Subterranean Fauna Extracts

Prepared for

Department of Environment and Conservation
Western Australia

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COVER: Troglobitic pseudoscorpion, *Pseudotyrannochthonius* sp. Body length approximately 5mm. Photo: © S. Eberhard.

NOTE & DISCLAIMER

This document has been prepared in response to a specific request for information relating to troglofauna in the Pilbara region, Western Australia. The information herein has been extracted from other reports by the author. As such it does not purport to be a complete or comprehensive review of information on subterranean fauna or potential impacts. Information not reviewed, or which subsequently becomes available, may alter the conclusions made herein.

CLASSIFICATION OF SUBTERRANEAN FAUNA

Subterranean organisms are traditionally classified into three ecological-evolutionary categories originally proposed in the mid 1800s (see for example Camacho 1992, Trajano 2005):

Trogloxenes are regularly found in subterranean habitats, but must leave it during some period(s) to complete their life cycles (usually food requirements). Bats and cave crickets which shelter in caves during the day and forage for food outside caves at night are trogloxenes.
Troglophiles are facultative subterranean species which are able to complete their whole life cycles both in underground and epigean habitats, forming populations in both habitats, with individuals commuting between them and maintaining genetic flow between these populations (Trajano 2005).
Troglobites are obligate subterranean species that are restricted to subterranean environments and typically possess character traits related to subterranean existence (troglomorphisms) such as reduction to loss of eyes and dark pigmentation, and enhancement of non-optic sensory structures.

Previously these categories were applied to all subterranean fauna, but more recently distinction has been made between terrestrial and aquatic species. The term *troglofauna* embraces the three categories above and is used to define terrestrial subterranean fauna. The term *stygofauna* refers to aquatic subterranean fauna which may be similarly classified into three equivalent ecological-evolutionary categories, viz.: *Stygoxene, Stygophile,* and *Stygobite.* Several variations and sub-classifications of this scheme exist (see Camacho 1992).

Two other relevant categories in the ecological classification of subterranean fauna are:
Accidentals are epigean species which have wandered underground or fallen in accidentally. Populations may survive underground for a period of time but further generations are not established underground.
Edaphobites are obligate soil dwelling species. They frequently display similar morphological traits to troglobites, such as loss of eyes and pigmentation. Edaphobites are frequently found deeper underground in caves but their primary habitat is soil. Distinguishing edaphobites from troglobites may sometimes be difficult.

The terms *troglofauna* and *stygofauna* are often used as synonyms for *troglobites* and *stygobites* respectively. The distinction in terms, and application of the correct ecological classification, becomes important when assessing the conservation status of species and potential impacts. From a conservation biology perspective, troglobites and stygobites are usually of more concern because they are frequently short range endemic (SRE) species. Because of their restricted distribution, SREs are more vulnerable to extinction from a range of threatening processes including mining, groundwater pumping, and contamination. In assessing the environmental impact of projects on subterranean species it may become important to distinguish troglobites and stygobites from other ecological categories of subterranean fauna.

OVERVIEW OF SUBTERRANEAN FAUNA HABITATS

Stygofauna

Stygofauna occupy groundwater across a diverse range of geologic / geomorphic settings, including karstic carbonate rocks, fractured rock aquifers, and porous unconsolidated sediments (eg. alluvium). They may be found in deep groundwater habitats tens to hundreds of metres below the surface, in addition to shallow groundwater habitats including springs and spring-brooks where groundwater discharges to the surface, also hyporheic and parafluvial setting (saturated sediments beneath and alongside surface water courses). Stygofauna are found in oxygenated groundwater ranging from fresh to brackish, but they may occur in salinities up to seawater (Humphreys 1999).

Troglofauna

Troglofauna are found in geologic / geomorphic environments with air-filled subsurface cavities that are humid and dark. A critical habitat requirement for troglobitic species is the maintenance of a high relative humidity because of their generally reduced cuticular impermeability (Howarth 1983).

