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Bundera Sinkhole — a fragile fauna site, unique in the southern hemisphere

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Bundera Sinkhole (C-28) is an anchialine cave — an inland cave fluctuating with marine tides — on the Cape Range peninsula in north-western Australia. It contains a specialised community of a type elsewhere known only from similar habitats on either side of the North Atlantic — the Canary Islands and the Caribbean area. It is the only site known outside these areas for the crustacean class Remipedia, a major division of the crustaceans whose very existence was discovered as recently as 1979 by Jill Yager in the Bahamas.

While the community of animals is quite recognisable between these widely separated regions, the species present in the remipede community of Cape Range are all unique to this cave. The remipede from C-28 belongs to the genus *Lasionectes* — elsewhere known only from the Turks and Caicos Islands in the Caribbean — and the species is *L. exleyi*, named for Sheck Exley who died shortly after the discovery of the remipede on the first deep penetration of C-28 in August 1993 by Andrew Poole and Dave Warren.

C-28 is a small drowned sinkhole on the coastal plain of the Cape Range peninsula and reaches a depth of 32 m at a maximum distance from the sinkhole of about 42 m and it is considered to be fully explored. The groundwater within this system, up to several kilometres inland, comprised a freshwater lens overlying a seawater wedge as is typical of karstic islands. The groundwater contains a remarkable assemblage of specialised subterranean fauna (stygofauna) including the only two species of blind fish known in Australia, the Blind Gudgeon and the Blind Cave Eel (both specially protected). The remaining fauna are predominantly crustaceans of various type including a number of lineages which have Atlantic connections similar to the remipede. Some are found to inhabit only the freshwater part of the system, some — including the remipede community — only the seawater part, while others, including the gudgeon, are found throughout the water profile.

Several members of the remipede community are specially protected under Western Australian legislation, while the remipede is also specially protected under Commonwealth legislation — only the second invertebrate to be so protected in Australia — the entire remipede community is considered threatened in Western Australia, particularly from point source pollution and diving.

Why is the site so vulnerable?

The sinkhole — mostly covered with a deep scum of green algae and the occasional bloated kangaroo — descends through strong hydrogen sulphide layers. Large veil-like colonies of presumed sulphur bacteria were suspended in the water associated with the hydrogen sulphide layers starting near the thermocline.

The water has a strong density interface with a sharp thermocline at about 8 m with the temperature increasing about 5°C, and the salinity of the water increases from about half to full seawater between 8 and 16 m. The physico-chemical profile of C-28 is complex, having a number of oxygen and redox minima that are vulnerable to disruption by SCUBA diving, and possibly even to semi-close circuit diving operations.

Within the profile conditions around the thermocline are consistent with nitrogen fixation and chemoautotrophic energy fixation by sulphur bacteria, a process recently demonstrated in a similar ecosystem in Mexico.

Globally, as all remipedes have been found by cave divers and this type of physico-chemical environment seems to be typical, it must be presumed that the stratification of the water is in some way important to the survival of the ecosystem. Hence, the disruption of the profile through mixing by exhaust gases and finning must be deemed a threatening process, at least till the system is better understood. As such C-28 is an inappropriate location for recreational diving and even research diving should be of minimum duration to achieve tightly specified aims.

This constraint was applied to the four day research trip undertaken by the Western Australian Museum from 21-24 September, 1997, during which nearly 17 diver (Andrew Poole and Stefan Eberhard) hours was used to sample many aspects of the cave and to repeatedly deploy sophisticated depth profilers through the full depth of the cave initially using rebreathers and

later SCUBA to examine the differential effect on the profile. This intensive field work examined:

- the physico-chemical profile (temperature, salinity, pH, redox, dissolved oxygen, hydrogen sulphide, nitrogen species)
- video taped the full extent of the profile
- change in profile through time to follow the impact of diving operations — using both SCUBA and rebreathers — on the physico-chemical stratification
- food relations using stable isotope ratio analysis
- depth distribution of the fauna
- tidal cycle

Detailed analyses of these data are in progress but they show clear mixing of the stratification through time. Maintenance of this unique ecosystem will depend on the goodwill of the diving community.

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CAPTIONS

Photo: The remipede, *Lasionectes exleyi*, from Bundera Sinkhole, the only location of this crustacean group in the southern hemisphere and the second continental location, after Mexico. Image based on a photograph by Douglas Elford and Western Australian Museum.

Survey of C-28 by Dave Warren and Andrew Poole.



