast numbers of dead snails, often located under rocks, and away from cave entrances, e.g., Bubs Hill, the Hastings karst, along the Mystery Creek Cave track at Ida Bay, at Precipitous Bluff and at Mt Cripps (Bonham, 2003). It is unclear whether the prevalence of land snails relates to improved preservation conditions under limestone compared to other geology, or if it reflects a lower rate of shell calcium recycling by living snails in an environment where calcium can be obtained directly from the rocks, or both.

Table 5.1 shows 520 records for 55 land snail species, with 103 records for *Caryodes dufresnii* from 21 areas; the three sub-species of *Caryodes dufresnii* in Kershaw (1989) are listed as one species. Several other species have wide ranging distribution including *Helicarion cuvieri* from 11 cave and karst areas, with *Pernagera kingstonensis*, *Stenacapha hamiltoni* and *Tasmaphena sinclairi* each recorded from nine karst areas. In a study of the biogeography and systematics of Tasmanian *Pernagera* land snails, Bonham (1997) noted species in several karst areas, but none that could be considered as karst endemics. Frequent high local endemism of land snail species occurs in mainland (Australian) karst areas and in a more recent study, Bonham (2003) has determined significant local endemism in three southern Tasmanian karsts: Hastings, Ida Bay and Precipitous Bluff.

In his recent thesis detailing the biogeography of Tasmanian land snails, incorporating records and/ or collections made by this present author, Stefan Eberhard and Albert Goede, Bonham (2003) has determined the presence of several new species, from cave entrances and karst surfaces in southern Tasmania (Table 5.5). Two of the species (*Geminoropa* sp. "Hastings" and *Allocharopa* sp. "Victoria Valley") are predominantly known from cave entrances and Bonham (pers. comm., 2005) suggests the *Geminoropa* species seen actively crawling inside the entrance gate to Newdegate Cave at Hastings could be a cave entrance specialist. Most of these new species recorded from karst areas are herbivorous charopids that feed on decaying leaf matter, fungi, moss, lichen etc. but the new *Prolesophanta* species recorded at from Precipitous Bluff is a carnivorous rhytidid. Another new charopid species (*Roblinella* sp. "Bubs Hill") is recorded from caves at Bubs Hill and a single live snail of the described charopid: *Bischoffena bischoffensis* is recorded from a karst surface at Mt. Cripps in NW Tasmania (Bonham, 2003).

Table 5.5: New undescribed land snail species (including local karst endemics) with limited distributions, recorded from caves or karst surfaces in southern Tasmania (sourced from Bonham, 2003); H = Hastings, IB= Ida Bay; JF = Junee-Florentine, NL = North Lune; PB = Precipitous Bluff.

Family	Genus species name	Caves	Surface	Conservation Status
Charopidae	Allocharopa sp. "Junee"	JF	JF	Rare: local endemic, secure
Charopidae	Allocharopa sp. "Victoria Valley"	JF		Rare: local endemic, secure
Charopidae	Roblinella sp. (cf. curaocae?)	PB	PB	Rare: local karst endemic
Charopidae	Geminoropa sp. "Hastings"	H, NL	PB	Rare: local karst endemic
Charopidae	Allocharopa sp. "Mystery Creek"		IB	Rare: local karst endemic
Charopidae	Roblinella sp. "Mystery"		IB	Rare: local karst endemic
Charopidae	Allocharopa sp. "Quarry"		IB	Rare: local karst endemic
Charopidae	Geminoropa sp. "Moonlight"	H, NL	H, IB	Common
Rhytididae	Prolesophanta sp. "Francistown"	PB	H, IB, PB	Uncommon: local endemic, secure

5.2.4. Collembola in caves

Table 5.1 indicates there are 62 species of springtails (Collembola) known from caves or karst surfaces in Tasmania. However, barely a handful are described and none of the cave dwelling collembola have been precisely defined to species level, though there is at least one new troglobitic genus (Figure 5.4) and two or more species recorded from caves in southern Tasmania; two of these new species, including the specimen in Figure 5.4, are described as highly troglobitic (Greenslade, *et al.*, 2002).

Figure 5.4: Undescribed species of troglobitic springtail collected in rotting staircase timber mulch in the dark zone of Newdegate Cave at Hastings. Approximately 3.5 - 4.0mm long, this cave dwelling springtail is a possible new species of *Trogolaphysa*, or a new genus (pers. comm., P. Greenslade, 2002). Note, the long tapered "springing" organ extending from rear of the abdomen.

Eight families are represented amongst the 17 obligate (troglobiont) species of collembola, listed in Table 5.6 (overleaf). Some troglobitic species are fungivores and often only recorded from one cave, or cave area. The troglobitic species of Oncopoduridae, Paronellidae and Sminthuridae are considered to be phylogenetic relicts (Greenslade, pers. comm., 1996). In analysis of the latitudinal gradients in taxon composition in cave regions from north to south throughout Australia, Greenslade (2002) notes the southernmost fauna being dominated by a diverse group of cool, moisture loving species of Gondwanan origin, many of which are endemic, whereas the lower diversity tropical fauna of northern latitudes includes a later incursion of Asian species. It is suggested that *Adelphoderia*, found in the leaf litter of humid forests replaces *Arrhopalites* in southern latitudes (Greenslade, 2002), though both genera occur in Tasmanian caves. Recorded by Greenslade as Sminthuridae, these two genera are respectively re-assigned to Spinothecidae and Arrhopalitidae in the database (see Table 5.6). A new genus of cave dwelling springtail (F. Brachystomellidae) in southern Tasmania is recorded by Greenslade (2002) based on a determination by John Ireson, for a species collected from a cave on Ile de Golfe (pers. comm., P. Greenslade).

Table 5.6: List of the troglobiont (cave obligate) collembola ordered by family including troglobitic species, from single cave or multiple cave sites in Tasmania. (Higher order taxonomy sourced from Bellinger, P.F., Christiansen, K.A. and Janssens, F. 1996-2005. *Checklist of the Collembola of the World*. http://www.collembola.org)

Family, Sub-family and tribe	Genus	Cave or cave area	Ecology
Arrhopalitidae	Arrhopalites sp. nov.	FG, JF	Tp or Tb?
Entomobryidae	undetermined: Gen. undet., sp. indet.	Newdegate Cave (H-1)	Tb
Entomobryidae: Entomobryinae: Entomobryini	Sinella (Coecobrya) sp.	JF, VF	Tb
Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Pseudosinella sp.	E, H	Tp or Tb?
Hypogastruridae	Ceratophysella sp. cf. denticulata	Cashion Creek Cave (JF-6)	Tb
Neanuridae: Pseudachorutinae	Anurida sp.	FG	Tb?
Oncopoduridae	Oncopodura sp.	IB, MC, MR, VF	Tb
Paronellidae: Cremastocephalini	Paronellides sp., cf. dandenongensis	IB, JF	Tp or Tb?
Paronellidae: Cremastocephalini	Paronellides sp., cf. mjobergi	Newdegate Cave (H-1)	Tp or Tb?
Paronellidae: Troglopetinae: Troglopedetini	Gen. et sp. nov. 1	Arthurs Folly (IB-110)	Tb
Paronellidae: Troglopetinae: Troglopedetini	Gen. et sp. nov. 2	H, IB, L, PB	Tb
Paronellidae: Troglopetinae: Troglopedetini	? Trogolaphysa sp. nov.	Newdegate Cave (H-1)	Tb
Sminthuridae	undetermined: Gen. undet., sp. indet.	MC	Tb
Spinothecidae: Spinothecinae	Adelphoderia sp. or spp. nov.	F, JF, L, MC, PB, WE	Tp and Tb

5.2.5. Multipedes (centipedes, millipedes, symphylans, pauropods and onychophorans) from caves or karst areas

The known and described multipede species in Tasmania are listed on the Queen Victoria Museum (QVM) website, in a section compiled by Dr. Robert Mesibov, who describes the word "multipede" as an old term used 260 years ago by Charles Owen and others (see http://www.qvmag.tas.gov.au/zoology/multipedes/mulintro.html). In his treatise on snakes, Owen (1742) uses the word "multipedes" to describe the "serpent-like" centipedes and millipedes. The term is more or less synonymous with "myriapoda", encompassing those invertebrates with "many legs" or "feet". In taxonomy, myriapoda is used as a classification for centipedes, millipedes, symphylans and pauropods, whereas the term multipedes can be used to cover all the myriapoda, plus velvet worms (Onychophora); all these groups are found in Tasmanian caves.

Like a number of other predominantly endogean or soil litter species including springtails and isopods, many of the multipedes are pre-adapted to cave life and can be described as eutroglophiles (Stoch, 2001). Centipedes are occasionally found in caves and there are three possibly cave adapted species associated with flood litter in riparian habitats in the inner zone of several caves. Two species of Craterostigmomorpha are known, an undescribed species from Exit Cave (IB-14) at Ida Bay and as recorded by Eberhard *et al*, (1991) an apparent cave ecotype of *Craterostigmus tasmanianus* (Craterostigmidae) from The Chairman (JF-99), a cave in the Junee-Florentine karst. Similarly, a cavernicolous form of *Tasmanophilus* (Chilenophilidae) is known from caves in the Bubs Hill, Franklin River, Ida Bay, Mole Creek, Trowutta and South Loddon karst areas. The most common multipede in caves are the millipedes (Diplopoda); an indication of their diversity and distribution is shown in Table 5.7. Although most millipedes occur as accidentals or possibly trogloxenes, there are a number of cave adapted species including the two recently described troglobites: *Atlalopharetra eberhardi* from Precipitous Bluff and *Atlalopharetra clarkei* (Figure 5.5) from Ida Bay (Mesibov, 2005) and several undescribed species from Acheron River, Bubs Hill, Gunns Plains, Junee-Florentine, Mount Cripps, Mount Wellington and Risbys Basin.

Figure 5.5: Recently described troglobitic dalodesmid millipede (*Atalopharetra clarkei* Mesibov, 2005) on moist boulder in riparian habitat beside stream in Base Camp Tributary passage, Exit Cave, Ida Bay; this specimen is approx. 2cm long.

The first record of a pauropod in a Tasmanian cave was recently collected by the present writer in the higher upper levels of a cave at Ida Bay; the specimen has not been formally identified. Shown on the QVM website, the pauropods (Pauropoda) and symphylans (Symphyla) share many of the structural features of smaller Chilopoda; however the anatomy of symphylans suggests a likeness to the millipedes (Diplopoda), but with long antennae. Eberhard (1992) records symphylans from several caves and Scheller (1996) has described a new troglobitic species: *Hanseniella magna* (Figure 5.6), known from limited collections and sightings in three caves at Hastings and only sighted once since 1991.

Figure 5.6: Troglobitic symphylan (*Hanseniella magna*), from Wolf Hole at Hastings in southern Tasmania; approximately 1.3cm long (excluding antennae). *Hanseniella magna* was described by Scheller (1996) as the largest known species of Symphyla.

Also referred to as "velvet worms" the onychophorans, (more popularly known as peripatus), located near cave entrances are epigean forest dwelling species, including the Blind Velvet Worm (*Tasmanipatus anophthalmus*) found on limestone karst surfaces in northeastern Tasmania (Mesibov, 1987; 1988; 1997). Considering its likeness to a cave dwelling troglobite, the presence of the pure white and eyeless Blind Velvet Worm (Figure 5.7) is enigmatic, because it has not been recorded from nearby caves on the slopes of Mt. Elephant, near Gray (Eberhard and Eberhard, 1989). Since discovery in 1987, when limited to a few karst and non-karst areas, the Blind Velvet Worm is now recorded from a much wider area adjoining the karst with a known extent of ca. 140 sq. km. (pers. comm., Bob Mesibov). However, it remains the subject of some speculation by cavers and field naturalists, wondering if it may have evolved on land surfaces from subterranean origins.

Figure 5.7: The Blind Velvet Worm (*Tasmanipatus anophthalmus*), approx. 4cm long, found on or near karst surfaces in northeast Tasmania, but not known from caves. (Sourced from QVM Tasmanian Multipedes site: http://www.qvmag.tas.gov.au/zoology/multipedes/tasonych/onytaano.html)

Table 5.7: Biodiversity and distribution of millipedes from caves and surface karst sites in Tasmania, listing described species, known genera and new undescribed "coded" species, showing ecological status as introduced, epigean, accidental (Acc), trogloxenes (Tx), troglophiles (Tp) or troglobites (Tb); see appendix 9.1.1 for list of codes for the cave or surface karst areas. (The writer gratefully acknowledges the assistance and support of Dr. R. Mesibov, Honorary Research Associate with QVM and the School of Zoology at University of Tasmania, in his determinations of millipedes.)

Family	Species	Ecology	Cave	Surface
Dalodesmidae	"19aa" (unpublished)	Tp?	AR	
Dalodesmidae	"19bb" (unpublished)	Tb?	H	
Dalodesmidae	"19p" (unpublished)	Tb	JF	
Dalodesmidae	"19Y" (unpublished)	Tp?	IB, RB	
Dalodesmidae	"19Z" (unpublished)	Tp or Tb?	IB, UW	
Dalodesmidae	"A2" (unpublished)	Tb	WE	
Siphonotidae	"Acu mes" (unpublished name)	Epigean	IB, WE	JF, JR
Dalodesmidae	"Cave" genus, sp. indet	Tb	BH, CP, GP, JF	
Siphonotidae	"Het aus" (unpublished name)	Epigean	MC	
Dalodesmidae	"Lis ana" (unpublished name)	Acc or Tx?	SR, T	
Dalodesmidae	"Lis cor" (unpublished name)	Acc or Tx?		AR, F
Dalodesmidae	"Lis dev" (unpublished name)	Acc or Tx?		MC
Dalodesmidae	"Lis lat" (unpublished name)	Acc or Tx?	BH, CP, GP, L, T, WL	CP
Siphonotidae	"Sip ins" (unpublished name)	Epigean		H, JF, JR
Siphonotidae	"Sip sex" (unpublished name)	Acc or Tx?	H, IB	
Siphonotidae	"Sip tas" (unpublished name)	Acc or Tx?		F, JF
Iulomorphidae	Amastigogonus sp.	Acc?	CP	
Haplodesmidae	Asphalidesmus sp. 1	Tp	IB	
Haplodesmidae	Asphalidesmus sp. 2	Tp	IB	

Family	Species	Ecology	Cave	Surface
Haplodesmidae	Asphalidesmus sp. 3 (including sp. "E")	Tp	F, IB, LA. LM, NL, NR, VF	
Haplodesmidae	Asphalidesmus sp. 4 (sp. "J")	Tb?	VF	
Haplodesmidae	Asphalidesmus sp. 5	Tp?	NL	
Haplodesmidae	Asphalidesmus leae Silvestri, 1910	Acc or Tx?	T	JR
Haplodesmidae	Asphalidesmus parvus (Chamberlin, 1920)	Acc or Tx?	IB, PB	IB
Dalodesmidae	Atalopharetra bashfordi Mesibov, 2005	Acc		H
Dalodesmidae	Atalopharetra clarkei Mesibov, 2005	Tb	IB	
Dalodesmidae	Atalopharetra eberhardi Mesibov, 2005	Tb	PB	
Dalodesmidae	Atalopharetra johnsi Mesibov, 2005	Tp?	F, IB, PB	HC, IB
Dalodesmidae	Atalopharetra sp. 1	Tp or Tb?	IB	
Dalodesmidae	Atopodesmus sp.	Epigean	BH	
Dalodesmidae	Atrophotergum "sp. nov. 2"	Tx?	WE	
Dalodesmidae	Atrophotergum silvaticum Mesibov, 2004	Tx?	MC	
Metopidiotrichidae	Australeuma mauriesi Shear and Mesibov, 1997	Epigean		JF
Metopidiotrichidae	Australeuma simile Golovatch, 1986	Epigean		CP
Blaniulidae	Blaniulus guttulatus (Fabricus, 1798)	Introduced	GP	
Polydesmidae	Brachydesmus superus Latzel, 1884	Introduced	FG	FG
Dalodesmidae	Bromodesmus rufus Mesibov, 2004	Epigean	CP	
Blaniulidae	Choneiulus palmatus (Nemec, 1895)	Introduced	GP	
Julidae: Julinae	Cylindroiulus latestriatus (Curtis, 1845)	Introduced	FG	
Dalodesmidae	Dasystigma huonense Mesibov, 2003	Epigean		IB
Dalodesmidae	Dasystigma margaretae (Jeekel, 1984)	Acc	JF	
Dalodesmidae	Dasystigma sp.	Epigean	L	
Dalodesmidae	Dasystigma tyleri Mesibov, 2003	Epigean		AR, WM
Dalodesmidae	Gasterogramma sp.	Epigean ?	BH, CP, L, T	BH, JR, MC, RB
Dalodesmidae	Gasterogramma extremum Mesibov, 2003	Epigean		H
Dalodesmidae	Gasterogramma psi Jeekel, 1982	Epigean	BH, CP, GP, JF, L, T	BH, CH, CP, JR, LL, MC
Dalodesmidae	Lissodesmus sp.	Acc or Tx?	BH, GP, L, LM, MC, NR	
Dalodesmidae	Lissodesmus sp. (cf. L. margaretae)	Acc or Tx?	IB	
Dalodesmidae	Lissodesmus alisonae Jeekel, 1984	Epigean		MC
Dalodesmidae	Lissodesmus modestus Chamberlin, 1920	Tx or Tp	BH, H, IB, PB	H
Dalodesmidae	Lissodesmus perporosus Jeekel, 1984	Tp?	BH, GP, MC, T	BH, CP, JR, MC
Dalodesmidae	Lissodesmus sp. nov. A	Acc or Tx?	MC	
Metopidiotrichidae	Neocambrisoma cachinnus Shear and Mesibov, 1997	Acc?	L	
Metopidiotrichidae	Nesiothrix sp.	Epigean	MA	
Metopidiotrichidae	Nesiothrix tasmanica (Golovatch, 1986)	Epigean		IB
? Dalodesmidae	Paredrodesmus sp.	Tp?	H, MC	MC, RB
? Dalodesmidae	Paredrodesmus bicalcar Mesibov, 2003	Tp?	PB	LL
? Dalodesmidae	Paredrodesmus taurulus Mesibov, 2003	Tp?	MC	MC
Peterjohnsiidae	Peterjohnsia titan Shear and Mesibov, 1994	Epigean ?	CP, L	
? Dalodesmidae	Procophorella innupta Mesibov, 2003	Tp?		CP, MC, SR
Sphaerotheriidae	Procyliosoma leae Silvestri, 1917	Tx?	JF	
Sphaerotheriidae	Procyliosoma sp.	Tx?	DW, IB, MA, PB	IB, MC, PB, RB
Metopidiotrichidae	Reginaterreuma tarkinensis Shear and Mesibov, 1995	Acc or Tx?	BH, CP, L, T	JR
Paradoxosomatidae	Somethus sp.	Acc	T	CH, MC, MU
Paradoxosomatidae	Somethus sp. nov. 1	Acc	MC	MC
Paradoxosomatidae	Somethus sp. nov. 2	Acc		JR
Dalodesmidae	Tasmaniosoma sp.	Tb	JF	
Dalodesmidae	Tasmaniosoma sp. 2	Acc? or Tx		MC
Dalodesmidae	Tasmaniosoma sp. 4	Tp or Tb?	E	
Dalodesmidae	Tasmaniosoma sp. 10	Tp or Tb?		H
Dalodesmidae	Tasmanodesmus hardyi (Chamberlin, 1920)	Tp	GP, JF, RO	TP
Dalodesmidae	Tasmanodesmus sp. = "sp. H"	Tp?	BH	

5.2.6. Amphipods and isopods

No cave dwelling or cave limited terrestrial amphipods (Talitroidea) occur in Tasmania, but several species documented by Friend and Richardson (1986) are found in litter near cave entrances. Three species not listed in Eberhard (1992) are recorded from karst surface sites: *Arcitalitrus sylvaticus* from Precipitous Bluff, *Austrotroides longicornis* from Hastings and *Mysticotalitrus cryptus* from Hastings, Ida Bay and Precipitous Bluff (Table 5.8).

Table 5.8: Diversity and distribution of terrestrial (talitrid) amphipods from Tasmanian cave and karst surface areas.

Family	Genus species name	Ecology	Cave area	surface
Talitridae	Austrotroides longicornis	Acc		H
Talitridae	Keratroides ?vulgaris	Epigean		MC
Talitridae	Keratroides angulosus	Acc	G, GP, IB, PB	MC
Talitridae	Keratroides sp. or spp. indet.	Acc?	CP, GP, IB, L, MC	
Talitridae	Keratroides vulgaris	Acc	BH, IB, L, NL, TC, UW, WE	H, JF, MC, PB
Talitridae	Mysticotalitrus cryptus	Acc		H, IB, PB
Talitridae	Neorchestia plicibrancha	Acc	F	H, IB, PB
Talitridae	Talitrus sylvaticus	Acc		PB
? Talitridae	Gen. undet., sp. indet.	Acc?	C, F, GP, L	

Knott (1985) described the aquatic amphipod taxonomy being in "a state of flux". Of the 60 crangonyctoid species recorded from Tasmanian cave or karst areas, a third of them obligate stygobionts restricted to one cave or karst hydrology, most species are undescribed. Several new stygobionts from NSW have been described (Bradbury and Williams, 1997a; 1997b) along with "stygo-amphipods" from subterranean groundwater in Western Australia and South Australia (Bradbury and Williams, 1997b, 1999; Bradbury, 2000; Bradbury and Eberhard, 2000). Table 5.9 shows the distribution and diversity of aquatic amphipods from cave and surface karst sites, including a new blind stygobiont from Gunns Plains, which is currently being described (Clarke and Knott, 2006, in prep.). The species from Tasmania are dominated by *Antipodeus*, mostly undescribed (e.g., Figure 5.8).

Figure 5.8: New undescribed species of *Antipodeus* (Paramelitidae), approx. 1.2cm long, collected under a streambed cobble in Loons Cave at Ida Bay, found sharing the same micro-habitat as the phreatoicid isopod in Figure 5.9. In similarity with other stygobiont crangonyctoid amphipods, it is depigmented and spinose.

Almost half the Tasmanian cave species belong to the genus *Antipodeus*, exemplifying the considerable character variation amongst subterranean amphipods, whose morphology is described as "plastic" (Knott, pers. comm., 2005). This is supported by recent allozyme studies of *Antipodeus* species indicating over 20 new species from about 20 sites (Bradbury, pers. comm., 2002). Most Tasmanian species are paramelitids (*Antipodeus*, *Austrochiltonia*, *Austrogammarus*, *Giniphargus* or nr. *Hurleya*) occurring in northern, western and southern Tasmania (Williams, 1974), with the neoniphargids (*Neoniphargus* sp.) mainly in the north-west and the few eusirids (*Paraleptamphopus*) restricted to the dark zone of caves in western Tasmania. There are three exceptions: a paramelitid species (nr. *Hurleya*) recorded from Rum Pot at Gray in eastern Tasmania and two unconfirmed identifications based on museum records listing an unidentified neoniphargid and a new species of *Austrocrangonyx* (Paramelitidae), both recorded from Exit Cave at Ida Bay.

Table 5.9: Distribution and diversity of aquatic amphipods (Amphipoda: Gammaridea: Crangonyctoidea) from cave and surface areas karst area sites in Tasmania.

Family	Genus species name	Ecology	Cave area	surface
Paramelitidae	"Ant bla" (unpublished)	Sb	GP	
Paramelitidae	? Antipodeus "sp. nov. A"	Sp or Sb?	JF	
Paramelitidae	? Antipodeus "sp. nov. B"	Sb	IB	
Paramelitidae	? Giniphargus sp. 2	Sb	CP	
Neoniphargidae	? Neoniphargus sp.	Sp or Sb?	IB	
Paramelitidae	? nr. Hurleya sp. indet.	Sb?	G	
Paramelitidae	? nr. Hurleya sp. A	Sb	L, LA, MU, T	
Paramelitidae	? nr. Hurleya sp. B	Sp or Sb?	IB	
Paramelitidae	? nr. Hurleya sp. B?	Sp or Sb?	NR	
Paramelitidae	? nr. Hurleya sp. C	Sp or Sb?	AR	
Paramelitidae	? Protocrangonyx sp.	Sb?	IB	
Paramelitidae	Antipodeus ?"franklinii"	Sp	JF, UW	
Paramelitidae	Antipodeus "franklinii" (1)	Acc?	IB	
Paramelitidae	Antipodeus "sp. nov. A"	Sp?	BH, C, IB, JF, L	JF
Paramelitidae	Antipodeus "sp. nov. B"	Sp	JF	
Paramelitidae	Antipodeus "sp. nov. C"	Sp or Sb?	BH	
Paramelitidae	Antipodeus "sp. nov. C"	Sb	VF	
Paramelitidae	Antipodeus "sp. nov. D"	Acc or Sp?	IB	
Paramelitidae	Antipodeus "sp. nov. E"	Sp or Sb?	H	
Paramelitidae	Antipodeus "stygobiont 1"	Sb	PB	
Paramelitidae	Antipodeus "stygobiont 2"	Sb	MW	
Paramelitidae	Antipodeus "stygobiont 2a"	Sb	MC	
Paramelitidae	Antipodeus "stygobiont 2b"	Sb	IB	
Paramelitidae	Antipodeus "stygobiont 3"	Sb	JF	
Paramelitidae	Antipodeus "stygobiont 4"	Sb	JF	
Paramelitidae	Antipodeus "stygobiont 5"	Sb	C	
Paramelitidae	Antipodeus "stygobiont" cf: A. wellingtoni	Sb	JF	
Paramelitidae	Antipodeus antipodeus (Smith, 1909)	Sp	MC	
Paramelitidae	Antipodeus franklinii	Sp?	BH, NR	
Paramelitidae	Antipodeus or Gen. nov., sp. nov. (1)	Sp or Sb?	MC	
Paramelitidae	Antipodeus or Gen. nov., sp. nov. (2)	Sp or Sb?	IB	
Paramelitidae	Antipodeus sp. or spp.	Sp?	JF, L, MC, RB	
Paramelitidae	Antipodeus sp., cf. ("humungus")	Epigean	JF	
Paramelitidae	Antipodeus sp., cf: "A. wellingtoni"	Sp or Sb?	MR	
Paramelitidae	Antipodeus sp., nr. A. franklinii	Sp?	IB	
Paramelitidae	Austrochiltonia australis	Sp	MC, T	H
Paramelitidae	Austrocrangonyx sp. 2	Sb	IB	
Paramelitidae	Austrogammarus sp.	Acc?	GP, JF, L, NR	GP, L
Paramelitidae	Austrogammarus sp. (1)	Sp?	MC	
Paramelitidae	Austrogammarus sp. (2)	Sb?	GP	
Paramelitidae	Austrogammarus sp. A	Acc or Sp?	F	F
Paramelitidae	Austrogammarus sp. B	Sp or Sb	LM	
Paramelitidae	Austrogammarus sp., near "A. smithi 2"	Acc?	SR	
Paramelitidae	Austrogammarus sp., near "A. smithi"	Sp or Sb	GP, LA	L
Paramelitidae	Austrogammarus sp., not "A. smithi 1"	Acc or Sp?	L	
Paramelitidae	Austrogammarus sp., not "A. smithi 2"	Acc or Sp?	L, LA	

Family	Genus species name	Ecology	Cave area	surface
Paramelitidae	Austrogammarus sp., not "A. smithi"	Acc or Sp?	GP	
Paramelitidae	Giniphargus sp. ("not G. pulchellus")	Sb	NR	
Neoniphargidae	Neoniphargus sp. 1	Sp?	L	
Neoniphargidae	Neoniphargus sp. 2	Sp or Sb?	CP	CP
Neoniphargidae	Neoniphargus sp. nov. 1 (D)	Sb	D	
Neoniphargidae	Neoniphargus sp. nov. 2 (BH)	Sp or Sb?	BH	
Neoniphargidae	Neoniphargus sp. nov. 3 (BH)	Sb	BH	
Neoniphargidae	Neoniphargus sp. nov. 4 (NR)	Sp or Sb?	NR	
Eusiridae	Paraleptamphopus sp. 1 (LA)	Sp or Sb?	LA	
Eusiridae	Paraleptamphopus sp. 2 (F)	Sp?		F
? Paramelitidae	undetermined: Gen. undet., spp. indet.	Sp?	BH, C, GP, H, IB, JF, L, MC, N, PB	CH, KS, L, VF
? Paramelitidae	undetermined: Gen. undet., sp. indet. 1	Sp or Sb?	IB	
? Paramelitidae	undetermined: Gen. undet., sp. indet. 2	Sp or Sb?	IB	
Eusiridae	undetermined: Gen. undet., sp. indet.	Sp?	LA	

41 species of isopods are recorded in the database: 14 aquatic species belonging to two suborders, Phreatoicidea (Knott, 1986; Wilson, 2001) and Asellota (Coineau, 1986; Wilson, 1994, 2001; Wilson and Wägele, 1994) and 27 terrestrial species; 25 of the latter are listed in Table 5.10. Although recorded in the database as "phreatoicid isopods", eight species of Phreatoicidea are known from two family groups: Hypsimetopodidae and Phreatoicidae, including preliminary descriptions of an undescribed phreatoicid genus (nr. *Crenoicus*) from Mersey Hill Cave (Knott, 1975; 1985); with its *nomen nudum* (or *nomen dubium*) name given in Knott (1986) and two species of *Phreatoicoides*: sp. "A" from Acheron River Cave and sp. "B" from Trowutta Caves (Wilson and Keable, 2002; Wilson and Edgecombe, 2003). At least three, possibly four, are undescribed troglobitic species (stygobites): a phreatoicine from Mt. Weld, at least one new paraphreatoicine from Mole Creek (see Figures 1.21 and 5.9) and a hypsimetopine from Trowutta. Many hypsimetopines are essentially pre-adapted cave species, living and burrowing in saturated sediment where they have evolved cave-like morphologies. Two of the undescribed cave phreatoicids are stygophiles, one from Acheron River and one from Ida Bay; with an additional species from Loons Cave at Ida Bay (Figure 5.9) that may possibly be a cave ecotype of an epigean species of Mesacanthotelsoninae (*Colubotelson* or *Metaphreatoicus*). In his discussion on the distribution and phylogeny of groundwater dependent isopod crustaceans in Australia, Wilson (2001) records *Colubotelson* as a common groundwater species in Tasmania, known from several "flocks".

The remaining aquatic isopods are the janirid Asellota, particularly *Heterias*, another ancient Gondwanan isopod with species also found in South America (Wilson, 2001). From amongst the new subterranean species or cave ecotypes of genus *Heterias* in Tasmania, four are recorded as stygobites and two lumped species groups include stygophiles or stygobites; four of the six janirid species occur in caves at Ida Bay.

Figure 5.9: Probable cave ecotype of an epigean mesacanthotelsonine phreatoicid isopod, from the dark zone of Loons Cave at Ida Bay, found underneath the same streambed cobble as the paramelitid (shown in Figure 5.8); approx.1.4cm long.

Figure 5.10: Male specimen of a new genus of paraphreatoicine phreatoicid from a cave at Mole Creek. Collected by the writer in May 2004 (see Figure 1.21), this new undescribed stygobiont species has a restricted habitat, presently only known from one cave site. [Photo by GDF Wilson, Australian Museum, Sydney.]

Several species of terrestrial isopods (Onisicidea) have been determined and recorded from Tasmanian caves (Green, 1963; 1971; 1974; 1988; 1996). Their taxonomy remains unchanged since their subterranean distribution was provided by Eberhard *et al.* (1991) who record the dominance of *Styloniscus* species including troglobitic species from many cave areas. As shown in Table 5.10, the oniscid fauna is represented by two styloniscid genera: *Notoniscus* and *Styloniscus* and a few isolated records for Armadillidae, Detonidae and Ligiidae. Sometimes found in pools or in a riparian habitat, and near or in the dark zone of caves, the four new undescribed species of *Notoniscus* from Bubs Hill, Franklin River, Gunns Plains and Mole Creek could be considered an amphibious or semi-aquatic species; all are categorised as troglophiles or possible troglobites. Despite the four or possibly five new troglobitic species of *Styloniscus*, including the cavernicolous species "A" and "B" (see Figure 5.11), both closely related to *S. nichollsi* (Eberhard, *et al.*, 1991), these all remain undescribed and there has been no taxonomic revision of the terrestrial styloniscids from Tasmania since the study by Green (1971). Cavernicolous species "A" is only known from riparian habitats of three caves in the Ida Bay karst, all with northern drainage; the more troglobitic species "B" (Figure 5.11) is recorded from 41 caves in 13 karst areas, including two caves at Ida Bay with northern drainage and nine caves with southern drainage.

Table 5.10: Distribution and diversity of terrestrial isopods recorded from cave areas and karst surface sites in Tasmania. (Note that the three separately listed undetermined species of unknown genera are listed on one line in the Table below.)

Family	Genus species name	Ecology	Cave Area	surface area
Armadillidae	? Acanthodillo sp.	Tx	IG	
Armadillidae	Cubaris sp.	Acc or Tx	N	
Detonidae	Deto marina	Acc or Tx	IG, PS	
Armadillidae	Echinodillo cavaticus	Tp	RA	
Ligiidae	Ligia (Nesoligia) australiensis	Acc or Tx	IG, S, SB	
Styloniscidae	Notoniscus sp. nov. 1	Tp or Tb?	BH	
Styloniscidae	Notoniscus sp. nov. 2	Tp or Tb?	F	
Styloniscidae	Notoniscus sp. nov. 3	Tb?	MC	
Styloniscidae	Notoniscus sp. nov. 4	Tp or Tb?	GP	
Styloniscidae	Styloniscus ?nichollsi	Tp?	GS, H, JF, WM	
Styloniscidae	Styloniscus ?squarrosus	Tx or Tp	F	
Styloniscidae	Styloniscus hirsutus	Tp	BH	IB
Styloniscidae	Styloniscus maculosus	Tp	BH, DW, GP, IB, JF, NL	F
Styloniscidae	Styloniscus nichollsi	Tx or Tp	AR, GP, H, IB, JF, LM, MC, NL, PB, WE	FG, PB, WM
Styloniscidae	Styloniscus sp.	Acc or Tx	DW, L	
Styloniscidae	Styloniscus sp. 1	Tp?	BH	
Styloniscidae	Styloniscus sp. 2	Tp or Tb?	BH	
Styloniscidae	Styloniscus sp. 3	Tb	JF, L	
Styloniscidae	Styloniscus sp. indet.	Tb	CP, E, F, G, GP, H, IB, JF, L, MC, MU, NR, PB, RB, SR, TC, UW, VF, WE	
Styloniscidae	Styloniscus sp. nov. (cave sp. A)	Tb	IB	
Styloniscidae	Styloniscus sp. nov. (cave sp. B)	Tb	BH, C, FG, GP, H, IB, JF, L, MC, NL, PB, R, VF	
Styloniscidae	Styloniscus sp. nov., nr. S. hirsutus	Tp	BH	
Styloniscidae	Styloniscus squarrosus	Tx or Tp	BH, MA	WM
Styloniscidae	Styloniscus sylvestris	Tx	DW	WM
Styloniscidae	undet. genus, sp. or spp. indet.	Acc	GP, JF	F, JF

Figure 5.11: Depigmented, setose and blind *Styloniscus* sp. nov. (cavernicolous sp. B) photographed in the mulch of rotting timber from an old wooden staircase, underneath the present day concrete stairs in Marakoopa Cave, a tourist cave at Mole Creek in northern Tasmania. Approximately 1.0cm long, this isopod was found 150-200m into dark zone, near junction of The Cathedral and underground river passage. [Photo by Paul Flood (11-Aug-2005), Parks & Wildlife Service, Mole Creek.]

5.2.7. The "new" bathynellacean syncarid from Exit Cave, Ida Bay

On December 21st 1974, in the company of Albert Goede, Shun-Ichi Uéno and Yoshinobu Morimoto (two members of the Japanese Ibaraki University Zoological Expedition to Oceania and Southeast Asia) visited Exit Cave at Ida Bay in southern Tasmania. During analysis of the species collected by filtering the interstitial waters of sandy stream banks in the far inner reaches of the cave, a new stygobiont bathynellacean syncarid was discovered (Goede, 1975). Less than a month later, members of this same expedition from Japan found a new species of a stygobiont stygocaridacean syncarid in New Zealand caves (Morimoto, 1977). Despite possessing a peculiar arrangement of uropodal peduncle spines in similarity with species of the genus *Cteniobathynella* (Schminke, 1973), the new species from Exit Cave was described by Morimoto (1978) as *Notobathynella tasmaniana* (F. Parabathynellidae). Like all cave and groundwater dwelling bathynellaceans it is blind; this species is less than 2mm long, extremely setose and highly troglobitic (see Figure 5.12).

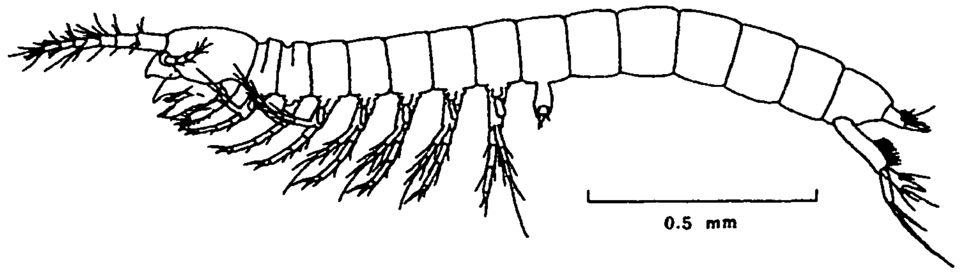

Fig. 1. ***Notobathynella tasmaniana*** **sp. n., ♂, from Exit Cave of the Ida Bay Caves, SE Tasmania.**

Figure 5.12: Figure 1 from Morimoto (1978) depicting the 1.6mm long holotype male of *Notobathynella tasmaniana*, the "new" bathynellacean syncarid from Exit Cave.

Although previously referred to as *Atopobathynella* sp. or as a new species thereof (e.g., Richards and Ollier, 1976; Lake and Coleman, 1977; Eberhard, *et al.*, 1991), it has not been previously recorded as *Notobathynella tasmaniana* in any of the biospeleological literature for Tasmania, e.g., Eberhard (1992; 2001a), Clarke (1997a; 2004; 2005c), or the general literature on syncarids in Australia, e.g., Williams (1980) or the global distribution of cave dwelling syncarids e.g., Botosaneanu (1986), Schminke (1986), Coineau (1996; 2003) and Hobbs (2000). However, its name was correctly recorded in the online edition of the ABRS Australian Faunal Directory, but with incorrect publication detail, cited as "*Bull. Mus. Natl. Hist. Nat. Paris (A, Zool.)*", whereas in Camacho (2004), the publication details are correct, but the species name is cited as "*Notobathynella tasmaniae*".

5.2.8. Anaspidacean syncarids: distribution, diversity and collection history

Aside from the stygobiont bathynellacean syncarid *Notobathynella tasmaniana* in Exit Cave (Morimoto, 1978), there are 22 forms of anaspidacean syncarids from three families in the database: Anaspididae, Koonungidae and Psammaspididae (Table 5.11); their diversity, distribution and taxonomy are detailed in Schminke (1986) and Eberhard *et al.*, (1991). Little has changed since then, although there are more cave distribution records, particularly for *Anaspides tasmaniae*. As shown in Table 5.11 (overleaf), in addition to *Anaspides tasmaniae*, three other syncarid species from the same Family Anaspididae are recorded from Tasmanian caves: a solitary specimen collected in Growling Swallet in February 1981 is recorded as *Anaspides ?spinulae*; an un-named species of *Paranaspides* is recorded from Exit Cave; and a similar un-named species of *Allanaspides* is recorded amongst collections by Stefan Eberhard from Trowutta. Species of *Eucrenonaspides* (F. Psammaspididae) are recorded from several cave areas, plus *Koonunga* and *Micraspides* (both F. Koonungidae) recorded caves in western and NW Tasmania (Eberhard, *et al.*, 1991).

Table 5.11: Distribution and diversity of anaspidacean syncarids, recorded from karst cave areas in Tasmania.

Genus species name	Family	Ecology	Karst Cave Area
Allanaspides sp.	Anaspididae	Sp?	T
Anaspides ?spinulae	Anaspididae	Acc or Sp?	JF
Anaspides ?tasmaniae (cave type)	Anaspididae	Sp or Sb?	C, CP, H, IB, JF, MA, MC, MR, PB
Anaspides tasmaniae ("blind" type)	Anaspididae	Sb	H
Anaspides tasmaniae (cave type)	Anaspididae	Sp and Sb?	BH, C, CP, F, GP, H, IB, JF, LL, MA, MC, NR, VF
Anaspides tasmaniae (normal type)	Anaspididae	Sp?	IB, JF, MC, RB, VF
Eucrenonaspides oinotheke	Psammaspididae	Sb	D
Eucrenonaspides sp. 1 (H)	Psammaspididae	Sb	H
Eucrenonaspides sp. 2 (IB)	Psammaspididae	Sb	IB
Eucrenonaspides sp. 3 (G)	Psammaspididae	Sb	G
Eucrenonaspides sp. 4 (C and PB)	Psammaspididae	Sb	C, PB
Eucrenonaspides sp. 5 (MC)	Psammaspididae	Sb	MC
Eucrenonaspides sp. 6 (JF)	Psammaspididae	Sb	JF
Eucrenonaspides sp. 7 (MR)	Psammaspididae	Sb	MR
Eucrenonaspides sp. or spp. indet.	Psammaspididae	Sb	IB, JF, MC, PB
? Gen. nov., sp. nov. (LM)	Koonungidae	Sb	LM
Koonunga sp. (MU)	Koonungidae	Sp	MU
? *Micraspides* sp.	Koonungidae	Sp or Sb?	F
Micraspides ?calmani	Koonungidae	Sb	LA
Paranaspides sp.	Anaspididae	Sb	IB
? *Psammaspides* sp.	Psammaspididae	Sp or Sb?	H
undet. Gen., sp. indet.	Koonungidae	Sp or Sb?	T

The thesis database shows that the first records of cave dwelling *Anaspides* in Tasmania were from sites at Mole Creek. The earliest record comes from a single specimen collected by A. Rafferty in Marakoopa Cave on 28-Apr-1938 and the second record for a "cave dwelling" *Anaspides* is from another solitary 3.3cm long specimen found (undigested) in the stomach of a pale coloured, almost white trout; determined as *Salmo fario*, this fish was collected by Albert Goede and John Wanless on 22-Feb-1958 in the River Alph of Kubla Khan (Scott, 1960). The cave dwelling Anaspides were first reported by Bill Williams based on eight specimens collected by Elery Hamilton-Smith in mid-November 1963 from two caves at Mole Creek: Sassafras Cave and Marakoopa Cave (Williams, 1965a).

Williams stated that the cave species were noticeably depigmented or paler than the surface species of *Anaspides tasmaniae*, but otherwise appeared to have a similar morphology, including eyes.

In late May 1964, Bill Williams collected specimens of *Anaspides tasmaniae* from Newdegate Cave at Hastings and subsequent sightings in Exit Cave at Ida Bay were also reported (Goede, 1967). During a 12 month period in 1968-1969, specimens with "normal" eyes were collected from three caves at Ida Bay: Exit Cave, Bradley-Chesterman Cave and Revelation Cave, plus Mersey Hill Cave at Mole Creek. During this same period, Albert Goede and Alan Dartnall collected six specimens from the small clear water stream flowing out of Lake Pluto in Wolf Hole at Hastings on August 10th 1968 (Goede, 1968). The specimens from Wolf Hole were forwarded to Bill Williams in Dept. of Zoology at Monash University and on examination, these were determined to be blind (see Figures 5.13 and 5.14), with no discernable eye structures on the end of their eye stalks (Goede, 1972). Four more specimens of this blind *Anaspides* species (three males and a female) were collected from Lake Pluto itself, by Peter Murray on June 22nd 1975; these were subsequently recorded by Lake and Coleman (1977) in their report on the subterranean syncarids of Tasmania, with detailed morphology of the eyeless cave dwelling forms.

As noted by Lee (2004), prior to the advent of DNA studies, most invertebrate species were systematically described on the basis to their morphology or anatomical characters often quite variable between the different classes, orders, family groups, genera and species of animals. Amongst the known characters that define anaspidacean syncarids, there are several features or characters that contribute much of the variability between cave dwelling species and to some extent, between cave and surface species. Two of these characters are the eye stalks on their heads and the presence (or absence) of eyes (Figure 5.14), and secondly the shape or form of their telson, a protuberance from the rear of the *Anaspides* that sits beneath the two pairs of splayed paddle-like uropods (Figure 5.15).

Figure 5.13: The anophthalmic anaspidacean syncarid from Wolf Hole at Hastings, presently recorded as *Anaspides tasmaniae* (blind form), but likely to be a new and distinct stygobiont species (Eberhard, *et al.*, 1991); this live specimen photographed in a petrie dish at Francistown: 27-ii-2006.

Lake and Coleman (1977) reported that the cave forms of *Anaspides tasmaniae* have varying telson spination, i.e., different numbers and lengths of spines, that are arranged symmetrically or irregularly around the perimeter of the telson (Figure 5.15). Based on a further and more detailed analysis of telson size and the variable spination in cave species, Eberhard (1990a) and Eberhard *et al.* (1991) suggest the presence of four types of cave dwelling *Anaspides*: normal telson: *A. tasmaniae* type; telson intermediate; cave type telson (including the "blind" species from Wolf Hole); and an undetermined type (O'Brien, 1990). One of the few "cave type" forms known to have a symmetrically arranged group of short telson spines are the species found at Lake Pluto in Wolf Hole (Lake and Coleman, 1977); see Figures 5.13 and 5.15. In her recent thesis study on the molecular phylogeny, biogeography and systematics of the Tasmanian Mountain shrimps, in discussion of the variability of telson spination, Andrew (2005) suggests that "*...it is by no means clear that this character is phylogenetically useful rather than merely highly variable*". Her remarks appear to be based on comments by Eberhard (1990a) reporting the variation of telson morphology and irregularly arranged numbers of spines amongst the populations of epigean species recorded as *Anaspides spinulae* in the Central Plateau lakes and tarns and a further recommendation in Eberhard *et al.* (1991) that cautions the use telson morphology variation as an indicator of species diversity.

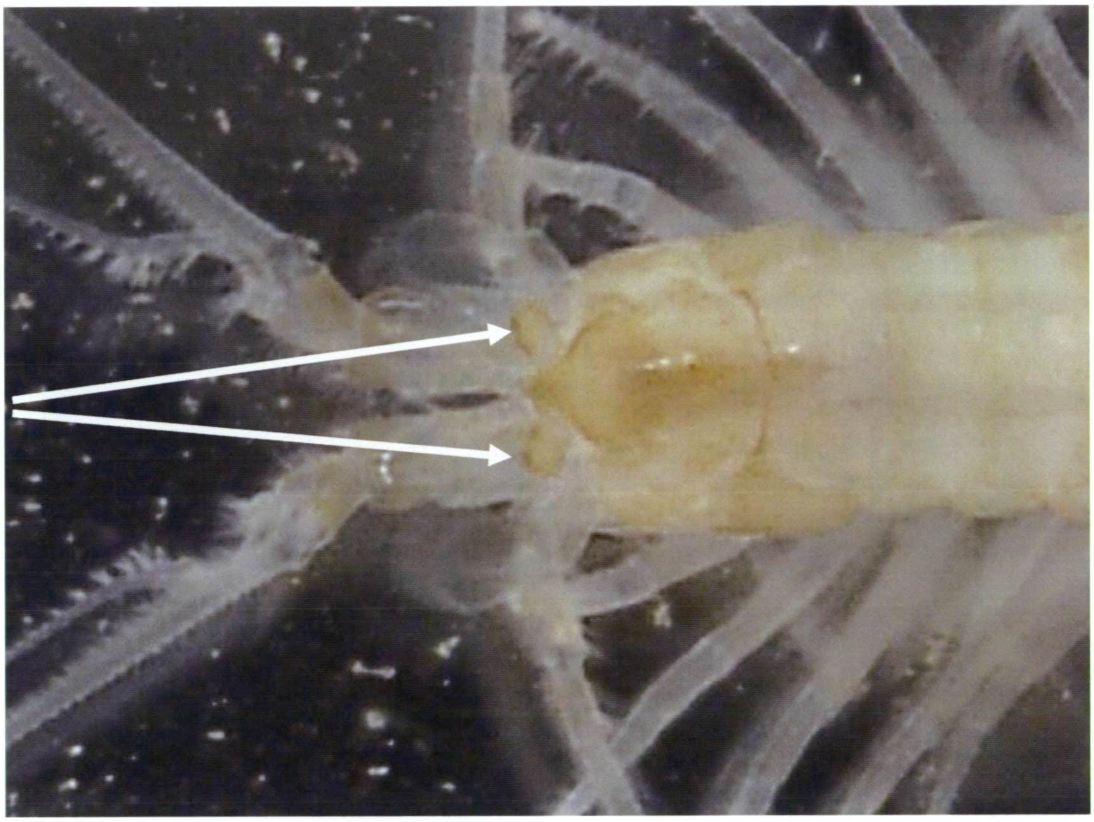

Figure 5.14: Dorsal view of posterior (head) region of the anophthalmic (blind) *Anaspides tasmaniae* from Wolf Hole at Hastings, showing eyeless eye stalks (arrowed), the setose (hairy) and spinose (spiny) antennae, antennules and thoracic appendages; live specimen photographed in a petrie dish at Francistown: 27-ii-2006.

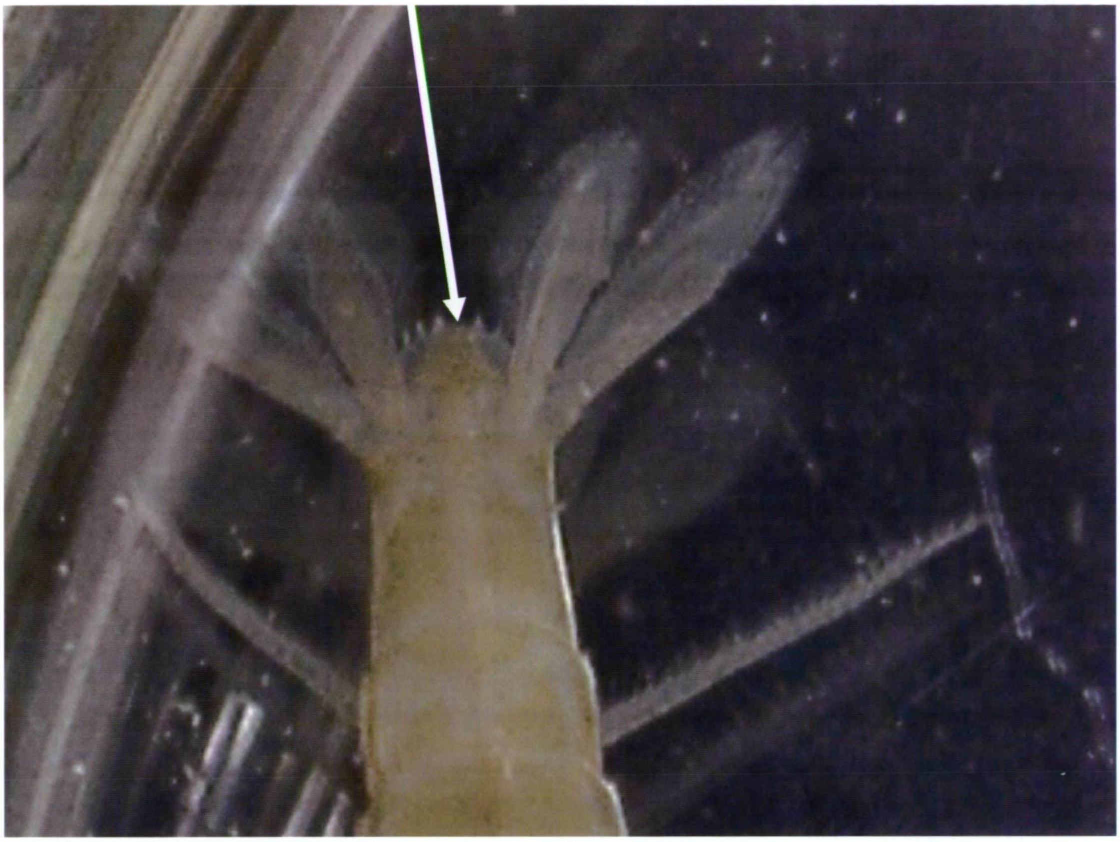

Figure 5.15: Dorsal view of posterior of the anophthalmic *Anaspides tasmaniae* from Wolf Hole at Hastings, showing the telson (arrowed, between splayed uropods) with symmetrically arranged short spines; live specimen photographed in a petrie dish at Francistown: 27-ii-2006.