Diverse troglobitic communities are usually recorded from caves in carbonate rocks which have been subject to karstification, such as those at Barrow Island and Cape Range (Humphreys 2000). Until relatively recently it was thought that troglobites were more or less restricted to caves in karstic terrains, however in montane environments in Europe diverse troglomorphic faunae have been recorded from the zone of fractured rocks between the soil and non-calcareous bedrock, the so-called mileau souterrain superficiel (MSS) (Juberthie et al. 1980). Diverse troglobitic faunas have also been recorded from lava caves and smaller voids (mesocaverns) in fractured basalts in Hawaii (Howarth 1983) and the Canary Islands (Oromi and Martin 1992) for example. In Australia there has been little sampling of troglofauna in non-karstic terrains but troglobitic species have been recorded from lava caves in Queensland (Howarth 1988), dolerite talus caves in Tasmania (Eberhard *et al.* 1991), and vuggy pioslite ore in the Pilbara (Biota 2006). The emerging understanding is that species specialised to subterranean existence are not necessarily restricted to caves and karst but are more widely distributed and may potentially occur where suitable habitat exists (Eberhard and Humphreys 2003).

The nature and structure of cavity development is likely to be important in determining potential habitat for troglofauna. Open cavities or partially filled cavities may provide a habitable space for troglofauna, however cavities completely filled with sediment are unlikely to be potential habitat. Similarly, isolated or internally sealed cavities which have limited or no inter-connectivity with other cavities are unlikely to be suitable habitat. In this respect, isolated and disconnected cavities which do not form part of a larger integrated void system are not considered prospective habitat for troglofauna. Diverse subterranean faunas are typically found in habitat matrices where well developed secondary and/or tertiary (conduit) porosity enhances the circulation of water, gases, and nutrients, and allows animal movements. Shear and fracture zones where secondary porosity is well developed via open and integrated fracture systems represent potential troglofauna habitat, especially where permanent groundwater maintains a humidified environment in the unsaturated portion of the aquifer.

EXISTING KNOWLEDGE (WESTERN AUSTRALIA AND PILBARA REGION)

Stygofauna

In Western Australia, stygofauna have been documented from most regions and areas including the Kimberley, Pilbara (Pilbara craton and Barrow Island), Carnarvon (Cape Range), Murchison, Goldfields, South West (Perth Basin and Leeuwin Naturaliste Ridge), South Coast (Albany and Nullarbor Plain). In the Pilbara region, sampling conducted in the last decade has revealed the Pilbara to be a globally significant hotspot for stygofauna diversity (Humphreys 2000b; Eberhard, Halse and Humphreys 2006). Stygofauna is widespread and occurs in a range of hydrogeological environments including karstic, fractured rock, vuggy CID and porous aquifers, in addition to springs, parafluvial and hyporheic environments (Eberhard *et al.* 2005).

Troglofauna

Troglofauna have been recorded predominantly from caves in karstified limestones in the Kimberley, Cape Range, Barrow Island, Perth Basin (eg. Eneabba, Jurien,Yanchep), the Leeuwin Naturaliste Ridge and the Nullarbor Plain. Beyond karst areas, there has been relatively little sampling effort, so there is limited knowledge about the occurrence of troglofauna in non-karstic environments. Recently however, rich troglobitic communities have been discovered in the humidified voids of pisolitic strata (Channel Iron Deposits CID) of mesa formations in the Robe River valley in the Pilbara (Biota 2006).

To date, rich troglobitic fauna communities have not been recorded in other geologic / geomorphic environments except karst and CID mesa formations. Other geologic / geomorphic environments that have been assessed and/or surveyed for troglofauna include, for example, gossans and banded iron formations (BIF) in the Murchison region. These surveys have been initiated as a component of environmetal impact assessment for mine development projects (eg. Biota 2007a,b). The results of other troglofauna surveys conducted in the Pilbara were not available to this review.

At Gossan Hill in the Murchison region, a desktop habitat assessment of geology and diamond drill cores did not identify any significant mesocaverns, consistent void spaces or vugs that might provide suitable microclimates and habitat for troglofauna. This was followed up with a field confirmation survey which was consistent with the desktop assessment and did not detect the presence of troglobitic fauna (Biota 2007a). Similarly at Gindalbie (Biota 2007b), the desktop assessment suggested a low probability that troglofauna occurred because the majority of drill cores showed no significant cavities, fractures, or vugginess below the superficial weathered zone. However, some drill cores showed evidence of cavities and vugs, and given the general lack of knowledge of troglofauna occurrence in these geologic / geomorphic environments, a targeted validation survey was initiated (Biota 2007b).

