Australian Glow-worms in Caves

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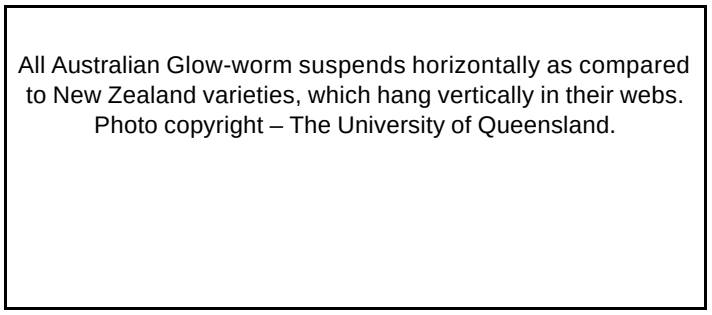
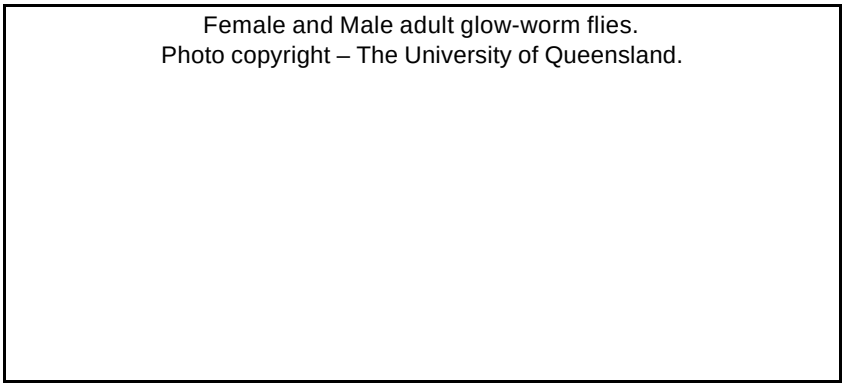


All Australian Glow-worm suspends horizontally as compared to New Zealand varieties, which hang vertically in their webs. Photo copyright – The University of Queensland.

Glow-worms are the larvae of a fly from the family Keroplatidae. Their closest relatives are the "fungus flies" that seek out mushrooms for their larvae to consume. Glow-worms have gone out on an evolutionary limb, albeit a successful one. They have lost their association with fungi and have instead become carnivorous. The unique feature of glow-worms is their ability to bioluminesce—to produce light. Because they are not very mobile the larvae must trap insects in their webs, much like spiders, and they use light to bait the trap. The larvae prey on flying insects, mostly small flies that are attracted to the bioluminescence. The larvae build a structure composed of a horizontal mucous tube suspended by a network of threads from the earth or rock substrate. The larva moves back and forwards in the tube and can turn in its own length. The larvae spend a considerable amount of time maintaining their "snares"—the many fine silken fishing lines that hang downwards, decorated by periodically placed sticky droplets. Flying insects are caught in the droplets and hauled up for consumption by the voracious larvae. In caves where the airflow is gentle the snares can reach 50 cm in length. In rainforest where they are exposed to stronger air movement they are usually up to 5 cm long.

The larval stage lasts many months, going through 4 moults and finally forming a pupa that lasts about a week. The pupa is suspended from the hardened thread-like remnants of the mucous tube that held the larva. One of the most obvious differences between the New Zealand species *Arachnocampa luminosa* and the Australian species is that *A. luminosa* pupae hang vertically from a single thread while all Australian species hang horizontally from a front and rear thread. The adults look like large mosquitoes with very long legs. They are sluggish fliers and frequently rest on the walls of embankments or caves. They are very short-lived, surviving for only a few days after emergence from the pupa and apparently do not feed. The males will find a female pupa and wait for her to emerge so that they can mate. Males are more slender than the females which emerge from the pupa with an abdomen swollen with eggs. The female flies live only 2 days so mating and oviposition (egg laying) begin immediately upon emergence. Each female lays 130 eggs that take 7-9 days to hatch.



Female and Male adult glow-worm flies.
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Bioluminescence

The bioluminescence is produced by internal cells located in a swelling at the posterior end of the larva. The blue-green light is visible through the transparent cuticle. The light producing cells are surrounded by a reflective structure composed of very fine air-filled tubes that appear as a white mass when examined closely. The light-producing chemical reaction is similar to the well-known firefly luciferin/luciferase reaction. However the enzyme and substrate are not identical to those used in fireflies.

Bioluminescence output can be rapidly modulated, for example, when disturbed or exposed to bright light larvae will douse their own light. In some caves of New Zealand the glow-worms can be made to increase the intensity of their light by splashing the water in these otherwise quiet caves. Glow-worms switch off their bioluminesce when exposed to daylight or intense torchlight. In caves they bioluminesce more or less continuously.

