North Island cave beetle. Photo: John Marris, Lincoln University

What creeps and fleets in New Zealand's caves?

By Anna Stewart, Annie Robertson and Julia Kasper

Have you ever wondered what critters dwell in the darkness of New Zealand caves? Some keen cavers are working hard to uncover the most cryptic creatures in New Zealand's fauna.

The geology of New Zealand's caves has been well studied ... but the biodiversity in these caves hasn't triggered great curiosity and research at all.

New Zealand caves contain a wide variety of fauna. The fauna is dominated by invertebrates and has a diverse range of aquatic and terrestrial species. The majority of species in New Zealand caves are troglophiles, which can live their whole life cycle in a cave, but can also live in outside habitats with similar success. There are also invertebrates that are known as troglobitic, which are species that are adapted to live solely in caves, and cannot live outside of them. Troglobitic species typically share the same attributes of reduced or absent eyes, reduced body pigmentation, and elongated appendages and sensory structures, such as hairs.

The knowledge of New Zealand's cave fauna urgently needs more attention. We have no solid idea of the abundance and diversity of cave animals today, making it extremely hard to monitor populations and distinguish which species have been

lost and gained.

So far, a few entomologists have undertaken studies on cave invertebrates in the 1960s and early 1970's: Brenda May with her research into cave beetles in Waitomo, (Brenda May 1962,1963, et al 1972); Ian Townsend, again on cave beetles, (Townsend 1963); and Ray Forster on cave harvestmen (Forster 1965). Since then there have been only a handful of papers published. The majority of observations have been sporadic, and not as part of broader research projects.

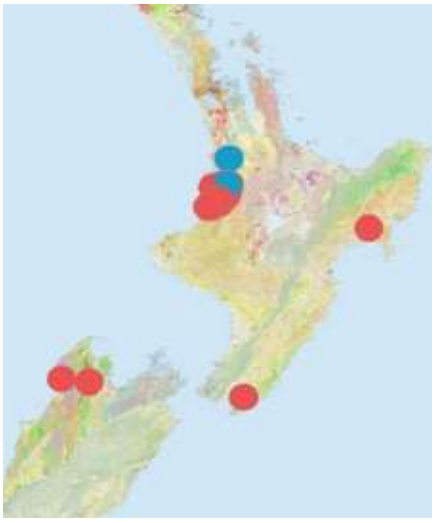
The Aotearoa Subterranean Biodiversity Project strives to discover more about our cave animals and is being carried out by Anna Stewart, a member of the New Zealand Speleological Society, along with Dr Ian Millar ex Department of Conservation, Nelson, John Marris from Lincoln University, Professor Gonzalo Giribet and Shahan Derkarabetian from Harvard University, and Drs, Rodrigo Salvador, Julia Kasper and Phil Sirvid from Te Papa.

The mapping is in conjunction with Jonathan Davies and Dave Meikle with arcGIS mapping program, with funding support from the New Zealand Speleological Society. They are recording cave fauna, and mapping species in karst areas.

The monitoring is being done by visual searching and photography, and the taxonomy and genetic analysis back in the laboratory. This is the first time that troglobitic cave animals have been systematically mapped and recorded across karst areas in New Zealand, including genetic mapping.

The South Island caves are home to some amazing little cave-adapted harvestmen, in particular *Nuncea* and *Hendea* species, and newly discovered species from the families Synthetonychidae and Pettatidae. Harvestmen are distant relatives to spiders, with only two eyes instead of six or eight, and only one body. They don't make webs and, best of all, don't produce venom.

These little animals are often on streamway cave walls and underhangs. A common defence mechanism is to sit still. This gives the photographer plenty of time to take a multitude of photos!



Mapping areas of cave animal presence.

Top: Dr Ian Millar searching for troglobites in a cave. Above right: Using a scale helps in the field with sizing. Photos: Anna Stewart

Troglobitic cave beetles

New Zealand is home to approximately 18 different species of cave beetles, as determined through morphological observations. Genetic analysis could change this, especially in caves in the Nelson karst, where troglobitic invertebrates may have been isolated for long enough to be subspecies.

