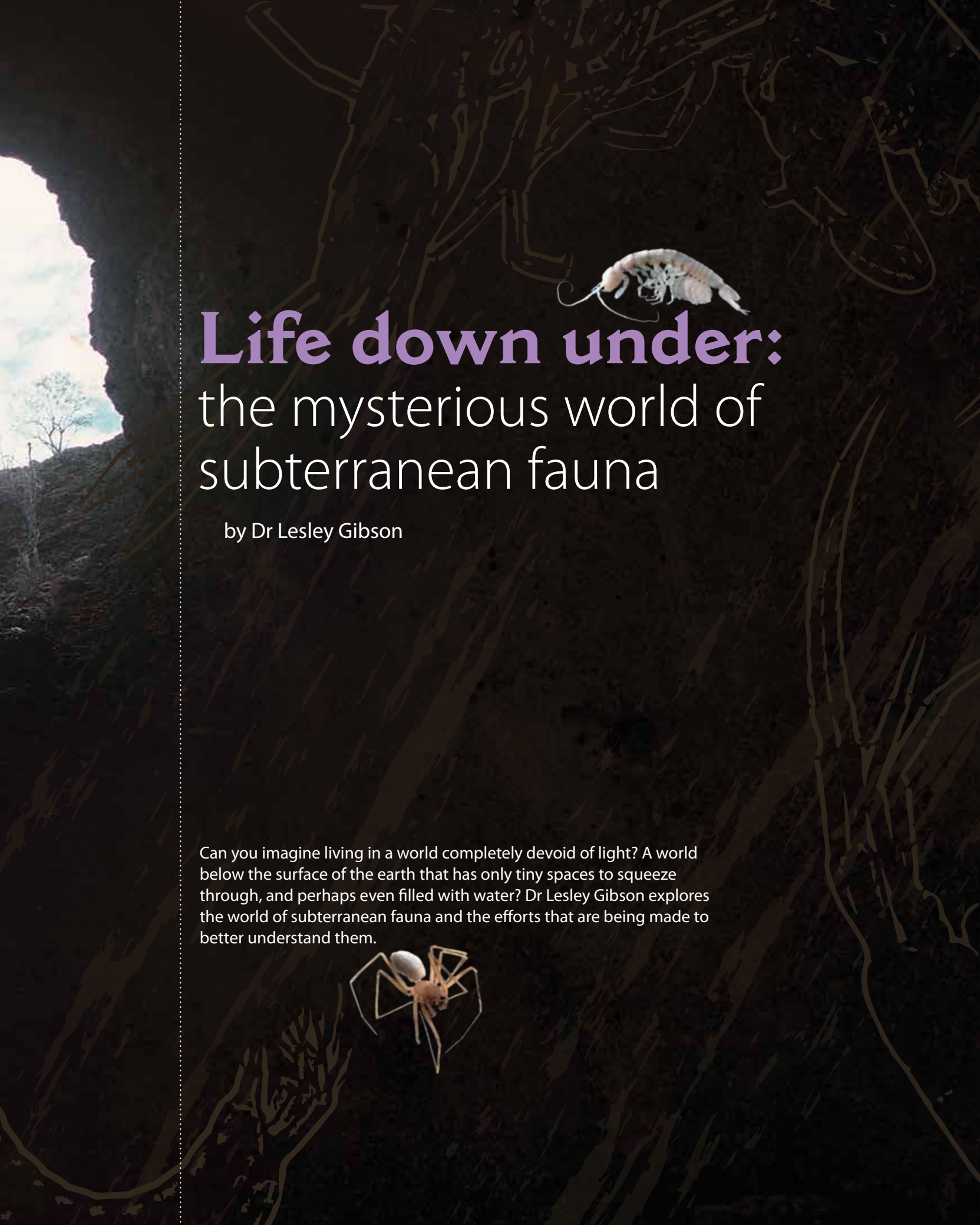


Life down under: the mysterious world of subterranean fauna

by Dr Lesley Gibson

Can you imagine living in a world completely devoid of light? A world below the surface of the earth that has only tiny spaces to squeeze through, and perhaps even filled with water? Dr Lesley Gibson explores the world of subterranean fauna and the efforts that are being made to better understand them.

Although it sounds terrifying to your average claustrophobe, a spectacularly diverse group of predominantly minute invertebrates thrives in a dark 'under' world beneath the surface of the earth.

Collectively termed subterranean fauna, they are either aquatic, living in the groundwater (stygofauna), or air-breathing, living in rock voids above the water table (troglofauna). Stygofauna consist mainly of crustaceans but there are also beetles, snails, worms and mites. Troglofauna include a variety of taxonomic groups such as isopods, springtails,insects, diplurans, myriapods and arachnids.