Like Eberhard, the writer has observed considerable variation within local, and between regional populations of *Anaspides tasmaniae*. The variability is expressed in different ways. The degree of pigmentation is quite noticeable, from slight to dark colouration in cave specimens from northern Tasmania, to species that are completely depigmented, white (often with pearly lustre), translucent and almost transparent, particularly from caves in southern Tasmania (see Figures 5.13, 5.14 and 5.15). There are varying degrees of eye reduction amongst specimens from caves other than Wolf Hole, including variations in eye size and degree of ocelli pigmentation. Apart from the variation in spination (position, length and number of spines) on the telson noted by Lake and Coleman (1977) and Eberhard (1990a), there is considerable variation in the development (length, position and density) of setae on antennae and legs. Although the most marked variability occurs between different karst regions, in some areas, e.g., at Mole Creek, three different forms are known with the 5-7cm long markedly pigmented epigean forms washed into Honeycomb I

Cave where they become stranded in the deep final sump pool, the smaller (2-3cm long) white forms in the nearby Wet Cave and the 3-4cm long translucent forms in Marakoopa Cave (see Figure 1.16, Chapter 1). It is unclear if this variability represents possible troglomorphic adaptations, some degree of speciation or development of ecotype varieties.

Speciation in *Anaspides* has been the focus of several studies relating to their biodiversity, including discussion of cave species. In analysis of the DNA evidence for morphological speciations of the *Anaspides* morphotype within Anaspididae, Jarman and Elliott (2000) determined the presence of at least three cryptic phylogenetic species determined by their clades, noting there were more phylogenetic species than morphological species. In their discussion of the morphological forms, Jarman and Elliott provide a summarised distribution for the predominantly alpine dwelling *Anaspides tasmaniae*, including the lower elevation subterranean form described in O'Brien (1990). In analysis of their molecular data, where three species are discussed, their most divergent clade is "*Anaspides tasmaniae* (Anaspides sp. 3)" from specimen samples in the south of Tasmania including "*a representative of the cave form of A. tasmaniae from the Wolfe Hole* [sic]" (Jarman and Elliott, 2000); see Figures 5.13 and 5.14 depicting the whole body and head of the blind *Anaspides* from Wolf Hole.

The findings of Jarman and Elliott are largely supported in another recent molecular study of *Anaspides* by Andrew (2005), who determines three genetically distinct geographical groups including a "Southern (Huon) Group". In her study, questioning the separate species status of *Anaspides spinulae* (Williams, 1965b), the *Anaspides tasmaniae* populations are characterised by low-levels of within-population genetic variation, and often high levels of among-population genetic differentiation, but she dismisses the existence of a cave group (Andrew, 2005). Based on her results, Andrew (2005) concludes that the cave populations of *Anaspides tasmaniae* do not form a distinct group despite the common loss of pigmentation, supported by the fact that all the cave populations sampled shared genotypes with the nearest epigean populations. However, Appendix 3 in Andrew (2005), listing the 33 collection sites, indicates that her conclusions have been based on the results of very limited cave species/ specimen sampling from three caves in two karst areas: Wolf Hole and Newdegate Cave at Hastings and Wet Cave at Mole Creek, the latter being a site fed by three surface streams. The Wet Cave specimens used for the DNA analysis were the large pigmented epigean-like types commonly found in Honeycomb I Cave (S. Eberhard, pers. comm.). From this writer's perspective, it would appear that an inadequate number of cave sites had been sampled to make the conclusions given about cave forms by Andrew (2005), considering that, as shown in Table 5.1 and detailed further in Table 5.11, cave populations of *Anaspides tasmaniae* are known from 16 areas and 58 cave sites.

Discussing the divergence within geographical groups, Andrew (2005) records that the Wet Cave species are similar to the core group of Central Plateau populations, "*although more divergent in allozymes than mt DNA*". In discussion of the differentiation of southern and south-western groups, Andrew states that the "*...most significant feature of the southern populations is the use of caves as refugia, most likely from climatic extremes during and since the last glaciations, as caves offer more stable conditions than surface environments. (This probably partially explains the extremely large individuals found in Wet Cave.) There are no separate cave genetic types, so the use of caves is likely to have been relatively recent. Some authors have described morphological differences in cave populations in addition to lack of pigmentation, but none of these are constant across all cave populations, and most are not constant within populations (O'Brien, 1990; S. Eberhard, pers. comm.) All three cave populations in this study exhibit similar genotypes to the closest epigean populations, although the Newdegate Cave and Wolfe Hole* [sic] *populations are genetically divergent populations from Anaspides elsewhere in Tasmania*" (pp. 89-90, Andrew, 2005).

5.2.9. Aquatic snails, chiefly Hydrobiidae

Table 5.12 records the distribution and biodiversity of hydrobiid snails (Gastropoda: Caenogastropoda: Rissooidea) from caves and karst surface sites in Tasmania. The identified hydrobiids including the morphospecies assigned with "Ps" numbers represent a small group of cave species with one of the best levels of taxonomic definition and the least "lumping" of separate species into one taxon, thanks to the efforts of Winston Ponder and staff in the Malacology Section of the Australian Museum. Aside from the hydrobiid snails, there are isolated records for two aquatic pulmonate gastropods (Planorbidae: Bulininae: Physastrini), *Ferrissia* sp. from Andrew River Cave and *Glyptophysa gibbosa* from

Broadsword (GP-63) at Gunns Plains. *Ferrissia* has a widespread distribution across Tasmania and similarly *Glyptophysa gibbosa* is a cosmopolitan species occurring across much of southern and SE Australia. Neither of them are considered to be significant as a cave species, although the former maybe a new species (pers. comm., W. Ponder).

Figure 5.16: Minute 2-3mm aquatic snails: *Nanocochlea* sp., nr. *N. pupoidea* (F. Hydrobiidae) on cobbles in clear stream waters of Base Camp Tributary in Exit Cave, 1.75km from the nearest known surface stream connection.

Aquatic (hydrobiid) snails tend to be confined to restricted areas, often small springs, streams or caves (Ponder, 1997). The accompanying Table 5.12 graphically illustrates the limited distribution of the hydrobiid snails with almost all taxa generally restricted to individual caves, cave systems or caves in same karst area. There are also numerous examples of sympatric populations of different species that co-exist in the same micro-habitat, or same cave system and karst area as indicated by the radiation of stygobiont species at Precipitous Bluff where the recently described taxa include different species from the same cave or system of connected caves (Ponder *et al.*, 2005). The tiny, often only 2-3 or 4mm long hydrobiids (Figures 5.16 and 5.17), have limited dispersal ability beyond their immediate environment and in stream caves such as Exit Cave at Ida Bay or Damper Cave at Precipitous Bluff, the major throughflow stream may act as a dispersal barrier to different species in tributary side passages. In their overview of the hydrobioid snails including Family Hydrobiidae, Hershler and Ponder (1998) describe the importance of suitable unpolluted habitats where snails feed on algae and natural organic detritus; in a cave environment, it is suggested that the endemic hydrobiids may also graze on waterborne bacteria (W. Ponder, pers. comm.). Showing a marked preference to unpolluted waters, the relative abundance of hydrobiids in caves, permits the species to be used as an indicator of water quality and environmental conditions (Eberhard, 1992b; Barmuta, 1998). The limited "narrow-range" distribution of hydrobiids makes them highly vulnerable to extinction from human activities (Davies, 1995) and dependent on long term permanency in a non-depleted habitat, favourable hydrological conditions and/ or rainfall, water chemistry, geology and the structure of the non-aquatic environment (Ponder and Colgan, 2002).

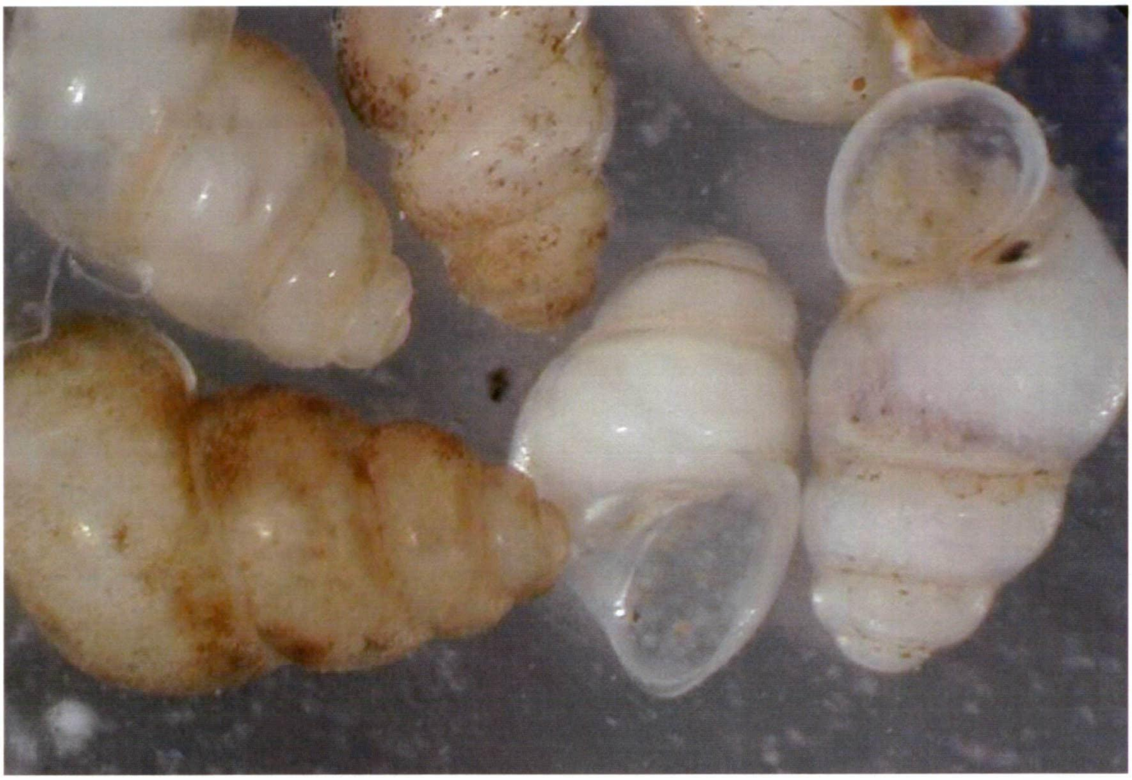

Figure 5.17: Photomicroscopy image of 3-4mm long hydrobiid snails (*Nanocochlea* sp.) collected from stream cobbles in the dark zone of Loons Cave at Ida Bay.

Table 5.12: Diversity and distribution of hydrobiids from cave sites, cave areas or surface karst sites, recording their ecology as epigean, accidental (Acc), stygophiles (Sp) or stygobites (Sb), plus number of occurrence records per species.

Genus species name	Ecology	Nos.	Cave/s and cave area	Surface area
(Ps01) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	1	Cauldron Pot (JF)	
(Ps02) Austropyrgus n. sp.	Acc or Sp?	3	Cow Hole (R)	
(Ps03) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	22	Exit Cave system (IB)	
(Ps04) Phrantela n. sp., cf P. pupiformis	Acc or Sp?	1	Salisbury River Cave (VF)	
(Ps05) uncertain taxonomy	Acc or Sp?	1	Salisbury River Cave (VF)	
(Ps15) Phrantela n. sp. (daveyensis group}	Acc or Sp?	1	Gahnia Cave (F)	
(Ps17) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	54	Little Grunt (IB)	
(Ps18) Austropyrgus n. sp.	Sb?	4	Swallownest Cave (L)	
(Ps19) Beddomeia n. sp., aff zeehanensis	Acc or Sp?	2	Mostyn Hardy Cave (L)	
(Ps20) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	3	Cauldron Pot (JF)	
(Ps21) Austropyrgus n. sp., aff petterdianus	Acc?	6	GP, L, MC	
(Ps22) Nanocochlea aff. N. pupoidea	Sp or Sb?	2	Khazad-Dum (JF)	
(Ps23) Nanocochlea n. sp.	Acc or Sp?	4	Capricorn Cave (MR)	MR
(Ps25) Nanocochlea n. sp. (parva group)	Sp or Sb?	1	Gastropod Cave (LM)	
(Ps26) Nanocochlea n. sp. (parva group)	Sp or Sb?	2	1935 Cave (BH)	
? (Ps27) Phrantela sp. ? P. warwicki group	Acc?	1	Loons Cave (IB)	
(Ps28) Phrantela n. sp. (daveyensis group}	Sp or Sb?	1	Gastropod Cave (LM)	
(Ps29) Phrantela sp. nov., cf. N. pupoidea	Sp or Sb?	1	King George V Cave (H)	
(Ps30) Phrantela n. sp. (daveyensis group}	Acc or Sp?	1	Rotuli Cave (NR)	
(Ps31) Austropyrgus n. sp., aff. petterdianus	Acc or Sp?	2	Mostyn Hardy Cave (L)	
(Ps32) Phrantela n. sp. (daveyensis group}	Acc or Sp?	3	JF-6, JF-8	
(Ps33) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	2	Rift Cave (JF)	
? (Ps34) Nanocochlea n. sp., cf. N. pupoidea	Sp or Sb?	2	IB-2, IB-98	
(Ps35) Beddomeia n. sp., cf. bowryensis	Acc or Sp?	3	Weerona Cave (GP)	
(Ps36) Austropyrgus sp. nov., aff petterdianus	Acc or Sp?	1	Weerona Cave (GP)	
(Ps37) Beddomeia n. sp. (hulli group)	Sp or Sb?	1	Weerona Cave (GP)	
(Ps38) Phrantela n. sp.	Sp or Sb?	1	Un-named Cave (C)	
(Ps39) Austropyrgus n. sp.	Sp or Sb?	1	Un-named Cave (C)	
(Ps40) Beddomeia n. sp., aff hulli	Sp or Sb?	3	GP-1, GP-27	
(Ps41) Phrantela n.sp. (WM)	Sb?	2	Cave 1 (WM)	
(Ps42) Phrantela n. sp. (daveyensis group}	Sp or Sb?	1	Cave 1 (WM)	
(Ps44) Nanocochlea n. sp.	Sp or Sb?	2	Arthurs Folly (IB)	
(Ps50) Austropyrgus n. sp., aff petterdianus	Acc?	1	Broadsword (GP)	
(Ps51) Nanocochlea sp., aff. N. pupoidea	Acc or Sp?	4	JF-X53, JF-229	
(Ps52) Beddomeia n. sp., aff ronaldi	Sb?	2	MC-32, MC-141	
(Ps53) Nanocochlea n. sp.	Acc or Sp?	3	Caryodes Cavern (RB)	
(Ps54) Austropyrgus n. sp., cf A. petterdianus	Sp ?	2	RB-X3, RB-X4	
(Ps55) Nanocochlea n. sp., cf. N. pupoidea	Acc or Sp?	1	Risby Basin Cave (RB)	
(Ps56) Beddomeia n. sp., aff lodderae	Acc or Sp?	1	Emperor Cave (GP)	
? Austropyrgus n. sp., near Ps31	Acc?	1	Sassafras Cave (MC)	
Austropyrgus conicus Clark, Miller and Ponder, 2003	Epigean	1		GP-surface
Austropyrgus gunnii Clark, Miller and Ponder, 2003	Epigean	1		MC-surface
Austropyrgus juliae Clark, Miller and Ponder, 2003	Epigean	2		GP-surface
Austropyrgus lochi Clark, Miller and Ponder, 2003	Epigean ?	8	Gunns Plains Cave (GP)	GP, MC
Austropyrgus nanoacuminatus Clark, Miller and Ponder, 2003	Epigean ?	2		SR-surface

Genus species name	Ecology	Nos.	Cave/s and cave area	Surface area
Austropyrgus nanus Clark, Miller and Ponder, 2003	Epigean	17		H-surface
Austropyrgus niger (Quoy and Gaimard, 1834)	Epigean	3		H and PB
Austropyrgus salvus Clark, Miller and Ponder, 2003	Acc?	11	F-51, LA-X1	F-Surface
Austropyrgus solitarius Clark, Miller and Ponder, 2003	Epigean	5		KS-surface
Austropyrgus sp.	Sp?	1	Kubla Khan (MC)	
Beddomeia franklinensis Ponder and Clark, 1993	Epigean ?	5	F-27, F-51	F and GS
Beddomeia paludinella levenensis Ponder and Clark, 1993	Epigean	1		GP-surface
Nanocochlea sp. (similar to Ps39)	Sp or Sb?	2	Riveaux Cave (HC)	
Nanocochlea sp., monticola group (IB99)	Sp or Sb?	1	Salt and Pepper (IB)	
Nanocochlea sp. nov.?	Acc or Sp?	1	Newdegate Cave (H)	
Nanocochlea sp. nov.? (Western Passage)	Sb	8	Exit Cave (IB)	
Nanocochlea sp. nov.?	Sp or Sb?	1	Slaughterhouse Pot (JF)	
Nanocochlea damperensis Ponder et al., 2005	Acc?	8		PB-surface
Nanocochlea exigua Ponder et al., 2005	Sp and Sb?	25	PB-1, PB-3, PB-6, PB-17	PB-surface
Nanocochlea parva Ponder and Clark, 1993	Epigean ?	3	F-27, LA-X1	LA-surface
Nanocochlea sp. nov.?, cf N. pupoidea	Epigean ?	1		IB-surface
Nanocochlea sp. nov., nr Ps22, cf. N. pupoidea	Acc or Sp?	2	Riveaux Cave (HC)	
Nanocochlea pupoidea Ponder and Clark, 1993	Sp and Sb?	28	Mystery Creek Cave	
Nanocochlea stylesae Ponder et al., 2005	Epigean	3		PB-surface
Phrantela sp.or spp. nov.?	Sp or Sb?	5	H, IB, NR	
Phrantela sp. 3	Sp	1	Kutikina Cave (F)	
Phrantela sp. 6 (= cf. P. daveyensis)	Acc or Sp?	5	F-X1, LA-X1	LA-surface
Phrantela daveyensis daveyensis Ponder and Clark, 1993	Epigean	4		DV-surface
Phrantela kutikina Ponder and Clark, 1993	Acc or Sp?	9	Kutikina Cave (F)	F-surface
Phrantela sp. (= cf. P. marginata)	Acc?	2	Pendant Cave (SR)	
Phrantela pupiformis Ponder and Clark, 1993	Epigean ?	1		JF-surface
Phrantela sp. or spp. indet. (= cf. P. warwicki)	Sp	1	Riveaux Cave (HC)	
Phrantela sp. (= cf. P. warwicki) (H)	Sp	5	Newdegate Cave (H)	
Phrantela sp. (= cf. P. warwicki) (IB)	Sp	1	Mystery Creek Cave (IB)	
Phrantela warwicki Ponder and Clark, 1993	Epigean ?	5	IB-2, IB-10	IB-surface
Phrantela umbilicata Ponder and Clark, 1993	Epigean	6		F-surface
Potamopyrgus antipodarum (Gray, 1843)	Acc	12	GP-1, GP-2, GP-14, GP-63	GP, IB, PB
Ps ? sp. indet.	Acc or Sp?	5	Salisbury River Cave (VF)	
? Pseudotricula, near P. arthurclarkei (PB)	Acc or Sp?	2	Quetzalcoatl Conduit (PB)	
Pseudotricula arthurclarkei Ponder et al., 2005	Sb	3	Quetzalcoatl Conduit (PB)	
Pseudotricula auriforma Ponder et al., 2005	Sb	3	Damper Cave (PB)	
? Pseudotricula, near Pseudotricula conica (PB)	Sb	11	PB-1, PB-4, PB-6, PB-17	
Pseudotricula conica Ponder et al., 2005	Sb	23	PB-1, PB-4, PB-6, PB-17	
Pseudotricula eberhardi Ponder, 1992	Sb	8	Cueva Blanca (PB)	
Pseudotricula elongata Ponder et al., 2005	Sb	3	PB-6, PB-17	
Pseudotricula expandolabra Ponder et al., 2005	Sb	18	PB-1, PB-6, PB-17	
Pseudotricula progenitor Ponder et al., 2005	Sb	14	PB-1, PB-6, PB-17	
undetermined: Gen., sp. or spp. indet.	Sb	2	IB-110, UW-X9	

Table 5.12 indicates the diversity of hydrobiid species known from Tasmanian caves and karst areas, including cave endemic and stygobiont species. There are eight described cave species; *Nanocochlea pupoidea* (Ponder, *et al.*, 1993) from the Exit Cave system at Ida Bay and the seven cave-limited stygobiont species of *Pseudotricula* from Precipitous Bluff (PB), including *P. eberhardi* (Ponder, 1992) and the six more recently described species, *P. arthurclarkei*, *P. auriforma*, *P. conica*, *P. elongata*, *P. expandolabra* and *P. progenitor* (Ponder *et al.*, 2005). In similarity to *P. eberhardi* which is only known from one cave (Cueva Blanca) in the PB karst, *P. arthurclarkei* is restricted to Quetzalcoatl Conduit and *P. auriforma* to Damper Cave. As shown in Table 5.12, the four remaining species are found as sympatric populations in two, three or four different caves at Precipitous Bluff, once more showing the value of cave species in demonstrating the connectivity of karst bio-space and karst hydrology.

Amongst the 21 remaining named hydrobiid species listed in Table 5.12, all predominantly found in surface karst areas, 13 of these are narrow range species (Ponder and Colgan, 2002) restricted to karst areas and/ or known from described species whose Type Locality is a karst surface stream, some located near a known cave entrance, or a spring. Two species of *Austropyrgus* are only known from karstic warm springs, *A. nanus* from thermal spring sites at Hastings and *A. solitarius* from Kimberley Warm Springs; a third species *A. salvus* is recorded from the Franklin River limestone karst (Clark, *et al.*, 2003). (Another more widespread snail species, *A. niger* is recorded from karst surface streams at Hastings and Precipitous Bluff.) Two species of *Beddomeia* appear to have predominantly karst limited distributions, *B. franklinensis* from the Franklin River and *B. paludinella levenensis* from the Leven River (Ponder *et al.*, 1993). *Nanocochlea parva* is only known from the Acheron River area (Ponder *et al.*, 1993) and three recently described species *N. damperensis*, *N. exigua* and *N. stylesae* are recorded from karst surface streams at Precipitous Bluff (Ponder *et al.*, 2005) though as indicated in Table 5.12, *N. exigua* has a sympatric relationship with at least three or possibly four of the *Pseudotricula* cave species. Four species of *Phrantela* may have karst limited populations; *P. daveyensis daveyensis* is only known from the Davey River limestone gorge, *P. kutikina* and *P. umbilicata* are both found in the Franklin River near Kutikina Cave and *P. pupiformis* appears to be possibly restricted to an edge of the Junee-Florentine limestone karst near the Tyenna River.

Although most of the other cave hydrobiids in Tasmania are still undescribed, many taxa are known at both the generic and/ or species level. Winston Ponder and staff in the Malacology Section of the Australian Museum have been assigned "Ps" numbers to distinguish the cave hydrobiids as individual species; the Ps numbers are also used as a tool to track potentially distinct morphospecies. Some of the specimens originally discriminated with different "Ps" numbers, including specimens of *Nanocochlea*, are part of a larger group and may be simply variations within the standard range of already described species (pers. comm., W. Ponder). Consequently, as shown in Table 5.13, on the basis of similar external shell character and common geographic location, several morphotypes from Ida Bay are recorded as *Nanocochlea pupoidea.* A few cave forms are conspecific with known surface species, which tend to be very cryptic although at Precipitous Bluff the surface *Nanocochlea* species outside the caves are clearly different (Ponder *et al*., 2005). As indicated by Table 5.13, as of February 2005, the databased Australian Museum collections contain at least another 23 cave taxa; 19 of these are ready for description, so there are further potential taxa that could be described if sufficient wet material was available (W. Ponder and J. Studdert, pers. comm., 2005).

The genera *Beddomeia* and *Phrantela* are restricted to Tasmania, along with a third of the known *Austropyrgus* species and together, they are the three largest (most speciose) hydrobiid genera in Australia (Ponder and Colgan, 2002). As shown in Tables 5.12 and 5.13, species of *Beddomeia* are predominantly found in northern Tasmania, except for the doubtfully congeneric (Ponder *et al*., 1993) *B. franklinensis* from Franklin River shown in Table 5.12. There is an overlapping distribution of *Beddomeia* and *Phrantela* (mainly southern and western Tasmania) while *Austropyrgus* has almost ubiquitous distribution across Tasmania, except for the central western highlands (Ponder and Colgan, 2002). Like the cave dwelling *Nanocochle*a, the more cryptic *Beddomeia* and *Phrantela* species are often found under rocks, cobbles or beneath stones, dead leaves (Ponder and Colgan, 2002) and the MPOM or CPOM wood fragments in cave streams and seepages (see Glossary definitions). Most of the *Austropyrgus* species prefer more open or exposed habitats (Ponder and Colgan, 2002) and from Table 5.12 it will be noted that these are either epigean species from warm springs or karst surface streams, considered as accidental species in the cave environment. Although *Phrantela warwicki* is a surface species, along with its variable forms, it is occasionally found in caves within its surface range, generally near entrances. Ponder (pers. comm.) suggests that given the apparent variation within the species and the wide range of habitats, with more detailed studies *P. warwicki* could prove to be composed of more than one taxon.

Table 5.13: Undescribed Tasmanian cave hydrobiid taxa, listed by cave site, coded karst area, their assigned "Ps" numbers, known genus and species type or affinity, showing the number of species within a given geographic cave area. The grouped Ps numbers are "lumped" together on basis of similar external shell character. Note that Ps21 recorded from Gunns Plains, Loongana and Mole Creek is an overlapping species with uncertain affinities. (Table based on data kindly supplied by W Ponder and J. Studdert Malacology Section, Australian Museum, 09-Feb-2005.)

Cave or Karst Area (coded)	Ps number/s	Genus	species	Spp / cave area
Rotuli Cave (NR)	Ps 30	Phrantella	n.sp	1
Gastropod Cave (LM)	Ps 28 = Ps 30	Phrantella	n.sp	2
Gastropod Cave (LM)	Ps 25	Nanocochlea	parva	
Gahnia Cave (F)	Ps 15	Phrantella	cf daveyensis	1
un-named cave (WM)	Ps 41 = Ps 43	Phrantella		2
un-named cave (WM)	Ps 42	Phrantella		
Capricorn Cave (MR)	Ps 23	Nanocochlea		1
1935 Cave (BH)	Ps 26	Nanocochlea	sp	1
Cow Hole (R)	Ps 02	Austropyrgus	sp	1
(GP), (L) and (MC)	Ps 21 = Ps18 Ps50, Ps36, Ps31	Austropyrgus	aff petterdiana	5
Mostyn Hardy Cave (L)	Ps 19	Beddomeia	aff zeehanensis	
GP-1 and GP-27 (GP)	Ps 40 = Ps 56	Beddomeia	aff lodderae	
GP-2 and GP-4 (GP)	Ps 35	Beddomeia	cf bowryensis	
GP-2 and GP-4 (GP)	Ps 35 (part)	Austropyrgus		
My Cave and Baldocks Cave (MC)	Ps 52	Beddomeia	aff ronaldi	2
My Cave and Marakoopa II (MC)	Ps 21	Austropyrgus	aff petterdiana	
Caryodes Cavern (RB)	Ps 53	Nanocochlea	sp	5
Cauldron Pot (JF)	Ps 01 = Ps20, Ps55	Nanocochlea	cf pupoidea	
Rift Cave (JF)	Ps 33 = Ps54	Austropyrgus	cf petterdiana	
Khazad-Dum (JF)	Ps 22	Nanocochlea	sp	
Wherretts Cave and JF-229 (JF)	Ps 51	Austropyrgus	sp	
Exit Cave system (IB)	Ps03=Ps16, Ps17, Ps24, Ps34, Ps44	Nanocochlea	pupoidea	2
Loons Cave (IB)	Ps 27	Phrantella	warwicki	
Salisbury River Cave (VF)	Ps 04	Phrantella	cf pupiforma	1
"Cracroft Cave" (C)	Ps 39	Austropyrgus		2
"Cracroft Cave" (C)	Ps 38	Phrantella		
Note of Explanation (from staff in Australian Museum): List compiled February 2005 and does not include the cave hydrobiids in more recent collections made by the writer from Mystery Creek Cave and Exit Cave (IB), Newdegate Cave and Boardwalk Spring (H), Riveaux Cave (HC) and Sassafras Cave (MC); these were not databased by AUSMUS at time of this compilation.		**4 x known genera**	**Possibly 23 new species; 3 previously described species**	**Spp. nos. in cave areas grouped on geographic proximity**

5.2.10. Cave beetles

A feature of cave fauna – almost globally – is the predominance of the small (5-8mm long) reddish-brown, flightless carabid beetles. Many of the known species are obligate cave-dwellers. Described as a troglobiont fauna with ecological specialisations (New, 1998), some cave carabids are highly troglomorphic, particularly the more globally prevalent trechine or trechini carabids (Vandel, 1965; Grebennikov and Maddison, 2005) which are flightless and characteristically have long attenuated legs and setose antennae (Figure 5.18). Moore (1972a) states that the most troglobitic trechine carabids in Australasia occur in Tasmania and New Zealand, with the greatest diversity in southern Tasmania and the south island of New Zealand. French entomologists and taxonomists raise the status of sub-family Trechinae to family level, classifying trechines as Coleoptera: Caraboidea: Trechidae, e.g., Deuve (2002; 2004). Many cave carabids are locally endemic, known only from one cave or one karst area (Culver, 1986; Hobbs, 1997; Elliott, 2000). The first described cave beetle in Tasmania, *Idacarabus troglodytes* (Lea, 1910), was the first troglobitic beetle discovered in Australia (Moore 1978); it is a member of the carabid sub-family Zolinae, a group which is confined to Australasia. Most of the cave dwelling beetles in Tasmania are generally only known from one cave, cave system or karst area; some examples are listed in Table 5.14.

Table 5.14: List of the described cave dwelling beetles recorded in Tasmania, showing the principal cave (or Type Locality) where individual species are known.

Genus species	Family and Sub-family	Authority, Year	Ecology	Type Locality or Cave
Cryptophagus troglodytes	Cryptophagidae: Atomarinae	Lea, 1910	Tp	Scotts Cave (MC-52)
Goedetrechus mendumae	Carabidae: Trechinae	Moore, 1972	Tb	Exit Cave (IB-14)
Goedetrechus parallelus	Carabidae: Trechinae	Moore, 1972	Tb	Cashion Creek Cave (JF-6)
Idacarabus cordicollis	Carabidae: Zolinae	Moore, 1967	Tb	Newdegate Cave (H-1)
Idacarabus longicollis	Carabidae: Zolinae	Moore, 1978	Tb	Damper Cave (PB-1)
Idacarabus punctipennis	Carabidae: Zolinae	Moore, 1994	Tb	Capricorn Cave (MR-204)
Idacarabus troglodytes	Carabidae: Zolinae	Lea, 1910	Tb	Mystery Creek Cave (IB-10)
Pterocyrtus cavicola	Carabidae: Zolinae	Moore, 1994	Tb	Rotuli Cave (NR-1)
Pterocyrtus globosus	Carabidae: Zolinae	Sloane, 1920	Tp?	Growling Swallet (JF-36)
Pterocyrtus rubescens	Carabidae: Zolinae	Sloane, 1920	Tp?	Dolerite Delight (WE-X2)
Pterocyrtus striatulus	Carabidae: Zolinae	Sloane, 1920	Tp?	Bottomless Pit (G-X1)
Tasmanorites elegans	Carabidae: Trechinae	Moore, 1972	Tp?	Bottomless Pit (G-X1)
Tasmanorites flavipes	Carabidae: Trechinae	(Lea, 1910)	Tp?	Mystery Creek Cave (IB-10)
Tasmanotrechus cockerilli	Carabidae: Trechinae	Moore, 1972	Tb	Georgies Hall (MC-201)
Tasmanotrechus compactus	Carabidae: Trechinae	Moore, 1983	Tp?	Thylacine Lair (BH-203)
Tasmanotrechus elongatus	Carabidae: Trechinae	Moore, 1994	Tb	Minimoria (BH-202)
Tasmanotrechus leai	Carabidae: Trechinae	Moore, 1994	Tp	Bubs Hill Cave (BH-16)
Trechimorphus diemenensis	Carabidae: Trechinae	(Bates, 1878)	Tp?	Huon Cave (SP-1)

Although the troglomorphic trechine carabids are prevalent in many karst areas, population numbers tend to be much lower than for zolines, such as *Idacarabus* (Eberhard, (1999b). When discovered by cave biologists in early March 1969, the highly troglobitic trechine beetle, *Goedetrechus mendumae* (Figure 5.18) was only known from two female specimens located in a confined riparian habitat within the narrow 150m long Kellers Squeeze passage of Exit Cave, at Ida Bay. A subsequent collection in late March and May (1969), yielded two males and two more females from the same site in Kellers Squeeze. In December 1974, Shun-Ichi Ueno a visiting carabid taxonomist from Japan collected another 6-7 specimens from an adjoining passage (Clarke 1987a) and the species was not reported again until March 1989 when a specimen (Fig. 5.17) was collected in Thun Junction (IB-20), a vertical cave that connects directly into Exit Cave in the vicinity of the earlier collection sites (Clarke, 1991a). Amongst the recommended management prescriptions for Tasmanian cave fauna, Clarke (1997a, 5.8.4a, p. 107), detailed the need to ascertain population numbers and habitat requirements for *G. mendumae* in order to confirm its conservation status (Clarke, 1997a). In a recent study, Eberhard (1999) noted sympatric populations of *Goedetrechus* and *Idacarabus* in two caves at Ida Bay and confirmed that *G. mendumae* had a wider distribution, though confined to three connected caves within the Exit Cave system.

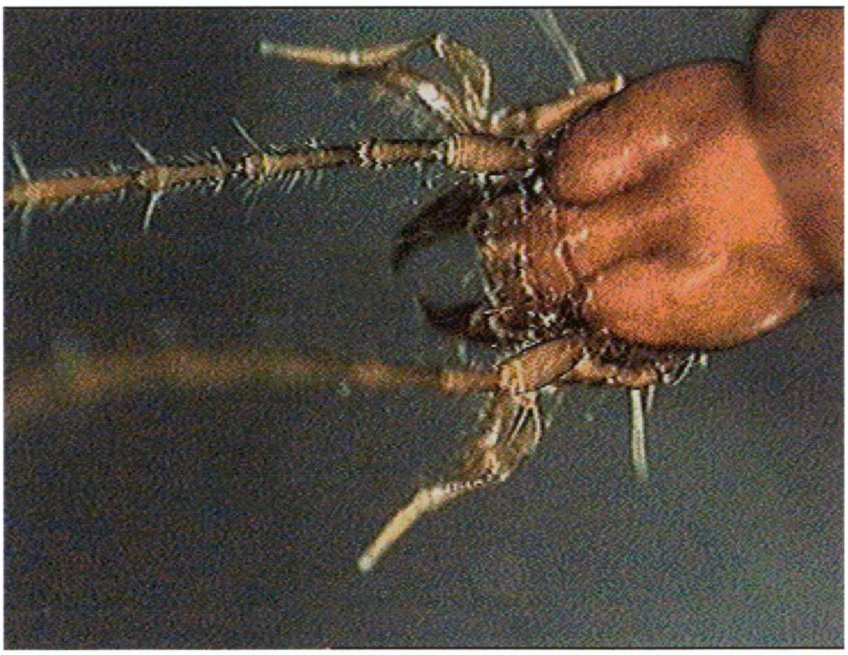

Figure 5.18: Head and setose antennae of the blind trechine carabid beetle: *Goedetrechus mendumae*, from a specimen collected by the writer in Thun Junction, a vertical cave connecting with Exit Cave at Ida Bay. (This photograph originally published as Figure 6, in Clarke, 1997a)

The genus *Goedetrechus* and its named species: the Blind Cave Beetle (*G. mendumae*) from Ida Bay and the Slender Cave Beetle (*G. parallelus*) from Junee-Florentine, is considered as a relict with Gondwanan distribution (Moore, 1972). In similarity with several other Tasmanian cave species, *Goedetrechus* is described as having a disjunct or vicariant distribution with separate occurrences of corresponding species in different karst areas; these species being all related to a common (now extinct), but once widespread surface-dwelling ancestor (Eberhard, *et al.* 1991). During fauna surveys in southern and western Tasmania (Clarke, 1988b; Eberhard 1987c, 1988, 1989; Eberhard, *et al.*, 1992; Hume and Clarke, 1989), some new cave-limited or obligate beetle species were collected. As listed in Table 5.15, these include species of carabid genera: *Goedetrechus*, *Idacarabus*, *Pterocyrtus*, *Tasmanorites*, *Tasmanotrechus* and *Trechistus* and two staphylinid genera: *Oxytelus* and *Typhlobledius* (pers. comm., F.C. Genest, P.M. Giachino and A. Newton).

Table 5.15: Some new undescribed species of obligate beetles, including troglobites from caves or cave areas in Tasmania. (Data kindly supplied by F.C. Genest, P.M. Giachino and A. Newton.)

Genus species	Family: sub-family	Cave or cave area	Ecology
? Goedetrechus sp.	Carabidae: Trechinae	PB, RB	Tb?
Goedetrechus sp.	Carabidae: Trechinae	Asteroid Pot (JF)	Tb
Goedetrechus sp. nov. 1	Carabidae: Trechinae	JF	Tb
Goedetrechus sp. nov. 2	Carabidae: Trechinae	Cauldron Pot (JF)	Tb
Goedetrechus sp. nov. 3	Carabidae: Trechinae	Niggly Cave (JF)	Tb
Goedetrechus sp. nov. 4	Carabidae: Trechinae	Damper Cave (PB)	Tb
Goedetrechus sp. nov. 5	Carabidae: Trechinae	Philrod Cave (CP)	Tb
? Idacarabus sp. indet. 1	Carabidae: Zolinae	PB	Tb
? Idacarabus sp. indet. 2	Carabidae: Zolinae	Growling Swallet (JF)	Tb
Idacarabus sp. nov. 1	Carabidae: Zolinae	G	Tb?
Idacarabus sp. nov. 2	Carabidae: Zolinae	VF	Tb
Idacarabus sp. nov. A	Carabidae: Zolinae	1935 Cave (BH)	Tb
Idacarabus sp. nov. B	Carabidae: Zolinae	un-named cave (MA)	Tb
Idacarabus sp. nov. C	Carabidae: Zolinae	H	Tb?
Oxytelus sp.	Staphylinidae: Oxytelinae	AR, BH, MA, NR, N	Tp?
Pterocyrtus (Sloane) sp. 1	Carabidae: Zolinae	APPM Cave (CP)	Tb?
Pterocyrtus (Sloane) sp. 2	Carabidae: Zolinae	F	Tb?
Pterocyrtus (Sloane) sp. 3	Carabidae: Zolinae	Rotuli Cave (NR)	Tb?
Pterocyrtus (Sloane) sp. 4	Carabidae: Zolinae	Campers Cavern (WE)	Tb?
Tasmanorites sp. nov. 1	Carabidae: Trechinae	Growling Swallet (JF)	Tp
Tasmanorites sp. nov. 2	Carabidae: Trechinae	Khazad-Dum (JF)	Tp?
Tasmanorites sp. nov. 3	Carabidae: Trechinae	Thylacine Lair (BH)	Tp
Tasmanotrechus sp. nov. 1	Carabidae: Trechinae	MC	Tb
Tasmanotrechus sp. nov. 2	Carabidae: Trechinae	Kubla Khan (MC)	Tb
Trechistus sp. (near T. sylvaticus)	Carabidae: Trechinae	Capricorn Cave (MR)	Tp?
Typhlobledius sp. 2 (nr T. cylindricus)	Staphylinidae: Orsorinae	BH	Tp or Tb?

5.2.11. Cave arachnids - 1: Acarina (ticks and mites)

Acarina (mites and ticks) are commonly found in caves and their adaptation to cave environments is described by Ducarme, *et al.* (2004). Some of the parasitic and free-living forms found in Tasmanian caves are listed in Eberhard *et al.* (1991), who describe the poorly known taxonomy of this group. Six of the eight taxa of ticks recorded in the database are named species, mostly mammal parasites of the genus *Ixodes*, plus the wombat tick: *Aponomma auruginans*.

The lack of taxonomic resolution is apparent amongst the terrestrial mites, where from 23 recorded species (predominantly Oribatida, Mesostigmata and Prostigmata) in the database, only two are determined to species level with another 12 known at genus level; four of the remainder are only determined to family level. *Anystis baccarum* (Anystidae) is recorded from one cave at Bubs Hill (Clarke, 1988b; Houshold and Clarke, 1988) and *Oribotritia contortula* (Oribotritiidae) in caves at Hastings (Clarke, unpublished records). Undescribed species of *Chyzeria* are known from Bubs Hill; *Erythrites* from Bubs Hill and Hastings; *Heydeniella* from Hastings; *Lanceoppia* from Mt. Cripps; *Linopodes* and *Uroobovella* at Bubs Hill and Ida Bay; with *Macrocheles* and *Uropoda* from Hastings. Undescribed species of *Microtrombidium* are known from 16 caves in seven karst areas. Terrestrial mites documented from the walls of "caves" on Macquarie Island (Watson, 1967) are not included in the database. An aquatic mite *Hydryphantes* sp. is recorded from Gunns Plains Cave in northern Tasmania. New species of terrestrial cave mites from the Jenolan Caves of NSW have been described by Halliday (2001) and a species of predatory cheyletid mite was described from Weelawadjia Cave in Western Australia (Fain and Bochkov, 2002).

5.2.12. Cave arachnids - 2: Pseudoscorpionidea (pseudoscorpions)

Amongst the less commonly seen arachnids in Tasmanian caves are the pseudoscorpions, often only known from one or two specimens in collections or sightings. The rarity of pseudoscorpions in caves is global, e.g., in the Appalachian Mountains of USA some species are known from less than ten individuals (Culver, 1986) and during an intensive survey of caves in the Blue River Bio Reserve of Indiana, a cave pseudoscorpion, previously not seen for over 100 years was recently re-discovered (Lewis *et al.*, 1997).

Following the classification and review of cave pseudoscorpions in Australia by Beier (1966), Harvey (1991; 1992) raised the Pseudotyrannochthonini tribe to sub-family level, stating that this group (Pseudotyrannochthoniinae) may ultimate deserve familial status. Brief descriptions of the distribution and ecology of Tasmanian cave pseudoscorpions are provided by Goede (1972) and Eberhard *et al.* (1991). There are two described species of the dominant though relatively rare cave adapted chthoniid genus *Pseudotyrannochthonius*: *P. tasmanicus* from Hastings (Figure 5.19) and *P. typhlus* from Mole Creek (Dartnall, 1970), with more than a dozen new cave species still undescribed (M. Harvey, pers. comm.). Many of these new species are only known from one cave per karst area, including Acheron River, Bubs Hill, Cracroft, Franklin River, Gunns Plains, Ida Bay, Junee-Florentine, Loongana, Lower Andrew River, Mt. Anne, Mt. Ronald Cross, Nelson River, Precipitous Bluff, Scotts Peak, Upper Weld and Vanishing Falls, plus a new species from two of the non-karst dolerite caves at Mt. Wellington. As outlined in Clarke (1997c), the Tasmanian cave species are highly specialised, with reduced body pigmentation, reduced eyes or loss of eyes, plus attenuation (lengthening) of legs and pedipalps (see Figure 5.19).

<u>Figure 5.19</u>: *Pseudotyrannochthonius tasmanicus* Dartnall, 1970: this specialised troglobitic pseudoscorpion has a body length of 3mm and attenuated pedipalps (4.0-4.5mm long); photographed in its Type Locality (King George V Cave) at Hastings.

5.2.13. Cave arachnids - 3: Opiliones (harvestmen)

Unlike the pseudoscorpions, the harvestmen (Opiliones) represent a group of cave and karst surface invertebrates with reasonably well defined taxonomy; most taxa are known to genus with many described species (Table 5.16), largely thanks to the sterling efforts of the two arachnologists: Vernon Hickman and Glenn Hunt. Most cave dwelling species belong to Family Triaenonychidae of the Sub-Order Laniatores, a primitive type of harvestmen common in southern Australia. Species of *Hickmanoxyomma* represent the dominant cave genus in Tasmania, including *H. cavaticum* (Figures 1.19, 5.20 and 5.22) and *H. gibbergunyar* (Figure 5.21). Most mainland karst areas only have one cave harvestmen species, but in several Tasmanian areas there are more than one species (Hunt, 1989). For example, at Hastings in southern Tasmania, there are possibly three species: the blind *Lomanella* and *Hickmanoxyomma* (formerly "Monoxyomma") both occurring in King George V Cave and Newdegate Cave, plus specimens of another blind species, *Calliuncus*, found under old staircase timbers amidst decomposing litter immediately outside the entrance of King George V Cave. As well as having no eyes, the *Calliuncus* harvestmen from Hastings (possibly a former "cave resident"), has no eye mound (Hunt, 1989).

Aside from the blind, possibly troglobitic *Calliuncus* collected on two occasions just outside the entrance to KGV Cave at Hastings (and not seen since), Table 5.16 shows there are five main genera with troglobitic taxa: two of them, *Hickmanoxyomma* and *Lomanella*, include described species (Hunt, 1990; Hunt and Hickman, 1993) and three, *Glyptobunus*, *Notonuncia* and *Nuncioides* are genera with new species. Apart from the enigmatic *Calliuncus,* which has not been collected in a cave, none of the cave dwelling species have been recorded in surface habitats, but as shown in Table 5.16 some epigean species are recorded from caves. For example, *Hickmanoxyomma silvaticum* is a surface species that occurs in "cave-like" epigean habitats in north-eastern Tasmania, deep within rotten logs, under fallen manferns and in mine adits. Four karst areas show a high diversity of harvestmen species: Bubs Hill, Hastings, Ida Bay and Junee-Florentine, but this may reflect the intensity of cave fauna collecting in these areas. The relatively high diversity of epigean species at Hastings, Ida Bay and Junee-Florentine is interesting given the prevalence of the lyrebird in these areas; rated as one of the major predators of harvestmen, it rakes through layers of rainforest litter and mulch with its strong claws in search of prey (Hunt, 1989).

Figure 5.20: Posterior view of the Ida Bay cave harvestman: *Hickmanoxyomma cavaticum* (var. 1: IB), on moist cave coral with moonmilk flecks, photographed in its Type Locality at Mystery Creek Cave, Ida Bay, in southern Tasmania.

Species of *Hickmanoxyomma* provide another example of a species group with a disjunct or vicariant distribution pattern, related to a widespread (but now extinct) surface-dwelling ancestor (Hunt, 1989; Eberhard, *et al.* 1991; Eberhard 1992c). With their specialised pedipalps (Figure 5.22) and attenuated limbs, the cave harvestmen are highly troglomorphic and studies of their metabolic rates (including oxygen consumption) show them at the lower end of the measured range for epigean species (Hüppop, 1985).

Hickmanoxyomma cavaticum is recorded from Ida Bay (Figures 1.19 and 5.20), Hastings and North Lune. In his description of the species, Hunt (1990) reported distinct differences in populations from each area, and based on results of electrophoresis analysis, showing variation in their allozymes, Hunt suggests the three populations may be reproductively isolated. Following agreement with Hunt (pers. comm., 1996), Clarke (1997a, 2006, in prep.) records the species from each area as varieties, listing the Ida Bay species as *H. cavaticum* "var. 1: IB", "var. 2: H" for the Hastings species and "var. 3: NL" for North

Lune. Based on morphological variation between populations of *Lomanella thereseae* recorded from Hastings, Ida Bay and Upper Weld (Hunt and Hickman, 1993), Hunt also agreed to a similar division/ separation for this species. Shown in the database and in Table 5.16, these are listed as *Lomanella thereseae* (var. 1: H), *L. thereseae* (var. 2: IB) and *L. thereseae* (var. 3: UW).

In similarity to the three varieties of both *Lomanella thereseae* and *Hickmanoxyomma cavaticum*, Hunt (1990) also records considerable morphological variation between populations of *Hickmanoxyomma clarkei* from caves in two neighbouring karst areas in southwest Tasmania. This species was first collected from three caves forming part of the Wargata Mina (Judds Cavern) system in the Cracroft karst; these collections include the type locality specimens. Prior to description, a number of specimens of *H. clarkei* were collected from Bauhaus (Hunt, 1990), part of a large cave system at Precipitous Bluff (PB). Although the two cave systems are approximately 23-25km apart, the PB karst is located immediately south of the Cracroft and west of the Vanishing Falls karst area; all three karst areas appear to be part of the same unit or block of limestone (Dixon and Sharples, 1986). Despite being described as the same species, Hunt (1990) records that the PB specimens of *H. clarkei* are bigger than the Cracroft specimens, with a longer pedipalp femur, larger femur-carapace ratio, longer tarsi and with other variations including the presence or number of tubercules and development of spines. Therefore it is quite possible that the species recorded as *Hickmanoxyomma clarkei*, from both Cracroft and Precipitous Bluff may represent two distinct species or at the very least two species varieties. Alternately, if considered to be ecotypes of the same species, this might indicate a degree of present (or past) karst bio-space connectivity between these two limestone areas as suggested by the results of geological reconnaissance mapping (Dixon and Sharples, 1986) and similarly inferred by Eberhard *et al.* (1992). Although not confirmed, it is possible that *H. clarkei* is also one of the two undetermined species of harvestmen recorded by Eberhard *et al.* (1992) from the Vanishing Falls karst, given its closer proximity to the Cracroft karst, located roughly midway between the two cave systems, lying SSE of Wargata Mina and NNE of Bauhaus at Precipitous Bluff.

Figure 5.21: The Mole Creek Cave Harvestman: *Hickmanoxyomma gibbergunyar* on flowstone surface above a stalactite in Sassafras Cave. The apparent "tan-orange" colouration is actually a form of depigmentation.