Cave beetles also show features of cave adaptation, with lighter pigmentation, longer legs and narrower bodies than their surface-dwelling relatives.

Troglobitic cave spiders

True cave spiders are not well recorded or known. But with this project, two new species have been identified and there is now an opportunity to improve our understanding of them, perhaps begin to put together their underground lifecycle, and even find out who are their closest surface relatives.

An interesting fact is they can be very small. The cobweb spider from an alpine cave in the photo below has a body length of only 3mm.

Top four photos: Troglobitic South Island short-legged harvestman. Bottom two photos (L to R): Synthetonychidae cave species and Pettatidae cave species with mite attached. Photos: Anna Stewart

***Nuncea* species and under UV light.** Photos: Gavin Holden

Troglobitic millipedes

This group is also very poorly known, and currently no-one is researching cave millipedes, which makes it very difficult to describe or even make reliable judgments about them. Some surface millipede species also show physical characteristics of cave-adapted species, so it is very hard to identify true troglobitic species from photos alone. However, even photos can give an indication of them being present in the cave and forming part of the cave food chain.

Troglophile and troglobitic snails

Snails have limited dispersal, and while some species are distributed over large areas (including several caves), others can be very cave-specific. The famous Maitai cave snail (as seen on RNZ's "Critter of the Week" with Jesse Mulligan) is a good example. Small and difficult to observe, they often live in the tiny pools and seepages on cave walls.

There are undoubtedly more troglobitic cave animals awaiting discovery. Studying our troglobitic cave dwellers is a chance to learn more about our geological history and how it has affected the biodiversity and ecology of our terrestrial and subterranean invertebrates.

Another important aspect is to find out how cave-and karst-specific our troglobitic animals are. This information can be used to guide conservation and protection work.

All the troglobitic animals identified so far are endemic to New Zealand, and some can be found in only a single cave system. This makes them highly susceptible to changes in cave entrances and water quality (where their main source of food comes from). The more we can do to record and photograph them, the better their chances of survival are.

Troglophile and occasional cave visitors

Approximately one hundred years ago there was a mass environmental change as forests were lost when farming was established. Those invertebrates lucky enough to be near caves found a safe haven of humid, dark conditions, and a reliable year-round temperature similar to the environment they had once had in the forest leaf litter. Slowly, some have moved to spend more time in caves than outside, while others, such as nursery spiders, continue to be occasional visitors.

"All the troglobitic animals identified so far are endemic to New Zealand, and some can be found in only a single cave system.

Top: North Island cave beetle. Middle: South Island alpine cave beetle. Above: *Fosteropsalis bona* (Te Reinga) is slowly moving into North Island caves as a permanent resident.
Photos: Top: John Marris, Lincoln University. Middle and lower: Anna Stewart

Tākaka Hill millipede. Photo: Nicole Miller

Troglophile glow-worms

Probably the best known and maybe the most astonishing troglophile cave critter in New Zealand is the glow-worm, *Arachnocampa luminosa* — meaning glowing spider-worm — a very suitable name. Next time you are in a cave, have a closer look and you'll see that only the rear tip of the worm-like larva glows, which is due to a bioluminescence process. It moves in a web of snares, or fishing lines, that are covered in sticky mucus, glittering in this glow. Other insects, attracted to the light, are caught very efficiently in those tacky strings for the carnivorous larvae to hoist and eat. Glow-worms pupate and develop into small inconspicuous fungus gnats (a group of flies).

The biology and behaviour of the glow-worm has been well studied (Plowman et al. 2013; Gibbs, 2003), but we do not know how glow-worms spread across Aotearoa, and how their populations, both in the bush and in caves, are connected. Examining their DNA can help us understand, not only the gene flow between bush and caves, but also speciation processes in isolated subterranean animals.