There are also at least three Australian species of fish (including the blind cave eel) and one blind snake. Like deep sea creatures, evolutionary adaptations to this extreme environment have resulted in similarities in their unusual appearance, such as reduced or non-existent eyes, loss of body pigmentation, loss of wings, and elongated sensory structures.

In Australia, subterranean fauna are relics of the past, evolving from ancient surface-dwelling creatures that migrated underground to escape an increasingly arid continent. They differ from their Northern Hemisphere counterparts in that most known Australian species occupy small underground cavities (< 500 millimetres), rather than cave systems.

Knowledge about this cryptic fauna began to rise when, in the mid-1990s, a number of natural resource developments in the Cape Range region of Western Australia prompted research into their significance. Since then, much has been learnt about their taxonomy, diversity and evolutionary history, but our understanding of their basic biology and ecology remains rudimentary.

Seemingly simple questions like how long they live and how many young they produce currently remain unanswered.

We do know that their limited ability to disperse and resulting small ranges and high level of endemism (i.e., only occur in a single defined geographic location), combined with their adaptations to life below ground, are likely to make subterranean fauna highly vulnerable to disturbance of their habitat.

WA HOTSPOT

Hot spots of diversity (estimates of > 4000 species) in arid WA coincide with areas of extensive, or planned, mining activity, such as in the Pilbara region. Mining operations, like excavation and drawdown of the groundwater can have significant consequences for subterranean fauna. Changes to hydrology, humidity, nutrient inputs and water quality are added threats.

Mainly due to their world being hidden from us, how resilient subterranean fauna are to these disturbances is difficult

Previous page
Main Cape Range - Cave system.
Photo – Geoff Taylor/Lochman Transparencies
Inset left A troglobitic spider from the Linyphiidae family.
Inset right A subterranean isopod from the Pilbara region.
Photos – Jane McRae/Bennelongia/DBCA

Above The aquifer supplying Weeli Wolli Creek in the central Hamersley Range of the Pilbara supports endemic stygofauna.
Photo – Adrian Pinder/DBCA

This page
1) An ostracod species detected during a survey of the Pilbara.
2) An amphipod species from the Pilbara.
3) A gastropod species from the Pilbara.
Photos – Jane McRae/DBCA

"Seemingly simple questions like how long they live and how many young they produce currently remain unanswered."

to establish. A poor understanding of subterranean ecosystems more generally, and the role of the fauna in them, can make decision-making for both impact assessment and conservation planning challenging.

CLOSING KNOWLEDGE GAPS

In 2017, the Western Australian Biodiversity Science Institute (WABSI) was engaged to develop a coordinated statewide research program to improve on the current state of knowledge of subterranean fauna. A diverse range of participants from the scientific and resources sector, policy makers, potential funders, and environmental consultants came together in a series of workshops to identify key knowledge gaps and develop a strategy to close these.

The agreed objective was to dramatically improve assessments of the impacts of resource developments and threat mitigation strategies on subterranean fauna by transforming our knowledge of patterns and processes in subterranean ecosystems. Four broad areas to research were identified, along with capture and consolidation of fauna records.

WHAT'S IN A NAME?

The rate of species discovery in Australia is high, and many subterranean fauna species are yet to be formally named. However, telling individual species apart based on appearance alone has proved to be challenging. This is because of convergent evolution, whereby distantly related organisms independently evolve similar characteristics as a result of having to adapt to a similar environment.

More recently, identifying species based on their DNA has become a useful approach. But this also brings challenges as there can be considerable variation in DNA sequences within species, the degree of distinctiveness between species varies among taxonomic groups, and practically, it can be tricky to extract DNA from these tiny and delicate organisms.

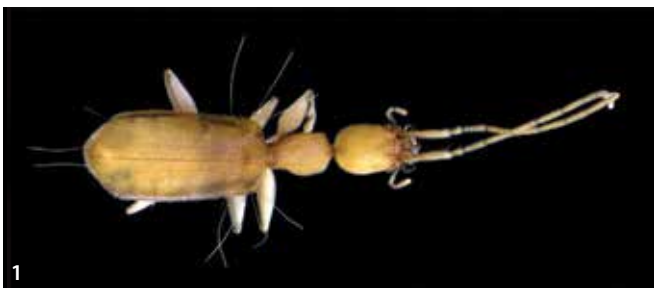
Taxonomists are now relying more on multiple lines of evidence including a combination of sophisticated morphological and molecular genetic techniques to tease species apart. To increase certainty about the identity of subterranean fauna species, one of the key focus areas identified is the development of a standardised best practice approach for recognising species appropriate to each taxonomic group.

