Synopsis of cave fauna studies in Australia

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Summary

Most areas of Australia have been examined for subterranean fauna to some degree, some intensively. The terrestrial cave fauna of north-west Australia is endemic but has affinities across northern Australia. The aquatic cave fauna of north-west Australia has no known counterpart elsewhere in Australia as expected on theoretical grounds.

Rich communities of living and obligatory inhabitants of underground voids have recently been found in tropical north-western Australia (Humphreys, 1993c) — an area of considerable resource development and potential. The terrestrial component (troglobites) is primarily a relict rainforest fauna with a high degree of endemicity, often at the generic level (Humphreys, 1993a). The aquatic fauna is, for the most part, a Tethyan fauna (Humphreys, 1993b; Knott, 1993) containing the only members of entire families, orders and classes of organisms known in the southern hemisphere, and containing species congeneric with those obligatory cave dwellers on either side of the North Atlantic (Humphreys, 1994). This fauna may have its origin with the dissolution of the supercontinent Pangea (>200 million years ago) and been dispersed by rafting on the tectonic plates (Poore and Humphreys, 1992; Humphreys, 1993b; Yager and Humphreys, 1996). Despite the recent recognition of its importance, the Cape Range/Barrow Island region is probably the most comprehensively researched karst region in Australia (E. Hamilton-Smith, pers. comm. 1996).

Owing to their endemicity, often at high taxonomic levels, and their wide disjunctions from related fauna at the ordinal level and above, these taxa occur in

refugia of the highest significance (Morton et al., 1995) and make an major contribution to the biodiversity of Australia (Humphreys, 1993c).

This note is not intended to be a complete review of the subterranean fauna of Australia, but rather, it intends to set the scene so that the significance of the fauna found in the north-west of Western Australia can be seen in an Australian and global context (Humphreys, 1993a, 1993b) and, in particular, to establish that no comparable stygofauna is known elsewhere in Australia.

The significance of underground faunas has been well recognised by statutory authorities but little action has been taken. With respect to the Kimberley, for example, Burbidge et al. (1991) report that the Conservation Through Reserves Committee recommended that *a survey of caves* [be made] *with the objective of proposing a conservation programme for important sites. Similarly, the* Environmental Protection Authority recommended *a survey* [be made] *of caves* [and springs] *in the Oscar Range.* These have never been fulfilled.

The biodiversity and functional importance of aquatic subterranean fauna (stygofauna) has only recently been recognised (Gibert et al., 1994). Humphreys (1994) recommended that *a concerted study of stygofauna should be undertaken in Australia* [because] *the Australian stygofauna is barely known and they are an important component of biodiversity and important indicators of, and contributors to, groundwater health.*

As long ago as 1962 a collection of cave fauna was assembled at the South Australian Museum — a collection that was subsequently dispersed throughout the various departments (E. Hamilton-Smith, pers. comm.) — and plans were made to conduct a general survey of Australian cave fauna (Hamilton-Smith, 1963) to supplement this collection but such a general collection was never made.

A review of the arthropods found in Australian caves as recently as 1967 concluded that few troglobites occurred in Australia, partly at least, because of changes to the water table associated with the onset of more arid climate (Hamilton-Smith, 1967). Then only seven species Australia wide were considered obligatory inhabitants of the underground realm, of which five were aquatic (four from the western tropics).

By 1988 the perception of the Australian underground realm had changed so completely that a paper could legitimately be entitled *the environmental ecology of north Queensland caves: or why are there so many troglobites in Australia* (Howarth, 1988).

Nonetheless, there has been considerable collecting from underground habitats Australia wide, even funding for specific studies, especially under the National Estate Grants Scheme and the former Australian National Parks and Wildlife Service. Overseas funding bodies supported research into the subterranean fauna of Far-north Queensland (the Explorers Club of New York supported F. Howarth) and the searches for stygofauna, especially anchialine fauna, throughout the Pacific, eastern and southern Australia (the U.S. National Science Foundation supported T.M Iliffe's expeditions).

Williams (1964) suggested areas that could be strong candidates for stygofauna, including the Nullarbor caves, the Great Artesian Basin, Victoria and south-west Western Australia. Many areas have been examined without yielding rich subterranean faunas. No troglobites are known from Victoria (Department of Conservation, Forests and Lands, 1986), and the vast Nullarbor karst region which borders the Great Australian Bight, despite having been relatively well explored, has only about 14 troglobitic species (seven in Nurina Cave), only one being aquatic. Iliffe's expeditions did not find the rich anchialine Tethyan faunas sought in the western Pacific or eastern or southern Australia (S. Eberhard, pers. comm. 1995).

Cave fauna provinces

Hamilton-Smith (pers. comm. 1996) considers that identifiable cave faunal provinces occur in Australia, a view with which I do not fully concur. However, they do form the basis from which to develop a regional discussion.

