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INVERTEBRATE BIODIVERSITY AND CONSERVATION IN TASMANIAN CAVES

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Abstract

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Tasmanian caves support a diverse invertebrate fauna, representing the richest known assemblages of cave obligate species in temperate Australia. Current studies have yielded much valuable and unusual information regarding spider, amphipod and cricket species in particular, while highlighting their sensitivity to environmental disturbance.

Introduction

Cave ecosystems offer unique opportunities to evolutionary biologists because of their often highly adapted fauna combined with their well-defined abiotic environmental parameters. Despite its barren appearance and slow rate of change, the cave environment can be remarkably speciose, and Tasmanian caves have recently been identified as hosting the richest assemblages of cave obligate invertebrates in temperate Australia (Eberhard et al., 1991). This high biodiversity combined with Tasmania's location at a climatic and geographic extreme, and its relative abundance of undisturbed sites, makes the region extremely valuable for the study of the evolutionary history of Australian cave biota.

In Tasmania as elsewhere, however, land management and land degradation problems pose a significant danger to caves and their fauna. Current studies of the life cycles of certain cave animals have highlighted their susceptibility to environmental disturbance (Richardson et al., in press, and our unpublished data), while at the same time indicating both the practical benefits that further study may provide, and the high scientific and conservation values of these delicate ecosystems.

General background

The deceptive first impression that caves are depauperate is based on a combination of the small size of many cave organisms, their frequently sparse distributions, and their cryptic nature, since animals more frequently occur in the smaller cracks, crevices, and folds of cave formations to which human access is severely limited. In Tasmania, the barren appearance of caves is increased by the absence of any major vertebrate usage; roosting bats and birds are not present (most probably due to the low temperature of Tasmanian caves), nor are any cave fish known. The only visiting vertebrates are humans and the occasional rodent, macropod, or snake seeking shelter. In spite of this, Tasmanian invertebrate cave assemblages are amongst the richest known in temperate zone Australia.

Cave animals, or **cavernicoles**, are essentially a heterogeneous assemblage occupying different regions of caves, and their classification is based around their relationship to particular cave zones. While there are many systems for such classification, the simplest (Vandel, 1965; with expansion by Howarth, 1983) divides animals into four groups as follows.

Troglobites are obligate cave species, strictly adapted to subterranean habitats and unable to survive outside them. These animals often display a large suite of distinctive morphological, physiological, and behavioural adaptations, many quite bizarre, and their domain is that of the deep cave.

Troglophiles are facultative cavernicoles that commonly live and reproduce in caves, but are not totally confined to them; they may be found in similar sheltered, cool, dark and humid epigean microhabitats.

Trogloxenes are occasional cavernicoles that regularly inhabit caves, usually near the entrance, for refuge and a favourable microclimate, but must periodically return to the surface to feed, usually at night. Such animals often require direct access to both the epigean and hypogean environments in order to survive.

Accidentals are surface animals which wander, fall, or are washed into caves, but cannot survive there.

Examples of the first three of these groups are presented in the following section.

Components of the Tasmanian cave fauna

The cavernicolous fauna of Tasmania consists of five major phyla, Platyhelminthes, Nemertini, Aschelminthes, Annelida, and Arthropoda, with the arachnids, crustaceans, and insects being particularly well represented (Eberhard et al., 1991). Ninety percent of the recorded Tasmanian cave genera are arthropods, and most of the cave obligate species belong to this phylum. In the course of numerous cave studies and surveys carried out by the authors, the following groups have received particular attention.

Spiders (Araneae)

Tasmanian caves support an interesting and diverse spider fauna, including *Hickmania troglodytes* (the Tasmanian Cave Spider) which is a troglophile, and an un-named amaurobiid spider, which is a troglobite.

Hickmania troglodytes (Family Austrochilidae) is the largest spider in Tasmania, with a leg-span of up to 18 cm when fully grown, and constructs a web of up to 120 by 60 cm. Endemic to Tasmania, and the only known species in the genus, *H. troglodytes* is of high systematic and zoogeographic interest. Its closest relatives live in Chile and Argentina, and it is of considerable evolutionary significance as it possesses major physical traits of both the primitive (liphistiomorph and mygalomorph) and advanced (araneomorph) spider groups. While the species is no longer considered a direct evolutionary link between these groups, it is considered one of the closest araneomorphs to the ancestral spider type from which they all diverged (Marples, 1968).

Hickmania troglodytes builds large pear shaped egg sacs which hang from the roof and sides of the cave. The young take approximately nine months to emerge from these sacs, a period significantly longer than the one to two months typical of epigean spiders, and their lifespan may cover decades (Doran, unpublished data). The egg sacs themselves are of intricate internal design and are highly resistant to fungal growth, which can over-run other organic materials in caves in a matter of days or even hours. A very ancient member of the Tasmanian fauna, *H. troglodytes*' stronghold is the twilight and transition (early) zones of caves, which may have ensured the animal's survival during the rapidly fluctuating conditions of the Pleistocene (Goede, 1967).