Glow-worms in Caves

The distribution of glow-worms is determined by their sensitivity to desiccation. They quickly die when exposed to low relative humidity or excessive air movement hence they are found only in the most sheltered habitats such as heavily treed, shady, moist gullies or in caves. It is in caves that they reach their highest density, producing spectacular displays of bioluminescence. In most cases the caves that contain glow-worms are within or near rainforest patches or tree fern-lined gullies, suggesting that caves are a secondary, although very suitable, habitat for these insects. Not all caves have glow-worms. Our surveys show that they occupy only those caves with organic input from outside environment, usually in the form of a stream bringing in organic matter in which chironomids or other small flies breed. Glow-worms are common in wet boulder caves with a high input of organic matter from an underground stream. In Victoria and Queensland we have collected glow-worms from granite boulder caves in areas where we would not otherwise expect to find them because rainforest is not found nearby. These populations may be relicts of a distant past when the surrounding vegetation was more lush. In caves, glow-worm numbers can fluctuate depending on the season and the history of floods. More research is needed to find out what characteristics determine their population levels in caves. They are rarely found deep in caves, rather they are usually found near cave entrances, and are true troglophiles.

Tourism, caves and glow-worms

Australia's best known glow-worm viewing site is at Natural Bridge, Springbrook National Park in the hinterland of the Gold Coast, visited by upwards of 300 people per night. A waterfall that has eroded its way through harder surface deposits forming a cavern and a natural arch or bridge. At Mole Creek in Tasmania a glow-worm display is featured as part of the guided show cave tour at Marakoopa Cave. Adventure cave tours featuring glow-worms take place at Mystery Creek Cave and at Mole Creek in Tasmania.

In New Zealand the world-famous Waitomo Caves have an impressive glow-worm display. Tourists are taken through the cave by boat. Adventure blackwater rafting at Waitomo also incorporates glow-worm viewing. Caves on the shore of Lake Te Anau on the south island of New Zealand also feature glow-worms.

How many species of glow-worms?

There are currently 3 described species of glow-worm in Australia: *Arachnocampa flava* from southeast Queensland, *Arachnocampa richardsae* from the Blue Mountains region, and *Arachnocampa tasmaniensis* from Tasmania. The New Zealand glow-worm is called *Arachnocampa luminosa*. It is now obvious that glow-worms are more widespread than suspected in Australia and that more species could be present. We have collected glow-worms along the east coast of Australia from the wet tropics in the Cairns region of Queensland to southern Tasmania and are currently determining the number of species, using the original scientific descriptions. Despite the geographical separation of glow-worms within Australia and New Zealand, the different species are remarkably similar in appearance and life habits.

Glow-worms found in boulder caves on Mt Bartle Frere in north Queensland are likely to be a new species because there is a large gap in glow-worm distribution along the coast of central Queensland. Claire Baker found that the northern Queensland glow-worms are parasitized by a wasp that consumes the larva from within and emerges from the glow-worm pupa. Such glow-worm parasites have never been described before and the wasp is a new species according to Dr. Chris Burwell of the Queensland Museum. Queensland and northern New South Wales is home to *Arachnocampa flava,* the species found at Natural Bridge. *Arachnocampa richardsae* is the Blue Mountains glow-worm. We are not certain where *Arachnocampa flava* and *Arachnocampa richardsae* come up against each other because glow-worms are distributed patchily in rainforest areas all along the Great Dividing Range. It is interesting that the best known location of the Blue Mountains glow-worm is the disused railway tunnel at Newnes. We repeatedly find that glow-worms readily occupy man-made caves such as railway tunnels, abandoned mines, and hydroelectric tunnels as long as they are wet and there is organic matter or flying insects in the vicinity. Canyoners will know that glow-worms are found throughout the Blue Mountains region in the many narrow and moist canyons.

Glow-worms are found in Victoria, where they have been tentatively identified as *Arachnocampa richardsae,* the same species as found in the Blue Mountains of new South Wales. Glow-worms are found at Melba Gully in

the Otway Ranges National Park west of Melbourne. They are also found in granite boulder caves and old mineshafts north east of Melbourne. A most interesting glow-worm is found in a granite boulder cave at Mt Buffalo in the Victorian Alps. The larva and adult show some very specific features indicating that this is a new, undescribed species. In some it more closely resembles the New Zealand and Tasmanian glow-worm than any mainland Australian specimens. At the moment their known distribution is confined to a single cave, so we are working with Victoria's Department of Natural Resources and Environment and Parks Victoria to list the species as potentially threatened. It is possible that it is distributed further afield in gorges of the rugged alpine region however specific searches will have to be carried out.

Glow-worms are common in Tasmania where they are found in the wet limestone caves. They are also found in the tree fern-filled gullies of Tasmania's rainforests. All Tasmanian glow-worms are reported to be a single species, *Arachnocampa tasmaniensis*.

The search for morphological features to distinguish species is still underway. We have started an analysis of nuclear and mitochondrial DNA sequences to help determine the relationships among Australasian glow-worms. It will be interesting to examine the "family distance" between the long-standing isolated cave populations such as the Mt Buffalo species and the mainland rainforest species. The relationships between the Tasmanian, Australian mainland and New Zealand species will also be of interest and may be integrated into the known biogeography of Australia and New Zealand and the history of rainforest contractions. Given that Australia and New Zealand were separated 60 million years ago these fascinating insects have stayed essentially unchanged and, given their very specific habitat needs, they have been remarkably lucky merely to survive.

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