There is little existing knowledge on the occurrence and distribution of troglofauna in the Pilbara region. This reflects the limited sampling undertaken at only a few locations to date. Excluding the rich troglofaunas known at Barrow Island, Cape Range and Robe Valley, the WA Museum has few records of troglofauna in the Pilbara region. These records are limited to three taxa (two species of Pauropoda and one species of Hemiptera) from three bores at Turee Creek (West Angelas) and Millstream (WA Museum unpublished records). These taxa were collected incidentally during routine sampling for stygofauna.

On the Pilbara craton there are abundant carbonate rocks (Precambrian dolomites and Cainozoic limestones, calcretes) and frequently these have been subject to karstification, however there are few caves known which are large enough to be entered and sampled by humans. Most access for sampling subterranean fauna has been gained via bores and wells drilled for water supply. Consequently, most sampling of subterranean fauna in the Pilbara has been directed towards aquatic subterranean fauna (stygofauna) sampled using nets lowered into boreholes and wells.

Terrestrial taxa are sometimes collected in haul nets used for sampling stygofauna. These animals have either fallen into the water or are brushed off the walls of the borehole and collected in the haul net. Most often these animals are epigean species occurring incidentally or accidentally in the borehole, but sometimes they may include edaphobites and troglofauna.

Troglobitic fauna in mesa formations of vuggy pioslite ore (Channel Iron Deposits) in the Robe River valley was discovered by chance after a single schizomid specimen was collected in a haul net used for sampling stygofauna (Biota 2006). Subsequent sampling using specially designed traps revealed a diverse and significant troglobitic fauna, including species of Schizomida, Pseudoscorpionida, Araneae, Polydesmida, Scolopendrida, Diplura, Thysanura, and Blattodea. All of these species were new to science, and the general biogeographic pattern observed was for each mesa to contain its own suite of short range endemic (SRE) species. This pattern was verified in the schizomids using DNA molecular genetic techniques, which showed a phylogeographic structure consistent with the distribution and evolutionary history of the mesa formations (Biota 2006).

Biota's (2006) study of troglofauna in the Robe Valley mesas was significant because it revealed:

1. Diverse troglobitic fauna in the Pilbara craton,
2. Diverse troglobitic fauna in non-karstic rocks - vuggy pisolite ore (Channel Iron Deposits),
3. Multiple short range endemic (SRE) species of conservation significance,
4. Potential impacts from mining operations.

Biota's (2006) study concluded that the primary fauna habitat within mesas was the humidified pisolitic strata, and that maintenance of a humid microclimate within the mesas would be central to maintaining a suitable habitat.

For the broader Pilbara region, the implications of Biota's study are:

1. Troglofauna may occur in the unsaturated zone of non-karstic rocks such as vuggy pisolite (Channel Iron Deposits).
2. Potential troglofauna habitat may be inferred in any other rock type where secondary permeability is sufficiently developed to provide a suitably dark, stable and humidified air-filled habitat.
3. Troglobitic fauna is highly cryptic and difficult to detect, and survey requires a dedicated sampling program using specially designed traps.

POTENTIAL IMPACTS OF MINING ON SUBTERRANEAN FAUNA

The potential impacts of mining on subterranean fauna may be categorised as;

1. direct impacts;
2. indirect impacts (Hamilton-Smith and Eberhard 2000).

Direct impacts are the obvious destruction or degradation of habitat which occurs within the mine footprint area, consequent upon the removal of rock or aquifer dewatering for example. On the other hand, indirect impacts tend to be less obvious and gradational, and thus more difficult to predict and manage because they may be exerted some distance away from the mine footprint area, or progressively expressed some time after mining has occurred. Examples include changes to hydrology, nutrient and microclimate regimes, contamination, reduced habitat area and population viability.

Specifically, for troglofauna at Mesa A in the Robe Valley, Biota (2006) predicted the potential impacts of mining to be:

1. Direct habitat removal,
2. Changes to surface hydrology,
3. Changes to subterranean microclimate,
4. Surface and groundwater contamination,
5. Reduction in organic inputs,
6. Vibration,
7. Reduced area of retained habitat and viable population sizes.

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