Figure 5.22: Spinose pedipalps of the Ida Bay Cave Harvestmen *Hickmanoxyomma cavaticum* (var. 1: IB); these sharpened pedipalpous spines serve a similar function to the cheliceral fangs of spiders and other arachnids.

Table 5.16: Diversity and distribution of described species and/ or known genera of harvestmen (Opiliones) from cave and karst areas in Tasmania.

Family	Genus or Genus species	Ecology	Cave or karst area	Surface area
Triaenonychidae	Ankylonuncia sp.	Epigean ?	LA, N	AR, F, IB, JF, LA, N
Triaenonychidae	Bryonuncia distincta Hickman, 1958	Epigean ?		H
Triaenonychidae	Bryonuncia sp.	Epigean ?		IB
Triaenonychidae	Calliuncus odoratus Hickman, 1958	Epigean ?		H
Triaenonychidae	Calliuncus sp.	Tx?	GP, WE	AR, IB, JF, N
Triaenonychidae	Calliuncus sp. nov.	Tb?		H
Triaenonychidae	Calliuncus sp., nr. C. odoratus Hickman	Epigean ?		JF
Triaenonychidae	Calliuncus vulsus Hickman	Epigean ?		JF
Triaenonychidae	Chilobunus spinosus Hickman, 1958	Tx?	JF	
Triaenonychidae	Chrestobunus fuscus Hickman, 1958	Epigean ?		AR, BH, N
Triaenonychidae	Chrestobunus sp.	Epigean ?		AR, H, IB
Triaenonychidae	Glyptobunus ?signatus	Tp	MC	
Triaenonychidae	Glyptobunus ornatus Hickman, 1958	Acc?		H
Triaenonychidae	Glyptobunus signatus Roewer, 1915	Acc?	F, LF, MC	JF
Triaenonychidae	Glyptobunus sp. nov. 1	Tb	GP	
Triaenonychidae	Glyptobunus sp. nov. 2	Tb?	R	
Triaenonychidae	Glyptobunus sp. nov. 3	Tp	MC	
Triaenonychidae	Glyptobunus sp. nov. 4	Tp	BH	
Triaenonychidae	Glyptobunus sp. nov., near G. signatus Roewer	Tp	JF, MC	
Triaenonychidae	Glyptobunus sp. or spp.	Tp	F	L
Triaenonychidae	Hickmanoxyomma cavaticum Hunt, 1990 (var. 1: IB)	Tb	IB	
Triaenonychidae	Hickmanoxyomma cavaticum Hunt, 1990 (var. 2: H)	Tb	H	
Triaenonychidae	Hickmanoxyomma cavaticum Hunt, 1990 (var. 3: NL)	Tb	NL	
Triaenonychidae	Hickmanoxyomma clarkei Hunt, 1990	Tb	C, PB	
Triaenonychidae	Hickmanoxyomma cristatum Hunt, 1990	Tb	PB	
Triaenonychidae	Hickmanoxyomma eberhardi Hunt, 1990	Tb	MA	
Triaenonychidae	Hickmanoxyomma gibbergunyar Hunt, 1990	Tb	MC	
Triaenonychidae	Hickmanoxyomma goedei Hunt, 1990	Tb	NR, SP	
Triaenonychidae	Hickmanoxyomma sp. (cave variety)	Tp or Tb	F, LA	
Triaenonychidae	Hickmanoxyomma tasmanicum Hunt, 1990	Tp	FG, SD	
Triaenonychidae	Hickmanoxyomma, nr. H. ?goedei	Tp?	NR	
Triaenonychidae	Leionuncia levis Hickman, 1958	Acc?	JF	H
Triaenonychidae	Lomanella parva Forster, 1955	Acc or Tx?	F	
Triaenonychidae	Lomanella raniceps Pocock 1903	Tx or Tp	JF, LF	H, IB, JF, SP, TP
Triaenonychidae	Lomanella sp. indet. (cave type)	Tb	CP, L, PB	
Triaenonychidae	Lomanella sp. indet. (surface type)	Epigean		F, FG, H
Triaenonychidae	Lomanella thereseae, Hunt and Hickman, 1993 (var. 1)	Tb	H	
Triaenonychidae	Lomanella thereseae, Hunt and Hickman, 1993 (var. 2)	Tb	IB	
Triaenonychidae	Lomanella thereseae, Hunt and Hickman, 1993 (var. 3)	Tp?	UW	
Triaenonychidae	Lomanella troglodytes Hunt and Hickman, 1993	Tb	PB	
Triaenonychidae	Lomanella troglophilia Hunt and Hickman, 1993	Tp	BH, CP, F, LA, NR	
Triaenonychidae	Mestonia ?acris	Acc ?	N	
Triaenonychidae	Mestonia acris Hickman, 1958	Acc ?	F	
Triaenonychidae	Mestonia picra Hickman, 1958	Epigean ?		H
Triaenonychidae	Mestonia sp. nov.	Tb	PB	
Triaenonychidae	Mestonia sp. nov.	Epigean	IB	
Triaenonychidae	Mestonia sp. nov. 3	Tb?	BH	

Family	Genus or Genus species	Ecology	Cave or karst area	Surface area
Triaenonychidae	Miobunus forficula Hunt, 1995	Acc?		H
Triaenonychidae	Miobunus johnhickmani Hunt, 1995 (BH)	Epigean		BH
Triaenonychidae	Miobunus sp.	Epigean ?		BH
Triaenonychidae	Notonuncia arvensis Hickman, 1958 (H-surface)	Epigean		H, IB
Triaenonychidae	Notonuncia obscura Hickman, 1958	Epigean		H
Triaenonychidae	Notonuncia sp. nov 1	Tb	WE	
Triaenonychidae	Notonuncia sp. nov 2	Tb	JF	
Triaenonychidae	Nucina dispar Hickman, 1958	Tp	MC	
Triaenonychidae	Nucina sp. or spp.	Acc? or Tx?	IB, MC, R	
Triaenonychidae	Nunciella badia (Hickman, 1958)	Tp	JF	
Triaenonychidae	Nunciella sp.	Acc? or Tx?	LA	AR, BH, LA, N
Triaenonychidae	Nuncioides ?dysmicus	Tp	BH	
Triaenonychidae	Nuncioides ?infrequens	Tp	BH	
Triaenonychidae	Nuncioides infrequens Hickman, 1958	Tp or Tb	MR	
Triaenonychidae	Nuncioides sp. indet.	Tp or Tb?	SX	
Triaenonychidae	Nuncioides sp. nov. 1	Tb	BH	
Triaenonychidae	Nuncioides sp. nov. 2	Tb	MR	
Triaenonychidae	Nuncioides sp. nov. 3	Tb	JF	
Triaenonychidae	Nuncioides sp. nov. 4	Tb	RB	
Triaenonychidae	Odontonuncia saltuensis (Hickman, 1958)	Tp	G	
Triaenonychidae	Paranuncia gigantea Roewer, 1915	Acc? or Tx?	CP, F, GP, L, LA, MC, MR, MU	F
Triaenonychidae	Paranuncia sp.	Tx		AR, LA, MU
Triaenonychidae	Phanerobunus sp.	Tx or Tp?	BH	
Triaenonychidae	Phoxobunus sp. nov.	Tx or Tp?	BH	
Triaenonychidae	Rhynchobunus arrogans Hickman, 1958	Acc?		FG, JF
Megalopsalididae	Spinicrus nigricans Hickman, 1958	Tx or Tp	BH, JF, RB	AR, H
Megalopsalididae	Spinicrus sp. indet.	Epigean	JF, SP, UW	F, MU, SP
Megalopsalididae	Spinicrus sp. nov.	Acc	BH	
Triaenonychidae	Tasmanonyx montanus Hickman, 1958	Epigean		H, IB
Triaenonychidae	Tasmanonyx sp.	Epigean		H
Triaenonychidae	Triaenobunus pectinatus Pocock 1903	Epigean		H, IB
Triaenonychidae	Triaenobunus sp.	Epigean ?		G, IB

5.2.14. Cave arachnids - 4: Araneae (spiders)

The database contains 1824 records of spiders (Query 9AA2A) assigned to 272 species, 70 known genera, 35 families and 12 superfamily groups (see Taxonomy Table and Query 9AA2B). Despite the large number of recorded spiders including possible troglobitic species from caves in karst and non-karst areas (Table 5.3), the taxonomic resolution of the Araneae is poor. This is due in part to the lack of taxonomists for the many specialised spider family groups, but also because some of the collected specimens from caves are juveniles and/ or females that cannot be identified or described (see discussion, Chapter 3).

Of the 272 spiders found in karst and non-karst cave areas of Tasmania, only 33 are named at species level, including the four cave dwelling species of *Tupua* (Synotaxidae) described by Platnick (Forster, *et al.*, 1990) and the species of *Tanganoides* (Amphinectidae) from Exit Cave (Davies, 2003; 2005). Amongst the remaining 88% (238 species), 150 are species of known genera, another seven are undetermined species of uncertain genera and 75 of the remainder have only been determined to Family level (Query 9AA1).

Aside from one undetermined mygalomorph spider (Family Ctenizidae) collected from a cave at Ida Bay, all the known or recorded spider species from caves in Tasmania belong to the Araneae: infra-order Araneomorphae. Prominent amongst these higher order araneomorph groups in terms of species numbers are the super families of Araneoidea: 117 species (Anapidae, Araneidae, Linyphiidae, Lycosidae, Mysmenidae, Synotaxidae, Tetragnathidae, Theridiidae and Theridiosomatidae); Amaurobioidea: 49 species (Agelenidae, Amaurobiidae, Amphinectidae, Nicodamidae and Stiphidiidae); Palpimanoidea: 34 species (Holarchaeidae, Malkaridae, Micropholcommatidae and Mimetidae); Philodromoidea: 18 species (Cycloctenidae, Sparassidae and Thomisidae); and Dictynoidea: 17 spp. (Desidae and Hahniidae). The three spider superfamily groups of most interest to cave biologists in Tasmania are Araneoidea, Amaurobioidea and Palpimanoidea, all of which contain families that include genera with obligate and/ or troglobitic species.

Most of genera names for spiders in the database with this thesis come from determinations given to cave biologists such as Albert Goede, Stefan Eberhard or the present writer by museum staff, particularly Liz Turner in TMAG, Lisa Boutin at QVM and Mike Gray or Graham Milledge in the Arachnology Section of Australian Museum. A number of these genus names now appear to be incorrect, relating to species whose precise taxonomy has not been determined. One example is the amphinectid currently recorded as *Amphinecta* and the amaurobiid listed as ?*Pakeha*; both these genera are endemic New Zealand spiders. With the exception of the generally smaller cave dwelling stiphidiids, the amaurobioids are quite large species and historically, aside from the Tasmanian Cave Spider, these have been amongst the most commonly seen, reported and collected groups of cave spiders. Although Amaurobioidea is generally accepted as a valid superfamily, their family level systematics is described as being in disarray and many genera remain poorly defined (Coddington and Levi, 1991). There has been a historical tendency for amaurobioid species to be lumped into just one or two particular family groups. In his early determinations of cave spiders in Australia, Gray (1973) records the presence of agelenids from numerous caves and karst areas of Tasmania and as noted by Dondale (1979), Agelenidae was used as a "dump heap" for those amaurobioid genera with uncertain affinities. In more recent decades, there was a trend away from Agelenidae, recording the cave dwelling amaurobioids, e.g., species of "*Rubrius*", as amaurobiids, i.e., Family Amaurobiidae (Eberhard, *et al.*, 1991).

Previously listed as genera of Amaurobiidae, the recent revisions by Davies (1998; 2002; 2003; 2005) indicate that many of these amaurobioids belong to Family Amphinectidae. The new Tasmanian amphinectids now include most of the cave spiders formerly known as *Rubrius*, re-assigned to a new genus: *Tasmarubrius*. In the course of her reclassification and descriptions of new species, Davies (2003) described an amphinectid amaurobioid from Exit Cave as *Tangana clarkei* (Figure 5.23), but after discovering that the generic name was "preoccupied in the Orthoptera", the species has been redescribed to the genus *Tanganoides* (Davies, 2005).

Figure 5.23: Penultimate male of a recently described, troglobitic cave dwelling amphinectid spider *Tanganoides clarkei* (Davies, 2003) with forelegs hunched in defence mode, photographed in its Type Locality riparian habitat on the sandy clay bank of Base Camp Tributary, in Exit Cave at Ida Bay. Note the depigmentation (compared to epigean species) and its long, setose and spinose legs.

The taxonomy of other spider groups also remains vague. To give one example, the family placement of the genus *Archemorus* (Araneidae) was sourced from the Australian Museum database. Although *Archemorus* is not recorded as a valid genus in The World Spider Catalog, in his introduction to the Family Araneidae Simon, 1895, Platnick (2006) lists a number of synonyms, stating that *Arkys* Walckenaer, 1837 is considered a senior synonym of *Archemorus* Simon, 1893, following on from Heimer (1984: 156); however, noting the slight spelling variation, Platnick adds that "...*Arcys is an unjustified emendation*".

Aside from other morphological differences or troglomorphic adaptations, spiders are distinguished by their eyes, their shape (round or oval), the relative size of eyes, presence or absence of eye pigment (as pearly eyes or translucent), their position on the cephalothorax and alignment in rows or varying curvature. For eight-eyed spiders, their eyes are arranged as diads (in pairs) and when viewed from front to rear: the anterior median eyes (AME), anterior lateral eyes (ALE), posterior median eyes (PME) and posterior lateral eyes (PLE); see Figure 5.?. For six-eyed spiders the eyes may form as three diads, e.g., the diagnostic arrangement in eyed species *Olgania*, such as *O. excavata* from Bubs Hill or as two triads in the case of the pholcids. Sometimes referred to as their direct eyes, the front pair of eyes (AME) are usually dark and can be smaller compared to the other indirect eyes (ALE, PLE and PME) that generally have a pearly or silvery appearance, are often larger and adapted for low light intensities. In evolutionary terms, most cave adapted species have very reduced or non-functional eyes compared to epigean relatives and their AME pair may have disappeared or be replaced by long setae or spines; some species such as the very tiny (<1.00mm long) troglobitic *Olgania* have no eyes (see Figures 5.25, 5.26 and 5.27).

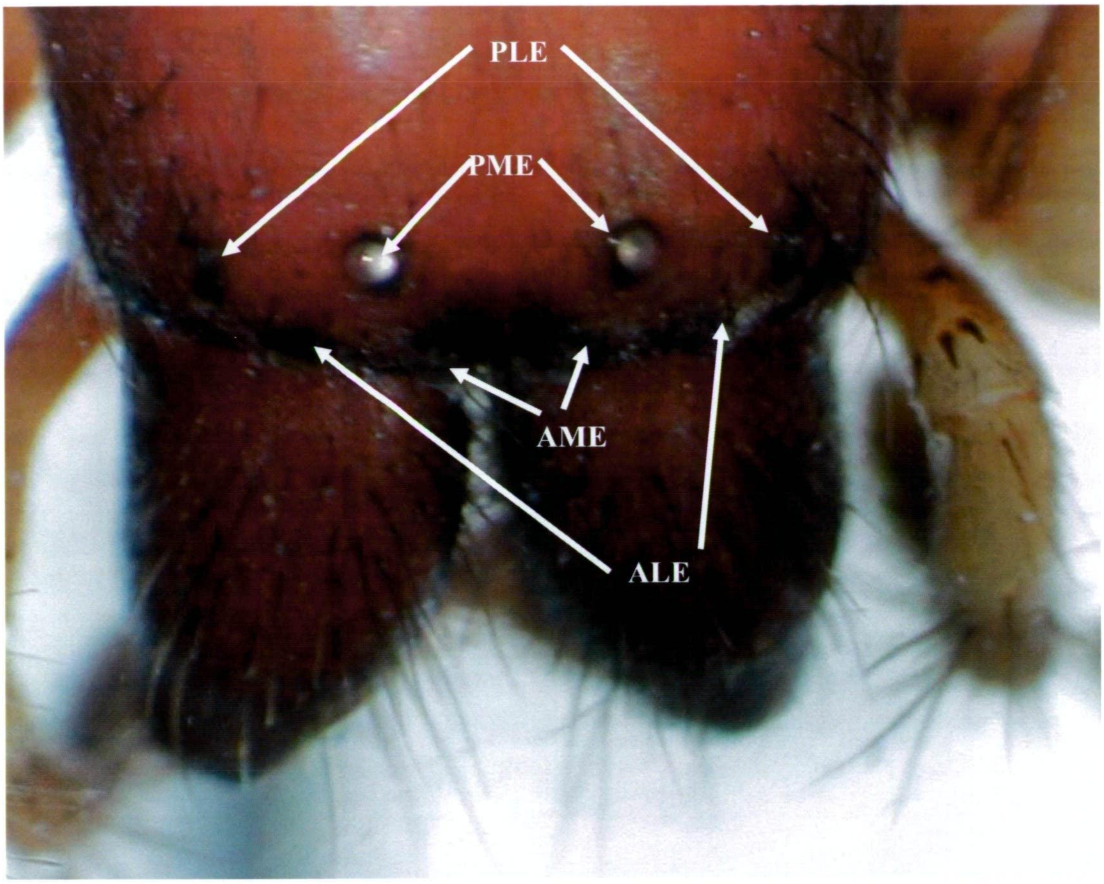

Figure 5.24: A new undescribed female species of *Clubiona* (near *C. elaphines*) with large setose chelicerae and spinose pedipalps, collected from the dark zone in Mystery Creek Cave at Ida Bay, showing arrangement of eyes in four diads (AME, ALE, PME and PLE). Although there is a thin circle of pigment around the pearl-like PME, the barely discernable AME and transparent lenses of the ALE and PLE, suggest this is likely to be a cave adapted ecotype (pers. comm., Michael Rix, 2006).

A number of species of "micro" spiders belonging to several genera and families are found in both the karst and non-karst caves of Tasmania, e.g., Anapidae: *Chasmocephalon* and *Pseudanapis*; Micropholcommatidae: *Micropholcomma*, *Olgania* and *Textricella*; Mysmenidae: *Mysmena* and *Trogloneta*; Synotaxidae: *Physoglenes* and *Tupua*; plus Theridiidae: *Icona*. Many of these are obligate species, including troglobites, often only known from a limital area within any cave or cave system. The super-family relationships of some of these spider family groups is still debated and Schütt (2000; 2003) argues that the micropholcommatids should be re-assigned to Araneoidea, rather than Palpimanoidea as listed in the database, reversing the decision by Forster and Platnick (1984). Similarly, the familial and generic status for some of these micro spiders is also still uncertain.

Figure 5.25: Male specimen of *Olgania* sp. nov. (Australian Museum, Sydney; registration KS:29532): a blind troglobitic micropholcommatid spider (with body length of 0.85mm) collected by Jean Jackson from a cave in the Cracroft karst area of southwest Tasmania. (Photo by Michael Rix, University of Western Australia.)

The distribution, diversity and ecology of the micropholcommatids in Tasmania, is of particular interest, especially the cave dwelling species of the tiny six-eyed *Olgania* spiders (M. Driessen, pers. comm., 2004) recorded in several karst areas of Tasmania. These minute spiders, which typically have a body length of less than 1mm, are solitary spiders occupying horizontal sheet webs in narrow cracks of cave walls, often in the vicinity of seepages. Their webs are generally found in clusters, often in the dark zone of caves and/ or at considerable depth from the surface in vertical cave systems. Some of the new species of blind (troglobitic) *Olgania* are shown in Figures 5.25, 5.26 and 5.27. In his current review of the *Olgania*, Michael Rix (pers. comm., 2006) believes there are several new species in Tasmanian cave populations; including at least one highly troglobitic species at Ida Bay, as well as similarly blind and cave adapted species from the Cracroft, Junee-Florentine and Upper Weld karst areas. Several other species (two different genera) of troglobitic micropholcommatids are known from caves in Tasmania (Michael Rix, pers. comm., 2006).

Figure 5.26: Female of blind *Olgania* sp. nov. (AMNH holdings, New York). Less than 1mm long, it is one of three specimens collected from a cave at Ida Bay by Arthur Clarke and Stefan Eberhard. Photo by Michael Rix, University of Western Australia.

Figure 5.27: Male of blind *Olgania* sp. nov. (AMNH holdings, New York), collected by Stefan Eberhard from a cave in the Junee-Florentine karst. Photo by Michael Rix.

Amongst the obligate mysmenid micro spiders in Tasmanian caves, a new possibly troglobitic species of *Mysmena* was discovered late last year at Mole Creek; this species has eyes, but three pairs of eyes (ALE, PLE and PME) appear top lack pigment and the AME pair appear to be reduced to eye spots without lenses (Figure 5.28). Known from a relatively substantial population, species numbers and web sites have been documented by Karst Watch volunteers during cave monitoring activities. Recorded as *Mysmena* sp. nov 2, this tiny spider inhabits small 2-3cm wide shallow pock-mark holes in a flowstone floor, where individual species have been observed guarding egg sacs and presumed mating couples are found in the centre of their fine 8-10 radial strand orb webs stretched horizontally across from surface rims (D. Lee and P. Flood, pers. comm., 2006).

Figure 5.28: A new species of *Mysmena* (Mysmenidae) with body length slightly less than 1mm, photographed on a lens cap in the St. Pauls Dome chamber, of Marakoopa Cave at Mole Creek. Note the setose and translucent legs of this adult female, with no pigment in eye lenses. (Discernable in the background are the letters "AP"; measuring 2mm high, these form part of the "Made in Japan" lens cap logo.) Photograph kindly supplied by Paul Flood, Parks & Wildlife Service, Mole Creek.

Based on the known genera of spiders alone, it is obvious that the Araneae are one of the most widespread and diverse invertebrate groups recorded from cave or karst areas of

Tasmania. An example of the diversity and distribution of species in carbonate rock karst areas in Tasmania is shown below, listing the 69 identified genera of araneomorph spiders recorded in the database taxonomy table and Database Query 9AA2B. In karst areas where the only records for araneomorphs relate to collections from surface sites, these are indicated. Karst area location records for species of four uncertain genera (shown with a "?" prefix) are also included. Aside from the taxonomy of described cave dwelling spiders sourced from Forster *et al.* (1990) and Davies (2003; 2005), the taxonomy for genera and family placement has been sourced from the online edition of American Museum of Natural History's World Spider Catalog, Version 6.5 (Platnick, 2006).

Achaearanea (Theridiidae): Acheron River (surface), Bubs Hill, Eugenana, Gunns Plains, Ida Bay, Ille de Golfe, Lower Andrew (surface), Nelson River (surface) and Montagu;
Acrobleps (Mysmenidae): Franklin River, Junee-Florentine, Lower Andrew and Mount Ronald Cross;
Ambicodamus (Nicodamidae): Mole Creek;
Amphinecta (Amphinectidae): Acheron River, Cracroft, Gray, Hastings, Ida Bay, Junee-Florentine, Mole Creek, Mount Cripps, Precipitous Bluff and Redpa;
Argiope (Araneidae): Lower Andrew River (surface);
Argoctenus (Zoridae): Mole Creek;
Arkys (Araneidae): Acheron River (surface), Franklin River (surface), Ida Bay (surface), Lower Andrew (surface) and Lower Maxwell;
Artoria (Lycosidae): Lower Andrew (surface) and Nelson River (surface);
Australomimetus (Mimetidae): Eugenana; Franklin River, Flowery Gully, Gunns Plains and Montagu;
Baalzebub (Theridiosomatidae): Bubs Hill, Davey River, Eugenana, Flowery Gully, Franklin River, Gray, Gunns Plains, Ida Bay, Loongana, Lower Andrew, Mole Creek, Montagu, Nicholls Range, Precipitous Bluff and Redpa;
Badumna (Desidae): Franklin River (surface), Lower Andrew (surface) and North Lune;
Carathea (Malkaridae): North Lune;
Chasmocephalon (Anapidae): Mole Creek;
Clubiona (Clubionidae): Acheron River (surface), Franklin River (surface), Ida Bay and Lower Andrew (surface);

*Cornifalx (*Orsolobidae*)*: Acheron River (surface), Franklin River (surface), Hastings (surface) and Scotts Peak (surface);

Cryptaranea (Araneidae): Franklin River (surface);

Cycloctenus (Cycloctenidae): Acheron River, Bubs Hill, Cracroft, Davey River, Franklin River, Gray, Ida Bay, Junee-Florentine, Lower Andrew (surface), Lower Maxwell, Mole Creek, Mount Ronald Cross, Nelson River (surface), North Lune, Precipitous Bluff, Ranga, Savage River, Timbs Creek, Trowutta (surface), Vanishing Falls and West Maxwell-Algonkian;

Cyclosa (Araneidae): Acheron River (surface);

Diaea (Thomisidae): Bubs Hill;

Diplocephalus (Linyphiidae): Nelson River (surface);

Dolomedes (Pisauridae): Trowutta;

Dolophones (Araneidae): Lower Andrew (surface);

Eriophora (Araneidae): Acheron River (surface), Franklin River (surface) and Nelson River (surface);

Ero (Mimetidae): Ranga;

Euryopsis (Theridiidae): Acheron River (surface), Franklin River (surface), Lower Andrew (surface) and Nelson River (surface);

Hickmanapis (Anapidae): Bubs Hill (surface);

Hickmania (Austrochilidae), see Figure 5.29 (overleaf): Bubs Hill, Cheyne Range, Claude Creek, Cracroft, Dante Rivulet, Eugenana, Flowery Gully, Franklin River, Gordon-Sprent, Gray, Gunns Plains, Hastings, Hustling Creek, Ida Bay, Jukes-Darwin, Julius River, Junee-Florentine, Keith River, Lake Lea, Loongana, Lorinna, Lower Andrew, Lower Huskisson, Moina, Mole Creek, Montagu, Mount Anne, Mount Cripps, Mount Weld, Nelson River, Newall Creek, Nicholls Range, North Lune, Precipitous Bluff, Redpa, Styx River, Trowutta, Upper Huskisson, Upper Weld, Vanishing Falls, White (Hawk) Creek, Wilmot River and Wilson River;

Holarchaea (Holarchaeidae): Acheron River, Lower Andrew and Montagu;

Holoplatys (Salticidae): North Lune and Lower Andrew (surface);

Icona (Theridiidae): Bubs Hill, Cracroft, Eugenana, Flowery Gully, Franklin River, Gordon-Sprent, Gray, Gunns Plains, Hastings, Ida Bay, Junee-Florentine, Loongana, Lower Andrew, Mole Creek, Montagu, Nelson River, Nicholls Range, North Lune, Precipitous Bluff, Redpa, Scotts Peak, Styx River and Vanishing Falls;

Figure 5.29: Spinose and setose legged female specimen of the Tasmanian Cave Spider clambering off its web and on to a wall in the twilight zone of Sassafras Cave at Mole Creek.

Laetesia (Linyphiidae): Acheron River (surface), Lower Andrew (surface) and Nelson River (surface);

Meta (Tetragnathidae): Acheron River, Bubs Hill, Franklin River, Lower Andrew (surface), McKays Peak, Mount Ronald Cross, Nelson River, Precipitous Bluff and Scotts Peak;

Micropholcomma (Micropholcommatidae): Acheron River (surface), Junee-Florentine and Nelson River (surface);

Mysmena (Mysmenidae): Franklin River and Mole Creek;

Namandia (Desidae): Acheron River (surface), Franklin River (surface), Lower Andrew (surface) and Nelson River (surface);

Nanometa (Tetragnathidae): Acheron River (surface) and Lower Andrew (surface);

Neon (Salticidae): Acheron River (surface), Franklin River (surface) and Lower Andrew (surface);

Neoscona (Araneidae): North Lune;

Neosparassus (Sparassidae): North Lune;

Novolaetesia (Linyphiidae): Franklin River;

Olgania (Micropholcommatidae): Acheron River, Bubs Hill, Cracroft, Franklin River, Ida Bay, Junee-Florentine, Mole Creek and Upper Weld;

Ommatauxesis (Amaurobiidae): Lower Andrew (surface) and Nelson River (surface);

? *Oramia* (Agelenidae): Bubs Hill;

Orsinome (Tetragnathidae): Acheron River (surface), Bubs Hill, Franklin River (surface), Gordon-Sprent, Ida Bay, Lower Andrew (surface), Mole Creek, Nelson River (surface) and Nicholls Range;

? *Pakeha* (Amaurobiidae): Ida Bay;

Phoroncidia (Theridiidae): Acheron River (surface), Bubs Hill, Franklin River (surface) and Lower Andrew (surface);

Physocyclus (Pholcidae): Junee-Florentine and Tasman Peninsula;

Physoglenes (Synotaxidae): Acheron River, Cracroft, Franklin River, Gunns Plains, Ida Bay, Junee-Florentine, Lower Andrew, Mount Anne and Precipitous Bluff;

Porrhomma (Linyphiidae): Ida Bay;

Prostheclina (Salticidae): Flowery Gully (surface), Lower Andrew and Nelson River (surface);

Pseudanapis (Anapidae): Ida Bay, Montagu and Precipitous Bluff;

Scotospilus (Hahniidae): Acheron River (surface);

Sidymella (Thomisidae): Acheron River (surface), Franklin River (surface), Nelson River (surface) and Nicholls Range;

Steatoda (Theridiidae): Eugenana, Franklin River (surface), Mole Creek and Ranga;

Stiphidion (Stiphidiidae): Eugenana, Flowery Gully, Franklin River, Gunns Plains, Hastings, Loongana, Mole Creek, Mount Ronald Cross, Nelson River, North Lune, Precipitous Bluff (surface), Redpa, Savage River and Trowutta;

Storenosoma (Amaurobiidae): Loongana;

Supunna (Corinnidae): Junee-Florentine;

? *Synotaxus* (Synotaxidae): Bubs Hill;

Tanganoides (Amphinectidae): Franklin River, Hastings, Ida Bay, Junee-Florentine, Mole Creek and Precipitous Bluff;

Tara (Salticidae): Acheron River (surface), Flowery Gully (surface) and Scotts Peak (surface);

Tasmabrochus (Amphinectidae): Franklin River;

Tasmanoonops (Orsolobidae): Acheron River (surface), Bubs Hill, Franklin River (surface) and Nelson River (surface);

Tasmarubrius (Amphinectidae): Acheron River, Bubs Hill, Franklin River, Gunns Plains, Ida Bay, Junee-Florentine, Lower Andrew (surface), Mole Creek and Mount Anne, Mount Cripps, Nelson River, North Lune, Precipitous Bluff and Vanishing Falls;

Tetragnatha (Tetragnathidae): Acheron River (surface), Lower Andrew (surface) Nelson River (surface) and Precipitous Bluff (surface);

Textricella (Micropholcommatidae): Acheron River (surface), Bubs Hill, Franklin River (surface), Ida Bay, Loongana, Lower Andrew (surface), Montagu, Nelson River (surface) and Upper Weld;

Theridiosoma (Theridiosomatidae): Mole Creek;

Thwaitesia (Theridiidae): Acheron River (surface) and Nelson River (surface);

Toxopsiella (Cycloctenidae): Ille de Golfe;

Toxopsoides (Desidae): Acheron River (surface), Flowery Gully, Franklin River (surface), Ida Bay and Lower Andrew (surface);

Trogloneta (Mysmenidae): Franklin River;

? *Trogloneta* (Mysmenidae): Ida Bay, Mole Creek and Mount Cripps;

Tupua (Synotaxidae): Franklin River, Gunns Plains, Hastings, Ida Bay, Junee-Florentine, Loongana, Mole Creek, Mount Anne, Mount Cripps, Nicholls Range, North Lune, Precipitous Bluff, Savage River and Styx River.

The most ubiquitous species is the Tasmanian Cave Spider (*Hickmania troglodytes*) shown in Figures 1.3, 2.1 and 5.29, recorded from caves in 43 karst areas and 9 non-karst areas, along with one surface karst record for Mount Cripps. The next most commonly found genera are *Baalzebub, Stiphidion* (usually *S. facetum*), *Tupua*, *Cycloctenus*, *Amphinecta, Icona*, *Meta* and *Olgania*. Some of these genera are included amongst the ten araneomorph species listed in Table 5.17, recorded from caves in 12 non-karst areas.

Table 5.17: List of the araneomorph (spider) species recorded from caves in non-karst areas of Tasmania.

Family	*Genus species*	Non-karst area	Ecology
Araneidae	*Araneus sp.*	Moonlight Creek	Acc?
Cycloctenidae	*Cycloctenus sp.*	Mount Wellington	Tx
Austrochilidae	*Hickmania troglodytes*	Donaldsons Landing	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Francistown	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Louisa Bay	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Mount Wellington	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Pieman River	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Rocky Boat Inlet	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Scottsdale	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Stoodley	Tx or Tp?
Austrochilidae	*Hickmania troglodytes*	Upper Natone	Tx or Tp?
Theridiidae	*Icona sp.*	Mount Wellington	Tp or Tb
Tetragnathidae	*Meta sp.*	Mount Wellington	Tx? or Tp
Micropholcommatidae	*Micropholcomma sp. nov. 2*	Mount Wellington	Tp
Salticidae	*Opisthoncus sp.*	Moonlight Creek	Acc?
Stiphidiidae	*Stiphidion facetum*	Birchs Inlet, (Port Davey)	Tx or Tp?
Stiphidiidae	*Stiphidion facetum*	Mount Wellington	Tx or Tp?
Synotaxidae	*Tupua bisetosa*	Mount Wellington	Tp
Synotaxidae	*Tupua raveni*	Liffey Falls	Tx or Tp

5.3: A discussion of species diversity with mainland karst comparisons

The previous eight sections provide an overview of the cavernicole diversity in Tasmania, plus species recorded from surface karst sites. The diversity of cavernicolous species is perhaps higher than expected (Sket, 1999) and with five caves at Hastings and Ida Bay each having 20 or more obligate species, their diversity is at world standards (Culver and Sket, 2000) and the writer believes there are many more cavernicoles yet to be discovered. More research is required in selected habitats, caves or karst areas to reveal the total diversity, along with taxonomic study and description of species, such as the crangonyctoid amphipods. Amongst the few groups not discussed, which might include stygobiont species, are the copepods, ostracods, aquatic flatworms (planarians), nemertines and freshwater crayfish, Similarly, amongst the terrestrial species not detailed, but likely to include troglobites, are the other non-carabid beetles, other insects including obligate fulgoroid Hemiptera and Trichoptera (both of which appear to complete their whole life cycle in the cave), diplurans and enchytraeid (oligochaete) worms. A few cavernicolous species including trogloxenes and troglophiles have not been discussed; some of these will be mentioned in Chapter 6.

Checklists of cave fauna commonly accompany descriptions of caves or karst areas, e.g., reports on limestone caves at Chillagoe and lava tubes at Undara in Far North Queensland and the baseline report by Smith (1982) describing cave fauna communities at Wombeyan in southern New South Wales (NSW). There have been very few detailed regional studies of cave fauna diversity in mainland karst areas, aside from an annotated checklist of the cavernicoles in Western Australia (Lowry, 1980) and the detailed report by Eberhard and Spate (1995b), recording fauna from 130 caves in 48 of the 95 cavernous karst areas of NSW. The paucity of cave fauna records from Victoria and South Australia is particularly noted by Hamilton-Smith and Eberhard (2000) and probably reflects the lack of any detailed or systematic study of the cavernicolous component of karst regions in these States. In a study of the stygofauna diversity and distribution of eastern Australia, Thurgate, *et al.* (2001) use the IBRA biogeographic regions proposed by Thackway and Cresswell (1995) to compare the range of taxa, number of endemic species and stygobites recorded from cave and karst areas in different regions.

In their study, Thurgate, *et al.* (2001: p. 41) noted that "*...most cave and karst areas in Eastern Australia have been cursorily sampled, although a few selected areas in Tasmania (e.g., Ida Bay, Mole Creek) and New South Wales (e.g., Wombeyan, Jenolan) have been intensively surveyed.*" In their comparative analyses of the stygal taxa of individual karst areas and IBRA regions, Thurgate *et al.* place emphasis on the number of described species and although noting 77% of the recorded paramelitids occur in karst areas of Tasmania, most of the described amphipods are found in the "SEH" (Southeast Highlands) region of NSW. In this writer's opinion, the use of IBRA regions may have lead to a slightly skewed result, for example showing that the SEH region of NSW (including Wombeyan and Jenolan) has a higher number of troglobitic taxa than the two major IBRA karst regions in Tasmania: WOO (Woolnorth) region, including Mole Creek and the DE (D'Entrecasteaux) region with Ida Bay. However, although selected karst areas of mainland Australia have a very high component of stygal taxa, e.g., 40 species recorded for Mount Gambier in South Australia and Wombeyan in NSW, there are only two other areas in NSW with over 10 taxa: Jenolan (15 taxa) and Cooleman Plain (10 taxa), but in Tasmania there are nine karst areas with this level of diversity. The data used by Thurgate, *et al.* was based on reports by Eberhard *et al.* (1991), Clarke (1997a; 2000b) and Eberhard and Spate (1995b).

In a summary of their systematic survey of NSW cave communities, Eberhard and Spate (1995b: p.2) record a minimum of 172 species belonging to 115 families of 30 orders and six phyla, reporting a "*...unsuspectedly diverse suite of highly specialised aquatic species (stygobionts) within karst groundwaters* ... [including]... *a new family of syncarid crustaceans...*" Amongst the stygobiont taxa recorded from caves in NSW, there were new species of syncarids, amphipods, asellote and phreatoicids isopods, ostracods, copepods, hydrobiid snails and turbellarian flatworms. Although impounded mainland karsts such as Wombeyan in NSW are areas of high stygofauna diversity, Thurgate, *et al.* (2001: p. 54) state that "*...in mainland karsts, diversity of individual caves is low. Most caves support less than five taxa, and it is rare for more than two obligate taxa to be present in the same cave. In contrast, at least 13 Tasmanian caves contain five or more stygobitic taxa.*" The authors add that Tasmanian caves contain "*...the greatest taxonomic diversity of anaspids* [sic]... (And)... *an outstandingly rich subterranean molluscan fauna (25 taxa) especially of hydrobiid gastropods*" (Thurgate, *et al.*, 2001: p. 56-57), a list that does not include the new stygobitic hydrobiids from Precipitous Bluff in southern Tasmania (Ponder, *et al.*, 2005).

Aside from the fact that species richness in any given cave or karst area may simply be a measure of the intensity of study there, it is difficult to precisely judge the significance of the apparent greater diversity of taxa in Tasmania, when there are very few studies of mainland karst species diversity for comparison and so many species remain undescribed. Hypogean bio-inventories by government bodies and museums in mainland Australia have enabled some specific groups of cave fauna to be better known. For example, descriptions of the new crangonyctoid amphipods recorded from caves in karst areas of NSW during the survey by Eberhard and Spate (1995b), and from caves and groundwater in Queensland and Western Australia, have resulted in a significantly greater taxonomic resolution than the equivalent Tasmanian fauna (e.g., Barnard and Williams, 1995; Bradbury and Williams, 1997b; Bradbury, 2000; Bradbury and Eberhard, 2000). However, despite the lack of taxonomic resolution in the Tasmanian cave fauna, there appears to be a greater diversity compared to most known mainland karsts, which poses interesting questions, discussed in the final chapter, considering the minimal input of organic matter and energy into Tasmanian cave systems and cave fauna habitats.

6. Habitat factors affecting distribution and biodiversity of cavernicoles

As discussed in Chapter 3, species occurrences in caves at Hastings and Ida Bay form the basis of this chapter describing the habitat factors affecting the distribution and biodiversity of cavernicoles. The species occurrences in these two karst areas are listed in the database records table on the basis of their recorded location within the cave zone region and their macro-habitat/ micro-habitats. An outline of the cave zone regions, macro-habitats and micro-habitats applied to caves in the two study areas (Hastings and Ida Bay) is described in section 4.3 of this thesis. Tables 4.1 – 4.11 list the ten coded macro-habitats and 44 micro-habitats recorded for species in the caves (and surface sites) at Hastings and Ida Bay and a list of cave species occurrences in each micro-habitat is shown in Table 6.1.

Several of the caves within the study area are large in terms of length and the internal dimensions of passages and chambers. Exit Cave at Ida Bay is arguably the longest cave in eastern Australia and is also one of the few caves at Ida Bay with an almost complete range of natural micro-habitat sites. The major difference in the defined habitats for cave species between the two karst areas, relates to the impact of past and present tourism at Hastings and the "evolution" of un-natural micro-habitat sites, albeit important sites for cave fauna. The two most studied caves are Exit Cave at Ida Bay, containing almost 40 different recorded species occurrence sites, and Newedgate Cave at Hastings with about 25 occurrence sites. The collection or observation sites that constitute a species occurrence cannot be adequately displayed on small scale map, but the respective cave zone regions can be shown. A series of maps are contained in this section showing the proximal relationship of known caves with opposing north-south drainage at Ida Bay, along with maps of two individual caves: Newdegate Cave at Hastings and Exit Cave at Ida Bay, showing detail of cave zone regions and sections of cave where collection sites are located.

Some cave zone regions are pre-determined by natural factors such as cave morphology or the presence of epigean influences, whereas other regions have been "manufactured" or modified to reflect the influence or regularity of disturbance, principally due to the impact of human visitation by tourism or recreational use by cavers (Clarke, 1999a).

Table 6.1: Coded micro-habitats with abbreviated descriptions (see Tables 4.2-4.11) with numbers of recorded occurrences for species in caves at Hastings and Ida Bay; from summary lists in Query 4G and 5G.

Codes	Abbreviated micro habitat description	Hastings	Ida Bay
A1	Low flow seepages or trickles	2	23
A2	Humic and fulvic acid (DOM) rich flowing water	5	9
A3	Flowing water (clear stream)	2	46
A4	Flowing water (riffle zone)	1	39
A5	Splash zone or plunge pools at base of shafts	1	15
A6	Still (flat water) surfaces with laminar flow	6	72
A7	Larger pools or natural impoundments (e.g. lakes)	6	2
A8	Still or STANDING water, e.g., gour pools and SPRINGS	3	3
B1	Riparian habitats beside running water	10	69
B2	Riparian habitats beside still water or springs	1	12
C1	Flat floor surfaces within caves	15	39
C2	Sloping floor surfaces within caves	8	52
C3	Wall related surfaces and crevices in caves	50	326
C4	Hard crystalline speleothem surfaces	15	10
C5	Soft speleothem surfaces, e.g. moonmilk	5	66
C6	Ceiling surfaces	4	40
C7	Cave atmosphere	4	27
D1	Living roots from surface trees in cave water	-	2
D2	Living roots from surface trees in cave atmosphere	2	11
D3	Ferns, bryophytes and lichens on entrance walls	-	4
D4	Fungi, e.g., Ascomycetes or stalked basidiomycetes	1	14
E1	Host animal habitats, including owl pellets	2	7
E2	Animal faeces, principally from mammals	-	2
E3	Habitats associated with animal structures	7	213
E4	Dead animal habitats	7	1
F1	Non-living plant matter in caves	-	5
F2	Coarse POM: logs and tree branches	22	23
F3	Medium POM: twigs and large leaves (entrance litter)	42	91
F4	Fine POM: detritus, mulch and flood litter	35	71
F5	Dissolved organic matter (DOM)	-	5
G1	Under broken rock, boulders, cobbles or pebbles	4	36
G2	On top or around the sides of broken rock etc.	4	49
G3	In or on top of soft sand, clay or mud substrate	6	28
G4	Interstitial spaces in saturated sediments	-	17
G5	Exposed bedrock surfaces (in pools or streams)	2	10
H1	Tourist cave infrastructure: stairs, pavements, etc	17	7
H2	Discarded timber debris in caves	280	2
H3	Discarded inorganic waste in caves	5	213
H4	Rubbish and waste from cave visitors	5	1
H5	Lampenflora in entrances or near artificial light	2	5
X1	Percolation fed pools in upper level relict karst passages	-	14
X2	Speleothem surfaces in upper level relict karst passages	4	22
Z1	Gravity fall accidental habitats	11	33
Z2	Wash-in accidental habitats	3	13
44 codes		**597**	**1521**

6.1: Defining and assigning cave zone regions at Hastings and Ida Bay

The determination of the traditional cave zones or cave zone regions (section 4.3.2) can be a very subjective process, with different observers arriving at different conclusions. For example, if using the extent of daylight penetration as a determinant, the human eye is not a very reliable judge, especially when – as cave visitors – we turn on our helmet mounted lights as we enter the cave. If we turn our cave lights off after travelling some distance into the cave, assuming there are no glow-worms there, the cave may appear darker than it actually is because the pupils in our eyes will have already narrowed, in partial adjustment to our artificial light.

In this study, four factors have been considered in determining the cave regions: light penetration, distance from the cave entrance, morphology (structure) of the cave and the influence or extent that epigean factors "invade" the cave environment. I will elaborate with some examples of the way cave regions have been assigned for a few of the developed, heavily visited and rarely visited caves from the Hastings and Ida Bay karst areas.

Newdegate Cave at Hastings is the main (only) commercially operated tourist cave (or "show cave") in southern Tasmania with an infrastructure of stairs, pathways and the style of electric lighting typically associated with show caves. Although the entrance is sheltered by a roof enclosure, it is still in daylight, but as you descend the entrance stairs, the "available" daylight rapidly diminishes. At the foot of the concrete stairs you are in what might be termed a "semi-daylight" zone, verging on "twilight", categorised as Entrance / Twilight in the database. Continuing along the gently inclined pathway to the "lookdown" at the head of the spiral staircase, you are trending into the twilight zone. If there are no lights turned on in the cave while you are standing near the lookdown, it appears to be "pitch dark" as you look ahead and down, but if you turn around looking back towards the entrance, you see a very slight glimmer of daylight. I am describing this region of the cave from the entrance to the top of the spiral staircase as the "Outer" region of the cave. The rest of the developed tourist section of the cave – the area in the immediate vicinity of the stairs, pathways, bridges and viewing stages – is recorded in this thesis as the "Middle" region of the cave, incorporating the "twilight/ transition" and "transition" zones of the cave.

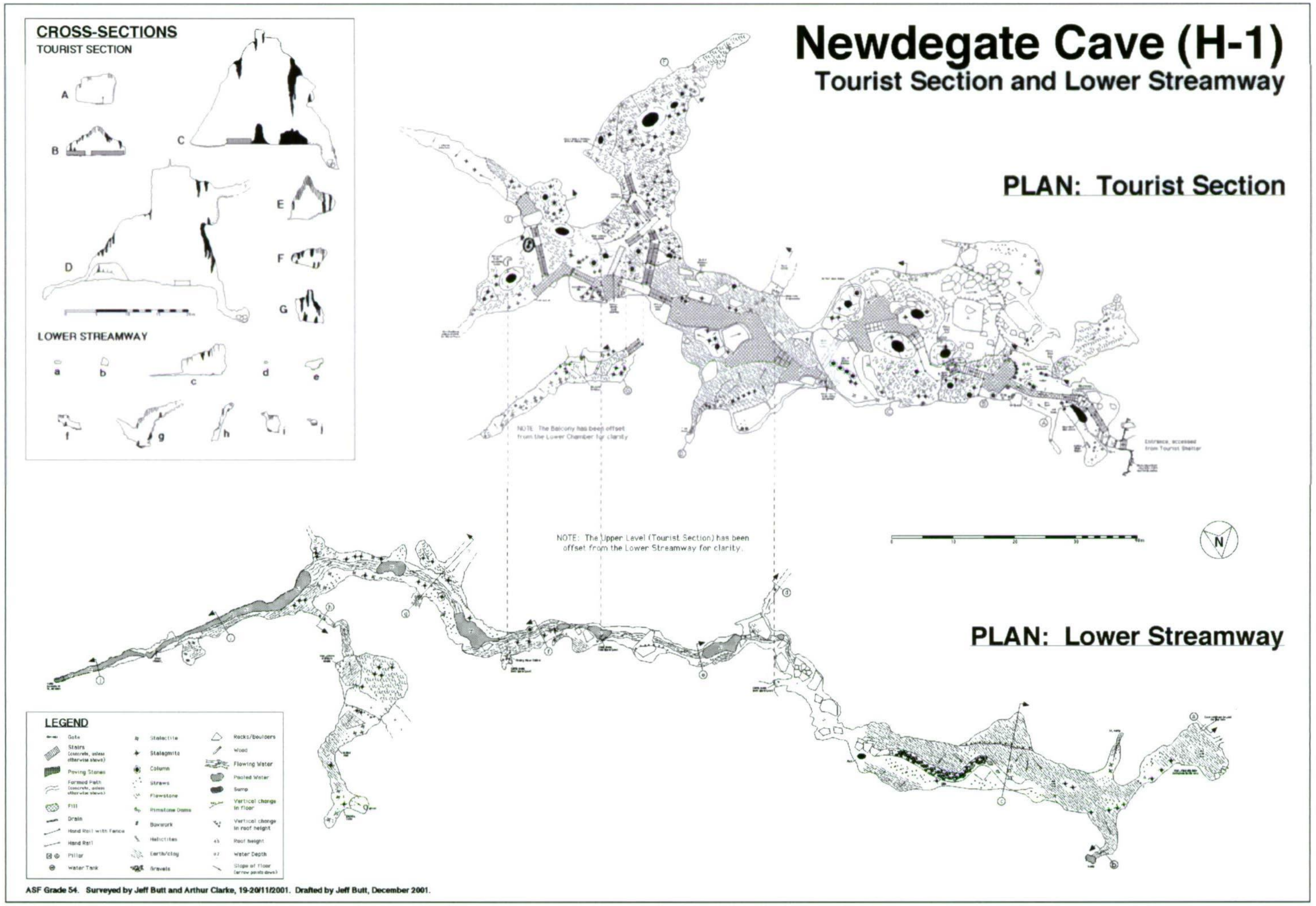

Figure 6.1: Map of Newdegate Cave (H-1) at Hastings, surveyed in considerable detail for this thesis study by Jeff Butt and Arthur Clarke (November 2001), in order to accurately pinpoint and mark the precise locations of cavernicole species occurrences.

Although the tourist portion of Newdegate Cave is now only minimally illuminated for a relatively short part of the day when there are cave tours, this developed section represents a region where epigean influences are present on a regular basis: the tour guides, cave visitors, plus the infrastructure. The "Inner" region of the cave is ascribed to those habitats some distance beyond the immediately developed sections, e.g., at the end of the Cathedral Chamber where Binney Tunnel commences and in Mystery Creek below the tourist section. However, since the proximity of the developed section of cave imposes an epigean influence, it could be argued that the Inner Region of Newdegate Cave starts in the upper level Binney Chamber beyond the Binney Tunnel. Similarly, there are epigean influences in the lower streamway resulting from the wash-down of debris from the tourist section above and dumping of discarded light globes and other cave fittings: a legacy of malpractices from a time before tourist caves were considered for their ecological and scientific values. Therefore, the Inner Region of the Mystery Creek streamway is probably located further towards each end of the accessible section, at or beyond the sump and near the Pop Hole.