WHAT LIES BENEATH

Adequate survey is essential to understanding both the species present within an area and to determine their distribution (or range size). Access to the subterranean world is via existing drill (or bore) holes created for minerals exploration or water supply. When sampling in bores, capturing stygofauna usually involves hauling a net through the water column, or using baited traps for troglofauna.

Above Weeli Wolli Creek, Pilbara.
Photo – Adrian Pinder/DBCA

This page
1) *Mangkurtu kutjarra*. A crustacean species found in the eastern Pilbara.
2) *Gomphodella yandi*. A stygofaunal species of ostracod crustacean found in the Hamersley Range.
3) *Limbodessus bennetti*. A subterranean diving beetle.
Photos – Jane McRae/DBCA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However, both the restricted sampling access, and generally low capture rates, mean that many species may not be detected even though they are present. There is also some ambiguity around how many times a bore should be sampled to adequately detect the diversity of species at that location. As such, research has been proposed to refine survey and sampling protocols to ensure contemporary methods are efficient, repeatable and effective.

A relatively new approach involving collecting DNA in the groundwater that has been shed from an organism (environmental or eDNA), has shown much promise in detecting subterranean fauna. As there is no requirement to capture the animals, this technique may be an improvement.

Above Millstream Chichester National Park in the Pilbara.
Photo – Steve Dillon/DBCA

This page
1) A species of troglobitic beetle.
2) *Scolopendra* sp. A species of centipede.
3) A species of troglobitic silverfish.
Photos – Jane McRae/Bennelongia

WHERE ARE THEY?

The added complexity of the third vertical dimension of subterranean environments challenges our understanding of local scale habitat availability. Micro-habitat requirements such as the size, degree and distribution of interconnected void spaces within the rock formations are likely to be important as they influence movement patterns.

On a broader scale, while we understand general geological associations with subterranean fauna, the location of suitable habitat in the landscape, both above and below ground, is difficult to predict.

To increase our understanding of preferred habitat for subterranean fauna, an area of research involving the development of a standardised approach for characterising subterranean fauna habitat in three dimensions was identified. Three-dimensional models of the sub-surface can already be produced by integrating geophysical data collected for minerals exploration. Similar approaches are also likely to be applicable to characterising subterranean fauna habitat.

CAN THEY PERSIST?

There is also much to be learnt about the influence of human-induced changes on subterranean fauna habitats. For example, in response to groundwater extraction, can stygofauna migrate to deeper depths in an aquifer, or will they be outcompeted by species already adapted to these depths?

This question, and many others, such as the influence of toxic substances and changes in the groundwater flow and nutrient inputs, are important to understand when assessing the potential impacts of mining developments.

Clearly, complete removal of habitat has severe consequences for both stygofauna and troglofauna, and

alterations in humidity levels can be potentially fatal to the latter. The ability of this underground fauna to respond to restoration of their habitat is also unknown.

We have learned from European studies that their life history characteristics, such as longer life cycles and lower reproductive rate compared to related surface water species, may limit their ability to recolonise an area, along with their poor ability to disperse. Laboratory and field experiments specifically designed to address these questions are clearly needed. Now, how do you keep them alive in captivity?

OUT OF SIGHT, OUT OF MIND

Given their 'invisibility', it is quite possible that some subterranean fauna species will go extinct before we even get to know them. Aside from the intrinsic value of these ancient and unique creatures, subterranean fauna are likely to play an important role in maintaining the health of our groundwater.

Above right Bundera Sinkhole, home of the Cape Range Remipede Threatened Ecological Community.
Photo – Tiffany Taylor/DBCA

This page
1) *Indohya* sp. A species of pseudoscorpion.
2) *Billibathynella* sp. Undescribed species of syncarid crustacean.
3) *Nocticola* sp. A species of cockroach.
4) *Palpigrade caramulla.* A palpigrade species or microwhip scorpion.
Photos – Jane McRae/Bennelongia

LOOKING AHEAD

The research program is currently being implemented under the guidance of the Subterranean Fauna Research Program Steering Committee, with projects funded under each of the core areas above. The initial focus has been on identifying 'quick-win' short-term projects with the aim to leverage from the success of these to commence addressing the more complex, long-term and resource demanding issues.

Dr Lesley Gibson led the development of the Subterranean Fauna Research Program when on secondment to the Western Australian Biodiversity Science Institute. She currently chairs the steering committee and is the Animal Science program leader with DBCA. Lesley can be contacted at lesley.gibson@dbca.wa.gov.au or (08) 9219 9069.

Further information is available at wabsi.org.au/our-work/programs/subterranean-fauna/ and check out the subterranean fauna display at the Western Australian Museum, Boola Bardip.