In contrast, very little has yet been discovered about the troglobitic amaurobiids (Family Amaurobiidae), which inhabit deeper parts of the cave not prone to external seasonal influence. These spiders do not spin webs, but wander widely, although they may display some degree of territoriality (our unpublished data). The amaurobiids are often locally abundant, and the juveniles at least are depigmented and display some degree of eye reduction (M. Gray, pers comm.).

Amphipods (Malacostraca)

Several genera and species of troglobitic amphipods in the Superfamily Crangonyctoidea inhabit streams and pools in Tasmanian caves. The stream dwelling *Antipodeus* sp. (Family Paramelitidae), the generic placement of which is currently under review (W.D. Williams, pers comm.), is a **stygobiont:** an obligate groundwater dweller, or aquatic troglobite. It is found at several sites in northern Tasmania, including Little Trimmer Cave at Mole Creek (see following section). In contrast to terrestrial troglobites, this species displays distinct seasonal tendencies, and its lifecycle appears to be almost directly dependent upon the yearly changes in stream flow. Mating occurs from late-winter to spring, and over the summer months the amphipods may display protective burrowing behaviour prior to stream drying (our unpublished data). This burrowing allows the amphipods to survive seasonal dry spells, and appears to be triggered (perhaps by increasing calcium concentrations in the water) before the pools dry. These amphipods generally feed on detritus that is carried in by the stream, although different size classes appear to have their own preferences amongst the selection that this material offers.

Crickets (Orthoptera)

Cave crickets (Family Rhaphidophoridae) are easily the most common trogloxenes in Tasmania, the two main genera being *Micropathus* and *Parvotettix*. While species from both genera may inhabit the same cave, species from the *same* genus appear not to coexist (Eberhard et al., 1991). *Micropathus* species are most common in the moister western and southern parts of Tasmania, where they are established in large colonies, and the distribution and derivation of the species-complexes may have been influenced by Pleistocene glaciation (Richards, 1971a). Cave crickets are generally omnivorous, and leave the cave at night to feed on forest floor invertebrates and materials (Barr, 1968), although they may also prey on juvenile spiders within the cave (our unpublished data). To adult spiders, beetles and other animals, the crickets provide a major source of food input to the cave, either directly as prey, or through their droppings and eggs. The latter are buried in silt banks of the deep cave, and possibly provide the sole food source for troglobitic beetles specially adapted to retrieve them.

Major sites and regions examined

In the Mole Creek region of northern Tasmania, 71 invertebrate taxa have been recorded from Kubla Khan and Genghis Khan caves (Eberhard, 1990b), including 3 species each of flatworms and springtails, 5 species each of annelids, myriapods and molluscs, 6 species of crustaceans, 21 arachnids and 23 insects. Although about 19 of these species were accidentals, at least 11, and possibly more, are troglobitic. The diversity of species recorded here is by far the highest for any single Tasmanian cave (Eberhard et al. 1991).

Precipitous Bluff, far southern Tasmania, supports the richest assemblage of cave obligate species presently known in temperate zone Australia, with at least 15 troglobitic or stygobiontic species recorded among a total cave fauna of some 32 (++) species (Eberhard et al., 1991). This area has the most highly cave adapted representatives in several animal groups, including amphipods, beetles, molluscs, and harvestmen, while the hydrobiid mollusc and opilionid (harvestmen) faunas are particularly notable for the diversity of species represented.

Ida Bay, far southern Tasmania, has 31 recorded cavernicolous species including 5 troglobites (21% of the fauna) from one survey (Richards and Ollier, 1976), and 30 species including 11 troglobites (36%) in another (Eberhard, 1990a). These figures exclude accidental or surface fauna, and cover such groups as the opilionids, pseudoscorpions, aranaeids, crustaceans, collembolans, hemipterans, and coleopterans amongst others (Eberhard et al., 1991).

Mount Anne (southern Tasmania) and Mount Ronald Cross (central to western Tasmania) support at least 5 and 3 troglobitic species respectively (Eberhard, 1987, 1989), while at Bubs Hill (western Tasmania) at least 6 definite troglobites and 6 other taxa of uncertain status have been recorded (Clarke 1989). Including accidentals, one cave in the Bubs Hill karst has yielded over 55 taxa (Houshold and Clarke 1988).