King George V Cave (KGV) was also a former tourist cave and following its discovery early in 1918, it was regularly visited (and vandalised) until the 1930s when gated and developed for commercial tourism with wooden entrance stairs and fern log pathways in a manner similar to Newdegate Cave. Again, more recently from the late 1990s till the end of last year (2004) it was frequently used for adventure cave tours. Prior to the cave entrance modifications to facilitate access for adventure tourists, the cave had been closed for several decades. Conveniently located beneath a fallen tree, the original steel bar entrance gate was loosely covered by a sheet of iron camouflaged with a 10cm plus layer of moist forest mulch. While still maintaining the natural air flow, this protective cover ensured that the KGV entrance chamber (Outer Region) beneath the gate was kept relatively natural with a constant high humidity maintaining active decay processes on a mulch heap composed of leaf litter and the rotting remains of staircase timbers. This entrance chamber to KGV was formerly a significant biological site where many new cave species had been collected over a period of nearly four decades and is the Type Locality for four troglobitic species, a carabid cave beetle: *Idacarabus cordicollis* (Moore, 1967); the cave pseudoscorpion: *Pseudotyrannochthonius typhlus* (Dartnall, 1970); Lomanella harvestman: *Lomanella thereseae* (Hunt and Hickman, 1993); and a cave symphylan: *Hanseniella magna* (Scheller, 1996).

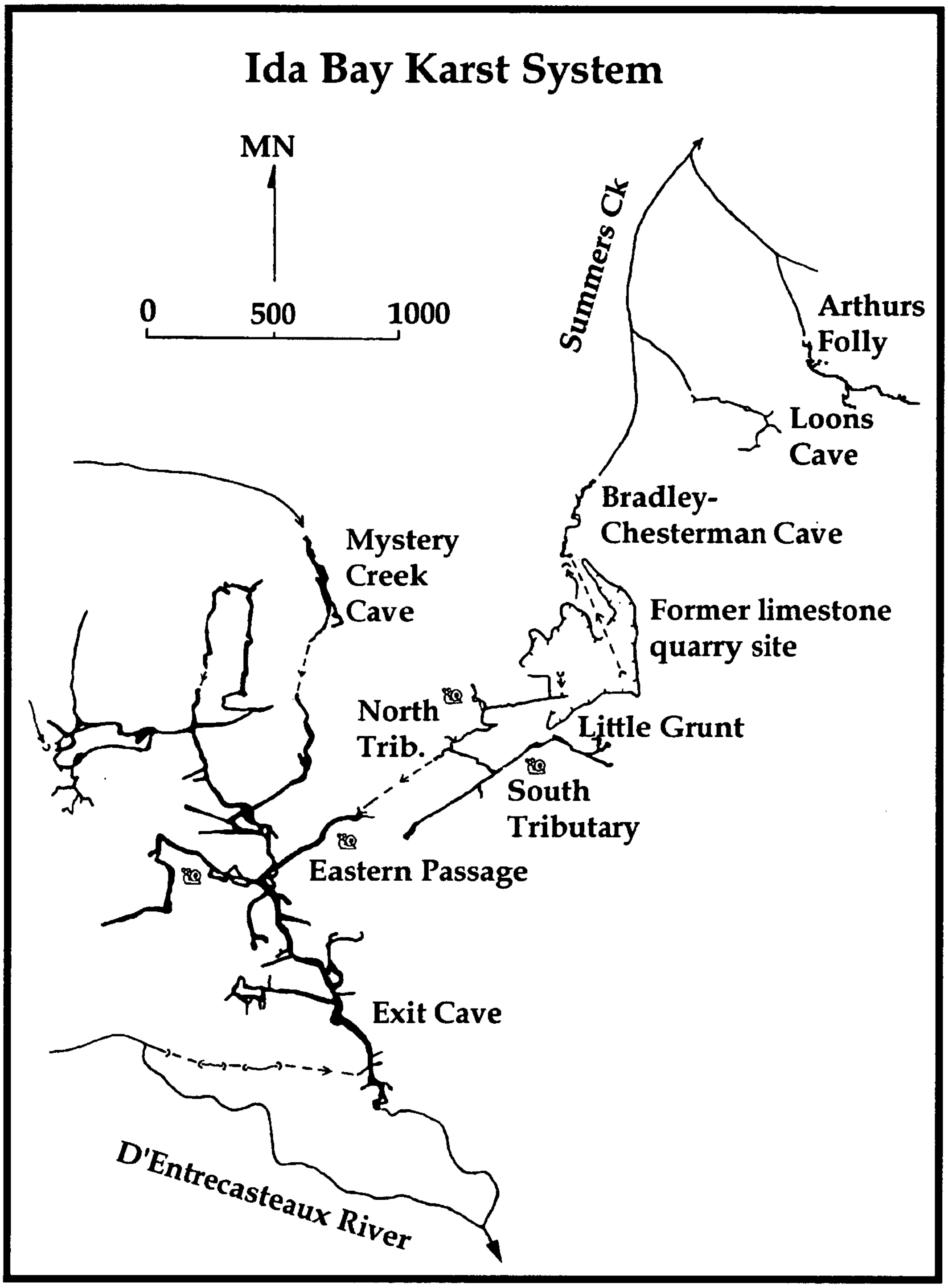

Figure 6.2: Map of Ida Bay karst system in southern Tasmania, showing plan view of surveyed cave passages, hydrological relationships with north and south draining cave systems and location of some of the sites mentioned in the text. (Adapted from Figure 1: p. 98, in Eberhard 2001b, showing drainage at Ida Bay, relationship of quarry and Little Grunt to Exit Cave and symbolised hydrobiid snail collection sites.)

KGV has a short vertical drop that leads directly into this twilight zone chamber, but beyond the chamber slope the cave passage takes an abrupt turn away from the influence of epigean effects as you stoop down to pass through a narrow and low roofed section. Although the morphology of KGV would suggest this point was the start of the Middle Region – despite being just 25-30m distant from the entrance – the cave entrance has now been exposed and modified by removal of the fallen tree and installation of a steel plate cover. Combined with the consequential decline in entrance chamber humidity and replenishment of moist litter, the added impact of adventure caving has effectively advanced this middle region boundary further into the cave, to a point close to where the Inner region was formerly situated.

Loons Cave is quite different. It has two "Outer Region" entrances: a lower water-filled efflux entrance (which is rarely used) and an upper 26m deep vertical entrance, beneath which is a narrow duck-under that effectively takes you immediately into the transition/ dark zone (Inner Region) of the cave. However, due to the impact of regular visitation of school groups over the last 10-15 years, there is now an extended Middle Region which effectively connects the upper entrance with the lower entrance and continues a short distance upstream.

It is also worth noting the assignation of cave regions for two other caves at Ida Bay: the heavily visited Mystery Creek Cave (inflow) system and less commonly visited Exit Cave efflux system. The Outer region in Mystery Creek Cave is quite extensive, if only due to the distance of light penetration and input of organic matter and epigean species from the surface. Similarly, the middle region of Mystery Creek Cave is quite extensive. It can be "measured" as the area extending from between the first and second glow-worm chambers into the chamber with the ramp and collapsed (broken) column, including the Cephalopod Creek side passage. The Inner region of this cave could be considered as the area with the upper level relict karst passages and the region of cave extending laterally beyond the furthest extent of glow-worms (which themselves are dependent on a supply of food from epigean sources), including the entire region laterally and vertically beyond the "Laundry Shute".

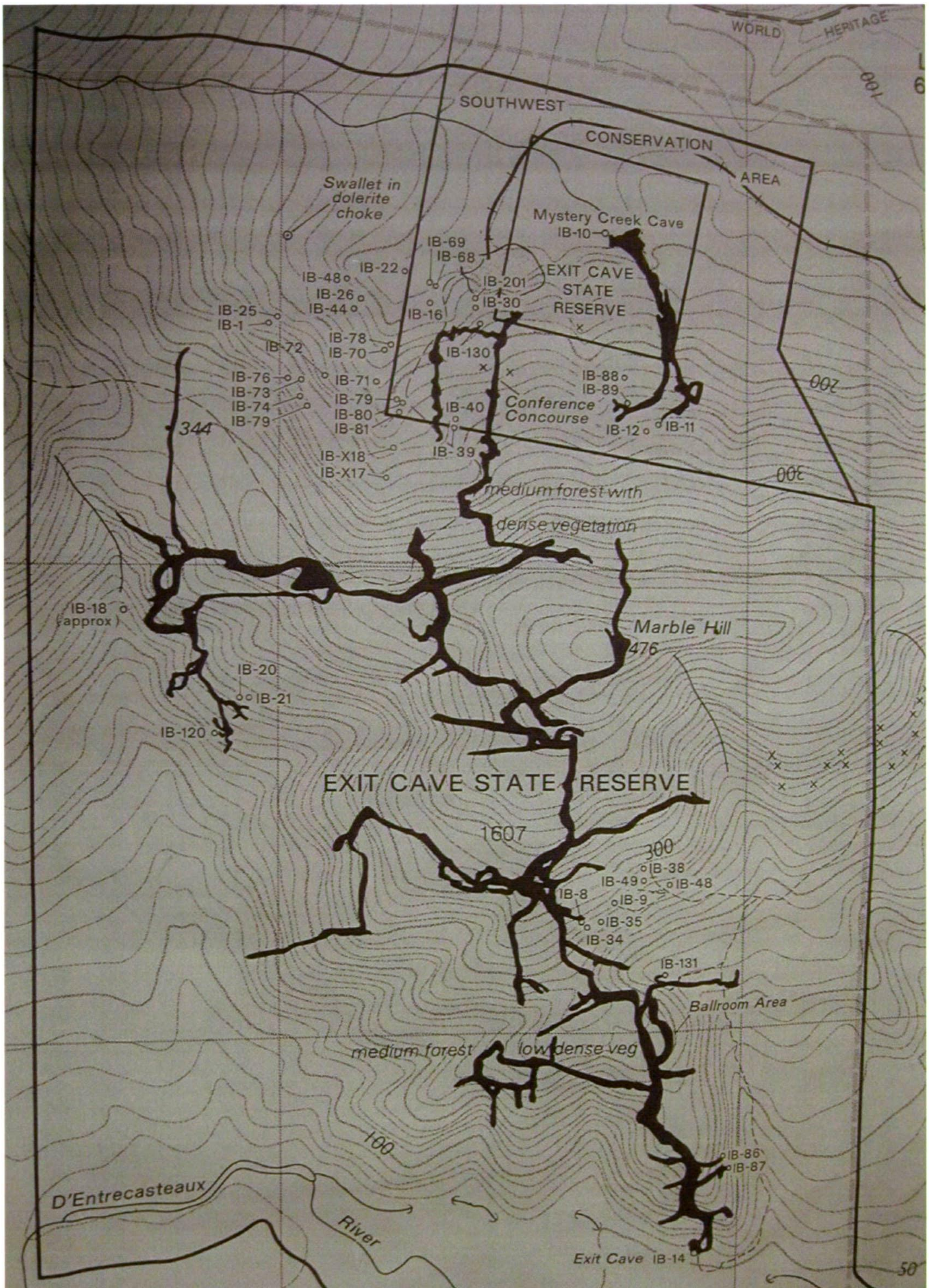

Figure 6.3: **Photographic image of map depicting Exit Cave and Mystery Creek Cave, showing position of surveyed cave passages (*circa* 1989) and "IB" numbered cave sites; the "x" symbols represent approximate locations for known but untagged and unsurveyed cave entrances. (Source: Clarke, 1991a; original map by Clarke, 1989b.)**

Based on its morphology alone, Exit Cave has a relatively short Outer region in the area of the entrance chamber outside the Wind Tunnel gate, but a very long Middle cave region that extends from the Entrance/ Twilight region in the Wind Tunnel into the transition zone of the cave. This middle region, incorporating the transition zone, includes the subterranean course of the D'Entrecasteaux River, and could possibly be extended further into the cave beyond the upstream extent of the glow-worm colonies. The reasoning behind this argument is simple. The D'Entrecasteaux River introduces an epigean influence into the cave carrying flood litter, aquatic larvae of flying insects and in recent years increasing amounts of dark organic soil humus, probably due to bioturbation by lyrebirds (Clarke, 2005a)). During periods of heavy rainfall, the river introduces large amounts of epigean material and given the cave's morphology with a restricted exit for resurging flood waters, back flooding occurs some distance beyond the river's entry point, hence the upstream glow-worm colonies. In Exit Cave, the cave regions have lateral and vertical boundaries, where for example, the high level relict karst passages located 30-40m vertically above the D'Entrecasteaux River, e.g., the "Balls and Udder Passage" and "Hammer Passage" can be classified as part of the Inner region. The similarly located high level Ballroom is regularly visited by cavers and in the proximity of the Old Ditch Road entrance, so warrants being considered part of the Middle Region. All the upstream side passages are obviously in the inner dark zone, e.g., Western Passage, Dribble Passage and the Eastern Passage.

In his study of cave fauna in the "Potholes" area of Ida Bay, south of the former Benders Quarry, Eberhard (1990b) determined four types of caves based on depth or length, epigean influences and an analysis of the species types. Most of his study sites were vertical caves (referred to as "potholes" or "pots" by cavers), but as demonstrated in his analysis, many of these caves were quite short in vertical depth, e.g., cave number IB-93 is only 10m deep, and were considered as "Twilight Caves". Similarly a number of other relatively short horizontal caves and/ or caves with several entrances permitting light and/ or surface litter were also ascribed by Eberhard as "Twilight-small caves". In this present thesis, all the twilight zone caves are assigned as Outer Region sites. In the Eberhard study, two other cave types were determined: "Medium-Deep dry caves" and "Deep Wet Caves". Both of these types of caves will have an Outer area, but depending on the cave morphology, the presence of epigean influences and the depth (or length) of the cave, this outer zone may be quite short giving way to a more extensive Middle Region and possibly an Inner Region.

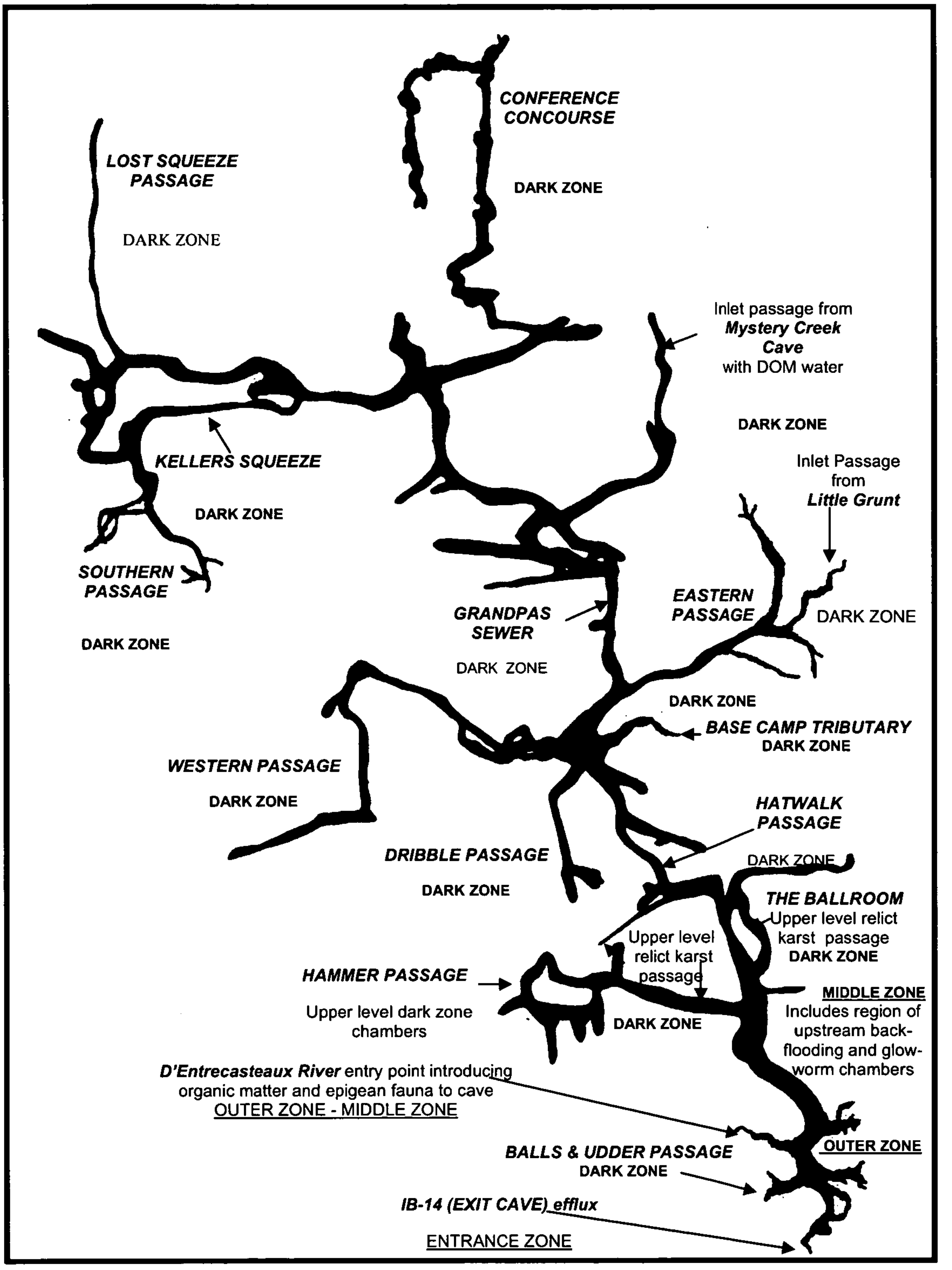

Figure 6.4: Plan view of Exit Cave, showing approximately 24km of the 28-29km of total surveyed length, incorporating some of the named sections of cave passage or chambers (referred to in text) and their respective cave zone regions.

6.2: Micro-habitats and species occurrences at Hastings and Ida Bay

Table 6.1 shows a spread of species occurrences for the coded micro-habitats assigned to occurrence data from study sites in caves at Hastings and Ida Bay in southern Tasmania. The significant micro-habitats are species occurring within them are discussed on a karst area basis.

6.2.1. Significant micro-habitat sites at Hastings

The database lists 597 species occurrence records for 152 species from 12 caves at Hastings. Database Query 4H for Hastings gives an analysis of the micro-habitats where the species occur, showing Family, genus species and animal type for the 152 species in caves at Hastings, along with the number of occurrences in the 36 micro-habitats where cavernicoles are recorded. The micro-habitat occurrences for Hastings (listed in Table 6.1) are detailed further in Query 4HA with an analysis of the species numbers and species (recorded in taxonomy table) in each coded habitat and similarly Query 4HB gives the same result showing families and family numbers represented in occurrences for each habitat. Query 4-HAS lists the families and species found in each micro-habitat enabling a detailed comparative analysis between species occurrence numbers and actual species.

From Table 6.1, ten micro-habitats at Hastings are listed with ten or more occurrences and a combined filter sort analysis on Query 4-HAS indicates the following numbers of species:

- B1: riparian zone beside running water (10 occurrences, 7 species);
- C1: flat floor surfaces in caves (15 occurrences, 12 species);
- C3: cave walls and crevices (50 occurrences, 16 species);
- C4: hard crystalline speleothem surfaces (15 occurrences, 10 species);
- F2: coarse POM (21 occurrences, 17 species);
- F3: medium POM (42 occurrences, 23 species);
- F4: fine POM (35 occurrences, 25 species);
- H1: tourist cave infrastructure (17 occurrences, 15 species);
- H2: discarded staircase timber debris and mulch rot in past or present show caves (280 occurrences, 76 species); and
- Z1: gravity fall accidentals (11 occurrences, 7 species).

With the exception of the cave wall site ("C3"), all the previously listed micro-habitats could be considered as extremely important, but by far the most significant sites, in terms of both occurrence numbers and species diversity, are three particulate matter (POM) sites and the two "H" sites associated with present or past tourist show cave developments. Fifty percent of the "F2" species occurrences were recorded from KGV Cave (H-214) and 40% from Wolf Hole (H-X08). The vast majority, i.e., over 90% of the "F3" and 89% of the "F4" POM habitat occurrences and species are located in KGV Cave. An extraordinary number of 76 species were recorded from the discarded timber debris and mulch rot with 88% of both the "H1" coded and "H2" occurrences recorded from Newdegate Cave (H-1). A small example of the cavernicole diversity at Hastings includes the ten occurrences for the seven "B1" (riparian zone) species, i.e., two different spiders (*Icona* and *Amphinecta*), a new troglobitic springtail (not yet described), an undetermined enchytraeid oligochaete worm, an undescribed troglobitic styloniscid isopod, the carabid beetle *Idacarabus cordicollis*, and the cave pseudoscorpion *Pseudotyrannochthonius tasmanicus*. It should be noted that all the occurrences for gravity fall accidentals (Z1) are land snail species and over 80% of these are from Newdegate Cave (H-1).

6.2.2. Significant micro-habitat sites at Ida Bay

The database provides records for 1521 occurrences relating to 272 species from 144 caves at Ida Bay. Database Query 5HC for Ida Bay gives an analysis of the micro-habitats where the species occur, showing Family, genus species and animal type for the 272 species occurring in caves at Hastings, along with the number of occurrences in the 39 micro-habitats where cavernicoles are recorded. The micro-habitat occurrences for Ida Bay (listed in Table 6.1) are detailed further in Query 5HD with an analysis of the species numbers and species (recorded in taxonomy table) in each coded habitat and similarly Query 5HE the same result showing families and family numbers represented in occurrences for each habitat. Query 5-HIB lists the families and species found in each micro-habitat enabling a detailed comparative analysis between species occurrence numbers and actual species.

Table 6.1, shows that 29 of the micro-habitats at Ida Bay have ten or more occurrence records for an unknown number of species. On the basis that the number of records for cave species occurrences at Ida Bay is 2.55 greater than Hastings (using the base figure of 25, instead of 10 for occurrence numbers), there are 17 micro-habitats at Ida Bay with 25 or more occurrence records. A combined filter sort analysis on Query 5-HIB indicates the following numbers of occurrences and the species represented in these 17 micro-habitats:

- A3: flowing (clear stream) water (46 occurrences, 15 species);
- A4: riffle zone in flowing water (39 occurrences, 9 species);
- A6: still water with laminar flow (72 occurrences, 19 species);
- B1: riparian zone beside running water (69 occurrences, 39 species);
- C1: flat floor surfaces in caves (39 occurrences, 22 species);
- C2: sloping floor surfaces (52 occurrences, 27 species);
- C3: cave walls and crevices (326 occurrences, 70 species);
- C5: soft crystalline speleothem surfaces (66 occurrences, 30 species);
- C6: ceiling surfaces (40 occurrences, 17 species);
- C7: cave atmosphere (27 occurrences, 16 species);
- E3: habitats associated with animal structures (213 occurrences, 38 species);
- F3: medium POM (91 occurrences, 49 species);
- F4: fine POM (71 occurrences, 43 species);
- G1: under rocks, cobbles or pebbles (36 occurrences, 26 species);
- G2: on top or around the sides of rocks etc (49 occurrences, 25 species);
- G3: in or on soft clay, mud and sand substrate (28 occurrences, 23 species);
- Z1: gravity fall accidentals (33 occurrences, 7 species).

Although a few sites in the Ida Bay area are visited semi-regularly on a recreational basis by cavers, the caves represent a more natural environment compared to the three caves at Hastings that have been variously developed for tourism, so the range of populated micro-habitats at Ida Bay is consequently quite different, with many more natural micro-habitats available for species colonisation. The absence of the "H" (human introduced) micro-habitat factors at Ida Bay is replaced by a wider range of aquatic, cave surface, substrate related and cave fauna related habitats. In common with Hastings, there are the riparian zone fauna sites (beside running water), the medium and fine POM habitats, the gravity fall accidental land snails (Z1) and the cave wall sites. Interestingly, the hard crystalline speleothem surfaces appear to be less frequented at Ida Bay, where moonmilk is more common and perhaps a preferred habitat for cavernicoles. The cave ceiling and cave atmosphere habitats are predominantly related to species attracted to, or associated with the presence of glow-worms in stream caves such as Exit Cave and Mystery Creek Cave, but also due in part that many of the Ida Bay caves have lower more observable passage roofs, whereas most caves at Hastings contain large high roofed chambers. Similarly, the "E1" animal structure micro-habitats include the glow-worm webbing and their snare threads, plus numerous spider web sites. Almost 40% of the "G1" (under rock) occurrences relate to aquatic species (anaspidacean syncarids, crangonyctoid amphipods, janirid or phreatoicid isopods and hydrobiid snails), with 70% of the "G2" hygropetric micro-habitats occupied by hydrobiids, but only 30% of aquatic species associated with the soft substrates (G3).

Although possibly less significant in terms of occurrence and species numbers, mention should be made to five other special micro-habitats not specifically listed above for Hastings or Ida Bay:

- A1: low flow seepages or trickles populated by hydrobiids, psammaspidid shrimps, i.e., *Eucrenonaspides* sp., and the janirid isopods or paramelitid amphipods;
- A2: the humic and fulvic acid rich stream water sites occupied by anaspidacean syncarids, crangonyctoid amphipods, hydrobiid snails and freshwater crayfish, e.g., *Astacopsis franklinii*;
- D4: the multi-lobed Ascomycetes fungi or stalked basidiomycetes which are frequented by several troglobitic species, including isopods, springtails, mites, small spiders, millipedes and symphylans. Amongst the 14 recorded occurrences in fungi at Ida Bay, there are 12 species including several new undescribed species;
- F5: dissolved organic matter (DOM). This micro-habitat has been specifically assigned to a clear water stream site in the Western Passages of Exit Cave described by Clarke (1997a), where three depigmented species are found in soft substrate, on hard bedrock and free-swimming: the *Anaspides tasmaniae* (cave type), at least two species of paramelitid amphipods and several planarians, along with hydrobiids. Analysis of the cave water reveals abnormally high nitrate levels which are assumed to be derived from nitrogen fixing nodules of surface tree roots;
- X2: speleothem surfaces including moonmilk in upper level relict karst passages where humidity is maintained by the predominance of percolation seepage recharge. From 22 occurrences at Ida Bay there are 15 species, including the two troglobitic carabids, cave harvestman and dalodesmid millipedes, e.g., *Atalopharetra clarkei*.

6.2.3. Significant cave sites at Hastings and Ida Bay

In their discussion on global hotspots for hypogean biodiversity Culver and Sket (2000) described 18 cave sites and two wells that contained 20 or more obligate species, listing Bayliss Cave, a lava tube with high CO_2 concentrations, at Undara in Far North Queensland as the only hotspot site in Australia. Analysis of the database queries shows that there are three caves at Ida Bay: Exit Cave, Mystery Creek Cave and Arthurs Folly, plus two caves at Hastings: Newdegate Cave and King George V Cave, which also have 20 or more obligate species.

6.3: Discussion of data

Particulate organic matter is the dominant or preferred habitat for cavernicoles at Hastings and Ida Bay, though as discussed in section 6.2.2, there are obvious differences in the range of species and micro-habitats between the developed cave sites and wild cave sites. At Hastings, where exotic plant matter (including bush poles, milled timber and tree fern logs) has been introduced to the cave environment, the rotting remains and humus have become an important habitat for many species including troglobites. The cave systems at Hastings and Ida Bay are quite different in terms of their geomorphic development and hydrology; at Hastings most of the recharge is a direct response to rainfall and streams disappear during dry periods, whereas at Ida Bay, most of the cave streams are perennial, fed by a mix of percolation water and subterranean karst catchment groundwater.

In caves where the dominant hydrological regime is seepage or percolation water, rather than throughflow water, there appear to be a greater diversity of aquatic cavernicoles, but species numbers are generally less abundant, particularly amongst the populations of obligates such as the troglobitic heterid isopod in Arthurs Folly at Ida Bay (Clarke, 1991b). However, from the database species taxonomy table, an analysis of the ecological niche field shows there are more stygobitic obligates (and troglobites or terrestrial obligates) in percolation fed stream caves compared to throughflow systems. Percolation fed seepages also occur in the cave walls or streambanks of throughflow cave systems, e.g., in side passages of Exit Cave and Wolf Hole, or on the walls of vertical caves such as Comet Pot, Pseudocheirus Cave and Skyhook Pot. These micro-habitat seeps or the low flow stream trickles fed by more expansive seepages are a very important habitat providing an energy or nutrient base for numerous cavernicoles and in the dark or deep zone of caves, many of the aquatic or terrestrial species living in/ or near the vicinity of seeps are cave adapted species, e.g., the psammaspidid syncarids and *Olgania* spiders.

Most stream caves have cobble or pebble strewn streambeds where in low flow conditions, hydrobiid snails are found in the hygropetric zone, grazing on the sides or towards the bottom of cobbles or pebbles, e.g., Southern Passage, Base Camp Tributary and the trickle seepage in the Hatwalk Passage (all in Exit Cave). Many of the same hydrobiid species are found grazing on the top of cobbles when water levels subside following a period of higher stream level activity during major rainfall events. The presence of these hydrobiids left "high and dry" after a flood event may reflect their limited mobility as a smaller species and slow response to environmental change, but it could also suggest the possibility that the snails are grazing on fresh algae or bacteria in the aqueous biofilms coating streambed cobbles. During prolonged periods without rainfall, when ephemeral cave streams revert to being "dry" streambeds with mud soaks and small ponds, e.g., the Mystery Creek passage underneath the tourist section in Newdegate Cave, hydrobiids embed themselves in the moist or partially saturated clay substrate and/ or "hide" on the wet underside of discarded staircase timbers that have been jettisoned into the streamway.

The principle of karst bio-space connectivity can be demonstrated at Ida Bay where caves on the north and south sides of Marble Hill appear to have separate hydrologies with their respective efflux streams from subterranean catchments draining north to the Lune River and south to the D'Entrecasteaux River. Based on hydrobiid species determinations, the database records indicate that the Ida Bay cave snail (*Nanocochlea pupoidea*) occurs in caves on both sides of Marble Hill, suggesting that the karst bio-space continues across the entire block of limestone. The connectedness of solution voids, crevices and drainage channels in both areas (north and south) of Ida Bay has already been demonstrated by water tracing methods. During times of high recharge at Ida Bay (i.e., prolonged periods of precipitation, heavy rainfall or snow melt from the catchment), when the aquifer level (water table) is high, cave waters that normally drain in a southern direction can "spill" over into northern karst catchments where such waters have been recorded at Loons Cave (Kiernan, 1993).

Although stream caves in cool temperate areas such as Tasmania may be subject to violent rushes of water draining through their subterranean conduits or channels (Clarke, 2000a), virtually all caves or cave systems have an ecosystem with species that have evolved over a millennia of time in the subterranean karst bio-space. Despite the very occasional turbulent water flows at cave entrances (Clarke, 2005a; 2005b), further into the cave in what we refer to as the "Dark Zone" or deep zone - where most obligate cave species are found - it is a relatively stable environment with high humidity and a near constant temperature all year round. A number of the obligate species in our caves including the cave beetles: *Goedetrechus* and *Idacarabus* are omnivores: predating on smaller arthropods and feeding on organic matter washed into caves. The subterranean environment for obligate cave dwellers in Tasmania (and other cool temperate karst areas) is quite fragile and potentially threatened due to an absolute reliance on this stable environment and the limited input of organic matter. The cavernicolous obligates have evolved and adapted to an ecosystem with very low energy/ low nutrient input, relying on lower order members in the food chain as prey species and/ or the fine particulate organic matter and dissolved organic carbon (DOM) consumed by heterotrophs or aquatic species. In a cave ecosystem, there is an inter-dependence of both aquatic and terrestrial species within the food chain, so any interference to any component of the ecosystem can affect the whole subterranean ecology, with particular impact on the obligate cave dwellers (Clarke, 1997b, 1997c, 1999a).

Considering that no two caves are alike… all caves are different in shape or morphology, length or depth, amounts of organic input, etc. it is quite difficult to devise an all encompassing set of criteria to provide a critical analysis of different cave habitat types. In the case of predominantly horizontal caves or those with swallet entrances or inflowing streams, the habitat niches for some hypogean invertebrates will be similar to the sites occupied by epigean species in the surrounding forest or surface environment. In horizontal caves where forest litter, mulch, rotting logs or leaves and ferns or bryophytes occur, e.g., in cave entrance zones (or on the walls and base of vertical entrance shafts), there will be ground dwelling or litter fauna and/ or species associated with decaying log and living plant habitats. Some populations of epigean species (which may have pre-adaptive traits to subterranean life) could migrate further into the cave and continue to evolve in the subterranean karst bio-space, sometimes competing with similar but distantly related hypogean species.

In caves where exotic plant matter and other energy sources have been introduced, e.g., the timber and tree fern trunks used for staircases and pathways in tourist caves at Hastings, there is a greater diversity of cavernicoles, with species of epigean origin tending to dominate the resource, but living sympatrically with cave obligates and/ or troglomorphic species. The substantial populations of epigean species such as the scarab beetle, *Saprus griffithi* (also determined as *Saprosites mendax*), found in staircase timber mulch several hundred metres into Newdegate Cave, have probably been "happily" evolving in the cave since the late 1930s, when they were brought into the cave *in situ* under the bark of bush timber. In fact this scarab beetle is just one amongst a suite of epigean species populating caves at Hastings that give the impression they are now evolving as obligate species. Beyond the developed section of tourist caves and in the dark zone of wild caves, where the organic input is more limited or diluted, there is generally less cavernicolous diversity but a greater number of ecologically adapted cave species.

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7. References

N.B.: For additional references (not quoted in thesis) but used as database information sources for the occurrences of Tasmanian cave species, see Appendix Section 9.2.2 (p. 345) "Database record sources: additional bibliography (collection site and species occurrence references) not included in thesis".

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8. Glossary of terms

8.1: Introduction, credits and explanation of abbreviations

The following glossary provides explanations for the mix of geological, geomorphic, zoological and ecological terms used in this thesis. The "Glossary of Terms" defined in Clarke (1997a) is expanded to included definitions for terms sourced from several texts and recognised internet sites:

- Australian Museum (Sydney) website: Spider collection database, e.g., types index: http://www.amonline.net.au/spiders/collections/types/index.cfm
- Coad, B.W. and Don E. McAllister, D.E. (2005), *Dictionary of Ichthyology*, Revised Edition: 23 May 2005. http://www.briancoad.com/Dictionary/L.htm
- Commonwealth of Australia, Dept. of Environment: *Glossary Search* (online);
- ABRS Australian Faunal Directory: Ecological Descriptors: http://www.deh.gov.au/biodiversity/abrs/online-resources/fauna/afd/ecological.html
- Humphreys, W.F. (2000) Part I. Background and Glossary. Ch. 0 in Wilkens, H, Culver, D.C. and Humphreys, W.F. (Eds.) *Subterranean Ecosystems*, (Ecosystems of the World Series, Vol. 30), Elsevier, Amsterdam, pp. 3-14;
- Lawrence, E (1989) *Henderson's Dictionary of Biological Terms*. Longman Scientific and Technical, Essex, England. 10th Edition;
- Lincoln, R.J., Boxshall, G.A. and Clark, P.F. (1983) *A dictionary of ecology, evolution and systematics*. Cambridge University Press, London. First Edition;
- Oxford English Edition, Oxford University Press, (Draft Revision, June 2005), Online Version, licensed to University of Tasmania;
- Schlumberger Oilfield Glossary: http://www.glossary.oilfield.slb.com/default.cfm;
- UCMP Glossaries (Berkeley University): http://www.ucmp.berkeley.edu/glossary/gloss2geol.html

Abbreviations and conventions:
syn. = synonym (word with same meaning);
cf. = confer (compare) with the following term which is not identical but related to it;
n. = noun;
adj. = adjective.
A word in brackets on the left-hand side (in upper case) is commonly used in conjunction with the following or preceding word without altering the meaning.
A word <u>underlined</u> is defined elsewhere in this glossary.

8.2: Glossary

ABIOTIC: Non-living. E.g., abiotic factors in cave environments would include physical and chemical attributes such as temperature, humidity and acidity (pH).

ACCIDENTAL: (n.) An animal accidentally living in a cave, arriving by involuntary means; usually by falling in, being washed in, or carried into the cave: i.e., parasites on mammals, other vertebrates or invertebrates. Used for both aquatic and terrestrial species.

ACTINOMYCETES: A group of minute organisms of the order Actinomycetales, commonly held to be filamentous bacteria; (see more detailed explanation in Section 1.2.2 of this thesis).

ADAPTATION: An inherited structural, functional or behavioural characteristic of an organism which improves its chances for survival and reproduction in a particular microhabitat or environment. (See also troglomorphic adaptations.)

ADIT: An excavated tunnel-like entrance to a mine, usually horizontal; often seen with a dump of mined waste rock outside the front of the adit entrance.

AGGRESSIVE: Refers to water – containing active chemical ingredients such as dissolved carbon dioxide and/ or sulphates - that is capable of dissolving limestone, other karst rock, or speleothems. Typically used in reference to meteoric (rain) water which - as it falls or is driven by wind - water becomes "charged" with carbon dioxide from the atmosphere, forming a weak solution of carbonic acid. Similarly, percolating soil water is acidified by respiring soil organisms and tannin or humus (forming tannic or humic acids), and along with sulphates emanating (in soil mantles or weathered palaeokarst fills), waters can become quite aggressive (with dilute sulphuric acid). Surface runoff from overland flow and stream/ river water is likely to also be aggressive.

ALGAE: A diverse group of aquatic unicellular, colonial and multicellular plant organisms with chlorophyll and other photosynthetic pigments, from microscopic size to large, e.g., the multicellular green, red and brown seaweeds; can also grow in damp terrestrial habitats.

ALLOPARATYPE: A paratype, q.v., of the same sex as the allotype.

ALLOPATRIC: Relates to populations or taxa (as related organisms) whose ranges do not overlap; i.e., in non-overlapping, geographically separated areas, unable to crossbreed because of their separation and isolation from one another.

ALLOTYPE: A paratype of opposite sex to the holotype and originally designated by the author; a term not regulated by the International Code of Zoological Nomenclature.

ANASTOMOSIS: A mesh or network of tubes or half-tubes often confined to a bedding plane and usually related to the tube conduits formed in the phreatic zone.

ANCHIALINE: Subterranean waters often local in near vicinity to coastal regions, sometimes under tidal influence, with only subterranean connections with the sea. Typically found in volcanic or limestone bedrock with a layer of freshwater lying over seawater. Anchialine wetland (or zone) where sea water and freshwater meet and diffuse into each other. Any change to the relative levels of sea water and the fresh groundwater could pose a threat to the fauna they contain. Initial work indicates that anchialine systems are very complex and the fauna they contain can also be threatened by changes in soil cover, associated algae and changes in the denitrifying bacteria within the zone.

ANTENNAE: Pair of "feelers" on heads of crustaceans, insects and other invertebrates that function as sensory organs.

APHOTIC ZONE: Syn. Dark zone; in theory could include the transition zone or region of caves where daylight does not penetrate.

APOTHECIA: The disk-shaped or cup-shaped mature fruiting body of an ascomycetous fungus (i.e., belonging to the *Ascomycetes* fungi); also found in some lichens.

AQUATIC: Pertaining to organisms that live in water.

AQUIFER: A body of rock capable of containing significant quantities of subterranean water, capable of receiving and absorbing recharge, storing it and transmitting to issue or yield as discharge. Usually described by whether they consist of sedimentary deposits (sand and gravel) or fractured rock. Aquifer types include Unconfined, Confined, and Artesian.

ARAGONITE: A less common crystalline form of calcium carbonate than calcite, denser and belonging to orthorhombic crystal class.

ARTEFACT: Products of human manufacture or art, e.g. bone tools, stone flakes, etc., paintings, engravings. In caves, tools are often buried in sediment.

ARTHROPODS: The most common group of animals inhabiting caves, including insects, crustaceans, spiders, millipedes, etc. They have jointed limbs and external skeletons.

ATTENUATED: In cave biology, a general term (used in describing troglomorphism) for a reduction in magnitude/ intensity/ or size of morphological structures, e.g., jointed limbs (or legs) and antennae of certain arthropods, where limbs of hypogean animals tend to become thinner, but often much longer cf. with epigean relatives.

ASSOCIATION: A relatively stable sub-community of different species living in a characteristic habitat and also characterised by essential uniformity of species composition.

AUTOTROPH: Any organism that is able to manufacture its own food from inorganic sources of carbon and nitrogen etc. as starting substances for biosynthesis. Although plants are autotrophs, in cave biology, the term is generally used for bacteria, e.g., chemoautotrophs.

AVEN: An underground vertical shaft leading upward from a cave passage or cave chamber, which often connects with other passages or shafts above and may be the underground entry point for recharge waters from a sinkhole, streamsink or swallet.

BACTERIA: Plural of bacterium. Unicellular microscopic plant organisms (microflora) sometimes aggregated in filaments, which can manufacture their own food without sunlight. Two forms found in caves: heterotrophic decomposers and chemoautotrophic synthesisers which play a significant role in the formation of several complex forms of calcium carbonate including moonmilk. (See more detailed explanation in section 1.2.2 of this thesis.)

BARE KARST: Karst with much exposed bedrock. syn. unmantled karst.

BASIDIOMYCETE: Any of a group of higher fungi bearing sexually produced spores on a basidium, including rusts, smuts and numerous edible forms (as many mushrooms), and variously considered to comprise a class (Basidiomycetes), a subdivision (Basidiomycotina), or a division (Basidiomycota).

BATHYPHREATIC: Referring to water moving with some speed through downward looping passages in the phreatic zone.

BED: A depositional layer of sedimentary bedrock or unconsolidated sediment.

BEDDING-GRIKE: A narrow, rectilinear slot in a karst rock outcrop due to solution along a bedding-plane.

BEDDING-PLANE: A surface separating two beds, usually planar.

BENTHIC: Bottom dwelling.

BIOFILMS: An accumulation of bacteria, possibly as a microbial mat usually attached to a solid substrate, such as cave ceiling, wall, earthen floor, stream cobbles or decaying tree roots; composed of a dynamic and metabolically interactive assemblage of bacteria.

BIOGENIC: Of biological origin. syn. organic.

BIOGEOGRAPHY: The study of the geographical distribution of animals and plants over the globe. cf. zoogeography and phytogeography.

BIOLITHIC: adj. Used as a term relating a sedimentary rock (or deposit) formed from living organisms or the remains of organic material.

BIOMASS: The total mass or weight of living matter, usually relates to a given area, habitat or community.

BIO-SPACE: The separated or interconnected network of "spaces" as air or water-filled cracks, pipes, vertical channels, tubes, voids or microcaverns, horizontal conduits and larger cavities including caves that are inhabited by invertebrates, including in the interstitial medium and saturated zone.

BIOSPELEOLOGY: The scientific study of plant or animal organisms living in caves; usually applied to studies of cavernicoles.

BIOSYNTHESIS: Formation of organic compounds by living organisms.

BIOTA: Sum total of all plants and animals.

BIOTIC: Pertaining to biota.

BIOTOPE: An area, habitat or micro-habitat of a particular type, defined by the organisms that inhabit it.

BIOTURBATION: The disturbance of sediment by organisms, e.g. worm and crustacean burrows, tracks, lyrebird scratching, etc. or complete mixing.

BLIND VALLEY: A valley that is closed abruptly at its lower end by a cliff or slope facing up the valley. It may have a perennial or intermittent stream which sinks at its lower end or it may be a dry valley.

(BONE) BRECCIA: A fragmented deposit usually composed of angular clasts (and/ or bone fragments).

BRANCHWORK: A dendritic system of underground streams or passages wherein branches join successively to form a major stream or passage.

CALCAREOUS: Term used to describe a biological structure or geological deposit largely composed of calcium carbonate ($CaCO_3$), e.g., the outer shell of a snail or bivalve other marine organism/ or a shoreline dune composed of small aeolian derived shell fragments.

CALCARENITE: A limestone or dolomite rock with a sandy texture, including silica sand fragments and sand-sized coral or shell fragments and possibly other sand sized particles derived from the weathering of older limestones; commonly deposited on or near coastlines by wind and referred to as aeolian calcarenites. Calcarenites are commonly found in the Late Tertiary/ Quaternary limestone of northeast Tasmania and on the Bass Strait islands.

CALCITE: The most common calcium carbonate (CaCO3) mineral and the main constituent of limestone, with different crystal forms in the rhombohedra subsystem.

CALCRETE: Carbonate deposit formed in the soil and/ or near the upper level of the groundwater aquifer (water table) as a result of evaporation of soil water or groundwater; typically formed in arid climates with high evaporation.

CANYON: (1) A deep valley with steep to vertical walls; in karst frequently formed by a river rising on impervious rocks outside the karst area.

(2) A deep, elongated cavity cut by running water in the roof or floor of a cave or forming a cave passage.

CARBONATE: A compound composed of carbon and oxygen which readily combines with other minerals, e.g., calcium (Ca) and carbonate (CO_3) ions form calcium carbonate (CaCO3), which may incorporate magnesium (Mg) and iron (Fe). The term describes rock or sediments derived from debris of organic materials composed mainly of calcium and carbonate (e.g., shells, corals, etc.) or from the inorganic precipitation of calcium (and other ions) and carbonate from solution (seawater). For example: limestone or dolomite.

CARNIVORE: An animal that lives by eating the "flesh" of other animals.

CATCHMENT: The area drained by various sized watercourses including dolines.

CAVE: A natural subterranean cavity (or series of cavities) large enough to be humanly enterable, commonly formed by solution of carbonate rock in karst, but may also be formed by wind, fluvial erosion or collapse (see "pseudokarst"). It may be an air-filled or water-filled cavity. Syn. "cavern" and "megacavern".

CAVE COMMUNITY: All the cavernicolous animals (and plants) that live together in cave habitats, "bound" together by food chains and other inter-related processes.

CAVE DEPOSIT: An accumulation of material other than speleothems, such as charcoal, fossils, skeletal remains and flood borne debris as well as clay, silt, sand and gravel. (See "cave fill".)

CAVE ECOLOGY: The study of the interaction and relationships between cave organisms and their environment, e.g. energy input from surface, climatic influences, etc. (See also cave ecosystem and cave community.)

CAVE EARTH: Clay, silt, fine sand and/or humus deposited in a cave. Syn. cave fill.

CAVE ECOSYSTEM: The ecological system formed by the interaction of the biotic community with its abiotic environment; in biospeleological terms: the co-acting organisms of the cave community with their subterranean bio-space environment.

CAVE FILL: Transported materials such as silt, clay, sand and gravel which cover the bedrock floor or partially or wholly block some part of a cave. (See also "palaeokarst")

CAVE SYSTEM: A collection of caves or cavities in a given area which are interconnected by enterable passages or linked hydrologically. Also used as a term for a cave with an extensive complex of chambers and passages.

CAVERN: A very large chamber within a cave. Also syn. cave.

CAVERNICOLE: An animal or organism which normally lives the whole or part of its life cycle in caves; includes accidentals, trogloxenes, troglophiles and troglobites and their aquatic equivalents: stygoxenes, stygophiles, and stygobites. Usually used as a term relating to the invertebrate species found living in a cave or the karst bio-space; (an alternate name for a troglobiont species).

CAVING: A term used to describe the act of visiting or exploring caves, including survey-mapping and study; generally used as a term that relates to the recreational use of caves.

CHAMBER: The largest order of cavity in a cave, with considerable width and length but not necessarily great height.

CHEMOAUTOTROPH: Organism that utilises the essential minerals for biosynthesis and metabolism by oxidation of an inorganic chemical energy source, such as sulphur, nitrogen, iron and calcium (cf. adjectival form of word: chemoautotrophic = chemotrophic.)

CHIMNEY: A vertical or nearly vertical opening in a cave, narrow enough to be climbed by chimneying.

COLLUVIAL: Transported sediment deposited on a slope.

COLUMN: A speleothem from floor to ceiling, formed by the growth of a stalactite and a stalagmite to join, or by the growth of either to meet bedrock.

CONDUIT: An underground stream course completely filled with water and under hydrostatic pressure or a circular or elliptical passage inferred to have been such a stream course.

CONTIGUOUS KARST: The interconnected air-filled or water-filled solutional or hydrological network of space/s in any area of karstified carbonate rock.

COPROPHAGE: A scavenger which feeds on animal dung, including guano.

CORRASION: The wearing away of bedrock or loose sediment by mechanical action of moving agents, especially wind, running water or glacial ice, i.e. corrosion and abrasion.

CORROSION: Dissolution of rock by chemically aggressive water. This term is also applies to the dissolution of rock by chemoautotrophs, e.g., that attack bedrock limestone.

COUPE: An area of forest of variable size, shape and orientation on which timber harvesting takes place, usually followed by forest regeneration activity.

COVERED KARST: An area of karst, in which the limestone bedrock is concealed by mulch and litter, soil or surficial deposits. Syn. mantled karst.

CPOM: Coarse Particulate Organic Matter. In this thesis, refers to logs and tree branches, predominantly found in cave entrances or at the base of shafts; see Table 4.8.

CRETACEOUS (PERIOD): Of or belonging to the geologic time (144-65 mya) characterised by the development of flowering plants and ending with the sudden extinction of the dinosaurs and many other forms of life; relates the system of rocks or sedimentary deposits belonging to the third and last period of the Mesozoic Era (248 - 65 million years ago),.

CREVICULAR: Refers to the crevice-like bio-space, primarily found in non-karst rock types.

CRYPTIC: (adj.) Term used to describe cavernicoles which may be difficult to locate, due to being very small (often <1-3mm) or secretive by nature or virtue of their preferred habitat, e.g., in narrow wall crevices or the interstitial spaces in soil and streamside deposits.

CRYPTOZOA: The assemblage of small terrestrial animals found living in darkness beneath stones, logs, bark, etc., often in cave entrances and/ or small crevices within caves; includes species which are potential colonisers of caves and/ or small species such as the tiny micropholcommatid or theridiid spiders already living in caves. Adj. = CRYPTOZOIC.

DARK ZONE: The insulated (inner) stable part of a cave shielded from external factors where conditions remain relatively constant all year round including a relatively constant temperature that approximates the annual surface mean and high humidity (often near saturation point) with a very low rate of evaporation and in Tasmanian caves, this zone is also characterised by low nutrient input. Syn. "troglic" zone; "deep cave" zone; aphotic zone.

DECOMPOSERS: Living things, chiefly heterotrophic bacteria and fungi that live by extracting energy from tissues of dead animals and plants, other particulate matter and dissolved organic matter (DOM).

DECORATION: Cave features due to secondary mineral precipitation, usually of calcite. Syn. speleothem, sometimes referred to as "formations".

DESICCATION: Removal of water (often due to evaporation from a heat source); the process of drying.

DETRITIVORES: Organisms which obtains most of its nutrients from the detritus in an ecosystem.

DETRITUS: Animal waste products and the aggregate of fragments from organic structures, as detached or broken-down tissue, small pieces or remains of dead and decomposing plants, animals and micro-organisms with associated microbial community (bacteria and fungi).

DIAGENESIS: The physical, chemical or biological alteration of sediments into sedimentary rock at relatively low temperatures and pressures that can result in changes to the rock's original mineralogy and texture. After deposition, sediments are compacted as they are buried beneath successive layers of sediment cemented by minerals that precipitate from solution. Grains of sediment, rock fragments and fossils can be replaced by other minerals during diagenesis. cf. lithification.

DISCHARGE: The outflow drainage of aquifer waters. cf. recharge.

DISJUNCT (VICARIANT) DISTRIBUTION PATTERN: Relates to the separate occurrences of corresponding species in separate karst areas; these species are related to a (now extinct) once widespread surface-dwelling common ancestor. cf: distributional relict (below), phylogenetic.