Tropical climate zone — (roughly the region north of a line between Broome [18°S] and Rockingham [22°S]) covering about 12 major karst areas in Western Australia, Northern Territory and Queensland. It is characterised by monsoonal rains concentrated in the summer months with little seasonal temperature variation. While Hamilton-Smith (pers. comm. 1996) considers these areas generally devoid of troblobites, save in 'bad air' caves — those with high CO_2 levels — this is certainly

not generally true and caves with high humidity but without elevated CO_2 levels, contain troglobites (Humphreys 1995; Roth 1995).

Subtropical dry climate zone — covers much of Central Australia from the Flinders Range and the Nullarbor, to the west coast including Cape Range and Barrow Island, northward to the Kimberley and other tropical climate zones. Karst development is generally impeded by the low rainfall but the Tertiary limestones of the area include one of the largest continuous limestone areas in the world (the Nullarbor), as well as a region of extremely high troglobite biodiversity (Cape Range/Barrow I.) — I would include the latter as a relict member of tropical climate zone classification.

Transitional zone with winter rain — occurs in south-west Western Australia, Otway Basin, south-west Victoria and south-east South Australia. A zone where few terrestrial troglomorphs occur and the fauna is dominated by guanophiles associated with the bat *Chalinolobus morio* in Western Australia and by *Miniopterus schreibersii* in South Australia and Victoria (Hamilton-Smith, pers. comm. 1996). The stygobiont community is diverse and shows Gondwanan affinities (Knott pers. comm. 1996).

Warm temperate to warm temperate/tropical transitional — essentially coincides with the Great Dividing Range, including Tasmania (Hamilton-Smith, pers. comm. 1996). This region contains in excess of 500 discrete karst areas and the fauna has been best studied in Tasmania and New South Wales. The fauna is diverse with Gondwanan and Pangean affinities.

Biogeographical considerations

The Tethyan affinities of the stygofauna of the Cape Range/Barrow Island region make it unlikely that a related fauna will occur in southwestern, south and eastern parts of Australia because north-west Australia formed the eastern shoreline of the Tethys (see Humphreys, 1993b, 1993c). However, as the fauna certainly colonised north-west Australia before the Tertiary limestones were formed, they should be sought in north-west Australia wherever marine inudation occurred in the Cretaceous. The discovery of a new genus of stygobiontic atyid shrimp (*Pycneus morsitans* Holthuis 1986) in one such area — the Gibson Desert — supports this hypothesis.

Regional notes

New South Wales

About 200 discrete karst localities occur through the length of the Eastern Highlands of continental Australia, mostly in Palaeozoic limestones (E. Hamilton-Smith, pers. comm. 1996). A recent survey of selected caves from 48 of the 95 cavernous karst areas of New South Wales showed that the biodiversity was at least an order of magnitude greater than previously established and the high degree of local endemism to be expected of cave fauna was confirmed. The fauna includes a previously unsuspected diverse suite of stygobionts within karst groundwater and probably other groundwater bodies (Spate and Eberhard, pers. comm. 1996). The fauna includes syncarids, amphipods, asellote and phreatoicid isopods, ostracods, copepods, hydrobiid molluscs, and turbellarian flatworms. It contains no species clearly referable to the Tethyan relict fauna of north-west Australia from which the NSW fauna is clearly distinct.

Victoria

Karst in Miocene limestones overlain with Pleistocene aeolian calcarenites occur in the Otway Basin (E. Hamilton-Smith, pers. comm. 1996). Extensive Tertiary basalt plains in western Victoria contain lava tunnels. No troglobitic species are known from Victoria (Conservation, Forests and Lands, 1986).

Tasmania

About 300 separate localities occur within Tasmania, mostly in Palaeozoic limestones with some in Precambrian dolomites (E. Hamilton-Smith, pers. comm. 1996). Detailed work over many decades, especially the recent synopsis by Eberhard (1992) have shown that the Tasmanian cave fauna is distinct from that of the Australian mainland, probably owing to its more humid climate and from having been extensively influenced by Pleistocene glacial events (Eberhard, 1992; Eberhard et al., 1991). A large number of terrestrial and aquatic obligate cave species occurs with Gondwanan, even Pangean affinities.

Northern Territory

There has been limited work in the Cambrian limestone peneplain at Katherine and the Cambrian dolomite in the Barkly region (E. Hamilton-Smith, pers. comm. 1996). The terrestrial cave fauna has some genera in common across northern

Australia but exhibits strong local endemicity at the specific level (Humphreys, 1995) . The stygofauna has unique elements with strong African/Madagascar connections but no elements are known with clear Tethyan affinities (Humphreys, 1995).

Queensland

Detailed work on karst and lava tube habitats has concentrated on the terrestrial fauna of far-north Queensland (Howarth, 1988; Hoch and Howarth, 1989a, 1989b; Howarth and Stone, 1990) but aquatic fauna have also been sampled to a limited extend and it contains amphipods (B. Knott, pers. comm. 1995). The significant fauna diversity in 'bad air' caves (high concentration of carbon dioxide) was first recognised here (Howarth and Stone 1990).