The model of 'adaptive-shift' (Howarth 1987; Rouch & Danielopol 1987; Desutter-Grandcolas & Grandcolas 1996) assumes the occurrence of active colonisation of the subterranean environment accompanied by adaptive differentiation of surface and cave populations, followed by a reduction in gene flow between those two and, eventually, speciation.

The situation of New Zealand glow-worms could show a snap-shot of exactly that process. Maybe some cave populations have been isolated long enough that they have actually evolved into new species.

The Trans-Tasman Glow-worm Committee, David Merritt (University of Queensland), Julia Kasper (Te Papa), Kurt Krause and Peter Dearden (Otago University), is conducting a

Top left: Charleston millipede. Top right: A small cave adapted cobweb spider. Middle left: Unidentified cave snail from Charleston. Middle right: A newly moulted cave wētā *(Macropathus filifer)* shelters in a cave entrance. Lower left: Isopod (Long John cave). Isopods are occasional visitors who might also now make permanent homes in caves. Lower right: Kuratahi cave glow-worms. Photos: Anna Stewart

Julia carefully places collected glow-worms into their new homes for further study.
Photo: Nicole Miller

study to analyse the genetic variety of glow-worm populations to find out more about cave evolution. They are collecting approximately 30 glow-worm larvae from caves across New Zealand and extracting DNA from half of these to provide a genetic comparison of populations. The other half are reared to adult fungus gnats to allow for further analysis of their physical attributes. This study will be essential for the conservation and monitoring of glow-worms, as the more we know about the characteristics of these unique critters the better our approaches to sustainably manage the populations will be.

It makes it an exciting time in caving. Subterranean biodiversity offers us a chance to explore and discover many new species, and perhaps learn more about how New Zealand's biological and geological history is linked. Cavers are the key to unlocking what lies and lives beneath us, alongside being at the forefront of cave animal conservation and preservation.

How can you help?

Please support this project by recording what living things you see in caves. Take a photo, note the location and share with us. Remember, you could well be the first person ever to see or record them, so take the opportunity and share your finds. Either email: nzss-conservation@caves.org.nz or publish the photos in your local caving newsletter and tag us in. ▪

Undescribed Tākaka cave Pettatidae species.
Photo: Pete Baxter

References

Desutter-Grandcolas L, Grandcolas P (1996): The evolution toward troglobitic life: a phylogenetic reappraisal of climatic relict and local habitat shift hypotheses. Memoirs of Biospeology 23: 57-63.

Forster, RR 1965. Harvestmen of the sub-order Laniatores from New Zealand caves. Records of the Otago Museum 2: 1–18.

Gibbs, G (2003): New Zealand Wild: Glow-worms.

Howarth, F (1987): The evolution of non-relictual tropical troglobites. International Journal of Speleology (Edizione Italiana). 16: 1-16.

Kasper J (2021): ttps://blog.tepapa.govt.nz/2021/09/07/glow-worms-in-permanent-lockdown-long-enough-for-evolution-to-show/ .

May, BM (1962): Cave beetles of the North Island. N.Z. SPELEOL. BULL.: 3:57-61.

May, BM (1963): New Zealand cave fauna -2 The limestone caves between Port Waikato and Piopio districts. TRANS. R. SOC. N.Z. ZOOL. 3:181-204.

May, BM, Kermode, LO (1972): Distribution and radiation in the troglobitic carabid beetle *Duvaliomimus mayae (Trechinae).* J. R. SOC. N.Z. 2:83-90.

Plowman, C, Merritt, D, and Fenton, J (2013): Living lights: the glow-worms of Australia and New Zealand.

Rouch R, Danielopol D. (1987): L'origine de la faune aquatique souterraine, entre le paradigme du refuge et le modèle de la colonisation active. Stygologia. 3: 345-372.

Townsend, JI. (1963): Cave beetles of the South Island. N.Z. SPELEOL. BULL. 3:94-96.