DISTRIBUTIONAL RELICT: Relates to a species surviving in an area isolated from the main or original distribution area usually as a result of intervention of broad scale environmental events such as glaciations or continental drift, e.g., Gondwanan relict or Pangean relict species.

DOLINE: A natural depression in the surface of the land caused by sub-surface solution and collapse of the roof of a cavern or subterranean passage, generally occurring in carbonate rock (limestone or dolomite) regions. Observed as a roughly circular closed depression, generally simple in form and either bowl or basin-shape in profile; if steep in profile, varying from conical to funnel-like in shape, possibly with vertical cliff walls. Dolines may occur as an individual stand alone feature or as a "nest" of two or more coalesced collapses… the larger feature is termed as an uvala. Sometimes in polygonal karst, as a network of adjoining collapses or swallet features separated by narrow ridges of limestone, e.g., "Potholes" region at Ida Bay and upper northern slopes of Precipitous Bluff. Where carbonate rock has dissolved or collapsed beneath other rock types, dolines may form in the overlying rock strata: these are commonly termed as subjacent dolines or interstratal karst depressions and in Tasmania, there are several examples in the Jurassic Dolerite at Mt. Field (adjoining the Junee-Florentine karst) and in the Permian Mudstone above the Hastings and Ida Bay karsts. May lead to a cave entrance, shaft or swallet; cf. sinkhole.

DOLOMITE: (1) A sedimentary rock composed of more than 50 percent of the double carbonate mineral (calcium-magnesium carbonate): $CaMg(CO3)2$, where magnesium is the dominant mineral.

DOM: Dissolved Organic Matter, derived from the gradual downstream breakdown, disintegration and eventual dissolution of organic matter from the catchment or immediate karst surface above.

DRY VALLEY: A valley without a surface stream channel; may be the result of solution or collapse of underlying carbonate rock strata (cf: doline) or may have been formed during a previous erosion cycle, when underground conduits where choked or filled with sediment.

ECOSYSTEM: A community or assemblage of communities of organisms, interacting with one another, and the specific environment in which they live and with which they also interact e.g. cave, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources; i.e., the elements of an ecosystem interact with each other in some way, and so depend on each other either directly or indirectly.

ECOSYSTEM DIVERSITY: In any given area, the variety of habitats, biotic communities and ecological processes. Ecosystems comprise the diversity of all-living organisms and non-living components and their relationships within a given area. They can be defined at almost any nominated scale. Cave ecosystems include abiotic components, which incorporate physical factors such as radiation, gases, groundwater and recharge cycle, rock chemistry, geological structure of the karst bio-space, sediments in the cave as well as the epigean land surface, soil forming processes and climate. Ecosystem diversity is harder to measure than species or genetic diversity because the boundaries of ecosystems (or component habitats and communities) are a matter of definition within a matrix. Provided a consistent set of criteria is used to define ecosystems, their number and distribution can be measured. It is therefore essential that scale/s and the basis for differentiation are defined and understood in any treatment of ecosystem diversity.

ECOTONE: A transitional zone between two ecological communities containing the characteristic species of each. In speleo-biological terms, this can be considered as synonymous with the transition zone between the epigean environment (entrance zone and twilight zone faunas) and the hypogean (dark zone) environment of cave ecosystems.

ECTOTHERMIC: Relates to "cold-blooded" organisms such as most cave invertebrates that have a body temperature that is determined primarily by the temperature of their immediate environment. (Ectothermic invertebrates in cool Tasmanian cave environments may be subjected to stress and desiccation due the influence of sudden heat gain, e.g., the heat emanating from the light globe of a torch or helmet mounted light.)

EDAPHOBITE: An animal (invertebrate) dwelling in the soil.

EFFLUX: Discharge waters, e.g., resurgence stream that flows out from a cave or spring.

ENDOGEAN: Pertaining to the domain immediately beneath the surface, i.e. under plant litter and within the soil; typically extends down to the depth of tree root penetration.

ENTRANCE ZONE: The interface between surface and subterranean (underground) environments leading internally into the twilight zone.

EOCENE: The epithet applied to strata in the lowest division of the Tertiary Period, and to the geological period which they represent.

EPIGEAN: Pertaining to the biological domain at the surface or above it, including streams.

EPIPHREATIC: Referring to water moving with some speed in the intermittently or seasonally saturated or floodwater zone on top of the phreatic zone or in the zone liable to be temporarily part of the phreatic zone in flood time.

EPIKARSTIC: Generally pertaining to the upper/ outer layer of karstified carbonate rock in the unsaturated zone, immediately below the soil layer. However, this term is sometimes used to describe the aquatic species in caves that occur in drip pools and are presumed or known to enter the cave via straw stalactites that drain water from cracks or crevices in the upper strata, which maybe part of a permanently or occasionally saturated zone.

EPILITHIC: Formation of a thin film or coating on the exterior of a substrate surface.

EROSION: The wearing away of bedrock or sediment by mechanical and chemical actions of all moving agents such as rivers, wind and glaciers at the surface or in caves.

EUTROGLOPHILES: troglophiles with special pre-adaptations to cave life. This term is popularly used in Italy and other parts of Europe (from Ruffo, 1957).

EVAPOTRANSPIRATION: A process by which water is lost from a catchment or karst surface which includes evaporation of water from wet surfaces as well as transpiration of water from trees and plants.

EXSURGENCE: A spring fed only by percolation water.

FAULT: A fracture separating two parts of a once continuous rock body with relative movement along the fault plane.

FACULTATIVE: Capable of functioning under varying environmental conditions and able to exist under more than one set of conditions; therefore not obliged to live in caves. This term can include species that are troglophiles.

FAMILY: A scientific name of a taxon at the rank of family. Such names have an "-idae" suffix.

FISSURE: An open crack in rock or soil.

FISSURE CAVE: A narrow, vertical cave passage, often developed along a joint but not necessarily so. Usually formed as a result of rock solution, but sometimes due to tension.

FLATTENER: A passage, which, though wide, is so low that movement is only possible in a prone position.

FLOCCULANT: syn. suspended sediment.

FLUVIAL: Pertaining to processes of flowing water. cf. lotic.

FOOD CHAIN: A series or sequence of organisms (plants or animals) at successive trophic levels within a community; the organisms are "linked" together by their food relationships and the specific pathway through which energy is transferred. Traditionally considered a three tier or stage process and in caves this is likely to include the primary producers: plants near cave entrances and micro-organisms (e.g., bacteria), secondary feeders which include herbivores and possibly omnivores and the carnivores as secondary or tertiary consumers. (See also food web.)

FOOD WEB: An interlocking / interconnected system or network of separate food chains in any (cave) community.

FOSSIL: The remains or traces of animals or plants preserved in rocks or sediments.

FOSSORIAL: Adj. Pertaining to an organism adapted to digging or burrowing in the soft silt substrate of pools etc, e.g., koonungid syncarids such as *Micraspides* sp.

FPOM: Fine Particulate Organic Matter. In this thesis, the FPOM is a coarser scale to that used by freshwater biologists, used here to include the small leaves and twigs in flood litter; see Table 4.8.

GEOCONSERVATION: The conservation of geodiversity protecting natural values that encompass its ecological and geoheritage values.

GEODIVERSITY: The range or diversity of geologic (bedrock), geomorphic (landform) and soil features, assemblages, systems and processes.

GLACIOFLUVIAL: Pertaining to the fluvial processes of melt water discharged from a glacier.

GROTTO: A room or chamber in a cave of moderate dimensions, often rich in an array of speleothems or decorations.

GROUNDWATER: Water found underground as a result of rainfall, ice and snow melt, submerged rivers, lakes, and springs... considered at or below the level at which all voids in the rock are completely saturated. syn.: phreatic water in saturated zone below water table. Groundwater often carries dissolved minerals.

GUANO: Large accumulations of excreted dung or faeces, often partly mineralised, including rock fragments, skeletal invertebrate material and in the case of old deposits may include the products of reactions between excretions and rock. In caves, the deposits of guano are usually derived from bats and to a lesser extent from birds.

GYPSUM: The mineral hydrated calcium sulphate, $CaSO_4.2H_2O$.

HABITAT: The immediate surroundings (in the specific bio-space) of plants or animals (cavernicoles), with everything necessary for life of the organism that normally lives there.

HABITUAL: A usual, regular or commonly occurring cave dweller, that may show a large degree of apparent adaptation to the deep and dark cave environment, but not obligatory; may exist outside in deep litter, under rotten logs or similar dark and moist habitats cf. obligate.

HALF-TUBE: A semi-cylindrical, elongate recess in a cave surface, often meandering or anastomosing.

HELICTITE: A speleothem with eccentric form, which at one or more stages of its growth changes its axis from the vertical to give a curving or angular form.

HERBICIDES: Chemicals used to kill plants.

HERBIVORE: An animal that eats plants or other autotrophic organisms.

HETEROTROPH: Organism only able to utilise organic sources of carbon, nitrogen etc. as starting materials for biosynthesis. Organisms using sunlight for energy (photoheterotrophs: some bacteria and algal flagellates) or chemical processes (chemoheterotrophs: animals, fungi, most bacteria, etc.).

HOLOTYPE: A single specimen chosen as the basis of the first description of a new species, thereby designated as the name-bearing type of a species or subspecies. Can also be applied for the single specimen on whom a taxon was based, when no type is specified.

HUMIDITY: The amount of water vapour in the air; usually expressed as a ratio of the amount of vapour present in air at a given temperature as compared to the amount of vapour that could be present in air at that temperature. Particularly relevant to the deep zone or dark zone of caves where climatic conditions tend to be constant with very little evaporative moisture loss, but also applicable in the entrance zone or twilight zone of many Tasmanian caves in forested karst areas.

HYGROPHILOUS: Relates to moisture loving species and/ or species that inhabit (and thrive in) moist places.

HYGROPETRIC: Relates to an organism living in the surface film of water on rocks.

HYPOGEAN: Pertaining to the subterranean domain below the endogean, including the dark zone of caves.

HYPORHEOS: Pertaining to the area of saturated sediment of streambeds beneath/ or streambanks beside the flowing water of streamways in lotic environments.

INCERTAE SEDIS: Latin term for an uncertain position or without assurance of relationship; used in taxonomy to define a group whose broader relationships are unknown or undefined.

INORGANIC: Of non-biological origin, e.g., mineral compounds in rocks or speleothems such as stalactites.

INSECTICIDES: Chemicals used to kill insects.

INSURGENCE: Surging up or rushing in.

INTEGUMENTS: In biological terms usually relates to the covering, investing or coating structure or layer on the outer surface of arthropods, e.g. spiders and beetles.

INTERSTITIAL MEDIUM: Spaces between grains of sand or fine gravel.

INVERTEBRATES: Animals without backbones. Includes the annelids (worms), molluscs (snails) and arthropods found in caves. (See also macro-invertebrates).

KARREN: The minor (small scale) surface forms of karst due to solution of carbonate rock on the immediate surface or under soil layers.

KARST: Terrain with special landforms and drainage characteristics due to greater solubility of certain rocks (notably carbonate rocks such as limestone or dolomite) in natural waters. Derived from the geographical names "*Krst*" and "*Kras*" for the region between Llubljana and Ttrieste in Slovenia were some of the first cave studies commenced (Juberthie, 2000).

KARST BIO-SPACE: an all encompassing term to cover the whole suite of saturated or unsaturated micro, meso-, and macro-cavern solutional or tectonic cracks, crevices and voids etc. in karst (and non-karst) rock that are the actual or potential living or foraging habitat space for hypogean animals.

KARSTIFICATION: A cyclic process, with phases of active solutional development of karst followed by infilling of karst conduits and voids, depending on global climatic regimes.

KARST HYDROGRAPHIC ZONES: The three vertically aligned subterranean divisions of karst into upper unsaturated zone, intermittently saturated epiphreatic (or floodwater) zone and lower saturated (phreatic) zone.

KARST WINDOW: An irregular opening often through a thin rock wall in a cave, usually with a stream flowing through.

LAMPENFLORA: Word from the German language for the green plant matter variously composed of algae, cyanobacteria, ferns and bryophytes growing on moist surfaces of speleothems and clay/ dirt substrates in response to natural or artificial light sources in cave entrances and cave interiors.

LARVA(E): The active immature, but self-sustaining and independent stage of invertebrate species, prior to assuming the characteristic features of an adult form.

LECTOTYPE: A specimen from the original type material (i.e., usually a syntypes) serving as the basis for a description of a new species, but selected as the type in the absence of a holotype. Typically a syntype designated as the single name-bearing type specimen, subsequent to the establishment of a nominal species or subspecies.

LIMESTONE: A sedimentary rock consisting mainly of calcium carbonate, (CaC03), derived from the accumulated deposition (and fossilisation) of the calcareous remains of marine or freshwater organisms.

LIMNICOID: inhabiting lakes. cf. limnicole = an inhabitant of lakes; limnicolous = living in lakes.

LIQUID MEDIUM: Contains the aquatic cavernicoles.

LITHIFICATION: The process by which unconsolidated sediments are converted into a solid sedimentary rock. The sediments are derived by the weathering of pre-existing sedimentary, igneous or metamorphic rocks which are variously transported, re-deposited, buried and compacted by the weight of overlying sediments. The process of lithification usually involves compaction, followed by cementation causing sediments to harden (cf. "diagenesis").

LOTIC: Pertaining to the aquatic environment of running water.

MACROCAVERNS: Predominantly air-filled cavities ranging in size from 20mm in diameter to "fist" sized voids and larger, generally referring to those bio-space voids in the epikarstic region of the unsaturated zone and can usually be considered to include all cavities that are not large enough to be defined as megacaverns or caves.

MACROINVERTEBRATES: Larger invertebrates that are visible to the naked eye.

MASS MOVEMENT: Dislodgment and downslope transport of soil and bedrock under the influence of gravity

METABOLIC RATE: The rate at which an organism transforms food into energy and body tissue. (Most cave animals, particularly obligate species in the dark zone have a reduced metabolic rate.)

METAMORPHIC ROCK: Any rock formed by alteration of its chemical or mineralogical composition or its structure resulting from pressure, temperature or shearing stress.

METEORIC: Pertaining to rain water.

MICROCLIMATE: The climate (i.e. temperature, humidity, air movements, etc.) of a restricted area or space, e.g. of a cave or on a lesser scale of the space beneath stones in a cave. (See microhabitat).

MICROHABITAT: The individual faunal habitat or niche within a larger (cave) environment; maybe used to encompass broad regions such as the dark zone or smaller defined habitat niches, where environmental conditions differ from those in a surrounding area, e.g., under logs, in wall crevices or in the interstitial medium.

MIOCENE: (adj.) Of, relating to, or designating the fourth epoch of the Tertiary period or sub-era, which occurred between about 24 million and 5 million years ago, following the Oligocene and preceding the Pliocene. (n.) The Miocene epoch; the series of rocks dating from this time, containing fossil evidence of numerous mammals and the first hominids.

MOONMILK: (n.) A soft whitish deposit of carbonate minerals found on the walls of limestone caves as a floury powder or porous mass consisting chiefly of calcite which may consolidate over time; possibly formed as a result of biological (bacteriological) action, forming as a precipitate off fungal hyphae or as an excreted waste product exuded from the hyphae of certain bacteria, including the *Actinomycetes*.

MORPH: A form, shape or structure; as any phenotypic or genetic variant with distinctive morphology or behaviour.

MORPHOSPECIES: A species established solely on morphological characters.

MORPHOTYPE: A term used in taxonomy to denote a specimen selected to represent a given intrapopulation variant (or morph). Commonly used when describing bacteria for an infrasubspecific group of bacterial strains distinguishable from other strains of the same species on the basis of morphologic characters.

MPOM: Medium Particulate Organic Matter. Large twigs and leaves, bark stringlets, often forming as cave entrance litter; see Table 4.8.

MSS: An acronym derived from the French term "Milieu Souterrain Superficiel", but sometimes described as the "Mesovoid Shallow Substratum", though a better English translation would be "shallow underground compartment". It relates to the finer voids (as solution holes, crevices and/ or fine cracks) at the top of a rock mass beneath the deep soil layer, similar to what the late Dr. Glenn Hunt refers to as the S.U.C. ("superficial underground compartment").

NETWORK: A complex pattern of repeatedly connecting passages in a cave.

NICHE: The portion of the cave ecosystem which a species occupies, defined in terms of the conditions under which an organism can survive, what it consumes, what consumes it, how it may be affected by the presence of other competing organisms, biotic and abiotic factors.

NOMEN NUDUM: A genus or genus species name is described as a *nomen nudum* if it has been not formally described and/ or insufficiently described or lacks a Type species.

NOMEN DUBIUM: A genus (or species) name is described as a *nomen dubium* if its classification is not certain; it does not fulfil the stringent criteria set by the International Code of Zoological Nomenclature and is not recognised as legal scientific name.

NOTHEPHREATIC: Referring to water moving slowly in cavities in the phreatic zone.

NYMPH: Pertaining to a juvenile form, particularly related to juvenile insects without wings or with incomplete wings.

OBLIGATE: Pertaining to a species which is unable to live outside the cave environment, often found in the dark zone and may display troglomorphic adaptations.

OMNIVORE: An animal (cavernicole) which habitually eats both plants and animals, e.g., the rhaphidophorid cave crickets.

OPPORTUNISTIC: Having the ability to exploit newly available habitats or resources or taking immediate advantage of any circumstance of possible benefit.

ORGANIC: Of biological origin. Syn. biogenic.

OUTFLOW CAVE: A cave from which a stream discharge flows or formerly did so, and which cannot be followed upstream to the surface.

PALAEOKARST: "Fossil" karst: cave or karst features remnant from a previous phase or period of karstification, characterised by the presence of ancient (buried) deposits, as lithified cave fills or (bone) breccias.

PARALECTOTYPE: Any one of the original syntypes remaining after the selection of a lectotype.

PARAPATRIC: Relates to populations of species with contiguous (adjacent) but non-overlapping geographic ranges, where gene flow between populations is possible.

PARATYPE: Each specimen of a type series other than the holotype, as specimens mentioned in the original description of a species in addition to the holotype.

PARASITE: An organism which at some stage in its life history derives its food from the tissues of another organism; in cave ecosystems, the Acarina (ticks and mites) are commonly found as parasites on other invertebrates or vertebrates.

PARIETAL (ASSOCIATION): Animals found on walls around cave entrances.

PASSAGE: A cavity which is much longer than it is wide or high and may join larger cavities.

PELAGIC: Usually related to free-moving marine organisms within the water column, but also used in this report to differentiate between the benthic and surface living aquatic invertebrates in cave streams.

PERCOLATION WATER: Water moving mainly downwards through pores, cracks and tight fissures in the unsaturated epikarstic zone and vadose zone.

PERMEABILITY: The property of rock or soil permitting water to pass through it. Primary permeability depends on interconnecting pores between the grains of the material. Secondary permeability depends on solutional widening of joints and bedding planes and on other solution cavities in the rock.

PHOLETEROS: The faunal assemblage found in crayfish burrows, including stygobitic crustacean species with apparent troglomorphic adaptations.

PHYLETIC: Pertaining to a line of direct descent or a course of evolution.

PHYLOGENETIC: Relates to the genetic history of a taxon and the evolutionary relationships within and between groups of species.

PHREATIC ZONE: Zone usually below the water table where voids or tubes in the rock are completely saturated with water. syn. saturated zone.

PHREATOBIA: An animal association found in the interstitial medium of water separating grains of sand or fine gravel. syn. phreatobites.

PHYLOGENETIC: Pertaining to an ancient lineage with a long history of development for the species.

PIEZOMETER: A bore that measures groundwater under pressure (in a confined aquifer).

PIPE: A tubular cavity projecting as much as several metres down from the surface into karst rocks and often filled with earth, sand, gravel, breccias, etc.

PLEISTOCENE: The Pleistocene epoch is part of the geologic timescale, representing the time scale following the Pliocene epoch and preceding the Holocene epoch. The Pleistocene is the third epoch of the Neogene period or sixth epoch of the Cainozoic era. Formerly considered to be the first epoch of the Quaternary, the Pleistocene is an epithet applied to the newest (most recent) division of the Pliocene or Upper Tertiary formation (as containing the greatest number of fossils of still existing species), also called Newer Pliocene and Post-Pliocene.

PLIOCENE: Epithet applied to the newest division of the Tertiary formation, distinguished from Eocene and Miocene as containing a larger proportion of fossil shells of still existing species; called also Upper Tertiary. Also used as term applied to animals, etc., of this period.

POLJE: A large closed depression draining underground, with a flat floor across which there may be an intermittent or perennial stream and which may be liable to flood and become a lake. The floor makes a sharp break with parts of surrounding slopes.

POLYGONAL KARST: Karst completely pitted by crowded closed depressions or dolines so that narrow ridge-like divides between them form a crudely polygonal shaped network.

POOL DEPOSIT: (1) Any sediment that accumulates in a cave pool. (2) Crystalline deposits precipitated in a cave pool, usually of crystalline shape as well as structure.

POPULATION: Individuals of a species in a given locality which potentially form a single interbreeding group separated by physical barriers from other such populations (e.g. populations of the same species in two quite separate caves).

POROSITY: The property of rock or soil of having small voids between the constituent particles. The voids may not interconnect.

POTHOLE: Cavers term for a vertical or near vertical cave, with a shaft or chimney shape and often quite wide cave entrance open to the surface; sometimes shortened to "pot" and used as name descriptor for vertical caves, e.g., Cauldron Pot or March Fly Pot. (Vertical cavers in England are sometimes referred to as "potholers".)

PREDATOR: An animal which captures other animals for its food.

PROTOZOANS: A phylum (Protozoa) of unicellular heterotrophic, generally non-photosynthetic, aquatic eukaryotes organisms with nuclei, but lacking cell walls... which move and feed using flagella (flagellates), cilia (ciliates) or pseudopodia (amoebae); also includes foraminifera, radiolarians, Sporozoa (parasitic protozoan). They can move singularly or in colonies; they may swim freely, glide in contact with a substrate, or be sedentary. Protozoa are sometimes classified with algae in a separate Kingdom as Protista.

PSEUDOKARST: Terrain, generally in non-carbonate rock types, with landforms (including caves) which resemble those of karst but are not the product of karst solution processes. Some examples could include granite boulder caves such as those on the Bass Strait Islands, and the quartzite rift features in NW Tasmania or the sandstone fissure or boulder caves etc in various parts of southern Tasmania.

PUPA(E): The inactive stage in the life history of certain insects during which the larva undergoes a gradual reorganisation of its tissues in the process of metamorphosis to becoming an adult.

QUATERNARY: The Quaternary Period is (was) the geologic time period from the end of the Pliocene Epoch, roughly 1.8-1.6 million years ago to the present. The Quaternary Period included two geologic subdivisions: the Pleistocene and the Holocene (or Recent) Epochs. Over the last 12-18months (in 2004-2005), during a revision of the international classification of geological time periods, the Quaternary Period was subsumed into the Neogene, but the Pleistocene epoch remains.

REEF: A large ridge or mound-like structure within a body of water that forms when calcareous organisms such as corals and red algae with attachment of marine organisms, e.g., bivalve molluscs; cf. barrier reef: formed offshore from a land mass and separated by a lagoon or stretch of sea water.
RECHARGE: The process involving the input or intake (absorption) of water into the zone/s of saturation in karst aquifers; also relates to the quantity of water added to the saturation zone.

REFUGIA: (Plural of Refugium).

REGRESSIVE EVOLUTION: Concept used to describe the adaptive traits or troglomorphies of obligate cavernicoles, particularly those species that only live in the dark zone. Examples of these traits include: reduced eye size, loss of visual ability or loss of eyes; reduced body pigmentation (or no pigment); loss of wings (in insects, such as carabid beetles); elongated appendages including antennae; longer and greater density spines or setae (hairs); and reduced metabolic rate.

(RELATIVE) HUMIDITY: syn. Humidity

RELICT: See Distributional Relict

RELICT KARST: Old cave forms produced by earlier geomorphic processes within the present phase or period of karstification and open to modification by present day processes such as deposition of speleothems, sediments or skeletal deposits.

RESURGENCE: A spring where a stream, which has a course higher up on the surface, reappears lower down at the surface.

RIFT: A long, narrow, high and straight cave passage controlled by planes of weakness in the rock. cf. fissure.

RILLENKARREN: Solutional karren formed by air currents with airborne moisture forming closely situated often parallel to sub-parallel vertical grooves.

RIMSTONE: A deposit formed by precipitation from water flowing over the rim of a pool.

RIMSTONE DAM: A ridge or rib of rimstone often curved convexly downstream.

RIMSTONE POOL: A pool held up by a rimstone dam; these may range in size from a few millimetres (micro-gours) to several metres. syn. gours.

RIPARIAN ZONE: Pertaining to streambanks and streamsides. The term could possibly be expanded to include the perimeter area around dolines, particularly those which act as swallets.

RIPICOLE: An organism living on the banks of streams or rivers, i.e., in the riparian zone.

RISING: syn. spring.

ROCK PENDANT: A smooth-surfaced, sometimes semi-rounded projection of rock (often found in groups) forming part of the cave roof; usually formed by solution at the interface of sediment, e.g., sand or gravel in water. cf. speleogen.

ROOM: Part of a cave, wider than a passage but not as large as a chamber.

RUNDKARREN: Surface karst solution feature consisting of rounded grooves in e.g., limestone, normally formed under soil or under heavy litter/ moss layers.

SAPROPHAGE: A scavenger feeding on decaying organic material.

SATURATED: (1) Referring to rock with water-filled voids. (2) Referring to water which has dissolved as much limestone or other karst rock as it can under normal conditions.

SATURATED ZONE: The zone below the water table, composed of the shallow phreatic zone, deep phreatic (or bathyphreatic) zone and stagnant phreatic zone. syn. phreatic zone.

SCALLOPS: Characteristically small shallow, asymmetric hollows produced by flowing water, with current markings that intersect to form points which are directed downstream.

SCATS: Faecal pellets or animal droppings, which may provide an important source of food in caves.

SCAVENGER: An animal that eats dead remains and wastes of other animals and plants (cf. coprophage, necrophage, saprophage).

SEA CAVE: A cave in present-day or emerged sea cliffs, formed by wave attack or solution.

SECTION: A plot of the shape and details of a cave in a particular intersecting plane, called the section plane, which is usually vertical.

SEDIMENT: The unconsolidated grains of minerals, organic matter or pre-existing rocks, which can be transported by water, ice or wind, and deposited and/ or precipitated after settling out of a state of suspension in water (or liquid). The processes by which sediment forms and is transported occur at or near the surface of the Earth and at relatively low pressures and temperatures.

Sedimentary rocks such as limestone or sandstone are formed from the accumulation and lithification of sediment.

SEEPAGE WATER: syn. percolation water.

SHAFT: A vertical cavity roughly equal in horizontal dimensions but much deeper than broad; generally consider to be wider than the vertical rift like feature that cavers refer to as a "chimney".

SINKHOLE: (Americanised word; Syn. doline). An emotive term - originally intended as for use in the North American forestry and agricultural industry - referring to those dolines that are sites where sinking water occurs; cf. swallet.

SIPHON: A water-filled passage of inverted U-profile which delivers a flow of water whenever the head of water upstream rises above the top of the inverted U.

SOLIFLUCTION: Usually relates to the slow movement or flow of saturated soil or rock fragment masses down slopes and may be applied to sub-aqueous flowage.

SOLUTION: In karst study, the change of bedrock from the solid state to the liquid state by combination with water. In physical solution the ions of the rock go directly into solution without transformation. In chemical solution acids take part, especially the weak carbonic acid formed by hydration of carbon dioxide (CO2).

SOLUTION FLUTE: A solution hollow running down the maximum slope of the rock, of uniform fingertip width and depth, with sharp ribs between it and its neighbours.

SOLUTION PAN: A dish-shaped depression on flattish rock; its sides may overhang and carry solution flutes. Its bottom may have a cover of organic remains, silt, clay or rock fragments.

SOLUTION RUNNEL: A solution hollow running down the maximum slope of the rock, larger than a solution flute and increasing in depth and width down its length. Thick ribs between neighbouring runnels may be sharp and carry solution flutes.

SPECIES: A group of (invertebrate) animals that have a high degree of genetic similarity and are actually or potentially interbreeding populations reproductively isolated from other such groups by their biology, not simply by physical barriers. cf. speciation. A terms of taxonomic classification, the "species" is placed in a category ranking below Genus or Sub-genus.

SPECIATION: The evolutionary process leading to the development of new biological species, usually by the division or radiation of a single species into two or more genetically distinct ones.

SPELEOGEN: A cave surface structure formed by erosion or solution weathering during the process in cave enlargement, e.g., such as directional current marking scallops, rock pendants, canyons or spongework.

SPELEOLOGY: The exploration, description and scientific study of caves, their contents, various related attributes of subterranean environments and related phenomena of karst terrains.

SPELEOTHEM: A cave feature (or "decoration") formed by the chemical deposition of secondary minerals, most commonly calcite (CaCO3).

SPONGEWORK: A complex of irregular, inter-connecting cavities intricately perforating the rock. The cavities may range from a few centimetres to more than a metre across.

SPRING: A natural flow of water from rock or soil onto the land surface or into a body of surface water; may be a source of cold water or warm water. syn. rising.

SQUEEZE: An opening in a cave only passable with effort because of its small dimensions. cf. flattener, crawl (way).

STALACTITE: A speleothem hanging or "growing" downwards from a roof or wall, usually of cylindrical or conical form, with a central hollow tube.

STALAGMITE: A speleothem projecting vertically upwards from a cave floor and formed by precipitation from drips, often found directly under a stalactite.

STEEPHEAD: A steep-sided valley in karst, generally short, ending abruptly upstream where a stream emerges or formerly did so.

STRAW (STALACTITE): A long, thin-walled tubular stalactite less than about 1cm in diameter that elongates as minerals are deposited at the lower tip by seepage water flows dripping through its hollow interior. A straw may eventually widen to form a stalactite.

STREAMSINK: A point at which a surface stream disappears underground. cf. swallet.

STRIKE: The orientation, relative to north, of beds of rocks, usually defined as the direction of a horizontal line in a bedding plane, especially applicable in rocks inclined from the horizontal. On level ground it is the direction of outcrop of inclined beds.

STYGOBIONT: A term originally coined to describe the aquatic obligates in subterranean groundwaters and cave streams (i.e., the stygofauna), particularly relevant to species with troglomorphies that are restricted to groundwater habitats, i.e., the aquatic troglobites and phreatobia (phreatobites). The term is now expanded to cover the aquatic equivalents of terrestrial cavernicoles in karstic groundwaters: stygobites, stygophiles and stygoxenes and also covers aquatic species in alluvial groundwaters (See Gibert, *et al.,* 1994).

STYGOBITE: An obligate aquatic species of hypogean waters with troglomorphic adaptations, an aquatic equivalent of a (terrestrial) troglobite. cf. stygobiont. In the expanded definition, these also include obligatory hypogean forms present in alluvial groundwaters, sometimes found very close to the surface and phreatobites, stygobite species restricted to the deep groundwater substrata of alluvial aquifers (See Gibert, *et al.,* 1994).

STYGOFAUNA: Ecologically descriptive term covering obligate (aquatic) groundwater fauna, i.e., confined to the saturated zone of karst bio-space.

STYGOPHILE: A facultative stygobiont, usually lacking troglomorphies, and considered as the aquatic equivalent of a (terrestrial) troglophile. In the expanded definition relating to porous aquifers, stygophiles are divided into three categories: occasional hyporheos, essentially the larvae of aquatic insects (which require an aerial epigean stage to complete their life cycle); amphibites, whose life cycle requires the use of both surface and groundwater systems; and permanent hyporheos - the diverse assemblage of species present in all life stages in the groundwater or benthic habitats (See Gibert, *et al.,* 1994).

STYGOXENE: A more or less nonsensical word designed as an aquatic equivalent for a trogloxene, defining a habitual stygobiont (aquatic species) which spends only part of its life cycle in cave waters and returns periodically to the epigean domain for food.

SUBFAMILY: A scientific name for taxon at the rank of subfamily. Such names have "-inae"as a suffix.

SUBJACENT: (adj.) situated underneath, lying below or at a lower level; underlying.

SUBTERRANEAN: Pertaining to underground environments (generally, but not exclusively in karst).

SUBTRIBE: A scientific name of a taxon at the rank of subtribe. Such names have "-ina"as a suffix.

SUMP: A point in a cave passage when the water meets the roof.

SUPERFAMILY: A scientific name for a taxon at the rank of superfamily. Such names have a suffix with "-oidea".

SUPERSATURATED: Referring to a state of water that has more dissolved calcium carbonate or other karst rock mineral in solution, than the maximum corresponding to normal conditions.

SURVEY: In caving, the measurement of directions and distances between survey points and of cave details from them, and the plotting of cave plans and sections from these measurements either graphically or after computation of co-ordinates.

SUSPENDED SEDIMENT: Referring to small particles of insoluble organic or inorganic matter suspended in the water column. syn. flocculant, suspended solid.

SWALLET: A streamsink or doline that takes sinking water, usually refers to karst, and often associated with a cave entrance and one of major entry points for recharge waters. Swallets may empty directly into open or choked cave features such as shafts or avens, or simply be a zone of gradual downward percolation from the base of a streambed.

SYMPATRIC: Relates to two or more populations, species or taxa found together in the same geographic area: populations may occupy the same habitat (biotic sympatry) or different habitats (neighbouring sympatry) within the same geographical area.

SYNTYPE: Any one of the original set of specimens from which a species has been described and named, from which neither a holotype nor lectotype has been designated.

TAGGING: Affixing a metal tag bearing a cave number near its entrance, normally by means of rock drill and a small nail or screw.

TAXA: plural of taxon.

TAXON: Relating to a single named (and individually described) species.

TECTONIC: Describes the forces creating movement and deformation of Earth's crust on a large scale, also describes the resulting structures or features from these forces.

TERRA ROSSA: Latin term for the reddish residual clay soil developed on limestone.

TERRESTRIAL: Pertaining to air-breathing animals living on "land" surfaces in epigean, endogean or hypogean environments.

TERTIARY: A period in geological history; the first period of the Cainozoic Era extending from after the Cretaceous Period (or Jurassic in Tasmania) to 1.7mya (prior to the Quaternary Period). The Tertiary period is sometimes divided into two sub-periods and five epochs as: the Paleogene sub-period (with the Paleocene, Eocene and Oligocene epochs) and the Neogene (with Miocene and Pliocene epochs). Tertiary Period characterised by the appearance of modern flora, the apes and other large mammals.

THALASSOID: freshwater organisms resembling (or originating as) marine forms; generally relates to species that have marine affinities.

THRESHOLD: (n.) (1) that part of a cave near the entrance where surface climatic conditions rapidly grade into cave climatic conditions. Not necessarily identical with twilight zone. (2) A slope or cliff facing up a blind or half-blind valley below a present or former streamsink.

THROUGH CAVE: A cave which may be followed from entrance to exit along a stream course or along a passage which formerly carried a stream.

TOPONYM: A name derived from a place or region.

TRANSITION ZONE: Ecotone region between the twilight zone and dark zone where no there is no visible light, but some external factors from the entrance environment may still be apparent, e.g., seasonally fluctuating air temperatures.

TRANSPIRATION: Loss of water by plants, usually by evaporation from leaves. cf. evapo-transpiration.

TRAVERTINE: Compact calcium carbonate deposit, often banded, precipitated from spring, river or lake water. cf. tufa.

TRIBE: The scientific name for a taxon at the rank of tribe. Such names have the suffix -INI.

TROGLOBIONT: More recently devised term used to describe a cavernicole or cave dwelling organism.

TROGLOBIOTIC: Syn. Troglobite; modern term commonly used to describe a troglobiont.

TROGLOBITE: An (obligate) cavernicole unable to live outside the cave environment; usually defines an obligate species with troglomorphic adaptations. The term is usually restricted to terrestrial species, but sometimes aquatic obligates maybe referred to as aquatic troglobites.

TROGLOBITISATION: Alternate word for "troglogenesis" (see below).

TROGLODYTE: A human cave dweller.

TROGLOFAUNA: Obligate cave or karst bio-space dwelling, air-breathing (terrestrial) animals, confined to living in the unsaturated zone or component of subterranean environments.

TROGLOGENESIS: The morphological, behavioural, physiological and other changes found in species lineages as they populate/ adapt to cave or hypogean life.

TROGLOMORPHIC (adj.); TROGLOMORPHISM (n.): Pertaining to the morphological, behavioural and physiological characters that are convergent in subterranean populations; syn. adaptations to the cave environment. Particularly relevant to the characters of obligates living in the dark zone e.g., lengthening of appendages; loss of pigment; modification of eyes; modified olfactory sensory organs (for "sniffing" out prey and mates etc.); extra sensory structures e.g., elongated legs used as feelers and sometimes modified chelicerae (the grasping organs used to hold prey foods etc.; and reduced metabolic rate are all considered adaptations to the dark zone of caves. syn. troglomorphies; troglomorphosis and troglobiomorphosis. cf. "regressive evolution".

TROGLOMORPHIES: Syn. troglomorphic adaptations. (N.B. Troglomorphies do not necessarily equate to level of adaptation to dark zone environment.)

TROGLOPHILE: A species able to live and reproduce in either the hypogean or epigean environment; often used in reference to a terrestrial cavernicole which frequently completes its life cycle in caves, but is not confined to this habitat;.

TROGLOXENE: A terrestrial cavernicole which spends only part of its life cycle in caves and returns periodically to the epigean domain for food.

TUBE: Smooth surfaced cave passage, elliptical or nearly circular in cross-section; cf. phreatic tube

TUFA: Spongy or vesicular calcium carbonate deposited from spring, river or lake waters. cf. travertine.

TUNNEL: A nearly horizontal cave open at both ends, fairly straight and uniform in cross-section.

TURBIDITY: Relates to the muddiness, cloudiness or "milkiness" of water and usually reflects the amount of suspended sediment in the water.

TWILIGHT ZONE: The outer part of a cave in which daylight penetrates and gradually diminishes to zero light, where transition zone takes over.

UNSATURATED (VADOSE) ZONE: The component of the karst hydrographic zone including endogean region in soil and the subterranean subcutaneous epikarst and free draining percolation water where voids in the rock are partly filled with air and through which water descends under gravity. syn. vadose zone.

UVALA: A complex closed depression with several lesser depressions or dolines within its rim.

VADOSE FLOW: Water flowing in free-surface streams in caves.

VADOSE SEEPAGE: Relates to percolation water that seeps down through the unsaturated zone above the water table.

VADOSE WATER: Water in the vadose zone.

VADOSE ZONE. Syn. unsaturated zone.

VICARIANCE: The existence of closely related taxa or biota in different geographical areas which speciated as a result of separation caused by the formation of a natural but non-biological barrier (a vicariance event); also termed as passive allopatric speciation.

WATER TRACING: Describes a process or method used to determine hydrological links (water connection) between points of stream inflow or soil water seepage and points of recharge or discharge underground or on the surface.

WATER TABLE: The surface between phreatic water which completely fills voids in the rock, and ground air, which partially fills higher voids.

WEATHERING: The physical, chemical, and biological processes by which rock is broken down and eroded into smaller pieces. Weathering is responsible for gradual, slow changes on earth.

WELL: A deep rounded hole in a cave floor or on the surface in karst.

WINZE: A steeply inclined ramp or vertical shaft between levels in a mine for the purpose of connecting with a lower level or of exploring the ground for a limited depth below a certain level or for the purpose of ventilation.

ZONES; ZONATION: The organisation of the hypogean environment or cave habitat into a series of zones relating to the extent of light penetration, influence of external (or epigean) environmental factors and degree of internal stability. Cave zones referred to in this report are the entrance zone, twilight zone, transition zone and dark zone.

9. Appendices

9.1: Taxonomic classification and species list for invertebrate species from Tasmanian cave areas, as recorded in thesis database

As shown in Table 9.1, the "-A" or "-T" coded species listed in the accompanying database are presented, arranged as an alphabetically ordered hierarchical taxonomy.

9.1.1: Explanation of the hierarchical classification method in Table 9.1

In Table 9.1, sourced from the "Species Taxonomy (rfa and tasuni)" table in the thesis database, the genus species names have been listed alphabetically and/ or chronologically in sequence on a hierarchical classification basis from "Higher Taxonomy", through to their respective "Family, Sub-Family and Tribe" groups using classifications as listed below. As given by ITZN (1999), the classification system adopts the principle of priority and the naming conventions of the International Code of Zoological Nomenclature (ICZN) with standard terminations or suffixes, from the rank of super-family downwards:
(a) Higher Taxonomy classifications:
Class; Sub-Class, Infra Class; Order; Sub-Order; Infra-Order; and Super-Family, with the "-oidea" suffix or termination.
(b) Family, Sub-family and Tribe classifications:
Family: with "-idea" termination; Sub-family: with "-inae"; Super-Tribe (for e.g., carabid beetles under Coleoptera: Adephaga): with "itae"; Tribe (or Tribus): with "-ini"; and Sub-Tribe: with "-ina" termination or suffix.
For further references, see also the "Principles of Nomenclature of Zoological Taxa" at:
http://www.bio.pu.ru/win/entomol/KLUGE/zoo-name.htm

9.1.2: Information sources for the taxonomy deployed in the classification of Tasmanian cave invertebrates

The taxonomic arrangement of species in the database, as shown in Table 9.1, generally follows the classification in the Australian Biological Resources Study (ABRS) Australian Faunal Directory, with the exception that the taxonomy for some specific groups of fauna has been sourced directly from internet sites such as Platnick's World Catalog of Spiders and the Texas A and M University (Department of Entomology) database of arachnids and other invertebrate groups. In the case of some of the more obscure cave animal groups or families, their taxonomy has been sourced from other stand alone but relatively recognised taxonomy database sources, such as those listed in the following examples:

- Index to Organism Names:
http://www.organismnames.com/query.htm
- ITIS (Integrated Taxonomic Information System) Catalogue of Life:
http://www.itis.usda.gov/
- Systema Naturae 2000 / Classification site:
http://www.taxonomy.nl/Main/Classification/
- "The Taxonomicon":
http://sn2000.taxonomy.nl/Taxonomicon/
- "Biology Catalog" website in the Department of Entomology, Texas A and M University:
http://insects.tamu.edu/research/collection/hallan/
- BayScience Foundation Zipcode Zoo site, enabling searches on several fields:
http://zipcodezoo.com/search.asp
- Wikipedia "Wikispecies Free Species Directory":
http://species.wikipedia.org/wiki/Wikispecies
- University of Michigan Museum of Zoology "Animal Diversity Web":
http://animaldiversity.ummz.umich.edu/site/accounts/classification/

For some groups of cave fauna, where levels of taxonomic classification are not adequately detailed in the Australian Faunal Directory and sites listed above, more precise information on higher taxonomy or family/ sub-family status has been sourced from sites dealing with the classification of specific animal groups, as shown in the following examples.

(a) Arachnida.

The list of valid spider genus names and their current Family status have been primarily sourced from Norm Platnick's The World Spider Catalog, Version 6.0 (2005) and now Version 6.5 (2006); see:
http://research.amnh.org/entomology/spiders/catalog/index.html
and in the case of Australian spider species, reference is made to the "Checklist of Australian Spiders" compiled by Rob Raven (Queensland Museum), which is based on Platnick's catalogue. Additional detail relating to spiders from caves or karst areas in

Tasmania in regard to their classification in terms of higher taxonomy and family groupings has been sourced from a range of authorities, including the Australian Faunal Directory and recent publications, e.g., the updated taxonomy of theridiid spiders in Agnarsson (2004), plus several internet websites such as:

- The Australasian Arachnology Page:
http://www.australasian-arachnology.org/arachnology
- The various Arachnology sites at the Texas A and M Entomology Department site, e.g.,
- "SYNOPSIS OF THE DESCRIBED ARACHNIDA OF THE WORLD" at:
http://insects.tamu.edu/research/collection/hallan/acari/Araneae1.htm
- Examples of links to other spider families at the above site include:
http://insects.tamu.edu/research/collection/hallan/acari/Theridiosomatidae.txt
http://insects.tamu.edu/research/collection/hallan/acari/Theridiidae.txt
http://insects.tamu.edu/research/collection/hallan/acari/Anapidae.txt
- For the triaenonychid opiliones (i.e., "FAMILY TRIAENONYCHIDAE"):
http://insects.tamu.edu/research/collection/hallan/acari/Triaenonychidae.txt
- "SYNOPSIS OF THE DESCRIBED MITE FAMILIES OF THE WORLD":
http://insects.tamu.edu/research/collection/hallan/acarfam.html

(b) Coleoptera (beetles), e.g., Carabidae.

Table 9.1 (and the thesis database) include reference to an additional level of classification below subfamily level, recording "super tribe" for some of the coleopteran (beetle) family groups, e.g., the Trechitae (Coleoptera: Carabidae: Carabinae), as recently described by Grebennikov and Maddison (2005). Sources for the classification of Carabidae and/ or Coleopteran families include the ABRS Australian Faunal Directory and other sites such as:
http://www.nhm.org/research/entomology/coleoptera/familylist.html
http://entomology.si.edu/Entomology/CarabidGenus/genweb.lasso
http://www.coleoptera.org/p1562.htm
http://inventory.ent.ncsu.edu/tree/dsp_families.cfm?orderID=23andorderNm=Coleoptera

(c) Diptera (flies).

Amongst the many sites dealing with the taxonomy of Diptera, there is the North Carolina University site on Insects:

http://inventory.ent.ncsu.edu/tree/index.cfm

and the Australasian/ Oceanian Diptera Catalog at the Bishop Museum - Web Version, e.g., see website link for Family Heleomyzidae:

http://hbs.bishopmuseum.org/aocat/heleomyzidae.html

(d) Collembola (springtails).

"The Checklist of the Collembola of the World" complied by Bellinger, Christiansen and Janssens, accessed on the internet via: http://www.collembola.org

or at: http://www.geocities.com/fransjanssens/index.html

This is considered the world's most authoritive and up to date guide on the classification of collembola. For example, a springtail collected from Newdegate Cave at Hastings and identified by Penny Greenslade as *Lepidosira (Lepidosira)* sp., nr. *L. australica* Schött, 1917, is simply listed as Entomobryidae on the ABRS website, but on the website above, the genus is recorded as: Entomobryidae: Lepidocyrtinae: Lepidocyrtini.

9.1.3: Taxonomy of listed species in present (May 2006) database

Extracted from the thesis database, the species list (Table 9.1) includes cave area code/s as a suffix, for any new or undetermined species, known only from one or two cave areas.