Comparisons with temperate mainland Australia

Few data have been published for caves in temperate mainland Australia, but the literature includes over 6 troglobites from the Nullabor Plain (e.g., Richards, 1971b; Knott, 1983), at least 6 more from five cave areas in Victoria (Davey and White, 1986), 2 troglobites and 5 troglophiles from Wombeyan Caves (Smith, 1982) and 2 species of troglophile from Bungonia Caves in New South Wales (Wellings, 1977), and 25 species of aquatic cavernicole from a cave at Yanchep in Western Australia (although the number of stygobiontic species is not given; Jasinska and Knott, 1991). Against these figures, it would appear that Tasmania is comparatively rich in troglobitic diversity.

Conclusions

While data currently show that Tasmanian caves support substantially higher biodiversity than caves in temperate mainland Australia, such comparisons will remain rather crude until sampling strategies and sampling intensities can be in some way standardised, and until all karst areas have been surveyed. However, Tasmania is likely to remain an extremely rich source of cave fauna, whose age and diversity is related to the geology and geomorphic history of the karst systems in which it is found.

As caves are entirely dependent on outside sources for their energy input, and as their environments are slow to change and/or predictable, these ecosystems are highly vulnerable to external events, which may even occur at some distance from the caves themselves. Two major sources of food input, cricket guano and water carriage, are at high risk from land use practices that affect surrounding forest and water quality. Even the disruption of flow levels into the cave, whether by an increase or decrease, can have devastating effects on the cave fauna. While water levels may fluctuate enormously during the normal yearly cycle, this is generally predictable, and exceptionally severe conditions during the normal season are not as potentially catastrophic as relatively minor floods occurring at unusual times, or even the absence of floods at the expected time (Howarth, 1983).

More direct effects are also important. Caves may be heavily affected by quarrying, rubbish dumping, the in-filling of entrances or clearance of surrounding land. Visitors are also a significant potential source of disturbance, and some cave inhabitants and habitats are particularly vulnerable to them (Richardson et al., in press). Indirect disturbance alone, such as light or movement, can disturb cave spiders and disrupt courtship and mating. Spiders may desert their egg sacs if disturbed frequently, which probably accounts for the rarity of these animals in tourist caves. Seepage pools supporting rare syncarid shrimps (Family Psammaspididae) can be destroyed by a single careless footstep, as can silt banks which support many of the small terrestrial invertebrates deep in caves. The cave environment is a very special, fragile habitat, into which even scientific visits should be carefully regulated to reduce potential, and very real, impacts.

Future directions: the Little Trimmer Cave Biological Monitoring Program — a model study

A faunal study designed to be of low impact was specifically formulated for Little Trimmer Cave at Mole Creek, Tasmania, in 1990. This program was established at the cave at the beginning of 1991 and is still ongoing today.

Little Trimmer Cave is a well decorated, stream bearing cave of reasonable length (the major passage is approx. 200 m). Situated in State forest, it has been gated by the Tasmania Forestry for several years, so that access is limited to facilitate scientific studies in an undisturbed hypogean environment. Visits are regular and infrequent (ranging from monthly to bimonthly), visitor numbers are restricted, and studies are designed around conservation of the cave environment and its fauna. Movement through the cave is kept smooth and quiet to minimise disturbance due to noise and sudden vibration, and in all but the most carefully considered cases the introduction of any foreign matter, particularly organic, volatile, or odoriferous substances which may attract or repel cavernicoles, is avoided. Pathways are marked by string to reduce the area exposed to disruption by researchers traversing the cave, and the greatest care is taken to avoid even the smallest animals and cave formations on and above these paths. Substrate Protection Zones are established thoughout the cave to preserve the more fragile habitats and subcommunity types, and study of the fauna is conducted by census, marking, and careful observation. With a strict regime of capture, measurement, description and release, the impact on the fauna is minimal. Records are also kept of the date, duration, party number, and course taken through the cave for each visit, so that the impact on the cave environment of even these few visits can be assessed.

The benefits of this monitoring strategy have been many. Little Trimmer Cave has been found to contain a rich invertebrate fauna in keeping with that observed in other areas of the state, and this diversity is due, at least in part, to the wide variety of substrates and consequently habitat types within the cave. Through the minimal impact nature of our program, these animals and habitat types have been able to be studied in an essentially undisturbed state, and this approach has yielded much valuable information. The species presented as examples in this paper are present in large numbers in Little Trimmer, and much of the new information reported has come about as a direct result of the Little Trimmer program. The slow rate of cave biological processes means that long-term, intensive studies are essential for comprehending the ecology of cave organisms, and the nine month incubation period and apparent longevity of the Tasmanian Cave Spider in particular demonstrate how ideal an opportunity the Little Trimmer program presents.

In view of the success of the Little Trimmer study, we fully endorse the 'sampling with replacement' recommendations of Slaney and Weinstein (at this conference), and believe that such low impact, non-collection studies are the way forward in biospeleological research. We believe that the Little Trimmer program is an excellent example of how data collection can be optimised yet at the same time balanced against the needs of faunal conservation.

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