South Australia

Work over many decades in the extensive Nullarbor caves in Tertiary limestones, including anchialine habitats, has yielded fewer than 20 troglobite species (Richards, 1971; Lowry, 1980; Roth, 1995; W.F. Humphreys, unpublished) which seem to be relicts of wetter climates. Cave divers experienced in sampling stygofauna have worked in the area (S. Eberhard, pers. comm. 1995) but only a single stygobiont (an amphipod) has been seen. The cave fauna is unrelated to that of the north-west. Little work has been conducted in the thinly bedded Cambrian dolomites and limestones of the Flinders Range (E. Hamilton-Smith, pers. comm. 1996). Karst in Miocene limestones overlain with Pleistocene aeolian calcarenites occur on Kangaroo Island (E. Hamilton-Smith, pers. comm. 1996).

Western Australia

Kimberley

Limited work has been conducted in the pseudokarst features on sandstone and the Devonian reef limestones, especially in the east Kimberley (Humphreys 1995). The Kimberley and Northern Territory contain a number of freshwater subterranean taxa that have their closest affinity (even congeneric) with the faunas of Madagascar and southern Africa, seemingly Gondwanan taxa (Humphreys, 1995). The terrestrial cave fauna has some genera in common across northern Australia but exhibits strong local endemicity at the specific level (Humphreys, 1995) - the Cape Range area contains high generic endemicity as well (Humphreys, 1994).

Nullarbor

See *South Australia*

Mid-west

The southwestern part of Western Australia contains an almost continuous strip of Pleistocene aeolian calcarenites on the coastal plain with intense karstification (E. Hamilton-Smith, pers. comm. 1996). Samples by Lowry (1980) and recent extensive collecting by R. Foulds (W.A. Museum collection), has yielded a number of troglobites and no stygobionts. The fauna is for the most part unrelated to that of the north-west and contains no elements known with clear Tethyan affinities.

Perth area

Recent collecting, especially by R. Foulds (W.A. Museum collection), has yielded a number of troglobites but the fauna is for the most part unrelated to that of the north-west. Recent work has yielded a rich stygofauna, especially of amphipods, but it is clearly not related to the north-west fauna (E. Jasinska and B. Knott, pers. comm. 1996).

South-west

Recent collecting, especially the recent extensive collecting by R. Foulds (W.A. Museum collection), has yielded a number of troglobites but the fauna is for the most part unrelated to that of the north-west. Recent work has yielded a moderately rich stygofauna, especially of amphipods, but it is clearly not related to the north-west fauna (B. Knott, pers. comm. 1996).

North-west

The north-west fauna has been extensively documented (Humphreys, 1993a, 1993b, 1993c) but the extent of the fauna is unknown as no sampling has been conducted in certain crucial areas. Elements of the fauna are known from the entire North West Cape peninsula and from Barrow Island (*ibid.*). This stygofauna, with clear Tethyan affinities (Humphreys, 1993b; Knott, 1993), and often highly disjunct from its congeners, is not known to the south, or from the Ashburton River catchment (Humphreys, 1994). However, other areas on and juxtaposed to the North West Shelf are considered likely to contain elements of the fauna. This results from

consideration of the biogeography of the fauna (the apparent vicariant origin of the fauna in the fragmentation of Pangea and the contemporary location of Greater India) which suggests that the original Australian location of the fauna should be sought juxtaposed to the Pilbara Craton (Humphreys, 1993b).

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Table 1: Major biospeleological surveys conducted in Australia with notes on their comparability with those from north-western Australia.

State	Authority	Note
Pacific Islands — eastern	T.M. Iliffe, pers. comm.	Some Tethyan taxa
western	T.M. Iliffe, pers. comm.	No comparable anchialine fauna found
Northern Territory	P. Bannick, pers. comm. Humphreys, 1995	Rich terrestrial fauna; north-west affinities in terrestrial but not aquatic fauna.
Victoria	Conservation, Forests and Lands, 1986	No troglobites
South Australia	Richards, 1971; T.M. Iliffe, pers. comm.; S.M. Eberhard, pers. comm.	Sparse aquatic and terrestrial: not comparable
New South Wales	A. Spate and S.M. Eberhard, pers. comm. 1995	Rich fauna, no connection with northwest
Queensland	Howarth et al. numerous papers	Rich terrestrial fauna; north-west affinities in terrestrial but not aquatic fauna.
Tasmania	Eberhard et al., 1991; Eberhard, 1992.	Rich aquatic and terrestrial fauna unrelated to tropical faunas.
Western Australia		
Nullarbor	Richards, 1971; T.M. Iliffe, pers. comm.; S.M. Eberhard, pers. comm.	Sparse terrestrial fauna, single aquatic species; unrelated to north-west fauna
Mid-west	Lowry, 1980; Foulds collection at WAM	Sparse but unrelated to northwest
Kimberley	Humphreys, 1995	No anchialine fauna: southern African and Madagascar affinities
Perth area	Knott, Foulds collection at WAM	Sparse troglofauna, rich stygofauna, ancient but non-Tethyan affinities
North-west	Humphreys, numerous 1989-1995	Very rich subterranean fauna — Tethyan anchialine fauna; relict rainforest fauna.