Table 9.1: Alphabetically ordered hierarchical taxonomy for species from Tasmanian cave areas (Arthur Clarke, March 2006)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
1	T-0105	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (1) (IB)
2	T-0106	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (2) (MC)
3	T-0107	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (3) (GP and MC)
4	T-0750	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (4) (G)
5	T-0822	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (5) (H)
6	T-0879	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (6) (Jiffs)
7	T-0891	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. (7) (IB)
8	T-0104	Acarina - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. or spp.
9	T-0097	Acarina: Acariformes: Oribatida	? Oribatidae (Family uncertain)	undetermined: Gen. and sp. or spp.
10	T-0557	Acarina: Acariformes: Oribatida: Euphthiracaroidea	Oribotritiidae	Oribotritia contortula Niedbala, 1993
11	T-0589	Acarina: Acariformes: Oribatida: Oppioidea	Oppiidae	Lanceoppia sp. (CP)
12	T-0103	Acarina: Acariformes: Prostigmata: Anystoidea	Anystidae: Anystinae	Anystis baccarum (Linnaeus, 1758)
13	T-0101	Acarina: Acariformes: Prostigmata: Erythraeoidea	Erythraeidae: Erythraeinae	Erythrites (Erythrites) sp. indet. (BH and H)
14	T-0102	Acarina: Acariformes: Prostigmata: Eupodoidea	Eupodidae	Linopodes sp. (BH and IB)
15	A-039	Acarina: Acariformes: Prostigmata: Hydryphantoidea	Hydryphantidae: Hydryphantinae	Hydryphantes sp. (GP)
16	T-0566	Acarina: Acariformes: Prostigmata: Labidostommatoidea	Labidostommatidae	undetermined Gen., sp. or spp. indet.
17	T-0553	Acarina: Acariformes: Prostigmata: Trombidioidea	Microtrombidiidae: Microtrombidiinae	? Microtrombidium sp. (CP)
18	T-0098	Acarina: Acariformes: Prostigmata: Trombidioidea	Microtrombidiidae: Microtrombidiinae	Microtrombidium sp. or spp. nov.
19	T-0099	Acarina: Acariformes: Prostigmata: Trombidioidea	Chyzeriidae: Trombellinae	Chyzeria sp., nr. C. hirsti Womersley, 1934 (BH)
20	T-0092	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Aponomma auruginans (Schulze, 1936)
21	T-0560	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes sp. (H)
22	T-0554	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes ?antechini, Roberts, 1960 (L)
23	T-0723	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes ?fecialis Warburton and Nuttall, 1909 (L)
24	T-0094	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes ornithorhynchi Lucas, 1846
25	T-0555	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes tasmani Neumann, 1899 (L and SX)
26	T-0093	Acarina: Parasitiformes: Ixodida: Ixodoidea	Ixodidae	Ixodes trichosuri Roberts, 1960
27	T-0684	Acarina: Parasitiformes: Mesostigmata	Family not determined	undetermined: Gen. and sp. or spp. indet. (GP and H)
28	T-0559	Acarina: Parasitiformes: Mesostigmata: Dermanyssoidea	Laelapidae	undetermined: Gen. undet., sp. indet. (H)
29	T-0095	Acarina: Parasitiformes: Mesostigmata: Eviphidoidea	Macrochelidae	Macrocheles sp. (H)
30	T-0556	Acarina: Parasitiformes: Mesostigmata: Rhodacaroidea	Ologamasidae: Gamasellinae	Heydeniella sp. (H)
31	T-0100	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Family not determined	undetermined: Gen. and sp. or spp. indet.(Uropodina)
32	T-0588	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Urodinychidae	Uroobovella sp. (BH and IB)
33	T-0561	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Uropodidae	Uropoda sp. A (H)
34	T-0562	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Uropodidae	Uropoda sp. B (H)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
35	T-0564	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Uropodidae	Uropoda sp. D (H)
36	T-0096	Acarina: Parasitiformes: Mesostigmata: Uropodoidea	Uropodidae	undetermined: Gen., sp. indet.
37	A-065	Amphipoda: Gammaridea: Crangonyctoidea	Eusiridae	Paraleptamphopus sp. 1 (LA)
38	A-220	Amphipoda: Gammaridea: Crangonyctoidea	Eusiridae	Paraleptamphopus sp. 2 (F)
39	A-185	Amphipoda: Gammaridea: Crangonyctoidea	Eusiridae	undetermined: Gen., sp. indet. (LA)
40	A-190	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	? Neoniphargus sp.(IB)
41	A-042	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. 1 (L)
42	A-189	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. 2 (CP)
43	A-218	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. nov. 1 (D)
44	A-090	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. nov. 2 (BH)
45	A-091	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. nov. 3 (BH}
46	A-192	Amphipoda: Gammaridea: Crangonyctoidea	Neoniphargidae	Neoniphargus sp. nov. 4 (NR)
47	A-183	Amphipoda: Gammaridea: Crangonyctoidea	? Paramelitidae	undetermined Gen., sp. indet. 1 (IB: Exit Cave system)
48	A-184	Amphipoda: Gammaridea: Crangonyctoidea	? Paramelitidae	undetermined Gen., sp. indet. 2 (IB: Marble Hill north)
49	A-068	Amphipoda: Gammaridea: Crangonyctoidea	? Paramelitidae	undetermined Gen., spp. indet.
50	A-106	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Ant bla (unpublished name) (GP)
51	A-209	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? Antipodeus "sp. nov. A" (JF)
52	A-210	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? Antipodeus "sp. nov. B" (IB)
53	A-107	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "franklinii" (1) (IB)
54	A-059	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. or spp. nov. A"
55	A-060	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. nov. B" (JF-36)
56	A-211	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. nov. C" (BH-203)
57	A-061	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. nov. C" (VF)
58	A-169	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. nov. D" (IB)
59	A-212	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "sp. nov. E" (H)
60	A-051	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 1" (PB)
61	A-052	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 2" (MW)
62	A-053	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 2a" (MC)
63	A-239	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 2b" (IB)
64	A-054	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 3" (JF)
65	A-055	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 4" (JF)
66	A-143	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont 5" (C)
67	A-056	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus "stygobiont" cf: A. wellingtoni (JF)
68	A-062	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus ?"franklinii" (UW)

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List	**sp ID**	**Higher taxonomy**	**Family, sub-family and tribe**	**Genus species**
69	A-058	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus antipodeus (Smith, 1909)
70	A-098	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus franklinii Williams and Barnard, 1988
71	A-067	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus or Gen. nov., sp. nov. (1) (MC)
72	A-213	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus or Gen. nov., sp. nov. (2) (IB)
73	A-099	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus sp. or spp.
74	A-112	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus sp., cf. ("humungus")
75	A-057	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus sp., cf: "A. wellingtoni" (MR)
76	A-191	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Antipodeus sp., nr. A. franklinii (IB-6)
77	A-064	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrochiltonia australis (Sayce, 1901)
78	A-040	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrocrangonyx sp. 2 (IB)
79	A-109	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. or spp. indet.
80	A-001	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. (1) (MC)
81	A-110	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. (2) (GP)
82	A-048	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. A (F)
83	A-092	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. B (LM)
84	A-108	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp., near "A. smithi 2" (SR)
85	A-046	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp. or spp., near "A. smithi"
86	A-050	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp., not "A. smithi 1" (L)
87	A-047	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp., not "A. smithi 2" (L and LA)
88	A-049	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Austrogammarus sp., not "A. smithi" (GP)
89	A-215	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? Giniphargus sp. 2 (CP)
90	A-041	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	Giniphargus sp. ("not G. pulchellus") (NR)
91	A-066	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? nr. Hurleya sp. indet. (G)
92	A-043	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? nr. Hurleya sp. or spp. A
93	A-044	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? nr. Hurleya sp. B (IB-110)
94	A-214	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? nr. Hurleya sp. B? (NR)
95	A-045	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? nr. Hurleya sp. C (AR)
96	A-198	Amphipoda: Gammaridea: Crangonyctoidea	Paramelitidae	? Protocrangonyx sp. (IB-34)
97	T-0795	Amphipoda: Gammaridea: Talitroidea	? Talitridae	undetermined: Gen., sp. or spp. indet.
98	T-0752	Amphipoda: Gammaridea: Talitroidea	Talitridae	Arcitalitrus sylvaticus (Haswell, 1879)
99	T-0974	Amphipoda: Gammaridea: Talitroidea	Talitridae	Austrotroides longicornis Friend, 1987
100	T-0455	Amphipoda: Gammaridea: Talitroidea	Talitridae	Keratroides sp. or spp. indet.
101	T-0453	Amphipoda: Gammaridea: Talitroidea	Talitridae	Keratroides angulosus (Friend, 1979)
102	T-0997	Amphipoda: Gammaridea: Talitroidea	Talitridae	Keratroides ?vulgaris (Friend, 1979)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
103	T-0452	Amphipoda: Gammaridea: Talitroidea	Talitridae	Keratroides vulgaris (Friend, 1979)
104	T-0975	Amphipoda: Gammaridea: Talitroidea	Talitridae	Mysticotalitrus cryptus Friend, 1987
105	T-0454	Amphipoda: Gammaridea: Talitroidea	Talitridae	Neorchestia plicibrancha Friend, 1987
106	T-0486	Annelida: Hirudinea: Arhynchobdellida	Haemadipsidae	Philaemon grandis Ingram, 1957
107	T-0973	Annelida: Hirudinea: Arhynchobdellida	Haemadipsidae	Philaemon pungens Lambert, 1899
108	T-0376	Annelida: Hirudinea: Arhynchobdellida	Haemadipsidae	undetermined: Gen., sp. or spp. indet.
109	T-0503	Annelida: Hirudinea: Arhynchobdellida	Hirudinidae	undetermined: Gen., sp. or spp. indet.
110	A-221	Annelida: Hirudinea: Rhynchobdellida	Family not determined	undetermined: Gen., sp. indet. (JF)
111	A-226	Annelida: Hirudinea: Rhynchobdellida	Glossiphoniidae	? Alboglossiphonia sp. indet. (F-surface)
112	A-199	Annelida: Hirudinea: Rhynchobdellida	Glossiphoniidae	Alboglossiphonia tasmaniensis (Ingram, 1957)
113	T-0129	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. 1 (GP and L)
114	T-0130	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. 2 (MC-1)
115	T-0131	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. 3 (MC-1)
116	T-0132	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. 4 (MC-1)
117	A-224	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. or spp.
118	T-0133	Annelida: Oligochaeta	unknown family	undetermined: Gen., sp. or spp.
119	A-113	Annelida: Oligochaeta: Crassiclitellata	Lumbricidae	undetermined: Gen., sp. indet. (CP and L)
120	A-114	Annelida: Oligochaeta: Crassiclitellata	Lumbricidae	undetermined: Gen., sp. indet. (RB)
121	T-0665	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	Amphimiximus delicans Blakemore 2000
122	T-0664	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	Megascolides croesus Blakemore 2000
123	T-0859	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	Megascolides xanthus Blakemore 2000
124	T-0124	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	Perionychella sp. nov. (BH and GP)
125	T-0125	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	undetermined Gen., sp. or spp. indet.
126	T-0874	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC5 (MC-surface)
127	T-0860	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC21 (MC)
128	T-0861	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: ? PC22 (H-surface)
129	T-0862	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC26 (MC-120)
130	T-0863	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC36 (MC-162)
131	T-0864	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC44 (H and MC)
132	T-0865	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC68 (MC-surface)
133	T-0866	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC90 (H-surface)
134	T-0867	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC92 (H-surface)
135	T-0868	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC124 (T-surface)
136	T-0869	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC130 (T-surface)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
137	T-0870	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC148 (T-surface)
138	T-0871	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC149 (T-surface)
139	T-0872	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC154 (T-surface)
140	T-0873	Annelida: Oligochaeta: Crassiclitellata	Megascolecidae: Megascolecinae	unknown Genus: PC156 (T-surface)
141	T-0372	Annelida: Oligochaeta: Diplotesticulata: Haplotaxida	Haplotaxidae	? Hologynus, or Gen. undet., sp. or spp. indet. (depig.)
142	T-0128	Annelida: Oligochaeta: Lumbriculata	Lumbriculidae	Lumbriculus variegatus (Muller, 1774)
143	T-0126	Annelida: Oligochaeta: Tubificata: Enchytraeina	Enchytraeidae	Enchytraeus sp. or spp. indet.
144	T-0127	Annelida: Oligochaeta: Tubificata: Enchytraeina	Enchytraeidae	undetermined: Gen. undet., sp. 1 (H)
145	T-0614	Annelida: Oligochaeta: Tubificata: Enchytraeina	Enchytraeidae	undetermined: Gen. undet., sp. 2 (H)
146	A-223	Annelida: Oligochaeta: Tubificata: Tubificina	Tubificidae: Tubificinae	? Tubifex tubifex (Muller, 1774) (GP and FG)
147	A-182	Annelida: Oligochaeta: Tubificata: Tubificina	Tubificidae: Tubificinae	undetermined: Gen., sp. indet. (H)
148	A-140	Annelida: Polychaeta	unknown family	undetermined: Gen. and sp. or spp.
149	T-0296	Araneae: Araneomorphae: super-family not determined	Family not determined	undetermined: Gen. and sp. or spp.
150	T-0970	Araneae: Araneomorphae: Amaurobioidea?	Family not determined	undetermined: Gen. and sp. or spp. (RB)
151	T-0629	Araneae: Araneomorphae: Amaurobioidea?	Family not determined	undetermined: Gen. and sp. or spp. (H and IB)
152	T-0617	Araneae: Araneomorphae: Amaurobioidea	Family not determined	undetermined: Gen. and sp. or spp.
153	T-0309	Araneae: Araneomorphae: Amaurobioidea	Family not determined	Gen. and sp. nov. (or Gen. nov., spp. indet.)
154	T-0063	Araneae: Araneomorphae: Amaurobioidea	? Agelenidae	Gen. nov., sp. or spp. nov.
155	T-0799	Araneae: Araneomorphae: Amaurobioidea	Agelenidae	? Oramia sp. (BH)
156	T-0369	Araneae: Araneomorphae: Amaurobioidea	? Amaurobiidae	Gen. nov. 1 ecrib: ("milvinus" group) sp. 1 (H)
157	T-0229	Araneae: Araneomorphae: Amaurobioidea	? Amaurobiidae	Gen. nov. 1 ecrib: ("milvinus" group) spp. nov.
158	T-0221	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov. (or undetermined), sp. or spp. nov. (or undet.)
159	T-0363	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov. 2 (cribellate) sp. nov. (PB)
160	T-0832	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov., sp. nov. (MC)
161	T-0888	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov., sp. or spp. 1 (surface)
162	T-0938	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov., sp. 2 (surface) (F)
163	T-0935	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov., sp. 3 (F)
164	T-0817	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Gen. nov., sp. 4 (LA)
165	T-0551	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	? Pakeha sp. (IB)
166	T-0830	Araneae: Araneomorphae: Amaurobioidea	Amaurobiidae	Storenosoma sp. (L)
167	T-0622	Araneae: Araneomorphae: Amaurobioidea	? Amphinectidae	undetermined: Gen., sp. or spp. indet.
168	T-0624	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae	undetermined: Gen., sp. indet. (H)
169	T-0619	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Amphinecta sp. or spp. nov.
170	T-0907	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Amphinecta sp. nov. 1 (IB and PB)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
171	T-0721	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Amphinecta sp. nov. 2 (H)
172	T-0061	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Amphinecta sp. or spp. nov.
173	T-0620	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides clarkei (Davies, 2003)
174	T-0812	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides sp. 1 (H)
175	T-0813	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides sp. 2 (JF)
176	T-0826	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides sp. 3 (F)
177	T-0923	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides sp. 4 (MC)
178	T-0925	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tanganoides sp. 5 (PB)
179	T-0827	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmabrochus sp. (F)
180	T-0047	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius sp. (cf. T. milvinus)
181	T-0591	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius milvinus (Simon, 1903)
182	T-0592	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius pioneer Davies, 1998
183	T-0590	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius sp. (IB)
184	T-0519	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius sp. (MA)
185	T-0896	Araneae: Araneomorphae: Amaurobioidea	Amphinectidae: Tasmarubriinae	Tasmarubrius sp. (PB)
186	T-0360	Araneae: Araneomorphae: Amaurobioidea	Nicodamidae	Ambicodamus sp. (MC)
187	T-0908	Araneae: Araneomorphae: Amaurobioidea	Nicodamidae	undetermined: Gen., sp. indet. (epigean ?)
188	T-0227	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov. (near Baiami), sp. nov. (SP)
189	T-0837	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. 1 (AR and F)
190	T-0838	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. 2 (CR)
191	T-0228	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. or spp. nov.
192	T-0353	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. nov. 1 (BH)
193	T-0791	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. nov. 2 (NR)
194	T-0354	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Gen. nov., sp. or spp. nov.
195	T-0062	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Stiphidion facetum Simon, 1902
196	T-0968	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	Stiphidion sp. (SR)
197	T-0565	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	undetermined: Gen., sp. indet. (IB)
198	T-0802	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	undetermined: Gen., sp. indet. (MR)
199	T-0962	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	undetermined: Gen. and sp. or spp.
200	T-0471	Araneae: Araneomorphae: Amaurobioidea	Stiphidiidae	undetermined: Gen. and sp. or spp.
201	T-0310	Araneae: Araneomorphae: Araneoidea	Anapidae	Gen. nov., sp. 1 (AR)
202	T-0311	Araneae: Araneomorphae: Araneoidea	Anapidae	Gen. nov., sp. 3 (NL)
203	T-0320	Araneae: Araneomorphae: Araneoidea	Anapidae	Gen. nov., sp. 4 (PB)
204	T-0233	Araneae: Araneomorphae: Araneoidea	Anapidae	Gen. nov., sp. or spp. nov.

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
205	T-0373	Araneae: Araneomorphae: Araneoidea	Anapidae	Gen. nov., sp. 2 (IB)
206	T-0230	Araneae: Araneomorphae: Araneoidea	Anapidae	Chasmocephalon sp. (MC)
207	T-0835	Araneae: Araneomorphae: Araneoidea	Anapidae	Hickmanapis renison Platnick and Forster 1989
208	T-0232	Araneae: Araneomorphae: Araneoidea	Anapidae	Pseudanapis sp. 1 (MU)
209	T-0833	Araneae: Araneomorphae: Araneoidea	Anapidae	Pseudanapis sp. nov. (IB)
210	T-0231	Araneae: Araneomorphae: Araneoidea	Anapidae	Pseudanapis sp. nov. (PB)
211	T-0312	Araneae: Araneomorphae: Araneoidea	Araneidae	Gen. nov., sp. nov. (G)
212	T-0118	Araneae: Araneomorphae: Araneoidea	Araneidae	undetermined: Gen., sp. indet. (IB)
213	T-0537	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Araneini	Araneus sp. (MN)
214	T-0919	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Araneini	Cryptaranea sp. 1 (F-surface)
215	T-0468	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Arkycini	Arkys sp. (F and LM)
216	T-1030	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Arkycini	Arkys sp. 1 (AR)
217	T-1031	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Arkycini	Arkys sp. 2 (LA)
218	T-1032	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Arkycini	Arkys sp. 3 (AR)
219	T-0774	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Arkycini	Arkys lancearius Walckenaer, 1837
220	T-1034	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Cyclosini	Cyclosa sp. 1 (AR-surface)
221	T-1017	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Cyclosini	Eriophora sp. or spp.
222	T-0939	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Dolophonini	Dolophones sp. 1 (LA-surface)
223	T-0357	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae: Mangorini	Neoscona sp. (NL)
224	T-0367	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae	undetermined: Gen., sp. indet. (IB)
225	T-0358	Araneae: Araneomorphae: Araneoidea	Araneidae: Araneinae	undetermined: Gen., sp. or spp. indet.
226	T-1033	Araneae: Araneomorphae: Araneoidea	Araneidae: Argiopinae	Argiope sp. 1 (LA-surface)
227	T-0924	Araneae: Araneomorphae: Araneoidea	Linyphiidae	Diplocephalus cristatus (Blackwall, 1833)
228	T-0930	Araneae: Araneomorphae: Araneoidea	Linyphiidae	Laetesia sp. or spp.
229	T-0401	Araneae: Araneomorphae: Araneoidea	Linyphiidae	Novolaetesia sp. (F)
230	T-0344	Araneae: Araneomorphae: Araneoidea	Linyphiidae	Porrhomma sp. nov. (IB)
231	T-0356	Araneae: Araneomorphae: Araneoidea	Linyphiidae	undetermined: Gen., sp. or spp. indet.
232	T-0349	Araneae: Araneomorphae: Araneoidea	Lycosidae: Pardosinae	Artoria sp. (N-surface)
233	T-0914	Araneae: Araneomorphae: Araneoidea	Lycosidae: Pardosinae	Artoria mckayi Framenau, 2002
234	T-0323	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Gen. nov., sp. or spp. nov.
235	T-0493	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Acrobleps hygrophilus Hickman, 1979
236	T-0321	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Acrobleps sp or spp. nov.
237	T-0496	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Acrobleps sp. 1 (F)
238	T-0324	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Mysmena sp. nov. 1 (F)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
239	T-0960	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Mysmena sp. nov. 2 (MC)
240	T-0325	Araneae: Araneomorphae: Araneoidea	Mysmenidae	Trogloneta sp. or spp. nov.
241	T-0370	Araneae: Araneomorphae: Araneoidea	Mysmenidae	undetermined: Gen., sp. or spp. indet.
242	T-0326	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. nov. 1 (AR, F and LA)
243	T-0327	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. nov. 2 (C)
244	T-0469	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. nov. 3 (JF)
245	T-0788	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. nov. 4 (MA)
246	T-0834	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. nov. 5 (IB)
247	T-0470	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Physoglenes sp. or spp. indet. (GP and PB)
248	T-0365	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. 1 (nr. T. cavernicola) (IB)
249	T-0625	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. nov. (nr. T. troglodytes) (H)
250	T-0810	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. nov. (nr. T. troglodytes) (PB)
251	T-0626	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. nov. 1 (H)
252	T-0808	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. nov. 2 (IB)
253	T-0809	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. nov. 3 (PB)
254	T-0329	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua sp. or spp. indet.
255	T-0330	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua bisetosa Platnick, 1990
256	T-0331	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua cavernicola Platnick, 1990
257	T-0458	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua ?raveni, or spp. (nr. T. cavernicola)
258	T-0682	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua raveni Platnick, 1990
259	T-0332	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Physogleninae	Tupua troglodytes Platnick, 1990
260	T-0345	Araneae: Araneomorphae: Araneoidea	Synotaxidae: Synotaxinae	? Synotaxus sp. nov. 1 (BH)
261	T-0964	Araneae: Araneomorphae: Araneoidea	Synotaxidae	undetermined: Gen. and sp. or spp.
262	T-0816	Araneae: Araneomorphae: Araneoidea	Tetragnathidae	Gen. nov., sp. or spp. nov.
263	T-0824	Araneae: Araneomorphae: Araneoidea	Tetragnathidae	undetermined Gen., sp. 1 (PB)
264	T-0359	Araneae: Araneomorphae: Araneoidea	Tetragnathidae	undetermined Gen., sp. or spp. indet.
265	T-0823	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Gen. nov., sp. nov. 1 (PB)
266	T-0234	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Gen. nov., sp. nov. 2 (JF)
267	T-0241	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Meta sp. or spp. indet. (type 1)
268	T-0046	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Meta sp. or spp. indet. (type 2)
269	T-0313	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Meta sp. or spp. Indet. (type 3)
270	T-1041	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Nanometa sp. (AR and LA)
271	T-0790	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Orsinome sp. or spp. indet. (type 1)
272	T-0067	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	Orsinome sp. or spp. indet. (type 2)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)				
List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
273	T-0368	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	undetermined: Gen., sp. or spp. indet.
274	T-0235	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Metinae	undetermined: Gen. undet., spp. nov.
275	T-0836	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Tetragnathinae	Tetragnatha sp. or spp. indet (epigean)
276	T-0751	Araneae: Araneomorphae: Araneoidea	Tetragnathidae: Tetragnathinae	Tetragnatha valida Keyserling, 1887 (epigean)
277	T-0472	Araneae: Araneomorphae: Araneoidea	Theridiidae	undetermined: Gen. and sp. or spp.
278	T-0334	Araneae: Araneomorphae: Araneoidea	Theridiidae	Gen. nov., sp. nov. (E)
279	T-0621	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	? Icona sp. (H)
280	T-0806	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	? Icona sp. (SX)
281	T-0798	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 01 (F and LA)
282	T-0839	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 02 (N)
283	T-0840	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 03 (MC)
284	T-0336	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 04 (PB)
285	T-0805	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 05 (H)
286	T-0814	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 06 (L)
287	T-0821	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 07 (NL)
288	T-0337	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 08 (IB) Tb
289	T-0338	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 09 (C)
290	T-0618	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 10 (IB) Tp
291	T-0887	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov. 11 (SP)
292	T-0961	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. nov., cf. I. alba Forster, 1955 (H)
293	T-0222	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. or spp. nov.
294	T-0223	Araneae: Araneomorphae: Araneoidea	Theridiidae (incertae sedis)	Icona sp. or spp. indet.
295	T-0904	Araneae: Araneomorphae: Araneoidea	Theridiidae: Hadrotarsinae	Euryopis sp. or spp.
296	T-0069	Araneae: Araneomorphae: Araneoidea	Theridiidae: Latrodectinae	Steatoda sp. nov. A (RA)
297	T-0088	Araneae: Araneomorphae: Araneoidea	Theridiidae: Latrodectinae	Steatoda sp. nov. B (MC)
298	T-0601	Araneae: Araneomorphae: Araneoidea	Theridiidae: Latrodectinae	Steatoda sp. nov. C (E)
299	T-0936	Araneae: Araneomorphae: Araneoidea	Theridiidae: Latrodectinae	Steatoda livens (Simon, 1894)
300	T-1042	Araneae: Araneomorphae: Araneoidea	Theridiidae: Pholcommatinae	Phoroncidia sp. 1 (F and LA)
301	T-1043	Araneae: Araneomorphae: Araneoidea	Theridiidae: Pholcommatinae	Phoroncidia sp. 2 (AR)
302	T-0347	Araneae: Araneomorphae: Araneoidea	Theridiidae: Pholcommatinae	Phoroncidia sp. 3 (BH)
303	T-0500	Araneae: Araneomorphae: Araneoidea	Theridiidae: Spintharinae	Thwaitesia sp. 1 (AR and N)
304	T-0220	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea sp. nov. 1 (IB)
305	T-0789	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea sp. nov. 2 (IG)
306	T-0642	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea sp. nov. 3, or spp. (BH and GP)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)				
List	**sp ID**	**Higher taxonomy**	**Family, sub-family and tribe**	**Genus species**
307	T-0643	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea sp. nov. 4, or spp. (E and MU)
308	T-0335	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea extrilida (Keyserling, 1889)
309	T-1013	Araneae: Araneomorphae: Araneoidea	Theridiidae: Theridiinae	Achaearanea propera (Keyserling, 1890)
310	T-0527	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	? Baalzebub sp. (GP)
311	T-0489	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Baalzebub sp. 1 (LA)
312	T-0339	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Baalzebub sp. 2 (F)
313	T-0340	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Baalzebub sp. 3 (FG and MC)
314	T-0792	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Baalzebub sp. 4 (NR)
315	T-0236	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Baalzebub spp. indet.
316	T-0501	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae: Theridiosomatinae	Theridiosoma sp. (MC)
317	T-0490	Araneae: Araneomorphae: Araneoidea	Theridiosomatidae	undetermined: Gen., sp. or spp. indet.
318	T-0002	Araneae: Araneomorphae: Austrochiloidea	Austrochilidae: Hickmaniinae	Hickmania troglodytes (Higgins and Petterd, 1984)
319	T-0630	Araneae: Araneomorphae: Clubionoidea	Clubionidae	Clubiona sp., nr. C. ?elaphines Urquhart, 1893 (AR and IB)
320	T-1022	Araneae: Araneomorphae: Clubionoidea	Clubionidae	Clubiona sp. 1 (LA)
321	T-0920	Araneae: Araneomorphae: Clubionoidea	Clubionidae	Clubiona sp. 2 (F)
322	T-0351	Araneae: Araneomorphae: Clubionoidea	Clubionidae	undetermined: Gen., sp. indet. (BH)
323	T-0361	Araneae: Araneomorphae: Clubionoidea	Corinnidae: Castianerinae	Supunna sp. (JF)
324	T-0967	Araneae: Araneomorphae: Dictynoidea	? Desidae	undetermined: Gen., sp. indet. (H)
325	T-1028	Araneae: Araneomorphae: Dictynoidea	Desidae	Gen. nov., sp. 1 (LA)
326	T-0952	Araneae: Araneomorphae: Dictynoidea	Desidae	Gen. nov., sp. 2 (N)
327	T-1026	Araneae: Araneomorphae: Dictynoidea	Desidae	Gen. nov., sp. 4 (LA)
328	T-0316	Araneae: Araneomorphae: Dictynoidea	Desidae	Gen. nov., sp. or spp. nov.
329	T-0355	Araneae: Araneomorphae: Dictynoidea	Desidae	Badumna insignis (Koch, 1872)
330	T-0921	Araneae: Araneomorphae: Dictynoidea	Desidae	Badumna sp. 1 (F and LA)
331	T-1027	Araneae: Araneomorphae: Dictynoidea	Desidae	Badumna sp. 2 (LA)
332	T-0905	Araneae: Araneomorphae: Dictynoidea	Desidae	Namandia (group) sp. or spp. indet.
333	T-1025	Araneae: Araneomorphae: Dictynoidea	Desidae	Namandia sp. (LA-surface)
334	T-0915	Araneae: Araneomorphae: Dictynoidea	Desidae	Ommatauxesis macrops Simon, 1903
335	T-0317	Araneae: Araneomorphae: Dictynoidea	Desidae	Toxopsoides sp. or spp. indet.
336	T-0937	Araneae: Araneomorphae: Dictynoidea	Desidae	Toxopsoides sp. 1 (F)
337	T-1029	Araneae: Araneomorphae: Dictynoidea	Desidae	Toxopsoides sp. 2 (LA)
338	T-0912	Araneae: Araneomorphae: Dictynoidea	Hahniidae	Gen. nov., sp. nov. (IB-surface)
339	T-0828	Araneae: Araneomorphae: Dictynoidea	Hahniidae	Gen. nov., sp. nov. (G)
340	T-0308	Araneae: Araneomorphae: Dictynoidea	Hahniidae	Scotospilus sp. 1 (AR-surface)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
341	T-0333	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	Cornifalx insignis Hickman, 1979
342	T-0897	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	Cornifalx sp. (H and SP)
343	T-0348	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	Tasmanoonops sp. (BH)
344	T-1016	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	Tasmanoonops sp. 1 (surface)
345	T-1038	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	Tasmanoonops sp. 2 (F-surface)
346	T-0892	Araneae: Araneomorphae: Dysderoidea	Orsolobidae	undetermined: Gen., sp. indet. (H-surface)
347	T-0632	Araneae: Araneomorphae: Gnaphosoidea	Gnaphosidae	undetermined: Gen., sp. or spp. indet.
348	T-0318	Araneae: Araneomorphae: Lycosoidea	Dolomedidae	Dolomedes sp. (T)
349	T-0528	Araneae: Araneomorphae: Lycosoidea	Oxyopidae	undetermined: Gen., sp. indet. (GP)
350	T-0064	Araneae: Araneomorphae: Lycosoidea	Zoridae	Argoctenus sp. (MC)
353	T-0319	Araneae: Araneomorphae: Palpimanoidea	Holarchaeidae	Holarchaea globosa (Hickman, 1981)
354	T-0903	Araneae: Araneomorphae: Palpimanoidea	Malkaridae	Carathea sp. (BH & NL)
355	T-0529	Araneae: Araneomorphae: Palpimanoidea	Malkaridae	undetermined: Gen., sp. indet. (GP)
356	T-0963	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae	undetermined: Gen., sp. indet. 1 (IB)
357	T-0598	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae	undetermined: Gen., sp. indet. 2 (H}
358	T-0846	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae	undetermined: Gen., sp. indet. 3 (JF)
359	T-0929	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae	undetermined: Gen., sp. indet. 4 (VF).
360	T-0932	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae	undetermined: Gen., sp. or spp. indet.
361	T-1019	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Micropholcommatinae	Micropholcomma sp. 1 (N-surface)
362	T-0948	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Micropholcommatinae	Micropholcomma sp. 2 (AR and N)
363	T-0226	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Micropholcommatinae	Micropholcomma sp. 3 (WE)
364	T-0518	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Micropholcommatinae	Gen. nov. (near Pua), sp. nov. (JF)
365	T-0341	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania excavata Hickman, 1979
366	T-0797	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 1 (IB)
367	T-0342	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 2 (UW)
368	T-0343	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 3 (IB)
369	T-0851	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 4 (MC)
370	T-0225	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 5 (F)
371	T-0889	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 6 (JF)
372	T-0890	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 7 (AR)
373	T-0895	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. nov. 8 (C)
374	T-0224	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Olgania sp. or spp. nov.
375	T-0916	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella fulva Hickman, 1945
376	T-1014	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella hickmani Forster, 1959

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
377	T-0906	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella luteola Hickman, 1945
378	T-1015	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella sp. 1 (N-surface)
379	T-0917	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella sp. indet. (BH)
380	T-0068	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella sp. nov. (MU)
381	T-0831	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella sp. nov. 1 (IB)
382	T-0796	Araneae: Araneomorphae: Palpimanoidea	Micropholcommatidae: Textricellinae	Textricella sp. nov. 2 (L)
383	T-1037	Araneae: Araneomorphae: Palpimanoidea	Mimetidae	Gen. nov., sp. 1 (AR-surface)
384	T-0568	Araneae: Araneomorphae: Palpimanoidea	Mimetidae	undetermined: Gen., sp. or spp. indet.
385	T-0322	Araneae: Araneomorphae: Palpimanoidea	Mimetidae: Mimetinae	Australomimetus spp. indet.
386	T-0066	Araneae: Araneomorphae: Palpimanoidea	Mimetidae: Mimetinae	Ero tasmaniensis Hickman, 1928
387	T-0237	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus cryptophilus Hickman, 1981
388	T-0238	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus flavus (NL)
389	T-0045	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp. or spp. indet.
390	T-1035	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp. 1 (AR-surface)
391	T-1036	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp. or spp. indet. 2
392	T-0350	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp. nov. 2 (BH)
393	T-0065	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp. nov. C (RA)
394	T-0969	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus sp., nr C. cryptophilus Hickman, 1981 (SR)
395	T-0239	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus spp. indet.
396	T-0315	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Cycloctenus spp. nov.
397	T-0240	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	Toxopsiella sp. (IG)
398	T-0627	Araneae: Araneomorphae: Philodromoidea	Cycloctenidae	undetermined: Gen., sp. or spp. indet.
399	T-0117	Araneae: Araneomorphae: Philodromoidea	Sparassidae: Deleninae	Neosparassus sp. (NL)
400	T-0459	Araneae: Araneomorphae: Philodromoidea	Sparassidae	undetermined: Gen., sp. indet. (WE)
401	T-1044	Araneae: Araneomorphae: Philodromoidea	Thomisidae: Stephanopinae	Sidymella sp. 1 (F-surface)
402	T-1045	Araneae: Araneomorphae: Philodromoidea	Thomisidae: Stephanopinae	Sidymella sp. 2 (AR-surface)
403	T-0778	Araneae: Araneomorphae: Philodromoidea	Thomisidae: Stephanopinae	Sidymella sp. 3 (NR)
404	T-0517	Araneae: Araneomorphae: Philodromoidea	Thomisidae: Thomisinae	Diaea pilula (Koch, 1867)
405	T-0328	Araneae: Araneomorphae: Salticoidea	Salticidae	Gen. nov., sp. or spp. nov.
406	T-1023	Araneae: Araneomorphae: Salticoidea	Salticidae	Gen. nov., sp. 1 (LA-surface)
407	T-1024	Araneae: Araneomorphae: Salticoidea	Salticidae	Gen. nov., sp. 2 (LA-surface)
408	T-1039	Araneae: Araneomorphae: Salticoidea	Salticidae	undetermined Gen., sp. indet. (AR-surface)
409	T-1040	Araneae: Araneomorphae: Salticoidea	Salticidae: Amycinae: Astiini	Tara sp. 1 (AR-surface)
410	T-0894	Araneae: Araneomorphae: Salticoidea	Salticidae: Amycinae: Astiini	Tara sp. 19 (FG and SP)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
411	T-0366	Araneae: Araneomorphae: Salticoidea	Salticidae: Euophryinae: Chalcoscirtini	Neon sp. (AR and F)
412	T-1021	Araneae: Araneomorphae: Salticoidea	Salticidae: Euophryinae: Chalcoscirtini	Neon sp. 11 (LA-surface)
413	T-0818	Araneae: Araneomorphae: Salticoidea	Salticidae: Euophryinae: Saitini	Prostheclina sp. (LA)
414	T-1012	Araneae: Araneomorphae: Salticoidea	Salticidae: Euophryinae: Saitini	Prostheclina sp. 1 (surface)
415	T-0893	Araneae: Araneomorphae: Salticoidea	Salticidae: Euophryinae: Saitini	Prostheclina sp. 9 (surface)
416	T-0352	Araneae: Araneomorphae: Salticoidea	Salticidae: Marpissinae: Holoplatysini	Holoplatys lhotskyi Zabka, 1991
417	T-1020	Araneae: Araneomorphae: Salticoidea	Salticidae: Marpissinae: Holoplatysini	Holoplatys tasmanensis Zabka, 1991
418	T-0536	Araneae: Araneomorphae: Salticoidea	Salticidae: Marpissinae: Simaethini	Opisthoncus sp. (MN)
419	T-0966	Araneae: Araneomorphae: Scytodoidea	Pholcidae	undetermined: Gen., sp. indet. (GP)
420	T-0922	Araneae: Araneomorphae: Scytodoidea	Pholcidae: Holocneminae	Physocyclus sp. or spp. nov. (near sp. 3) (JF and TP)
351	T-0558	Araneae: Mygalomorphae: Ctenizoidea	Ctenizidae	undetermined: Gen., sp. indet. (IB)
352	T-0882	Araneae: Mygalomorphae: Hexatheloidea	Hexathelidae	undetermined: Gen., sp. indet. (T-surface)
421	T-0613	Aschelminthes: Nematoda	unknown family	undetermined: Gen., sp. indet. (H)
422	A-076	Aschelminthes: Nematoda	unknown family	undetermined: Gen., sp. indet. (MC)
423	T-0409	Blattodea: Blattoidea	Blattidae: ?Blattinae	undetermined: Gen. and sp. or spp.
424	T-0933	Chilopoda: Craterostigmomorpha	? Craterostigmidae	undetermined: Gen., sp. indet. (cave form) (IB)
425	T-0299	Chilopoda: Craterostigmomorpha	Craterostigmidae	Craterostigmus tasmanianus Pocock, 1902
426	T-0843	Chilopoda: Craterostigmomorpha	Craterostigmidae	Craterostigmus tasmanianus Pocock, 1902 (cave form) (JF)
427	T-0298	Chilopoda: Geophilomorpha	Family not determined	undetermined: Gen. and sp. or spp.
428	T-0965	Chilopoda: Geophilomorpha	Chilenophilidae	Tasmanophilus sp. or spp.
429	T-0636	Chilopoda: Geophilomorpha	Chilenophilidae	Tasmanophilus sp. (cavernicolous sp. A)
430	T-0300	Chilopoda: Geophilomorpha	Chilenophilidae	Tasmanophilus opinatus (Newport)
431	T-0580	Chilopoda: Geophilomorpha	Chilenophilidae	Zelanion sp. or spp. indet.
432	T-0754	Chilopoda: Lithobiomorpha	Family not determined	undetermined: Gen., sp. indet. (PB-surface)
433	T-0546	Chilopoda: Lithobiomorpha	Henicopidae	Henicops maculatus Newport, 1845
434	T-0944	Chilopoda: Lithobiomorpha	Henicopidae	Paralamyctes (Haasiella) subicolus Edgecombe, 2004
435	T-0301	Chilopoda: Lithobiomorpha	Henicopidae: Anopsobiinae	Tasmanobius sp. 1 (BH)
436	T-0478	Chilopoda: Lithobiomorpha	Henicopidae: Anopsobiinae	undetermined: Gen., sp. indet.
437	T-0953	Chilopoda: Scolopendromorpha	Cryptopidae	Cryptops sp. (or spp.) A
438	T-0954	Chilopoda: Scolopendromorpha	Cryptopidae	Cryptops sp. B (CP and JR)
439	T-0112	Chilopoda: Scolopendromorpha	Cryptopidae	Cryptops megalopora Haase, 1887
440	T-0362	Chilopoda: Scolopendromorpha	Scolopendridae	? Cormocephalus sp. (AR-surface)
441	A-227	Cirripedia: Thoracia: Balanomorpha: Chthamaloidea	Catophragmidae	Catomerus polymerus (Darwin 1854)
442	A-228	Cirripedia: Thoracia: Balanomorpha: Chthamaloidea	Chthamalidae: Chthamalinae	Chthamalus antennatus Darwin, 1854

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
443	A-101	Coleoptera	Family not determined	undetermined: Gen. and sp. or spp. (aquatic)
444	T-0180	Coleoptera	Family not determined	undetermined: Gen. and sp. or spp. (terrestrial)
445	T-0577	Coleoptera	Family not determined	undetermined: Gen. and sp. or spp. (pupae) (H)
446	T-0440	Coleoptera: Adephaga: Caraboidea	Carabidae	undetermined: Gen. and sp. or spp.
447	T-0612	Coleoptera: Adephaga: Caraboidea	Carabidae	undetermined: Gen. and sp. or spp. (epigean)
448	T-0850	Coleoptera: Adephaga: Caraboidea	Carabidae	undetermined: Gen. and sp. or spp. (hypogean)
449	T-0115	Coleoptera: Adephaga: Caraboidea	Carabidae	undetermined: Gen., sp. indet. 1 (MC)
450	T-0116	Coleoptera: Adephaga: Caraboidea	Carabidae	undetermined: Gen., sp. indet. 2 (MC)
451	T-0198	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Chylnus ater (Putzeys, 1868)
452	T-0194	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Percosoma carenoides (White, 1846)
453	T-0514	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Percosoma sulcipenne Bates, 1878
454	T-0201	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Promecoderus sp. (IB and MW)
455	T-0203	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Promecoderus sp., nr P. ?cordicollis Sloane, 1908 (IB)
456	T-0202	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	Promecoderus tasmanicus Castelnau, 1867
457	T-0441	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Broscitae: Broscini	undetermined: Gen., sp. indet. (BH)
458	T-0204	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Callistitae	Lestignathus cursor Erichson, 1842
459	T-0183	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Elaphritae: Migadopini	Stichonotus leai Sloane, 1910
460	T-0145	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Elaphritae: Migadopini	Stichonotus piceus Sloane, 1915
461	T-0760	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Psydritae	Mecyclothorax ambiguus (Erichson, 1842)
462	T-0759	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Psydritae	Theprisa convexa (Sloane, 1920)
463	T-0195	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	Notagonum marginellum (Erichson, 1842)
464	T-0510	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	Notonomus politulus (Chaudoir, 1865)
465	T-0412	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	Pseudoceneus (Pseudoceneus) sp. (BH)
466	T-0196	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	Rhabdotus reflexus (Chaudoir, 1865)
467	T-0511	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	Rhabdotus sp. (IB)
468	T-0743	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Pterostichitae	undetermined: Gen., sp. indet. (IB-surface)
469	T-0187	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini	undetermined: Gen., and sp. or spp. indet.
470	T-0188	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	? Goedetrechus sp. or spp. (PB and RB)
471	T-0022	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus mendumae Moore, 1972
472	T-0023	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus parallelus Moore, 1972 (JF)
473	T-0844	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. (JF)
474	T-0761	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. nov. 1 (JF)
475	T-0762	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. nov. 2 (JF)
476	T-0763	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. nov. 3 (JF)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
477	T-0764	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. nov. 4 (PB)
478	T-0765	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Goedetrechus sp. nov. 5 (CP)
479	T-0024	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites elegans Moore, 1972
480	T-0006	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites flavipes (Lea, 1910)
481	T-0543	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites sp. nov. 1 (JF)
482	T-0771	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites sp. nov. 2 (JF)
483	T-0186	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanorites sp. nov. 3 (BH)
484	T-0021	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus cockerilli Moore, 1972
485	T-0768	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus compactus Moore, 1983 (BH)
486	T-0184	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus elongatus Moore, 1994 (BH)
487	T-0182	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus leai (Sloane) cave variety (BH)
488	T-0766	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus sp. nov. 1 (MC)
489	T-0767	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus sp. nov. 2 (MC)
490	T-0185	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus sp. nov. B-1 (MA) (nr. T. sp. nov. B)
491	T-0749	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Tasmanotrechus sp. nov. B-2 (BH) (nr. T. sp. nov. B-1)
492	T-0628	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Trechimorphus diemenensis (Bates, 1878)
493	T-0200	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Trechistus humicola Moore, 1972
494	T-0769	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Trechistus sp. (near T. sylvaticus) (MR)
495	T-0770	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Trechini: Trechina	Trechistus sp. 1 (near T. humicola) (JF)
496	T-0192	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	? Idacarabus sp. indet. 1 (PB)
497	T-0926	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	? Idacarabus sp. indet. 2 (JF)
498	T-0012	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus cordicollis Moore, 1967 (H)
499	T-0026	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus longicollis Moore, 1978 (PB)
500	T-0189	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus punctipennis Moore, 1994 (MR)
501	T-0756	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus sp. nov. 1 (G)
502	T-0677	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus sp. nov. 2 (VF)
503	T-0190	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus sp. nov. A (BH)
504	T-0191	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus sp. nov. B (MA)
505	T-0491	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus sp. nov. C (H)
506	T-0005	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Idacarabus troglodytes Lea, 1910
507	T-0119	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus (Sloane) sp. 1 (CP)
508	T-0199	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus (Sloane) sp. 2 (F)
509	T-0777	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus (Sloane) sp. 3 (NR)
510	T-0600	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus (Sloane) sp. 4 (WE)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
511	T-0078	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus cavicola Moore, 1994 (NR and F)
512	T-0757	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus globosus Sloane, 1920 (JF)
513	T-0758	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus rubescens Sloane, 1920 (JF)
514	T-0193	Coleoptera: Adephaga: Caraboidea	Carabidae: Carabinae: Trechitae: Zolini: Zolina	Pterocyrtus striatulus Sloane, 1920 (G)
515	A-141	Coleoptera: Adephaga: Caraboidea	Dytiscidae: Dytiscinae	undetermined: Gen., sp. indet. (GP)
516	T-0539	Coleoptera: Myxophaga: Microsporidae	Microsporidae	undetermined: Gen., sp. or spp. indet.
517	T-0513	Coleoptera: Polyphaga: Bostrichoidea	Anobiidae	undetermined: Gen., sp. indet. (IB)
518	T-0676	Coleoptera: Polyphaga: Byrroidea	? Byrrhidae	undetermined: Gen., sp. indet. (BH)
519	T-0435	Coleoptera: Polyphaga: Byrroidea	Byrrhidae	Pedilophorus sp. (BH)
520	T-0411	Coleoptera: Polyphaga: Chrysomeloidea	Cerambycidae	undetermined: Gen., sp. indet. (NR)
521	T-0602	Coleoptera: Polyphaga: Chrysomeloidea	Chrysomelidae	undetermined: Gen., sp. indet. (L)
522	T-0442	Coleoptera: Polyphaga: Cleroidea	Melyridae: Dasytinae	? Dasytes sp.(BH)
523	T-0597	Coleoptera: Polyphaga: Cucujoidea	Coccinellidae: Coccinellinae	Cleobora mellyi Mulsant, 1850
524	T-0008	Coleoptera: Polyphaga: Cucujoidea	Cryptophagidae: Atomarinae	Cryptophagus troglodytes Lea, 1910
525	T-0197	Coleoptera: Polyphaga: Cucujoidea	Lathridiidae: Corticariinae	Aridius nodifer (Westwood, 1838)
526	T-0596	Coleoptera: Polyphaga: Cucujoidea	Nitidulidae: Cillaeinae	Brachypeplus sp. (H)
527	T-0445	Coleoptera: Polyphaga: Cucujoidea	Phalacridae: Phalacrinae	Litocrus sp. (BH)
528	T-0644	Coleoptera: Polyphaga: Curculionoidea	? Anthribidae: Anthribinae	undetermined: Gen., sp. indet. (GP)
529	T-0436	Coleoptera: Polyphaga: Curculionoidea	Curculionidae	undetermined: Gen., sp. or spp. indet.
530	T-0113	Coleoptera: Polyphaga: Curculionoidea	Curculionidae	Mandelotus sp. (IB)
531	T-0523	Coleoptera: Polyphaga: Curculionoidea	Curculionidae: Cossoninae	undetermined: Gen., sp. indet. (IB)
532	T-0603	Coleoptera: Polyphaga: Curculionoidea	Curculionidae: Cryptorhynchinae	Poropterus sp. (H)
533	T-0645	Coleoptera: Polyphaga: Curculionoidea	Curculionidae: Molytinae	Exeiratus carinatus (Lea, 1928)
534	T-0494	Coleoptera: Polyphaga: Elateroidea	Elateridae	undetermined: Gen., sp. indet. (G)
535	T-0432	Coleoptera: Polyphaga: Elateroidea	Lycidae	undetermined: Gen., sp. indet. (SP)
536	A-096	Coleoptera: Polyphaga: Hydrophiloidea	Hydrophilidae	undetermined: Gen., sp. indet. (MC)
537	A-071	Coleoptera: Polyphaga: Hydrophiloidea	Hydrophilidae	undetermined: Gen., sp. or spp. indet.
538	T-0181	Coleoptera: Polyphaga: Scarabaeoidea	? Lucanidae	undetermined: Gen., sp. indet. (WE)
539	T-0574	Coleoptera: Polyphaga: Scarabaeoidea	Lucanidae	undetermined: Gen. and sp. or spp.
540	T-0465	Coleoptera: Polyphaga: Scarabaeoidea	Lucanidae	undetermined: Gen. and sp. or spp.
541	T-0443	Coleoptera: Polyphaga: Scarabaeoidea	Lucanidae: Syndesinae	Syndesus cornutus (Fabricius, 1801)
542	T-0573	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae	undetermined: Gen., sp. indet. (larva) (H)
543	T-0466	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae	undetermined: Gen., sp. or spp. indet.
544	T-0526	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Aphodiinae	Aphodius tasmaniae Hope, 1847

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
545	T-0572	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Aphodiinae	Saprosites mendax (Blackburn, 1892)
546	T-0571	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Aphodiinae	? Saprus griffithi (larvae) (H)
547	T-0570	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Aphodiinae	Saprus griffithi Blackburn, 1904
548	T-0998	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Dynastinae	Cheiroplatstys latipes (Guerin-Meneville, 1831)
549	T-0745	Coleoptera: Polyphaga: Scarabaeoidea	Scarabaeidae: Melolonthinae	undetermined: Gen., sp. indet. (MC)
550	T-0007	Coleoptera: Polyphaga: Scirtoidea	Scirtidae	Cyphon doctus Lea, 1910
551	T-0679	Coleoptera: Polyphaga: Staphylinoidea	Scaphidiidae: Scaphidiinae: Scaphidiini	Scaphiosoma sp. (JF)
552	T-0448	Coleoptera: Polyphaga: Staphylinoidea	Scydmaenidae: Scydmaeninae	Horaeomorphus sp. (BH and LM)
553	T-0575	Coleoptera: Polyphaga: Staphylinoidea	? Staphylinidae	undetermined: Gen., sp. indet. (larvae) (H)
554	T-0177	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae	undetermined: Gen., sp. or spp. indet.
555	T-0521	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Aleocharinae	? Atheta sp. (IB)
556	T-0599	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Aleocharinae	Gyrophaena sp. (H)
557	T-0744	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Aleocharinae	undetermined: Gen., sp. or spp. indet.
558	T-0444	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Goniaceritae: Tyrini	Tasmanityrus sp., nr T. auricomus (Lea, 1911)
559	T-0446	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Orsorinae: Osoriini	Typhlobledius sp. 1, nr T. cylindricus Lea, 1906
560	T-0447	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Orsorinae: Osoriini	Typhlobledius sp. 2, nr T. cylindricus Lea, 1906
561	T-0674	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Orsorinae: Osorini	undetermined: Gen., sp. indet. (Orsorini sp.) (BH)
562	T-0174	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Oxytelinae	Oxytelus sp. or spp. indet.
563	T-0678	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Oxytelinae	Oxytelus collaris Erichson, 1840
564	T-0675	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Paederinae	? Hyperomma sp. (BH)
565	T-0291	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Pselaphinae: Pselaphitae: Pselaphini	undetermined: Gen., sp. or spp. indet.
566	T-0522	Coleoptera: Polyphaga: Staphylinoidea	Staphylinidae: Xanthopyginae	Creophilus erythrocephalus (Fabricus, 1775)
567	T-0449	Coleoptera: Polyphaga: Tenebrionoidea	Prostomidae	Prostomis atkinsoni Waterhouse, 1877
568	T-0576	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae	undetermined: Gen., sp. indet. (larvae) (H)
569	T-0934	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae	undetermined: Gen., sp. indet. (IB)
570	T-0178	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae	undetermined: Gen., sp. or spp. indet.
571	T-0416	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Lagriinae: Adeliini	Adelium sp. (FG)
572	T-0219	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Lagriinae: Adeliini	Adelium abbreviatum Boisduval, 1835
573	T-0535	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Lagriinae: Adeliini	Diemenoma tuberculifera (Champion, 1894)
574	T-0025	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Lagriinae: Adeliini	Licinoma sp. (IB and MC)
575	T-0525	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Lagriinae: Lagriini: Lagriina	Ecnolagria grandis (Gyllenhal, 1817)
576	T-0524	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Tenebrioninae: Tenebrionini	Bassianus colydioides (Erichson, 1842)
577	T-0512	Coleoptera: Polyphaga: Tenebrionoidea	Tenebrionidae: Tenebrioninae: Tenebrionini	Meneristes australis (Boisduval, 1835)
578	T-0205	Collembola	Family not determined	undetermined: Gen., sp. or spp. indet.

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
579	T-0274	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae	undetermined: Gen., sp. indet. (H)
580	T-0270	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Entomobryinae: Entomobryini	Entomobrya sp. (IG)
581	T-0273	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Entomobryinae: Entomobryini	Sinella (Coecobrya) sp. or spp. (JF and VF)
582	T-0634	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Lepidocyrtoides sp. (CP)
583	T-0272	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Lepidocyrtus sp. or spp. indet.
584	T-0641	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Lepidocyrtus (Ascocyrtus) cinctus Schaffer, 1898
585	T-0638	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Lepidosira (Lepidosira) sp., nr. L. australica Schött, 1917 (H)
586	T-0271	Collembola: Entomobryomorpha: Entomobryoidea	Entomobryidae: Lepidocyrtinae: Lepidocyrtini	Pseudosinella sp. (E and H)
587	T-0278	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Cremastocephalini	Paronellides, cf. P. dandenongensis (Womersley, 1934) (IB and JF)
588	T-0639	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Cremastocephalini	Paronellides, cf. P. mjobergi (Schött, 1917) (H)
589	T-0056	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Paronellinae	Gen. nov., sp. or spp. nov. (GP and L)
590	T-0275	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Troglopetinae: Troglopedetini	Gen. nov., sp. nov. 1 (IB)
591	T-0531	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Troglopetinae: Troglopedetini	Gen. nov., sp. nov. 2 (MC)
592	T-0276	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Troglopetinae: Troglopedetini	Gen. nov., sp. or spp. nov.
593	T-0544	Collembola: Entomobryomorpha: Entomobryoidea	Paronellidae: Troglopetinae: Troglopedetini	? Trogolaphysa sp. nov. (H)
594	T-0456	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae	undetermined: Gen., sp. indet. (CP)
595	T-0264	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Anurophorinae	Cryptopygus antarcticus Willem, 1901
596	T-0265	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Anurophorinae	Cryptopygus caecus Wahlgren, 1906
597	T-0266	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Anurophorinae	Cryptopygus loftyensis (Womersley, 1934)
598	T-0268	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Isotominae	Isotoma (Isotoma) sp. (MR)
599	T-0267	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Isotominae	Parisotoma sp. or spp. indet.
600	T-0547	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Proisotominae	Folsomia candida Willem, 1902
601	T-0269	Collembola: Entomobryomorpha: Isotomoidea	Isotomidae: Proisotominae	Folsomia candida Willem, 1902 (var. sp. F) (FG-surface)
602	T-0279	Collembola: Entomobryomorpha: Tomoceroidea	Oncopoduridae	Oncopodura sp. or spp. indet.
603	T-0286	Collembola: Entomobryomorpha: Tomoceroidea	Tomoceridae: Lepidophorellinae	Lepidophorella sp. (BH and GP)
604	T-0284	Collembola: Entomobryomorpha: Tomoceroidea	Tomoceridae: Lepidophorellinae	Novacerus sp.(MA)
605	T-0285	Collembola: Entomobryomorpha: Tomoceroidea	Tomoceridae: Lepidophorellinae	Novacerus sp., cf. N. tasmanicus (Womersley, 1937) (AR)
606	T-0283	Collembola: Neelipleona: Neelidoidea	Neelidae	Megalothorax sp. (L)
607	T-0282	Collembola: Neelipleona: Neelidoidea	Neelidae	Neelides sp. (IB and L)
608	T-0259	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Ceratophysella sp. or spp. indet.
609	T-0054	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Ceratophysella armata (Nicolet 1842)
610	T-0256	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Ceratophysella sp. (cf. C. denticulata) (JF)
611	T-0258	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Hypogastrura ?purpurescens (LA)
612	T-0257	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Hypogastrura purpurescens (Lubbock, 1867)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
613	T-0260	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	Xenylla sp. (IG)
614	T-0640	Collembola: Poduromorpha: Hypogastruroidea	Hypogastruridae	undetermined: Gen., sp. indet. (H)
615	T-0248	Collembola: Poduromorpha: Neanuroidea	Brachystomellidae	Gen nov., sp. nov. (Greenslade, in prep. 2002) (IG)
616	T-0253	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Neanurinae: Lobellini	Lobellina sp. (F)
617	T-0249	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Neanurinae: Paleonurini	Australonura sp. (GP and JF)
618	T-0251	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Neanurinae: Paleonurini	Australonura sp. (cf. "wellingtonia" group) (NR)
619	T-0683	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Neanurinae: Paleonurini	Australonura sp. (cf. A. wellingtonia and M. tasmaniae) (IB)
620	T-0250	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Neanurinae: Paleonurini	Australonura wellingtonia (Womersley, 1936)
621	T-0255	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Pseudachorutinae	Anurida sp. (FG)
622	T-0516	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Pseudachorutinae	Ceratrimeria sp.(H)
623	T-0252	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Pseudachorutinae: Pseudachorutini	Pseudachorudina sp. (MR)
624	T-0280	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Pseudachorutinae: Pseudachorutini	Pseudachorutes sp. (SP)
625	T-0885	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Uchidanurinae	Acanthanura dendyi (Lubbock, 1899)
626	T-0254	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Uchidanurinae	Megalanura tasmaniae (Lubbock, 1899)
627	T-0487	Collembola: Poduromorpha: Neanuroidea	Neanuridae: Uchidanurinae	Womersleymeria bicornis (Womersley, 1940)
628	T-0635	Collembola: Poduromorpha: Onychiuroidea	Onychiuridae	undetermined: Gen., sp. indet. (epigean?) (GP)
629	T-0263	Collembola: Poduromorpha: Onychiuroidea	Onychiuridae: Onychiurinae: Onychiurini	Onychiurus sp. (FG and G)
630	T-0262	Collembola: Poduromorpha: Onychiuroidea	Tullbergiidae	Mesaphorura sp. (L)
631	T-0261	Collembola: Poduromorpha: Onychiuroidea	Tullbergiidae	Tullbergia sp. or spp. indet.
632	T-0462	Collembola: Poduromorpha: Poduroidea	Poduridae	Podura sp. or spp. indet.
633	T-0055	Collembola: Symphypleona: Katiannoidea	Arrhopalitidae	Arrhopalites sp. nov. (FG and JF)
634	T-0281	Collembola: Symphypleona: Katiannoidea	Spinothecidae: Spinothecinae	Adelphoderia sp. or spp. nov.
635	T-0607	Collembola: Symphypleona: Sminthurididoidea	Sminthuridae	undetermined: Gen., sp. indet. (MC)
636	A-187	Copepoda: Cyclopoida	Cyclopidae	Diacyclops bisetosus (Rehberg, 1880)
637	A-217	Copepoda: Cyclopoida	Cyclopidae	undetermined: Gen., sp. indet. (IB)
638	A-083	Copepoda: Cyclopoida	Cyclopidae	undetermined: Gen., sp. indet. (n. Tas.)
639	A-216	Copepoda: Cyclopoida	Cyclopidae	undetermined: Gen., sp. indet. (VF)
640	A-225	Crustacea (pholeteros ?)	Family groups not identified	undetermined: Gen. and sp. or spp.
641	A-032	Decapoda: Astacidea: Parastacoidea	Parastacidae	Spinastacoides sp. or spp. (unpublished name)
642	A-031	Decapoda: Astacidea: Parastacoidea	Parastacidae	Spinastacoides inermis (unpublished name)
643	A-201	Decapoda: Astacidea: Parastacoidea	Parastacidae	Spinastacoides ?leptomerus (unpublished name)
644	A-028	Decapoda: Astacidea: Parastacoidea	Parastacidae	Astacopsis sp. indet.
645	A-208	Decapoda: Astacidea: Parastacoidea	Parastacidae	Astacopsis sp. nov? (IB)
646	A-008	Decapoda: Astacidea: Parastacoidea	Parastacidae	Astacopsis franklinii (Gray, 1845)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
647	A-027	Decapoda: Astacidea: Parastacoidea	Parastacidae	Astacopsis gouldi Clark, 1936
648	A-100	Decapoda: Astacidea: Parastacoidea	Parastacidae	Astacopsis tricornis Clark, 1936
649	A-030	Decapoda: Astacidea: Parastacoidea	Parastacidae	Engaeus cisternarius Suter, 1977
650	A-029	Decapoda: Astacidea: Parastacoidea	Parastacidae	Engaeus fossor (Erichson, 1846)
651	T-0610	Diplopoda	Family not determined	undetermined: Gen., sp. indet. (IB)
652	T-0878	Diplopoda	Family not determined	undetermined: Gen., sp. indet. (JF)
653	T-0160	Diplopoda	Family not determined	undetermined: Gen., spp. indet. (cave)
654	T-0134	Diplopoda	Family not determined	undetermined: Gen., sp.1 (melanic) (MC and MU)
655	T-0135	Diplopoda	Family not determined	undetermined: Gen., sp.2 (large) (MC and JF)
656	T-0136	Diplopoda	Family not determined	undetermined: Gen., sp.3 (small) (MC)
657	T-0170	Diplopoda: Chordeumatida	Metopidiotrichidae	New Genus: sp. "F" sp. 2 (BH)
658	T-0707	Diplopoda: Chordeumatida	Metopidiotrichidae	Australeuma mauriesi Shear and Mesibov, 1997
659	T-0946	Diplopoda: Chordeumatida	Metopidiotrichidae	Australeuma simile Golovatch, 1986
660	T-0701	Diplopoda: Chordeumatida	Metopidiotrichidae	Neocambrisoma sp. (UW)
661	T-0670	Diplopoda: Chordeumatida	Metopidiotrichidae	Neocambrisoma cachinnus Shear and Mesibov, 1997 (L)
662	T-0686	Diplopoda: Chordeumatida	Metopidiotrichidae	Nesiothrix sp. (MA)
663	T-0666	Diplopoda: Chordeumatida	Metopidiotrichidae	Nesiothrix tasmanica (Golovatch, 1986)
664	T-0697	Diplopoda: Chordeumatida	Metopidiotrichidae	Reginaterreuma tarkinensis Shear and Mesibov, 1995
665	T-0710	Diplopoda: Chordeumatida	Peterjohnsiidae	Peterjohnsia titan Shear and Mesibov, 1994
666	T-0711	Diplopoda: Julida	Blaniulidae	Blaniulus guttulatus (Fabricus, 1798)
667	T-0942	Diplopoda: Julida	Blaniulidae	Choneiulus palmatus (Nemec, 1895)
668	T-0696	Diplopoda: Julida	Julidae: Julinae	Cylindroiulus latestriatus (Curtis, 1845)
669	T-0949	Diplopoda: Polydesmida	Family not determined	Gen. nov., sp. "T14" (BH-surface)
670	T-0776	Diplopoda: Polydesmida	Family not determined	undetermined: Gen., sp. indet. (NR)
671	T-0277	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus sp. 1 (IB)
672	T-0841	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus sp. 2 (IB)
673	T-0169	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus sp. 3 (including sp. "E")
674	T-0173	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus sp. 4 (sp. "J" - VF)
675	T-0842	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus sp. 5 (NL)
676	T-0657	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus leae Silvestri, 1910
677	T-0658	Diplopoda: Polydesmida	Haplodesmidae	Asphalidesmus parvus (Chamberlin, 1920) (= A. sp. 1)
678	T-0854	Diplopoda: Polydesmida	Paradoxosomatidae	Somethus sp. or spp.
679	T-0457	Diplopoda: Polydesmida	Paradoxosomatidae	Somethus sp. nov. 1 (MC)
680	T-0853	Diplopoda: Polydesmida	Paradoxosomatidae	Somethus sp. nov. 2 (JR)

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681	T-0695	Diplopoda: Polydesmida	Polydesmidae	Brachydesmus superus Latzel, 1884
682	T-0715	Diplopoda: Polydesmida: Dalodesmidea	? Dalodesmidae	Paredrodesmus sp. or spp.
683	T-0945	Diplopoda: Polydesmida: Dalodesmidea	? Dalodesmidae	Paredrodesmus bicalcar Mesibov, 2003
684	T-0927	Diplopoda: Polydesmida: Dalodesmidea	? Dalodesmidae	Paredrodesmus taurulus Mesibov, 2003
685	T-0163	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Gen. nov., sp. and spp. indet.
686	T-0950	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	undetermined Gen., sp. "ER7" (BH-surface)
687	T-0955	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Cave genus, sp. or spp. indet.
688	T-0956	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Genus E, sp. 1 ((CP-surface))
689	T-0957	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Genus F, sp. 1 (BH-surface)
690	T-0700	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	19aa (unpublished) (AR)
691	T-0705	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	19bb (unpublished) (H)
692	T-0690	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	19p (unpublished) (JF)
693	T-0687	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	19Y (unpublished) (IB and RB)
694	T-0694	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	19Z (unpublished) (IB and UW)
695	T-0702	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	A2 (unpublished) (WE)
696	T-0609	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lis ana (unpublished) (SR and T)
697	T-0667	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lis cor (unpublished) (AR and F)
698	T-0415	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lis dev (unpublished) (MC-surface)
699	T-0488	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lis lat spp. (unpublished)
700	T-0563	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atalopharetra sp. 1 (IB)
701	T-0940	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atalopharetra bashfordi Mesibov, 2005
702	T-0672	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atalopharetra clarkei Mesibov, 2005 (IB)
703	T-0673	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atalopharetra eberhardi Mesibov, 2005 (PB)
704	T-0688	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atalopharetra johnsi Mesibov, 2005
705	T-0479	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atopodesmus sp. (BH)
706	T-0685	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atrophotergum "sp. nov. 2" (WE)
707	T-0402	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Atrophotergum silvaticum Mesibov, 2004
708	T-0480	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Bromodesmus rufus Mesibov, 2004
709	T-0668	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Dasystigma sp. (L)
710	T-0662	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Dasystigma huonense Mesibov, 2003
711	T-0876	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Dasystigma margaretae (Jeekel, 1984)
712	T-0663	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Dasystigma tyleri
713	T-0476	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Gasterogramma sp. or spp.
714	T-0661	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Gasterogramma extremum Mesibov, 2003

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715	T-0477	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Gasterogramma psi Jeekel, 1982
716	T-0164	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus sp. or spp.
717	T-0742	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus sp. nov. A (MC)
718	T-0703	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus sp. nov. SE1 (IB)
719	T-0943	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus alisonae Jeekel, 1984
720	T-0689	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus sp. (cf. L. margaretae) (IB)
721	T-0058	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus modestus Chamberlin, 1920
722	T-0417	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Lissodesmus perporosus Jeekel, 1984
723	T-0928	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Procophorella innupta Mesibov, 2003
724	T-0691	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	? Tasmaniosoma sp. (JF)
725	T-0958	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmaniosoma sp. 2 (MC-surface)
726	T-0692	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmaniosoma sp. 4 (E)
727	T-0714	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmaniosoma sp. 7 (JF)
728	T-0959	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmaniosoma sp. 10 (H-surface)
729	T-0172	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmanodesmus sp." H" (BH)
730	T-0057	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	Tasmanodesmus hardyi (Chamberlin, 1920)
731	T-0699	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	unknown dalodesmid Genus: sp. "C" or spp. C indet.
732	T-0698	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	unknown dalodesmid Genus: sp. "C: sp. 6" ("G" at IB)
733	T-0704	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	unknown dalodesmid Genus: sp. "F2" (L)
734	T-0171	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	unknown dalodesmid Genus: sp. "G" (BH)
735	T-0941	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	undetermined: Gen. and sp. (IB)
736	T-0161	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	undetermined: Gen. and sp. or spp. indet.
737	T-0162	Diplopoda: Polydesmida: Dalodesmidea	Dalodesmidae	undetermined: Gen. and sp. or spp. indet.
738	T-0708	Diplopoda: Polyzoniida	Siphonotidae: Siphonotinae: Siphonotini	Acu mes spp. (unpublished)
739	T-0671	Diplopoda: Polyzoniida	Siphonotidae: Siphonotinae: Siphonotini	Het aus (unpublished) (MC)
740	T-0712	Diplopoda: Polyzoniida	Siphonotidae: Siphonotinae: Siphonotini	Sip ins spp. (unpublished)
741	T-0706	Diplopoda: Polyzoniida	Siphonotidae: Siphonotinae: Siphonotini	Sip sex (unpublished) (H and IB)
742	T-0713	Diplopoda: Polyzoniida	Siphonotidae: Siphonotinae: Siphonotini	Sip tas (unpublished) (F and JF-surface)
743	T-0059	Diplopoda: Sphaerotheriida	Sphaerotheriidae	Procyliosoma sp. or spp.
744	T-0720	Diplopoda: Sphaerotheriida	Sphaerotheriidae	Procyliosoma leae Silvestri, 1917
745	T-0709	Diplopoda: Spirostreptida	Family not determined	undetermined: Gen., sp. or spp. indet.
746	T-0753	Diplopoda: Spirostreptida	Cambalidae	undetermined: Gen. and sp. indet. (PB)
747	T-0507	Diplopoda: Spirostreptida	Iulomorphidae	Amastigogonus sp. (CP)
748	T-0693	Diplopoda: Spirostreptida	Iulomorphidae	undetermined: Gen., sp. or spp. indet.

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
749	T-0439	Diptera	Family groups not identified	uncertain taxonomy: sp. or spp. indet.
750	T-0463	Diplura	Family not determined	undetermined: Gen. and sp. or spp.
751	T-0414	Diplura	Campodeidae	Campodea sp. or spp.
752	T-0604	Diptera: Brachycera	Calliphoridae	Calliphora stygia (Fabricus, 1782)
753	T-0430	Diptera: Brachycera	Calliphoridae	undetermined: Gen., sp. or spp. indet.
754	T-0423	Diptera: Brachycera	Phoridae	undetermined: Gen. and sp. or spp.
755	T-0048	Diptera: Brachycera	Sphaeroceridae	Sphaerocera sp. (MC)
756	T-0918	Diptera: Brachycera: Schizophora	Drosophilidae: Drosophilinae	Drosophila rhabdote (Bock, 1976)
757	T-0293	Diptera: Brachycera: Schizophora	Heleomyzidae: Allophylopsini	Austroleria extensa (McAlpine, 1967)
758	T-0294	Diptera: Brachycera: Schizophora	Heleomyzidae: Allophylopsini	Diplogeomyza hardyi tasmanica (McAlpine, 1967)
759	T-0295	Diptera: Brachycera: Schizophora	Heleomyzidae: Allophylopsini	Diplogeomyza maculpipennis (Malloch, 1926)
760	T-0651	Diptera: Nematocera	unknown Family	undetermined: Gen. and sp. or spp.
761	T-0578	Diptera: Nematocera	? Chironomidae	uncertain taxonomy: sp. or spp. indet.
762	T-0785	Diptera: Nematocera	? Culicidae	undetermined: Gen., sp. indet. (CR)
763	T-0153	Diptera: Nematocera	? Keroplatidae: Arachnocampinae	? Arachnocampa (Arachnocampa) sp.
764	T-0803	Diptera: Nematocera	? Tipulidae	undetermined: Gen., sp. indet. (MR)
765	T-0420	Diptera: Nematocera	Anisopodidae	? Sylvicola sp. (cave fly?) (BH)
766	T-0424	Diptera: Nematocera	Cecidomyiidae	undetermined: Gen. and sp. or spp.
767	T-0422	Diptera: Nematocera	Ceratopogonidae	Culicoides sp. (BH)
768	T-0410	Diptera: Nematocera	Chironomidae	Lopesoladius sp. or spp. (SRV sp. 39) (IB and NR)
769	T-0217	Diptera: Nematocera	Chironomidae	Podonomopsis discoceros Brundin, 1966
770	T-0305	Diptera: Nematocera	Chironomidae	undetermined: Gen., sp. or spp. indet.
771	T-0608	Diptera: Nematocera	Chironomidae: Orthocladiinae	Diplocladius (Stictocladius) uniserialis (Freeman, 1961)
772	T-0431	Diptera: Nematocera	Chironomidae: Tanytarsini	Tanytarsus sp. or spp.
773	T-0425	Diptera: Nematocera	Culicidae	undetermined: Gen. and sp. or spp.
774	T-0218	Diptera: Nematocera	Sciaridae	Sciara sp. or spp. indet.
775	T-0426	Diptera: Nematocera	Sciaridae	unknown Genus: sp. 1 (IB)
776	T-0427	Diptera: Nematocera	Sciaridae	unknown Genus: sp. 2 (BH)
777	T-0428	Diptera: Nematocera	Sciaridae	unknown Genus: sp. 3 (BH)
778	T-0579	Diptera: Nematocera	Sciaridae	undetermined: Gen. and sp. or spp.
779	T-0297	Diptera: Nematocera	Sciaridae	undetermined: Gen. and sp. or spp.
780	T-0438	Diptera: Nematocera	Simuliidae	undetermined: Gen. and sp. or spp.
781	T-0292	Diptera: Nematocera	Tipulidae: unknown sub-family	undetermined: Gen. and sp. or spp.
782	T-0035	Diptera: Nematocera	Tipulidae: Limoniinae	Limnophila sp. or spp.

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
783	T-0034	Diptera: Nematocera	Tipulidae: Limoniinae	Molophilus sp. (MC)
784	T-0036	Diptera: Nematocera	Tipulidae: Limoniinae	Paralimnophilus sp. (IB)
785	T-0429	Diptera: Nematocera	Tipulidae: Tipulinae	Dolichopeza sp. (SP)
786	T-0038	Diptera: Nematocera	Trichoceridae	Nothotrichocera sp. (IB)
787	T-0037	Diptera: Nematocera	Trichoceridae	Trichocera sp. (JF and MC)
788	T-0581	Diptera: Nematocera: Mycetophilodea	Keroplatidae: Arachnocampinae	Arachnocampa (Arachnocampa) sp., cf. A. tasmaniensis (FR)
789	T-0001	Diptera: Nematocera: Mycetophilodea	Keroplatidae: Arachnocampinae	Arachnocampa (Arachnocampa) tasmaniensis Ferguson, 1925
790	T-0206	Ephemeroptera	Leptophlebiidae	Atalonella sp. or spp. indet.
791	T-0538	Ephemeroptera	Leptophlebiidae	Atalophlebia sp. (IB)
792	T-0656	Ephemeroptera	Leptophlebiidae	Australonousia sp. (IB)
793	T-0783	Ephemeroptera	Leptophlebiidae	Austrophlebiodes sp. (NR)
794	T-0782	Ephemeroptera	Leptophlebiidae	Nousia sp. (NR)
795	T-0288	Ephemeroptera	Leptophlebiidae	undetermined: Gen. and sp. or spp.
796	A-104	Eutardigrada	Macrobiotidae	undetermined: Gen., sp. indet. (L)
797	A-222	Gastropoda	Family not determined	undetermined: Gen., sp. indet. (IB)
798	A-111	Gastropoda	Family not determined	undetermined: Gen., sp. indet. (GP-surface)
799	A-094	Gastropoda: Caenogastropoda: Rissooidea	? Hydrobiidae	undetermined: Gen., sp. or spp. indet.
800	A-137	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? Ps (?) sp. indet. (VF)
801	A-148	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps01) Nanocochlea n. sp., cf. N. pupoidea (JF)
802	A-172	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps02) Austropyrgus n. sp. (R)
803	A-131	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps03) Nanocochlea n. sp., cf. N. pupoidea (IB)
804	A-135	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps04) Phrantela n. sp., cf P. pupiformis (VF)
805	A-136	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps05) uncertain taxonomy (VF)
806	A-155	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps15) Phrantela n. sp. (daveyensis group} (F)
807	A-146	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps17) Nanocochlea n. sp., cf. N. pupoidea (IB)
808	A-021	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps18) Austropyrgus n. sp. (L)
809	A-019	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps19) Beddomeia n. sp., aff zeehanensis (L)
810	A-149	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps20) Nanocochlea n. sp., cf. N. pupoidea (JF)
811	A-115	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps21) Austropyrgus n. sp., aff petterdianus (GP, L and MC)
812	A-150	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps22) Nanocochlea aff. N. pupoidea (JF)
813	A-156	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps23) Nanocochlea n. sp. (MR)
814	A-166	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps25) Nanocochlea n. sp. (parva group) (LM)
815	A-167	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps26) Nanocochlea n. sp. (parva group) (BH)
816	A-117	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? (Ps27) Phrantela sp. ? P. warwicki group (IB)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
817	A-157	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps28) Phrantela n. sp. (daveyensis group} (LM)
818	A-179	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps29) Phrantela sp. nov., cf. N. pupoidea (H)
819	A-158	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps30) Phrantela n. sp. (daveyensis group} (NR)
820	A-017	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps31) Austropyrgus n. sp., aff. petterdianus (L)
821	A-159	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps32) Phrantela n. sp. (daveyensis group} (JF)
822	A-160	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps33) Nanocochlea n. sp., cf. N. pupoidea (JF)
823	A-151	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? (Ps34) Nanocochlea n. sp., cf. N. pupoidea (IB)
824	A-163	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps35) Beddomeia n. sp., cf. bowryensis (GP)
825	A-038	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps36) Austropyrgus sp. nov., aff petterdianus (GP)
826	A-164	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps37) Beddomeia n. sp. (hulli group) (GP)
827	A-152	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps38) Phrantela n. sp. (C)
828	A-153	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps39) Austropyrgus n. sp. (C)
829	A-165	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps40) Beddomeia n. sp., aff hulli (GP)
830	A-018	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps41) Phrantela n.sp. (WM)
831	A-161	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps42) Phrantela n. sp. (daveyensis group} (WM)
832	A-154	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps44) Nanocochlea n. sp. (IB110)
833	A-120	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps50) Austropyrgus n. sp., aff petterdianus (GP)
834	A-121	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps51) Nanocochlea sp., aff. N. pupoidea (JF)
835	A-171	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps52) Beddomeia n. sp., aff ronaldi (MC)
836	A-122	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps53) Nanocochlea n. sp. (RB)
837	A-123	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps54) Austropyrgus n. sp., cf A. petterdianus (RB)
838	A-124	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps55) Nanocochlea n. sp., cf. N. pupoidea (RB)
839	A-125	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	(Ps56) Beddomeia n. sp., aff lodderae (GP)
840	A-129	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? Austropyrgus n. sp., near Ps31 (MC)
841	A-229	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus sp. (MC)
842	A-230	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus conicus Clark, Miller and Ponder, 2003
843	A-037	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus gunnii Clark, Miller and Ponder, 2003
844	A-242	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus juliae Clark, Miller and Ponder, 2003
845	A-069	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus lochi Clark, Miller and Ponder, 2003
846	A-231	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus nanoacuminatus Clark, Miller and Ponder, 2003
847	A-134	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus nanus Clark, Miller and Ponder, 2003
848	A-180	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus niger (Quoy and Gaimard, 1834)
849	A-034	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus salvus Clark, Miller and Ponder, 2003
850	A-181	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Austropyrgus solitarius Clark, Miller and Ponder, 2003

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851	A-020	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Beddomeia franklinensis Ponder and Clark, 1993
852	A-244	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Beddomeia paludinella levenensis Ponder and Clark, 1993
853	A-132	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. (similar to Ps39) (HC)
854	A-133	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. nov.? (H)
855	A-015	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. nov.? (IB-14: Western Passage)
856	A-147	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. nov.? (JF)
857	A-138	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea damperensis Ponder et al., 2005
858	A-105	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea exigua Ponder et al., 2005
859	A-144	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp., (N. monticola group) (IB99)
860	A-013	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea parva Ponder and Clark, 1993
861	A-207	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. nov., nr Ps22, cf. N. pupoidea (HC)
862	A-200	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea sp. nov.?, cf. N. pupoidea (IB)
863	A-130	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea pupoidea Ponder and Clark, 1993
864	A-118	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Nanocochlea stylesae Ponder et al., 2005
865	A-010	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. 3 (F and LA)
866	A-011	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. 6 (= cf. P. daveyensis) (LA and F)
867	A-033	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. or spp. nov.
868	A-126	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. (= cf. P. marginata) (SR)
869	A-203	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. (= cf. P. warwicki) (H)
870	A-204	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. (= cf. P. warwicki) (IB)
871	A-206	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela sp. or spp. indet. (= cf. P. warwicki) (HC)
872	A-202	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela daveyensis daveyensis Ponder and Clark, 1993
873	A-012	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela kutikina Ponder and Clark, 1993
874	A-241	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela pupiformis Ponder and Clark, 1993
875	A-036	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela umbilicata Ponder and Clark, 1993
876	A-016	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Phrantela warwicki Ponder and Clark, 1993
877	A-128	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Potamopyrgus antipodarum (Gray, 1843)
878	A-243	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? Pseudotricula, near P. arthurclarkei (PB)
879	A-170	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula arthurclarkei Ponder et al., 2005
880	A-103	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula auriforma Ponder et al., 2005
881	A-178	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	? Pseudotricula, near P. conica (PB)
882	A-145	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula conica Ponder et al., 2005
883	A-009	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula eberhardi Ponder, 1992
884	A-175	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula elongata Ponder et al., 2005

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885	A-173	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula expandolabra Ponder et al., 2005
886	A-174	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	Pseudotricula progenitor Ponder et al., 2005
887	A-035	Gastropoda: Caenogastropoda: Rissooidea	Hydrobiidae	undetermined: Gen., sp. or spp. indet.
888	T-0811	Gastropoda: Heterobranchia	Family not determined	undetermined: Gen. and sp. or spp.
889	T-0377	Gastropoda: Heterobranchia: Pulmonata: Acavoidea	Caryodidae	Caryodes dufresnii Leach, 1815
890	T-0718	Gastropoda: Heterobranchia: Pulmonata: Acavoidea	Caryodidae	Hedleyella ?maconelli (Reeve, 1853)
891	T-0398	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Arionidae	Arion intermedius Normand, 1852
892	T-0387	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa kershawi (Petterd, 1879)
893	T-0388	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa legrandi (Cox, 1868)
894	T-1001	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa sp. "Junee" (JF)
895	T-1005	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa sp. "Mystery Creek" (IB)
896	T-0856	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa sp. "Quarry" (IB)
897	T-1004	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa sp. "Teepookana" (T)
898	T-1000	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Allocharopa sp. "Victoria Valley" (JF)
899	T-1009	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Bischoffena bischoffensis (Petterd, 1879)
900	T-0389	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Dentherona (Kannaropa) dispar (Brazier, 1871)
901	T-0396	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Discocharopa mimosa (Petterd, 1879)
902	T-0505	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Geminoropa cf. G. hookeriana (former H. antialba)
903	T-0506	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Geminoropa hookeriana Petterd, 1879
904	T-0807	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Geminoropa sp. "Hastings" (H)
905	T-0384	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Geminoropa sp. "Moonlight" (H, IB, NL)
906	T-0386	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Mulathena fordei (Brazier, 1871)
907	T-0515	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Oreomava johnstoni Iredale, 1933
908	T-0390	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Pernagera kingstonensis (Legrand, 1871)
909	T-0883	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Pernagera officeri (Legrand, 1871)
910	T-0680	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Pernagera tasmaniae (Cox, 1868)
911	T-0383	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella sp. (cf. R. ?curaocae) (PB)
912	T-0382	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella curacoae (Brazier, 1871)
913	T-1002	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella gadensis (Petterd, 1879)
914	T-0829	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella sp. "Bubs Hill" (BH)
915	T-1006	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella sp. "Mystery" (IB-surface)
916	T-1003	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Roblinella sp. "Tahune"(AR and JF)
917	T-0681	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	sp. nov. ("Swallet") (JF-surface)
918	T-1007	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Stenacapha (cf. S. ducani) (CP-surface)

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
919	T-0385	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Stenacapha hamiltoni (Cox, 1868)
920	T-0858	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Thryasona sp. or spp. (cf. T. marchianae)
921	T-0391	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	Thryasona diemenensis (Cox, 1868)
922	T-0392	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Charopidae	undetermined: Gen., sp. or spp. indet.
923	T-0801	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Magilaoma penolensis (Cox, 1868)
924	T-0533	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Paralaoma or spp. (cf. P. "halli")
925	T-0534	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Paralaoma sp. or spp. (cf. P. "mucoides") (JF and MC)
926	T-1008	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Paralaoma caputspinulae (Reeve, 1851)
927	T-0532	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Paralaoma sp. (GP)
928	T-0394	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Trocholaoma parvissima (Legrand 1871)
929	T-0722	Gastropoda: Heterobranchia: Pulmonata: Arionoidea	Punctidae	Trocholaoma sp. or spp. (cf. T. "spiceri")
930	T-0381	Gastropoda: Heterobranchia: Pulmonata: Bulimuloidea	Bulimulidae	Bothriembryon (Tasmanembryon) tasmanicus (Pfeiffer, 1853)
931	T-1010	Gastropoda: Heterobranchia: Pulmonata: Helicoidea	Hygromidae	Cernuella (Microxeromagna) vestita (Rambur, 1868)
932	T-0855	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Cystopeltidae	Cystopelta bicolor Petterd and Hedley, 1909
933	T-0395	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Helicarionidae	Helicarion cuvieri Férussac, 1821
934	T-0631	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Limacidae	Deroceras reticulatum (Müller, 1774)
935	T-0397	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Zonitidae	Oxychilus cellarius (Müller, 1774)
936	T-0595	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Zonitidae	Oxychilus ?draparnaldi (Beck, 1837) (GP)
937	T-1011	Gastropoda: Heterobranchia: Pulmonata: Limacoidea	Zonitidae	Vitrea crystallina (Müller, 1774)
938	A-093	Gastropoda: Heterobranchia: Pulmonata: Lymnaeoidea	Planorbidae: Bulininae: Physastrini	Ferrissia (Pettancylus) sp. (LA)
939	A-127	Gastropoda: Heterobranchia: Pulmonata: Lymnaeoidea	Planorbidae: Bulininae: Physastrini	Glyptophysa (Glyptophysa) gibbosa (Gould, 1846)
940	T-0393	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Prolesophanta dyeri (Petterd, 1879)
941	T-0719	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Prolesophanta sp. or spp. "Francistown"
942	T-0549	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Prolesophanta sp. or spp. "Marriotts"
943	T-0378	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Tasmaphena sinclairi Pfeiffer, 1845
944	T-0594	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Victaphanta lampra (Reeve, 1854)
945	T-0379	Gastropoda: Heterobranchia: Pulmonata: Rhytidoidea	Rhytididae	Victaphanta milligani (Pfeiffer, 1853)
946	A-078	Gastropoda: Patellogastropoda	Lottiidae: Lottinae	Notoacmea petterdi (Tenison Woods, 1876)
947	T-0406	Hemiptera: Auchenorryncha: Cercopoidea	Family not determined	undetermined: Gen. and sp. or spp.
948	T-0407	Hemiptera: Auchenorryncha: Membracoidea	Family not determined	undetermined: Gen. and sp. or spp.
949	T-0583	Hemiptera: Auchenorryncha: Membracoidea	? Cicadellidae: Ledrinae	uncertain taxonomy: sp. indet. (H)
950	T-0408	Hemiptera: Auchenorryncha: Fulgoromorpha: Fulgoroidea	Family not determined	undetermined: Gen. and sp. or spp.
951	T-0114	Hemiptera: Auchenorryncha: Fulgoromorpha: Fulgoroidea	? Dictyopharidae	undetermined: Gen., sp. indet. (GP)
952	T-0584	Hemiptera: Auchenorryncha: Fulgoromorpha: Fulgoroidea	? Fulgoridae	undetermined: Gen., sp. indet.1 (IB)

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List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
953	T-0290	Hemiptera: Auchenorryncha: Fulgoromorpha: Fulgoroidea	? Fulgoridae	undetermined: Gen. and sp. or spp.
954	T-0884	Hemiptera: Heteroptera: Dipsocoroidea	Schizopteridae: Hypselosomatinae	Hypselosoma hickmani Wygodzinsky, 1959
955	T-0403	Hemiptera: Heteroptera: Enicocephaloidea	Enicocephalidae	undetermined: Gen. and sp. or spp.
956	A-080	Hemiptera: Heteroptera: Gerromorpha: Gerroidea	Veliidae (Pond Skaters)	Microvelia sp. or spp. (N and H)
957	A-082	Hemiptera: Heteroptera: Gerromorpha: Mesovelioidea	Mesoveliidae (aquatic)	undetermined: Gen., sp. indet. (T)
958	T-0586	Hemiptera: Heteroptera: Gerromorpha: Mesovelioidea	Mesoveliidae: Mesoveliinae (terrestrial)	Mesovelia sp. (L)
959	A-079	Hemiptera: Heteroptera: Nepomorpha: Notonectoidea	Notonectidae (aquatic)	undetermined: Gen. and sp. or spp.
960	T-0464	Hemiptera: Heteroptera: Nepomorpha: Notonectoidea	Notonectidae: Notonectinae (terrestrial)	undetermined: Gen., sp. indet. (GP)
961	T-0530	Hemiptera: Heteroptera: Pentatomomorpha: Lygaeoidea	Lygaeidae	undetermined: Gen., sp. indet. (WL)
962	T-0587	Hemiptera: Heteroptera: Pentatomomorpha: Lygaeoidea	Rhyparochromidae: Plinthisinae	Plinthisus sp. (H-surface)
963	T-0404	Hemiptera: Sternorrhyncha: Aphidoidea	Aphididae	Myzus (Nectarosiphon) persicae (Sulzer, 1776)
964	T-0405	Hemiptera: Sternorrhyncha: Aphidoidea	Aphididae	undetermined: Gen. and sp. or spp.
965	T-0550	Hymenoptera	Family not determined	undetermined: Gen., sp. or spp. indet.
966	T-0552	Hymenoptera: Megalyroidea	? Megalyridae	uncertain taxonomy: sp. indet. (H)
967	T-0593	Hymenoptera: Proctotrupoidea	Diapriidae: Belytinae	Stylaclista sp. (JF)
968	T-0647	Hymenoptera: Sphecoidea	Sphecidae	undetermined: Gen. and sp. or spp.
969	T-0437	Hymenoptera: Vespoidea	Formicidae: Myrmicinae	Monomorium leae Forel, 1913
970	T-0461	Hymenoptera: Vespoidea	Formicidae	undetermined: Gen. and sp. or spp.
971	T-0540	Hymenoptera: Vespoidea	Vespidae: Eumeninae	undetermined: Gen. and sp. or spp.
972	A-234	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 1 larva (L)
973	A-235	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 2 larva (L)
974	A-237	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 3 larva (CP)
975	T-0650	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 4 larva (H)
976	T-0648	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 5 larva (IB)
977	T-0652	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. or spp. (larvae)
978	T-0495	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. or spp. (larvae and eggs)
979	T-0649	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. or spp. (larvae and eggs)
980	T-0653	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 1 pupa (H)
981	T-0654	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. Type 2 pupa (H)
982	T-0655	Insecta - (higher taxonomy not determined)	Family not determined	undetermined: Gen. and sp. or spp. (pupae)
983	A-086	Isopoda: Asellota: Janiroidea	Janiridae	? Heterias sp. or spp. indet.
984	A-085	Isopoda: Asellota: Janiroidea	Janiridae	Heterias sp. nov. (nr. H. petrensis) - 1 (IB)
985	A-139	Isopoda: Asellota: Janiroidea	Janiridae	Heterias sp. nov. (nr. H. petrensis) - 2 (IB)
986	A-162	Isopoda: Asellota: Janiroidea	Janiridae	Heterias sp. nov. (nr. H. petrensis) - 3 (NR)

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List	**sp ID**	**Higher taxonomy**	**Family, sub-family and tribe**	**Genus species**
987	A-188	Isopoda: Asellota: Janiroidea	Janiridae	Heterias ?nichollsi (Chappuis, 1951) (T)
988	A-084	Isopoda: Asellota: Janiroidea	Janiridae	Heterias petrensis Roberts, 1975
989	T-0931	Isopoda: Oniscidea: Ligiamorpha	Family not determined	undetermined: Gen. and sp. or spp.
990	T-0793	Isopoda: Oniscidea: Ligiamorpha: Armadilloidea	Armadillidae: Acanthodillinae	? Acanthodillo sp. (IG)
991	T-0011	Isopoda: Oniscidea: Ligiamorpha: Armadilloidea	Armadillidae: Akermaninae	Echinodillo cavaticus Green, 1963
992	T-0089	Isopoda: Oniscidea: Ligiamorpha: Armadilloidea	Armadillidae: Cubarinae	Cubaris sp. (N)
993	T-0090	Isopoda: Oniscidea: Ligiamorpha: Diplocheta	Ligiidae	Ligia (Nesoligia) australiensis (Dana, 1853)
994	T-0091	Isopoda: Oniscidea: Ligiamorpha: Oniscoidea	Detonidae	Deto marina (Chilton, 1884)
995	T-0087	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Notoniscus sp. nov. 1 (BH)
996	T-0176	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Notoniscus sp. nov. 2 (F)
997	T-0800	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Notoniscus sp. nov. 3 (MC)
998	T-0972	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Notoniscus sp. nov. 4 (GP)
999	T-0977	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. or spp.
1000	T-0086	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. indet. (Tb)
1001	T-0541	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. 2 (JF)
1002	T-0542	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. or spp. 3 (BH)
1003	T-0085	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. 1 (L)
1004	T-0081	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. nov. (cavernicolous sp. A) (IB)
1005	T-0082	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. or spp. nov. (cavernicolous sp. B)
1006	T-0175	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sp. nov. (nr. S. hirsutus) (BH)
1007	T-0080	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus hirsutus Green, 1971
1008	T-0079	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus maculosus Green, 1961
1009	T-0084	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus ?nichollsi, or spp.
1010	T-0042	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus nichollsi Vandel, 1952
1011	T-0794	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus ?squarrosus (F)
1012	T-0083	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus squarrosus Green, 1961
1013	T-0976	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	Styloniscus sylvestris Green, 1971
1014	T-0881	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	undetermined: Gen. and sp. or spp.
1015	T-0633	Isopoda: Oniscidea: Ligiamorpha: Styloniscoidea	Styloniscidae	undetermined: Gen. and sp. or spp. (epigean)
1016	A-088	Isopoda: Phreatoicoidea	Family not determined	undetermined: Gen. and sp. or spp.
1017	A-193	Isopoda: Phreatoicoidea	Hypsimetopodidae: Hypsimetopinae	Phreatoicoides sp. nov. A (AR)
1018	A-194	Isopoda: Phreatoicoidea	Hypsimetopodidae: Hypsimetopinae	Phreatoicoides sp. nov. B (T)
1019	A-142	Isopoda: Phreatoicoidea	Phreatoicidae: Mesacanthotelsoninae	Colubotelson sp. (IB)
1020	A-006	Isopoda: Phreatoicoidea	Phreatoicidae: Paraphreatoicinae	Gen. nov., sp. nov. 1 (MC) (undescribed "Lake trog")

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1021	A-232	Isopoda: Phreatoicoidea	Phreatoicidae: Paraphreatoicinae	Gen. nov., sp. nov. 2 (MC)
1022	A-195	Isopoda: Phreatoicoidea	? Phreatoicidae: Phreatoicinae	undetermined: Gen. undet., sp. nov. (MW)
1023	A-070	Isopoda: Phreatoicoidea	Phreatoicidae: Phreatoicinae	undetermined: Gen., sp. indet. (MC)
1024	T-0852	Lepidoptera	Family not determined	undetermined: Gen., sp. indet. (MC)
1025	T-0421	Lepidoptera	Hepialidae	undetermined: Gen. and sp. or spp.
1026	T-0611	Lepidoptera	Micropterigidae	undetermined: Gen. and sp. or spp.
1027	T-0434	Lepidoptera	Oecophoridae	Barea sp. (BH)
1028	T-0485	Lepidoptera	unknown family	undetermined: Gen., sp. or or spp. indet. (accidental)
1029	T-0041	Mecoptera	Nannochoristidae	Nannochorista holostigma Tillyard, 1917
1030	T-0616	Mecoptera	Nannochoristidae	undetermined: Gen. and sp. or spp.
1031	A-097	Mollusca: Bivalvia: Eulamellibranchia	Sphaeriidae	Pisidium (Euglesa) etheridgei Smith, 1883
1032	A-238	Mollusca: Bivalvia: Eulamellibranchia	Sphaeriidae	Pisidium (Euglesa) hallae Kuiper, 1983
1033	A-240	Mollusca: Bivalvia: Eulamellibranchia	Sphaeriidae	Pisidium (Euglesa) tasmanicum Tenison-Woods, 1876
1034	A-247	Mysidacea: Mysida	Mysidae: Mysinae: Leptomysini	Mysidetes halope O'Brien 1986
1035	A-074	Nematomorpha: Gordioidea	Gordiidae	Gordius sp. or spp.
1036	A-075	Nematomorpha: Gordioidea	Gordiidae	undetermined: Gen., sp. or spp. indet.
1037	A-077	Nemertea: Nemertina	unknown family	undetermined: Gen. and sp. or spp.
1038	A-002	Nemertea: Nemertina	unknown family	undetermined: Gen. undet., sp. indet. (IB)
1039	T-0374	Nemertea: Nemertinea	Plectonemertidae	Argononemertes australiensis Dendy, 1892
1040	T-0875	Nemertea: Nemertinea	Plectonemertidae	undetermined: Gen., sp. indet. (CP)
1041	T-0497	Neuroptera	Family not determined	undetermined: Gen. and sp. or spp.
1042	T-0605	Neuroptera	Osmylidae: Kempyninae	undetermined: Gen. and sp. or spp.
1043	T-0606	Neuroptera	Myrmeleontidae	undetermined: Gen. and sp. or spp.
1044	A-233	Odonata	Family not determined	undetermined: Gen. and sp. or spp.
1045	T-0289	Odonata	Aeshnidae	Austroaeschna hardyi Tillyard, 1917
1046	T-0947	Onycophora	Peripatopsidae	Ooperipatellus sp. or spp. indet.
1047	T-0615	Onycophora	Peripatopsidae	Ooperipatellus decoratus Baehr, 1977 (var. B)
1048	T-0504	Onycophora	Peripatopsidae	Ooperipatellus sp., cf: O. insignis (CP)
1049	T-0060	Onycophora	Peripatopsidae	Ooperipatellus insignis (Dendy, 1890)
1050	T-0951	Onycophora	Peripatopsidae	Tasmanipatus anophthalmus Ruhberg, Mesibov, Briscoe and Tait, 1991
1051	T-0306	Opiliones: Laniatores: Phalangodoidea	? Oncopodidae	undetermined: Gen., sp. or spp. indet.
1052	T-0460	Opiliones: Laniatores: Travunioidea	Triaenonychidae	undetermined: Gen. and sp. or spp.
1053	T-0880	Opiliones: Laniatores: Travunioidea	Triaenonychidae	undetermined: Gen. and sp. or spp. (epigean)
1054	T-0141	Opiliones: Laniatores: Travunioidea	Triaenonychidae	undetermined: Gen. 1, sp. indet. 1 (MA)

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1055	T-0825	Opiliones: Laniatores: Travunioidea	Triaenonychidae	undetermined: Gen. 2, spp. indet. (C and F)
1056	T-0179	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	? Tasmanonuncia sp. or spp.
1057	T-0735	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Chilobunus spinosus Hickman, 1958
1058	T-0902	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Chrestobunus sp. or spp.
1059	T-0137	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Chrestobunus fuscus Hickman, 1958
1060	T-0157	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. or spp.
1061	T-0155	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. nov. 1 (GP)
1062	T-0156	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. nov. 2 (R)
1063	T-0154	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. nov. 3 (MC)
1064	T-0138	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. nov. 4 (BH)
1065	T-0857	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus ornatus Hickman, 1958
1066	T-0730	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus sp. nov., near G. signatus Roewer, 1915 (JF and MC)
1067	T-0139	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus ?signatus (MC)
1068	T-0734	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Glyptobunus signatus Roewer, 1915
1069	T-0152	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia sp. nov. (PB)
1070	T-0909	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia sp. nov. (IB)
1071	T-0741	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia sp. nov. 3 (BH)
1072	T-0246	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia ?acris (N)
1073	T-0151	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia acris Hickman, 1958
1074	T-0901	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Mestonia picra Hickman, 1958
1075	T-0913	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Miobunus sp. (BH-surface)
1076	T-0772	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Miobunus forficula Hunt, 1995
1077	T-0773	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Miobunus johnhickmani Hunt, 1995
1078	T-0245	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Phanerobunus sp. (BH)
1079	T-0159	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Phoxobunus sp. nov. (BH)
1080	T-0911	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Triaenobunus sp. or spp.
1081	T-0733	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenobunini	Triaenobunus pectinatus Pocock 1903
1082	T-0243	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Ankylonuncia sp. or spp.
1083	T-0910	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Bryonuncia sp. (IB-Surface)
1084	T-0900	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Bryonuncia distincta Hickman, 1958
1085	T-0144	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Calliuncus sp. or spp.
1086	T-0736	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Calliuncus sp. nov. (H-surface)
1087	T-0737	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Calliuncus sp., nr. C. odoratus Hickman (JF-surface)
1088	T-0899	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Calliuncus odoratus Hickman, 1958

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
1089	T-0728	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Calliuncus vulsus Hickman
1090	T-0142	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	? Hickmanoxyomma sp.? or spp. nov.
1091	T-0820	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma sp. (cave variety) (F)
1092	T-0775	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma sp., nr. H. ?goedei (NR)
1093	T-0050	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma cavaticum Hunt, 1990 (var. 1: IB)
1094	T-0051	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma cavaticum Hunt, 1990 (var. 2: H)
1095	T-0052	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma cavaticum Hunt, 1990 (var. 3: NL)
1096	T-0053	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma clarkei Hunt, 1990
1097	T-0073	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma cristatum Hunt, 1990
1098	T-0071	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma eberhardi Hunt, 1990
1099	T-0049	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma gibbergunyar Hunt, 1990
1100	T-0070	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma goedei Hunt, 1990
1101	T-0072	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Hickmanoxyomma tasmanicum Hunt, 1990
1102	T-0731	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Leionuncia levis Hickman, 1958
1103	T-0545	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Gen. nov., sp. nov., near ?Lomanella (H)
1104	T-0314	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Gen. nov., sp. indet. (near Lomanella) (IB)
1105	T-0242	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella sp. or spp. indet. (cave type)
1106	T-0716	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella sp. or spp. indet. (surface type)
1107	T-0307	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella parva Forster, 1955
1108	T-0725	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella raniceps Pocock 1903
1109	T-0075	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella thereseae, Hunt and Hickman, 1993 (var. 1: H)
1110	T-0726	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella thereseae, Hunt and Hickman, 1993 (var. 2: IB)
1111	T-0815	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella thereseae, Hunt and Hickman, 1993 (var. 3: UW)
1112	T-0076	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella troglodytes Hunt and Hickman, 1993
1113	T-0074	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Lomanella troglophilia Hunt and Hickman, 1993
1114	T-0143	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Notonuncia sp. nov 1. (WE)
1115	T-0637	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Notonuncia sp. nov 2. (JF)
1116	T-0738	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Notonuncia arvensis Hickman, 1958
1117	T-0724	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Notonuncia obscura Hickman, 1958
1118	T-0158	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nucina sp. or spp.
1119	T-0140	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nucina dispar Hickman, 1958
1120	T-0244	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nunciella sp. or spp.
1121	T-0739	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nunciella badia (Hickman, 1958)
1122	T-0498	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides sp. indet. (SX)

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1123	T-0148	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides sp. nov. 1 (BH)
1124	T-0149	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides sp. nov. 2 (MR)
1125	T-0150	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides sp. nov. 3 (JF and RB)
1126	T-0646	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides sp. nov. 4 (RB)
1127	T-0147	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides ?dysmicus Hickman, 1958 (BH)
1128	T-0146	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides ?infrequens (BH)
1129	T-0786	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Nuncioides infrequens Hickman, 1958 (MR)
1130	T-0044	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Odontonuncia saltuensis (Hickman, 1958)
1131	T-0848	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Paranuncia sp. (F and MU)
1132	T-0043	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Paranuncia gigantea Roewer, 1915
1133	T-0729	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Rhynchobunus arrogans Hickman, 1958
1134	T-0732	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Tasmanonyx sp. (H-surface)
1135	T-0727	Opiliones: Laniatores: Travunioidea	Triaenonychidae: Triaenonychinae: Triaenonychini	Tasmanonyx montanus Hickman, 1958
1136	T-1018	Opiliones: Palpatores: Phalangioidea	Monoscutidae: Megalopsalidinae	undetermined Gen., sp. or spp. indet.
1137	T-0499	Opiliones: Palpatores: Phalangioidea	Monoscutidae: Megalopsalidinae	Spinicrus sp. or spp. indet.
1138	T-0346	Opiliones: Palpatores: Phalangioidea	Monoscutidae: Megalopsalidinae	Spinicrus sp. nov. (BH)
1139	T-0740	Opiliones: Palpatores: Phalangioidea	Monoscutidae: Megalopsalidinae	? Spinicrus sp. nov. (JF)
1140	T-0247	Opiliones: Palpatores: Phalangioidea	Monoscutidae: Megalopsalidinae	Spinicrus nigricans Hickman, 1958 (BH and JF)
1141	T-0569	Opiliones: Palpatores: Phalangioidea	Phalangiidae	undetermined: Gen., sp. or spp. indet.
1142	T-0585	Orthoptera	Family not determined	undetermined: Gen., sp. or spp. indet.
1143	T-0111	Orthoptera	? Acrididae	undetermined: Gen., sp. indet. (MC)
1144	T-0451	Orthoptera	Acrididae	Gen. nov., sp. nov. (BH)
1145	T-0433	Orthoptera	Gryllacrididae	Gen. nov., nr. Apotrechus ambulans (Erichson, 1842) (BH)
1146	T-0020	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Cavernotettix craggiensis Richards, 1974
1147	T-0010	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Cavernotettix flinderensis (Chopard, 1944)
1148	T-0077	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. or spp. indet.
1149	T-0548	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus n. sp. (?) (LP)
1150	T-0748	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. nov (LF)
1151	T-0746	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. nov. (near M. cavernicola) (WA)
1152	T-0003	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus cavernicola Richards, 1964
1153	T-0508	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus ?fuscus (GP and KR)
1154	T-0014	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus fuscus Richards, 1968
1155	T-0019	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus kiernani Richards, 1974
1156	T-0509	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. nov. 1 (near M. montanus) (LM)

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1157	T-0784	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. nov. 2 (near M. montanus) (CR)
1158	T-0787	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus sp. nov. 3 (near M. montanus) (GS)
1159	T-0017	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus montanus Richards, 1971
1160	T-0004	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Micropathus tasmaniensis Richards, 1964
1161	T-0167	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	? Parvotettix sp. or spp. indet.
1162	T-0013	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Parvotettix goedei Richards, 1968
1163	T-0016	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Parvotettix maydenaensis Richards, 1971
1164	T-0015	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Parvotettix rangaensis Richards, 1970
1165	T-0747	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Parvotettix sp. nov. 1 (MI)
1166	T-0018	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Parvotettix whinrayi Richards, 1974
1167	T-0009	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	Tasmanoplectron isolatum Richards, 1971
1168	T-0502	Orthoptera: Ensifera: Gryllacridoidea	Rhaphidophoridae: Macropathinae: Macropathini	undetermined: Gen., sp. or spp. indet.
1169	A-095	Ostracoda	Family not determined	undetermined: Gen. and sp. or spp.
1170	A-186	Ostracoda: Podocopida: Cypridoidea	Cyprididae: Candoninae	? Candona sp. nov. (JF)
1171	A-168	Ostracoda: Podocopida: Cypridoidea	Cyprididae: Candoninae	Candona sp. nov. 1 (MC)
1172	T-0971	Pauropoda	? Pauropodidae	undetermined: Gen., sp. indet. (IB)
1173	T-0467	Plecoptera	Family not determined	undetermined: Gen., sp. or spp. indet.
1174	T-0780	Plecoptera: Antarctoperlaria: Eustheniodea	Eustheniidae	Eusthenia sp. (NR)
1175	T-0040	Plecoptera: Antarctoperlaria: Eustheniodea	Eustheniidae	Eusthenia costalis Banks, 1913
1176	T-0039	Plecoptera: Antarctoperlaria: Eustheniodea	Eustheniidae	Eusthenia spectabilis Gray, 1832
1177	T-0492	Plecoptera: Antarctoperlaria: Eustheniodea	Eustheniidae	undetermined: Gen., sp. or spp. indet.
1178	T-0669	Plecoptera: Antarctoperlaria: Gripopterygoidea	Austroperlidae	Tasmanoperla larvalis (Illies, 1969)
1179	T-0582	Plecoptera: Antarctoperlaria: Gripopterygoidea	Austroperlidae	Tasmanoperla thalia (Newman, 1839)
1180	T-0207	Plecoptera: Arctoperlaria: Nemouroidea	Notonemouridae	Austrocerca tasmanica (Tillyard, 1924)
1181	T-0450	Plecoptera: Arctoperlaria: Nemouroidea	Notonemouridae	Austrocercella christinae Illies, 1975
1182	T-0781	Plecoptera: Arctoperlaria: Nemouroidea	Notonemouridae	Notonemoura lynchi Illies, 1975 (NR)
1183	T-0484	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae	undetermined: Gen., sp. or spp. indet.
1184	T-0999	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Chthoniinae	Austrochthonius sp. or spp.
1185	T-0413	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Chthoniinae	Austrochthonius australis Hoff, 1951
1186	T-0623	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. or spp.
1187	T-0482	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. or spp. indet.
1188	T-0030	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 1 (PB)
1189	T-0029	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 2 (JF)
1190	T-0031	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 3 (JF)

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1191	T-0032	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 4 (IB)
1192	T-0418	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 5 (GP)
1193	T-0819	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 6 (LA)
1194	T-0845	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 7 (VF)
1195	T-0849	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. no. 8 (MC)
1196	T-0847	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 1 (nr. P. solitarius) (UW)
1197	T-0168	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 2 (nr. P. solitarius) (BH)
1198	T-0399	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 1 (nr. P. tasmanicus) (MA)
1199	T-0717	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 2 (nr. P. tasmanicus) (IB)
1200	T-0483	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 3 (nr. P. tasmanicus) (MR)
1201	T-0481	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. 4 (nr. P. tasmanicus) (WE)
1202	T-0027	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius tasmanicus Dartnall, 1970 (H and IB)
1203	T-0033	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. nov. (nr. P. typhlus) (BH)
1204	T-0886	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius sp. (possibly P. typhlus) (MC)
1205	T-0028	Pseudoscorpiones: Epiocheirata: Chthonioidea	Chthoniidae: Pseudotyrannochthoniinae	Pseudotyrannochthonius typhlus Dartnall, 1970 (MC)
1206	T-0475	Pseudoscorpiones: Iocheirata: Cheliferoidea	Chernertidae: Goniochernetinae	Conicochernes sp. (H and RO)
1207	T-0898	Pseudoscorpiones: Iocheirata: Olpioidea	Olpiidae	undetermined: Gen., sp. or spp. indet. (epigean ?)
1208	T-0400	Pseudoscorpiones: Iocheirata: Olpioidea	Olpiidae: Garypininae	Protogarypinus sp. or spp. nov.
1209	T-0371	Scorpiones: Iurida: Scorpionoidea	Bothriuridae	Cercophonius squama (Gervais, 1844)
1210	T-0755	Siphonaptera	Family not determined	undetermined: Gen. and sp. or spp.
1211	T-0877	Symphyla: Cephalostigmata	Family not determined	undetermined: Gen., sp. indet. (JF) epigean?
1212	T-0804	Symphyla: Cephalostigmata	Family not determined	undetermined: Gen., sp. indet. (MR-surface)
1213	T-0166	Symphyla: Cephalostigmata: Scutigerelloidea	Scutigerellidae	Hanseniella sp. or spp.
1214	T-0660	Symphyla: Cephalostigmata: Scutigerelloidea	Scutigerellidae	Hanseniella ?hardyi (Chamberlin, 1920) (IB)
1215	T-0659	Symphyla: Cephalostigmata: Scutigerelloidea	Scutigerellidae	Hanseniella magna Scheller, 1996
1216	T-0165	Symphyla: Cephalostigmata: Scutigerelloidea	Scutigerellidae	undetermined sp. or spp., nr. ?Hanseniella
1217	A-246	Syncarida: Anaspidacea	Anaspididae	Allanaspides sp. (T)
1218	A-087	Syncarida: Anaspidacea	Anaspididae	Anaspides ?spinulae Williams, 1965 (JF)
1219	A-005	Syncarida: Anaspidacea	Anaspididae	Anaspides tasmaniae Thomson, 1892 ("blind" type) (H)
1220	A-102	Syncarida: Anaspidacea	Anaspididae	Anaspides tasmaniae Thomson, 1892 (cave type)
1221	A-004	Syncarida: Anaspidacea	Anaspididae	Anaspides tasmaniae Thomson, 1892 (intermediate type)
1222	A-003	Syncarida: Anaspidacea	Anaspididae	Anaspides tasmaniae Thomson, 1892 (normal type)
1223	A-245	Syncarida: Anaspidacea	Anaspididae	Paranaspides sp. (IB)
1224	A-026	Syncarida: Anaspidacea	Koonungidae	? Gen. nov., sp. nov. (LM)

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1225	A-024	Syncarida: Anaspidacea	Koonungidae	Koonunga sp. (MU)
1226	A-014	Syncarida: Anaspidacea	Koonungidae	? Micraspides sp. (F)
1227	A-023	Syncarida: Anaspidacea	Koonungidae	Micraspides ?calmani Nicholls, 1931 (LA)
1228	A-025	Syncarida: Anaspidacea	Koonungidae	undetermined: Gen., sp. indet. (T)
1229	A-007	Syncarida: Anaspidacea	Parabathynellidae	Notobathynella tasmaniana Morimoto, 1978
1230	A-022	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. or spp. indet.
1231	A-063	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 1 (H)
1232	A-081	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 2 (IB)
1233	A-116	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 3 (G)
1234	A-119	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 4 (C and PB)
1235	A-176	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 5 (MC)
1236	A-177	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 6 (JF)
1237	A-197	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides sp. 7 (MR)
1238	A-089	Syncarida: Anaspidacea	Psammaspididae	Eucrenonaspides oinotheke Knott and Lake, 1980
1239	A-219	Syncarida: Anaspidacea	Psammaspididae	? Psammaspides sp. (H)
1240	T-0216	Trichoptera	Family not determined	undetermined: Gen. and sp. or spp. indet.
1241	T-0109	Trichoptera	Family not determined	undetermined: Gen., sp. indet. 1 (MC)
1242	T-0110	Trichoptera	Family not determined	undetermined: Gen., sp. indet. 2 (MC)
1243	T-0985	Trichoptera: Annulipalpia: Glossosomatoidea	Glossosomatidae	Agapetus tasmanicus (Mosely, 1953)
1244	T-0986	Trichoptera: Annulipalpia: Glossosomatoidea	Glossosomatidae	Agapetus cralus (Mosely, 1953)
1245	T-0212	Trichoptera: Annulipalpia: Hydropsychoidea	Hydropsychidae	Asmicridea sp. (JF)
1246	T-0989	Trichoptera: Annulipalpia: Hydropsychoidea	Hydropsychidae	Asmicridea edwardsi (McLachlan, 1866)
1247	T-0213	Trichoptera: Annulipalpia: Hydropsychoidea	Hydropsychidae	undetermined: Gen., sp. indet. (HC)
1248	T-0473	Trichoptera: Annulipalpia: Hydropsychoidea	Hydropsychidae	undetermined: Gen. and sp. or spp.
1249	T-0988	Trichoptera: Annulipalpia: Hydropsychoidea	Polycentropodidae	Plectrocnemia altera Neboiss, 1977
1250	T-0987	Trichoptera: Annulipalpia: Philopotamoidea	Philopotamidae	Hydrobiosella anasina Neboiss, 1977
1251	T-0211	Trichoptera: Annulipalpia: Philopotamoidea	Philopotamidae	Hydrobiosella tasmanica Mosely, 1953
1252	T-0419	Trichoptera: Annulipalpia: Philopotamoidea	Philopotamidae	Hydrobiosella tasmanica Mosely, 1953 (cave form?) (IB)
1253	T-0520	Trichoptera: Annulipalpia: Philopotamoidea	Philopotamidae	undetermined: Gen., sp. indet. (IB)
1254	T-0208	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Apsilochorema obliquum (Mosely, 1853)
1255	T-0982	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Ethochorema nesydrion (Neboiss, 1962)
1256	T-0984	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Keotonga clivicola Neboiss, 1962
1257	T-0209	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Taschorema sp. or spp. Indet.
1258	T-0983	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Taschorema asmanum Mosely, 1936

Table 9.1: Alphabetically ordered hierarchical taxonomy from thesis database for species from Tasmanian cave areas (Arthur Clarke, May 2006)

List	sp ID	Higher taxonomy	Family, sub-family and tribe	Genus species
1259	T-0981	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Ulmerochorema rubiconum Neboiss, 1962
1260	T-0980	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	Ulmerochorema seonum (Mosely, 1953)
1261	T-0210	Trichoptera: Annulipalpia: Rhyacophiloidea	Hydrobiosidae	undetermined: Gen. and sp. or spp. indet.
1262	T-0474	Trichoptera: Annulipalpia: Rhyacophiloidea	Rhyacophilidae	undetermined: Gen., sp. indet. (LA)
1263	T-0214	Trichoptera: Integripalpia: Leptoceroidea	Leptoceridae	undetermined: Gen., sp. or spp. indet.
1264	T-0978	Trichoptera: Integripalpia: Leptoceroidea	Philorheithridae	Aphilorheithrus decoratus Neboiss, 1977
1265	T-0979	Trichoptera: Integripalpia: Leptoceroidea	Philorheithridae	Aphilorheithrus stepheni Mosely, 1936
1266	T-0996	Trichoptera: Integripalpia: Leptoceroidea	Philorheithridae	Tasmanthrus angustipennis Mosely, 1936
1267	T-0567	Trichoptera: Integripalpia: Leptoceroidea	Philorheithridae	undetermined: Gen., sp. indet. (JF)
1268	T-0990	Trichoptera: Integripalpia: Sericostomatoidea	Calocidae	Caenota plicata Mosely, 1953
1269	T-0215	Trichoptera: Integripalpia: Sericostomatoidea	Calocidae	Caloca saneva (Mosely, 1953)
1270	T-0991	Trichoptera: Integripalpia: Sericostomatoidea	Calocidae	Tamasia variegata Mosely, 1936
1271	T-0994	Trichoptera: Integripalpia: Sericostomatoidea	Conoesucidae	Costora ebenina Neboiss, 1977
1272	T-0995	Trichoptera: Integripalpia: Sericostomatoidea	Conoesucidae	Costora seposita Neboiss, 1977
1273	T-0993	Trichoptera: Integripalpia: Sericostomatoidea	Conoesucidae	Matasia satana Mosely, 1936
1274	T-0992	Trichoptera: Integripalpia: Sericostomatoidea	Helicophidae	Alloecella grisea Banks, 1939
1275	T-0779	Trichoptera: Integripalpia: Sericostomatoidea	Helicophidae	undetermined: Gen., sp. indet. (NR)
1276	T-0122	Turbellaria: Lecithoepitheliata	? Prorhynchidae	undetermined: Gen. indet., sp. 1 (WE)
1277	A-236	Turbellaria: Tricladida: Paludicola	Planariidae	? Cura sp. (CP)
1278	A-072	Turbellaria: Tricladida: Paludicola	Planariidae	Cura sp. (BH)
1279	A-205	Turbellaria: Tricladida: Paludicola	Planariidae	undetermined: Gen., sp. indet. (Sb) (IB-23)
1280	A-073	Turbellaria: Tricladida: Paludicola	Planariidae	undetermined: Gen. and sp. or spp. indet. (Sb?)
1281	A-196	Turbellaria: Tricladida: Paludicola	Planariidae	undetermined: Gen. and sp. or spp. indet. (Sx)
1282	T-0120	Turbellaria: Tricladida: Terricola	Family not determined	undetermined: Gen. undet., sp. 1 (MC)
1283	T-0121	Turbellaria: Tricladida: Terricola	Family not determined	undetermined: Gen. undet., sp. 2 (IB & PB)
1284	T-0375	Turbellaria: Tricladida: Terricola	Geoplanidae	undetermined: Gen., sp. or spp. indet.
1285	T-0304	Turbellaria: Tricladida: Terricola	Geoplanidae: Caenoplaninae	Australoplana ?typhlops (BH)
1286	T-0123	Turbellaria: Tricladida: Terricola	Geoplanidae: Caenoplaninae	Australoplana typhlops (Dendy, 1894)
1287	T-0108	Turbellaria: Tricladida: Terricola	Geoplanidae: Caenoplaninae	Fletchamia sugdeni (Dendy 1891)
1288	T-0380	Turbellaria: Tricladida: Terricola	Geoplanidae: Caenoplaninae	? Tasmanoplana sp. or spp. Indet.
1289	T-0364	Turbellaria: Tricladida: Terricola	Geoplanidae: Caenoplaninae	Tasmanoplana tasmaniana (Darwin, 1844)
1290	T-0302	Turbellaria: Tricladida: Terricola	Geoplanidae: Geoplaninae	Geoplana sp. A (BH)
1291	T-0303	Turbellaria: Tricladida: Terricola	Geoplanidae: Geoplaninae	Geoplana sp. B (BH)
1292	T-0287	Zygentoma (Thysanura)	Lepismatidae	Ctenolepisma (Ctenolepisma) sp. (BH)

9.2: Database records: information sources and references

Aside from the occasional collection or observation records sourced from caving club magazines, the most authoritive and detailed records have been obtained directly from collectors or their published records, various publications, e.g., descriptions and reviews of cave dwelling species and museum records (see Section 9.3). There have been four main collectors of cave fauna in Tasmania: Goede, Hamilton-Smith, Eberhard and Clarke, and each have had their own system for recording cave species occurrences.

9.2.1: Recording systems of Goede, Hamilton-Smith, Eberhard and Clarke

Albert Goede assigned numbers from 1–468 for the cave and surface fauna collections taken by himself, his wife (Therese) and other cavers, during the period from 27-Feb-1968 till 21-Aug-1982. The collection details were recorded in a small notebook and cross referenced to numbered correspondence files that contained copies of letters relating to the dispatch and identification of specimens and further information including published cave fauna articles. A number of the Goede records relate to surface collections made by Therese Goede, while Albert Goede was underground investigating fauna in caves or old mine workings. Museum records and published references indicate that Albert and Therese Goede were jointly or individually involved with cave fauna collections prior to February 1968 and subsequent to 1982; these collections do not appear to have accompanying reference numbers.

Although the first collection of Tasmanian cave fauna by Elery Hamilton-Smith dates back to 15-Nov-1953, he performed most of his cave fauna studies during the time when he had a long standing relationship with the South Australian Museum (SAM) in Adelaide, leading up to his appointment as Honorary Associate in Zoology. During this period, Hamilton-Smith developed a Bio-Speleological ("BS") Card Index for registering or recording the collections of cave species from all over Australia (see Section 2.2.2 and Clarke, 2000c); these collections included his own studies, other cave biologists and the early investigators such as Arthur Lea. Many of these specimens collected by Hamilton-Smith and others, all recorded with "BS" numbers, were purportedly lodged in SAM (Clarke, 2000c).

Stefan Eberhard introduced a more complex system for assigning reference codes to collected cave species, including those collected by others; a system that initially involved giving reference numbers for individual specimens. This system was subsequently modified to exclude the collections made by others, concentrating on his studies or observations and using record number codes to define a collection site, particular habitat and/ or a vial of similar species from a particular collection site or habitat. His collection records were recorded in notebooks and transferred to a database. In the notes accompanying his collection forwarded to the Queen Victoria Museum in Launceston for lodgement, Eberhard quoted the example of a cave at Precipitous Bluff (PB), using "PB4-1V" as a guide to explain the prefixes and suffixes associated with his "Record Number Code".

"PB" = Karst Area prefix (1 or 2 letters only);

"4" = Cave number: (1 to 3 numbers, or if un-numbered, then "-Xn" where n = arbitrary ID number, e.g., MR-X1-1. If letter "s" instead of cave number, then = surface collection, e.g., MRs-1G.);

"-" = Hyphen to separate Cave id from vial id.);

"1" = Vial number (or Record): consecutive numbers for each vial per cave site;

"V" = Suffix (not required), e.g., V = voucher specimen; S = sighted, but not collected (therefore no vial in collection; G = gone to specialist; F = frozen; R = record/ reference in literature.

The numbering method for collections by the present writer (Arthur Clarke) is a date-based (month-year) system involving a 3 or 4 digit number with a consecutively ordered figure, allocated to individual vials (usually one species type) from a collection site on a particular date. These number are generally (but not always), chronologically ordered from the first vial specimen of the first collection (or observation) for any given month. Two vial numbering date systems have been used. Prior to February 1988, the year component occurred first, e.g., 8508-01 represents vial specimen number one for August 1985, and from February 1988 onwards, the month component appears first, so "288" represents a collection in February 1988 and "1004-03" is vial number 3 for a collection during October 2004. On occasions where more than one species is determined for all the specimens in a vial, each species from that vial is given a suffix: a, b, c, etc. The Clarke records are recorded in three notebooks as well as being incorporated in the thesis database.

9.2.2: Database record sources: additional bibliography (collection site and species occurrence references) not included in thesis

The database that supports this thesis has three main tables (Records, Caves and Taxonomy) which include a field listing the principal sources of published information for each occurrence record, cave or surface site and the species taxonomy. The references for described species can be sourced by checking the current species authority or name of the taxonomist shown as a suffix to the species in the taxonomy list. In the case where species have been redescribed, the original taxonomist's name appears in brackets; see Table 9.1 (Appendix 9.1.3). References to the cave locality sites are generally the same as the reference sources relating to species occurrences. Although this field listing the references is not yet completed, the following list of sources relate to those collected or observed cave species included in the occurrence record table that are not otherwise cited in the thesis. Note that some reference citations maybe incomplete, with the journal details and pagination recorded, but no article or manuscript titles, e.g., the club trip reports with mention of cave fauna in the Savage River Caving Club's magazine: *Speleopod.*

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9.2.3: Database record sources: cave site location data

As mentioned in Section 4.2.1 (p. 97), occurrence site location data has been principally sourced during thesis research by the writer, caving club records (surface survey traverses or GPS readings) including the Australian Speleological Federation Karst Index database and the Commonwealth Department of the Environment and Heritage website: "GIS Tools - Find an address or place". See:
http://www.deh.gov.au/erin/ert/imap/imapfiles/jsp/addresssearch.jsp?mode=standalone
The geographic coordinates for site localities are given as decimal degrees of Latitude and Longitude that can be converted to Degrees, Minutes and Seconds at:
http://www.deh.gov.au/erin/tools/dd2dms.html
Geographic localities can also be sourced through the Geosciences Australia website.

9.3: Museum lodgements and their database or collection classification systems

As described in Clarke (2000c), the collected specimens from Tasmanian caves and karst surface sites have been disbursed far and wide throughout Australia and internationally, either directly by the specimen collectors or on extended loan from the original institution or taxonomist with whom the specimens were first donated. Before recording (databasing) the information in museum lodgements including their specimen registration or accession numbers, arrangements were made with several institutions in order to access their records, some of which are now databased. As sourced from the Records table, the known or recorded lodgement sites are listed in Section 9.3.2. The sections following list the various database and/ or classification systems used by the three major institutions (Australian Museum, Queen Victoria Museum and Tasmanian Museum) including the numbers/ letters representing different animal groupings that are assigned by those institutions as a prefix to their accession or registration numbers. Section 9.3.7 provides an outline of the suggested search criteria given to museums when sorting through their collections or databases to locate Tasmanian cave species.

9.3.1: Accessing museum database sources and permissions

Although access to museum held specimen Types is generally freely available, several museums have quite defined policies regarding access to information stored in their databases or card file indexes, especially their own lodgement (accession or registration) numbers, name of the collector and any geo-referenced collection site localities. Prior to obtaining access and permissions to access museum lodgement records, a formally documented data license agreement was entered into with the Australian Museum (Sydney). Similar, but more informal agreements via email or personal communication were arranged with the South Australian Museum (Adelaide), Queen Victoria Museum (Launceston), Tasmanian Museum (Hobart), American Museum of Natural History and the Otago Museum (Dunedin, New Zealand) and various other institutions.

9.3.2: Specimen lodgement (accession) institutions or locations

The records table of the database includes a field titled "Sp Lodgement" giving detail of the known lodgement site for collected specimens, with individuals, private collections or institutions; some of these institutions are listed as acronyms or as an abbreviated museum/ institution name. These are detailed below:

- ABRS: Australian Biological Resources Survey, Dept. of Environment and Heritage, Canberra, ACT.
- ABRS (G. Dyne): earthworms held by Geoff Dyne at Australian Biological Research Systems section of ANIC.
- Adelaide University: collections held by Bill Williams or John Bradbury in School of Biological Sciences at University of Adelaide.
- AMNH (New York): American Museum of Natural History in New York, USA.
- ANIC Australian National Insect Collection, CSIRO Division of Entomology, Canberra, Australian Capital Territory (ACT), Australia
- ANU: Australian National University, Canberra, ACT.
- AUSMUS: Australian Museum, South Sydney. Note specimens are housed in one of four different collections for Malacology, e.g., hydrobiid snails; Entomology, e.g., rhaphidophorid crickets; Arachnology, e.g., spiders and harvestmen; or Marine Invertebrates (including freshwater and terrestrial species), e.g., anaspidacean syncarids, phreatoicidean isopods, annelids and styloniscid isopods.
- Ian Ball (Canada), private collection of aquatic flatworms.
- Bayer Australia, Sydney: (silverfish specimens held in private collection by Graeme Smith).
- BBSR (Bermuda): Bermuda Biological Station for Research, St. George, Bermuda (aquatic and terrestrial cave crustaceans held in private collection by Tom Iliffe).
- BMNH (London): Natural History Museum, London, England (formerly British Museum of Natural History).
- Kevin Bonham collection: (land snails for ID or as part of reference collection).
- BPBM: Bernice P. Bishop Museum, Honolulu, Hawaii, USA.
- CAS: California Academy of Sciences
- Clarke collection (via B.P. Moore).
- Clarke collection (via A. Goede).

- CMNZ (Christchurch): Canterbury Museum, Christchurch, New Zealand.
- Bob Cockerill (private collection): specimen of *Tasmanotrechus cockerilli* (Goede: 54, from Herberts Pot at Mole Creek).
- Geoff and Tricia Deer (Gunns Plains Cave ticket office), sample specimens of cave fauna from tourist cave.
- Alan Dartnall collection: collections held by Alan Dartnell (??) or TMAG.
- Dept. of Health, Sydney: E.W. Ferguson collection of cave glow-worms.
- DPIWE (New Town, Tas.): Dept. of Primary Industries Water and Environment, New Town (Tasmania) laboratories (museum collection); formerly as the museum collection in DPIF (Dept. Primary Industries and Fisheries) and previously listed as TDA (Tasmanian Department of Agriculture, Hobart, Tasmania).
- Mike Driessen (DPIWE): Tas. cave cricket (rhaphidophorid) specimens currently held for ID.
- DZMU (Monash Uni): Dept of Zoology at Monash University (where Bill Williams used to work).
- S.M. Eberhard: private collection held by Stefan Eberhard or at UT (MOZ).
- EUQ: Department of Zoology and Entomology (or Dept. of Integrative Biology), Queensland University, Brisbane, Queensland, Australia.
- FMNH, Chicago: Field Museum of Natural History, Chicago, Illinois, USA, includes cave beetles in private collection of Alf Newton.
- Ray Forster (N.Z.), private collection of arachnids, now mainly lodged with OMNZ or AMNH.
- FSU (Jena, Germany): Friedrich-Schiller University, Jena, central Germany.
- A. Green collection: private collection of terrestrial isopods held by Alison Green, or possibly lodged at QVM.
- Penny Greenslade (private collection of cave collembola), some specimens may be lodged at ANIC/ or ANU.
- Hannelore Hoch, Berlin (?), (private collection of fulgoroid hemiptera).
- Hickman collection: specimens retained by John Hickman (at Uni. of Tasmania) or by V.V. Hickman, now donated (?) to AUSMUS.
- Pierre Horwitz (W.A.); uncertain lodgement.
- Peter Johns (NZ), possibly now lodged in CMNZ.
- Latrobe Uni. (Melbourne).

- Latrobe Uni (via John Hickman): Specimens fwd. to L. Windsor at Latrobe University, Melbourne.
- LS: Linnaean Society, London, England.
- LTV Latrobe University, Bundoora, Victoria, Australia.
- MCZ (Harvard University): Museum of Comparative Zoology (in the Dept. of Invertebrate Zoology in HMNH (Harvard Museum of Natural History), Harvard University, Cambridge, Massachusetts, USA.
- Alejo Mesa: rhaphidophorid cave crickets, possibly in Melb. Uni. Dept. of Genetics.
- Bob Mesibov collection: multipede specimens (mainly cave millipedes) destined for lodgement at QVM. MNHNP: Museum National d'Histoire Naturelle, Paris, France.
- Karyl Michaels collection: (cave beetles in K. Michaels reference collection at School of Geography and Environmental Science, University of Tasmania).
- B.P. Moore (private collection): some held at ANIC and some at private residence of Barry Moore,
- J. Moore in U.K.: (nematodes).
- Dr. Yoshinobu Morimoto (private collection of syncarids and other Crustacea from Exit Cave, collected 21-Dec-1974), unknown lodgement, possibly National Science Museum of Tokyo (NMST), Japan.
- Moulis Laboratory, France (??): cave beetles forwarded to L. C. Genest by Stefan Eberhard for ID at Moulis Subterranean Laboratories in southern France, but not yet returned.
- MOV: National Museum of Victoria (NMV).
- MQU, Sydney: Macquarie University, Sydney.
- NAMRU, Cairo, Egypt: (U.S.) Naval and Medical Research Unit, Cairo, Egypt
- Norm Platnick (NZ): private collection, now in AMNH.
- NSMT (Japan): National Science Museum (Natural History section), Tokyo.
- NMV: National Museum of Victoria (= MOV: Museum of Victoria), Melbourne, Australia.
- OMNZ, Otago: Otago Museum (Dunedin), New Zealand
- OWU, Delaware (via TMAG): Ohio Wesleyan University (Zoology Department Museum), Delaware, Ohio, USA.

- QM (Arachnology): Various specialists in Arachnology at Queensland Museum, Brisbane.
- QVM: Queen Victoria Museum and Art Gallery, Launceston, Tasmania, Australia. For more detail of QVM collection sections, see Appendix section 9.3.2.
- A.M. Richards: private collection of Aola Richards, possibly held either in School of Biological Sciences at the Uni of NSW, ANIC or BMNH.
- SAM: South Australian Museum, North Terrace, Adelaide. Likely to be part of the "BS" (Bio-Speleological) collection established by Elery Hamilton-Smith. N.B. These "BS" numbers were misquoted as "B 5" numbers by Williams (1965a).
- TASUNI (Clarke collection): collection in section of the Level 3 lab. occupied by Arthur Clarke.
- TASUNI (Swain collection): nominally held by Roy Swain as part of University of Tasmania, Museum of Zoology; see UT (MOZ).
- TASUNI (AMMR): collection nominally held by Alastair Richardson as part of University of Tasmania, Museum of Zoology; see UT (MOZ).
- TASUNI: unknown location at University of Tasmania, possibly in UT (MOZ) or in Dept. of Geography and Environmental Science.
- TCWC: Texas A. and M. University, College Station, Texas, USA.
- TMAG: Tasmanian Museum and Art Gallery, Hobart. (Note: TMAG invertebrate collection and staff recently located to new premises at Rosny).
- Dr. Shun Ichi Ueno (private collection: 21-Dec-1974), unknown lodgement, possibly National Science Museum of Tokyo (NMST), Japan.
- Uni of Toulouse, France: Prof. A. Vandel's collection of cave isopods.
- UNSW: University of New South Wales, Sydney (School of Biological Sciences).
- UQ (Dept. of Entomology and Zoology): Department of Entomology and Zoology, University of Queensland Insect Collection; see also EUQ.
- USNM: United States National Museum (Smithsonian Institute).
- UT (MOZ): University of Tasmania, Museum of Zoology, Laboratory, 3rd Floor, School of Zoology, Churchill Avenue, Hobart.
- UWA: University of Western Australia (School of Animal Biology); specimens in collections held by Pierre Horwitz or Brenton Knott (??).
- V.V. Hickman collection, now largely dispersed to museums such as AUSMUS.

- WAM: Western Australian Museum, Perth; mostly for cave arachnids held in the Arachnology section by Mark Harvey.)
- John Yaldwyn (NZ): talitrid amphipods and other cave Orthoptera.

9.3.3: Collection systems at the Australian Museum (AUSMUS), Sydney

In the Australian Museum, their specimens are listed according to various letter prefix codes and housed in separate collections:

- Malacology;
- Entomology;
- Arachnology; and
- Marine Invertebrates.

The latter group (marine invertebrates) includes a number of cave species including many non-marine freshwater species such as anaspidacean syncarids, crangonyctoid amphipods, phreatoicids, janirid isopods and possibly some terrestrials including styloniscid isopods, annelids, planarians, millipedes, centipedes and perhaps symphylans.

9.3.4: Collection systems at the Tasmanian Museum (TMAG), Hobart

Although some species have been inadvertently assigned to the wrong classification in their database, the Tasmanian Museum and Art Gallery (TMAG) in Hobart generally uses the following prefix codes for their groups of invertebrate specimens:

E = Mollusca;

F = Insecta;

G = Crustacea;

H = Echinodermata;

J = Arachnida.

9.3.5: Collection systems at Queen Victorian Museum (QVM), Launceston.

In the Queen Victoria Museum (QVM) collection, prefix code numbers 1 to 7 have been reserved for vertebrate specimens. Following is the full list of prefix codes for the registered invertebrate specimens in the QVM collection. Prefix codes shown with an asterisk include fauna groups from the QVM records that are recorded in the accompanying MSc cave fauna database.

8 = Hemichordata and Chordata (not vertebrates)
*9 = Mollusca: includes aquatic and terrestrial snails (gastropods) and marine molluscs
*10 = Crustacea, Pycnogonida. Includes isopods, amphipods, phreatoicids, copepods, syncarids, freshwater crayfish etc.
11 = Tardigrada, Onychophora
*12 = Insecta: e.g., beetles, bugs, crickets, cockroaches.
*13 = Arachnida: e.g., Acarina, harvestmen, pseudoscorpions and spiders.
*14 = Annelida. For segmented (Annelida) worms: leeches and oligochaet worms.
15 = Echinodermata
16 = Bryozoans, Kamptozoa
17 = Sipunculida, Echiura
*18 = Rotifera, Nematoda, Nematomorpha
*19 = Platyhelminthes; for aquatic and terrestrial Turbellaria, e.g., flatworms.
20 = Cnidaria, Ctenophora
21 = Porifera
22 = Protozoa
*23 = Diplopoda, Chilopoda.
24 = Brachiopoda
*25 = Symphyla
26 = other minor phyla.

9.3.6: Crustacean collections held in the University of Tasmania: Museum of Zoology (TASUNI), Hobart

The first system for cataloguing for specimens (mainly Crustacea) in the University of Tasmania's Museum of Zoology – some recorded in the present database as "UT (MOZ)" - was initiated by John Hickman. Using a geographically based regional index, Tasmania was divided into 43 drainage regions and collected species were recorded on the basis of their ecological and biotic interest.

The next more recent system commenced by Piers Allbrook in July 1973 was based directly on higher order taxonomy, using a series of small spiral bound notebooks with indexed "T" codes for species groups and consecutively ordered vial and sample numbers that related to the separately listed records with habitat and collection detail. Specimens were indexed according to species type as "S" (sample) numbers, related to one or more respective "V" (vial) numbers. A cross-referenced index is given for every vial number in order to locate "T" coded species group for that sample. For example, amongst the Syncarida, coded as "T17" in the blue cover book, Vial number V:809 is sample number S:463 for specimens of *Anaspides tasmaniae*; the habitat site and collection detail for these specimens collected by P. Murray from Lake Pluto in Wolf Hole at Hastings on 22-June-1975 is recorded in the brown covered book.

Locating the whereabouts of actual vials of cave fauna purported to be in the University of Tasmania's Museum of Zoology collection has proved to be quite difficult. Some of the material originally lodged in the university museum collection has been disbursed to other institutions including TMAG and QVM (pers. comm., S. Eberhard and A. Richardson), but there does not appear to be an electronic record or easily found paper trail to verify what specimens went where. It is possible that some of the university lodgements have also "followed" the original collector or person/s researching that species group.

9.3.7. Desired fields of information from Museum records and databases

The following fields of information were requested from museums and other institutions housing Tasmanian cave fauna specimens:

- Museum registration, accession or lodgement number (and possibly lodgement/ acquisition date);
- Lodgement medium – e.g., dry collection (pinned) or spirit collection;
- Collector's name;
- Date of collection;
- Collector's reference number (find number/ field number), if any;
- Collection site (cave name and/ or cave number);
- Locality and grid references or Latitude/ Longitude;
- Higher order taxonomy: Class, order and family (as separate fields?);
- Genus and species (if determined);
- Maturity, sex and specimen numbers;
- Type status (if any);
- Specimen/ species identifier (and date of identification if recorded);
- Additional comments - perhaps in separate fields related to collector's notes including collection locality (named area) within cave, micro-habitat data and cave zone, e.g., dark zone; taxonomic data from person identifying/ describing specimen and any published reference; museum specimen loan information.

The following keywords were suggested as search criteria for museums and other institutions to locate lodgements of Tasmanian cave fauna specimens, listed in their databases, spreadsheet records, card index files or shelved in other cataloguing systems:

- Collector surnames (e.g., Clarke, Cockerill, Eberhard, Goede, Hamilton-Smith, Kiernan, Middleton, Richards, Terauds);
- Specimen donors (e.g., Dartnall, Gray, Green, Hickman, Hunt, Moore, Richards, Turner);
- Karst areas (e.g., Bubs Hill, Cracroft, Franklin, Hastings, Ida Bay, Junee-Florentine, Mole Creek, Mount Anne, Mount Weld and Precipitous Bluff);
- Cave number prefixes (e.g., BH, C, F, H, IB, JF, MC, MA, MW and PB);

- Cave descriptor names (e.g., arch, cave, cavern, chamber, cleft, conduit, crevasse, crypt, den, entrance, fissure, grotto, hole, house, lair, outflow, palace, passage, pot, resurgence, rift, shaft, sink, spring or swallet);
- Unusual cave names (e.g., Annakananda, Arrakis, Arthurs Folly, Gormenghast, Hamoik 1, Khazad-Dum, Kubla Khan, Little Grunt, Mostyn Hardy, Quetzacoatl, Serendipity, The Chairman, The Quoin, Udensala, Wargata Mina, Welcome Stranger etc.);
- Additional keywords or fields for typical Tasmanian cave species groups, e.g., for terrestrial species: Cave Crickets (F. Rhaphidophoridae); Cave Beetles (Carabidae); Harvestmen (Triaenonychidae); Isopods (Styloniscidae); Millipedes (Dalodesmidae, Haplodesmidae); Pseudoscorpions (Chthoniidae); Spiders (Amaurobiidae, Amphinectidae, Anapidae, Cycloctenidae, Micropholcommatidae, Mysmenidae, Stiphidiidae, Synotaxidae, Tetragnathidae, Theridiidae); Springtails (Neanuridae, Paronellidae). Suggested keywords for aquatic cave fauna included species groups such as anaspidacean syncarids, crangonyctoid amphipods, hydrobiid snails, janirid and phreatoicid isopods.

9.4: Geological Time Scale

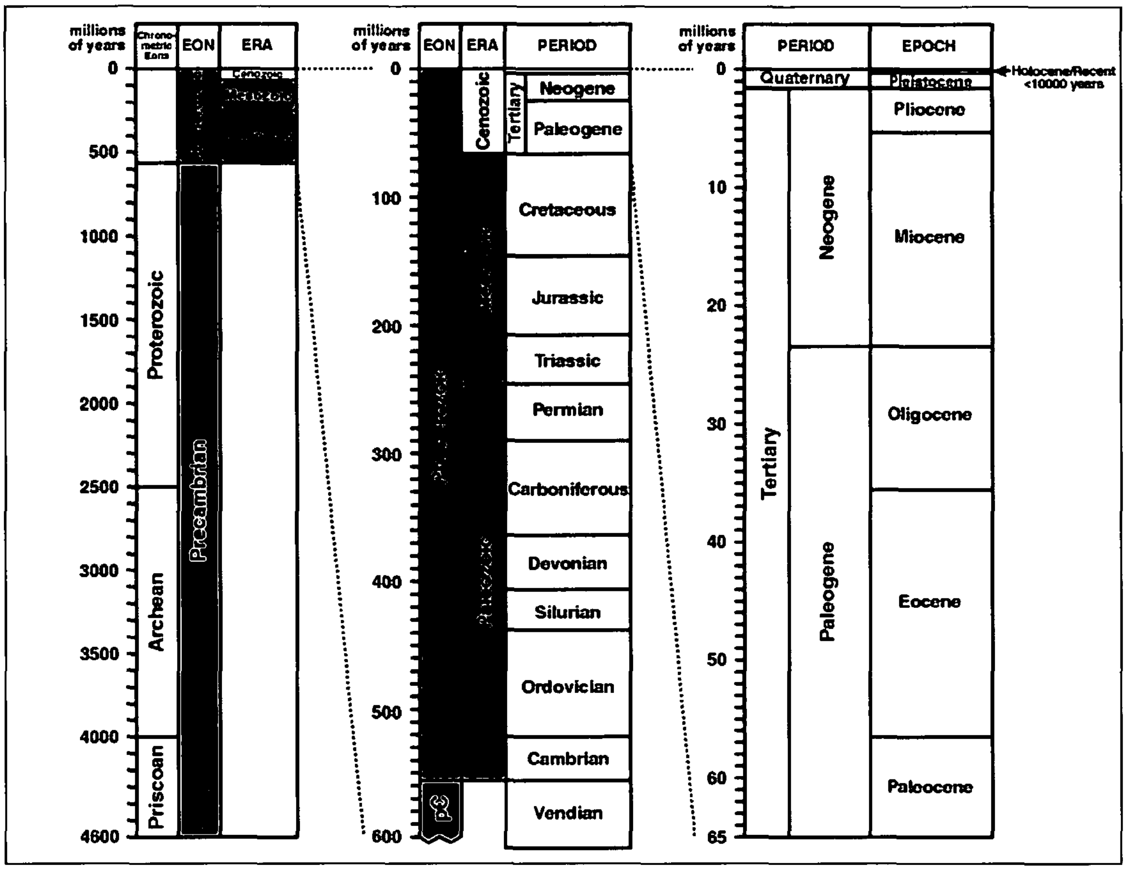

Figure 9.1: Geological time scale, sourced from the School of Geology and Geophysics, University of Calgary, Canada.
http://www.geo.ucalgary.ca/~macrae/timescale/timescale.html

9.5: Database peculiarities

9.5.1. The problem of databasing collection dates

For biological recording, collection dates are normally listed with three components: "dd" (day date), "mm" or "mmm" (for month) and "yy" or "yyyy" (for year). Unlike the traditional British system of "dd-mm-yyyy" dates, there are different international formats for recording dates, e.g., yyyy-mm-dd or mm-dd-yyyy. To avoid confusion between the day and month component of a date (and year when recorded as "yy"), the month in a three part biological date is often recorded as Roman numeral, e.g. "iii" for March (third month) or "xi" for November (11^{th} month). In instances where the month component of a date was known, these dates were recorded with Roman numerals during compilation of the RFA database.

During construction of a database or spreadsheet, users can determine how the data of any field is stored on a computer, i.e., in formats such as text, numbers, date/ time or currency etc. Most database and spreadsheet software programmes configure any date as a numeral or serial number consecutively ordered from a defined date in the past. For example, in Ms Access the serial number represents the number of days elapsed since December 30^{th} 1899, i.e., number 1 represents December 31^{st} 1899, with earlier dates stored as negative numbers back to January 1^{st} 100 AD. Software programmes generally do not recognise Roman numerals as the month component of a date; in the RFA database, these dates were recorded as text format (Clarke, 1997a). On the positive side, recording dates as text permitted multiple date formats to be entered, enabling inclusion of a number of early and historical cave fauna records which only had "mm-yy", "mm-yyyy" (month and year) or "yyyy" (year) collection dates. However, it was impossible to do a chronological sort of collection records.

The conversion of dates with Roman numeral months to chronologically sortable dd-mmm-yyyy dates involved several stages and some SQL or VBA programme coding assistance was sought via the US-based Microsoft newsgroup for MsAccess Table Design (see Appendix Section 9.4.1). Firstly, on all the computers where this new MSc database was compiled, it was necessary to reconfigure the "short date" under Regional Settings

Properties to read as: dd-mmm-yyyy (e.g., 07-Apr-2004). This Control Panel setting enabled the equivalent short date style or format to be listed as an optional setting in field properties under Ms Access. The second stage involved copying the field column into Excel and conducting a simple "find and replace" search to convert hyphenated Roman numeral figures to three digit "mmm" month dates, e.g., replacing "iv" with "Apr". This process entailed some care and planning to avoid replacing the "x", "v" and "i" values (altering the dates) until the surrounding Roman numeral month dates had been converted, e.g., starting with "xii" to "Dec" first, before converting "xi" to "Nov", then "ix" to "Sep" prior to changing "x" to "Oct" to give the respective "mmm" month component. This resulted in four styles or formats of collection source dates:

- A blank entry, where no date details were known;
- A year-only date as "yyyy";
- A month and year date as "mmm-yyyy";
- A more precise three component day, month and year date as "dd-mmm-yyyy".

The new dates were still in text format and despite any expression that might be created in the Validation Rules for the field property related to permissible styles for dates, any attempted conversion to date formats would result in the unrecognisable "mmm-yyyy" and "yyyy" dates being discarded from the data set. There were three possible options for the partial dates:

(a) To convert the partial or approximate "mmm-yyyy" and "yyyy" source dates into artificial, but chronologically sorted full or real dates (see below).

(b) To retain the original source dates as a text data field, but create a second column (field) with "mmm-yyyy" and "yyyy" dates converted to real dates as in (a) above. Storing the source dates as text would enable any subsequently published report to print the original data (e.g. "after 2000", "2004", "April 2004", "April 7th 2004").

(c) To use two date-time fields and store two dates for each item. For an occurrence on a known date, both fields would store the same value, e.g. 07-Apr-2004. Where the date is only known approximately, the first and last relevant dates are stored, e.g. for an undated collection in 2004, two dates are stored: "1-Jan-2004" and "31-Dec-2004". This method makes it simple to record a particularly vague collection date, e.g. "between 2000 and 2005" and also permits the databasing of an unknown collection date, with two "Null" values being entered, one in each field column. (Null is conventionally used to represent an unknown value. Ms Access distinguishes between an unknown value, which it stores as Null and a value that is known to be nothing which it can store as an empty string.)

In order to perform (a) and (b) above (converting partial dates into real dates), there were virtually only two viable options: treating them as if they were dates when species were collected (or observed) on the first day or last day of the year/ month.

Despite the obvious downside in not knowing whether the cave fauna collections were made on this actual date or whether the date is an artefact, it was deemed these first two options would be more desirable and functional than the more convoluted third option. The writer decided to opt for the second option and source some VGA coding for a function to create a field with date values that could be used purely for chronological sorting purposes (see Appendix section 9.4.1). This would enable a second column or field with the original source dates for all occurrences to be displayed as text in order to distinguish partial dates from full dates. The partial "dd-yyyy" dates in the new field named "Date (new format)" are recorded from the first day of the month and "yyyy" dates from the first day of the year: e.g., January 1901 is recorded as "01-Jan-1901" and 1924 is shown as "01-Jan-1924". Although this method can effectively slew the result of collection dates to the first day of the month (and compromise those collections that were actually made on the first day of the month), it is considered a necessary device in order to maintain a chronological data sort. Unfortunately, the second field with the original source dates was accidentally deleted following a minor catastrophe with the database which occurred after an attempt to re-name the source data field.

9.5.2: Coding to convert text dates to real time dates

As detailed in Section 3.2.1, occurrence dates in the original RFA database had been stored as text in a format that could not be sorted by date, so this data had to be converted into a date/ time format. During early April 2004, the writer entered into dialogue with software programmers and database consultants at an internet newsgroup forum site where members of the public could seek assistance with problems encountered during use of Microsoft products such as Ms Access. The following set of instructions and VBA coding to convert text dates to real time dates was principally sourced from Andrew Smith: <andydsmith@ntlworld.invalid> at the Ms Access newsgroup site where problems concerning design of databases were addressed. Members of the public are invited to contribute via:

anonymous@discussions.microsoft.com. The site can be accessed at:

http://support.microsoft.com/newsgroups/default.aspx?NewsGroup=microsoft.public.access.tablesdbdesignandSLCID=USandICP=GSS3andsd=GNandid=fh;en-us;newsgroups

Prior to introducing any new coding to any field in the Records table, the field column of dates was copied and another field was created with an auto number to ensure that each record in the table was maintained in that same precise order. The conversion of the existing text format date should was performed as a query, leaving the original text in place in the table. This enabled a sort by the converted value, but still displayed the original source text to alleviate any problems with formatting of original species collection or observation dates in reports etc. The VGA coding supplied by Andrew Smith replaced those anomalous dates with unrecognised formats into a pre-determined date (1 Jan 1900) for ease of recognition, e.g., Julien dates in wrong years, such as February 29th 2003 or April 31st 2004. The following instructions are sourced from a reply the Ms Access newsgroup by Andrew Smith:

If the dates are all either, a recognisable date (e.g., 1-Apr-2004, or 1/4/04), or a year (e.g., 2004), or a month and year in the format Apr-2004, then it should be fairly simple. The following code should work in this case - it will return the first of the year/ month for partial dates, the full date for complete dates or 1 Jan 1900 for unrecognised dates.

```
Public Function TextToDate(strDate As String) As Date
Dim strYear As String
Dim strMonth As String
If IsDate(strDate) Then
   TextToDate = strDate
ElseIf IsNumeric(Right(strDate, 4)) Then
   'Last 4 digits are numeric, so assume it is the year
   If Len(strDate) = 4 Then
      TextToDate = DateSerial(CLng(strDate), 1, 1)
```

```
  ElseIf Len(strDate) = 8 Then
    strYear = CLng(Right(strDate, 4))
    strMonth = Left(strDate, 3)
    TextToDate = CDate("01-" and strMonth and "-" and strYear)
  Else
    'Unrecognised format - treat all these cases as 1 Jan 1900
    TextToDate = DateSerial(1900, 1, 1)
  End If
Else
  'Unrecognised format - treat all these cases as 1 Jan 1900
  TextToDate = DateSerial(1900, 1, 1)
End If
End Function
```

To implement the code, just follow these steps:

i) Create a new standard code module - click on "modules" in the database window, then click on "New". This will bring up the code editor. Copy and paste in the code that I posted yesterday, and then save the module with a suitable name.

ii) Test the code by using the "immediate" window (this may be visible below the code window, but if it isn't press Crtl-g to show it). In the intermediate window type each of the following and then press the return key:

```
?TextToDate("1 Jan 2004")
?TextToDate("Jan 2004")
?TextToDate("2004")
?TextToDate("some rubbish")
```

If the code is working then each of these lines will result in a date being printed in the immediate window.

iii) Once you've got a function that works, create a new query in design view. Add your table to it, and then double click the date field to add this to the query. Then in an empty field cell, to the right of the name of the date field, type

ConvertedDate:TextToDate([PutTheNameOfYourDateFieldHere])

i.e., ConvertedDate:TextToDate([Date])

Set the sort order of this new field (ConvertedDate) to Ascending or Descending, and then look at the query results. If your text date is formatted as I assumed in the function then it should work. I expect, however, that it will need a bit of tweaking to allow for how your text is actually formatted.

Arthur Clarke
31-May-2006