

THE NEW ZEALAND GLOW WORM

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SUMMARY

The glow-worms of the celebrated Glow-worm Grotto of Waitomo Caves, North Island, New Zealand, are the larvae of a mycetophilid fly. The larvae prey upon midges which they capture by means of sticky fishing lines suspended from the roof of the cave. The light emitted by the larva serves as a lure for the prey. The unique density of the population of glow-worms in this cave results from the existence of ideal ecological conditions, notably the existence of an abundant food supply in the shape of gnats which breed in the mud banks of the subterranean river, and permanent darkness.

WAITOMO CAVES, one of the main tourist attractions in the North Island of New Zealand, has become world-famous for its Glow-worm Grotto. In this underground limestone cavern, estimated to have been formed about one million years ago, live thousands of glow-worm larvae, each emitting a bluish-green light from the tip of its abdomen. The Waitomo Glow-worm Cave consists of four separate caverns, each with its own system of corridors; but it is only in the vicinity of the underground stream that the glow-worms occur in large numbers on the walls, roof and stalactites. Because bright light and noise disturb the glow-worms, the Grotto portion of the cave has been left in its natural state since it was discovered, and it is only quite recently that the habits of these interesting little insects have been studied.

In pre-European days in New Zealand, caves were often used by the Maoris as burial places for their dead, and for this reason they were regarded as the dwelling place of spirits and fabulous monsters. Thus it was left to a European surveyor, Fred Mace, to discover and explore the Waitomo Glow-worm Cave in 1887.

The large mouth of the cave, now known as the river entrance, had been known to the Maoris for generations, but no Maori had ever penetrated its forbidding depths. After constructing a raft, Mace entered the cave accompanied by Tane Tinorau, the Maori chief of the district, whom he had prevailed upon, after much persuasion, to be his companion. In 1889 Thomas Humphries, Chief Surveyor at Auckland, surveyed the cave and presented an enthusiastic report to the Surveyor-General. Both Mace's account of his first exploration and Humphries's report are still extant, and it is interesting to note that Mace does not mention the glow-worms, and that Humphries makes only passing reference to them.

The New Zealand glow-worms are not beetles, as are the European glow-worms, but are the larval stage of a luminous species of fungus gnat, *Arachnocampa luminosa* (Skuse) (Diptera, Mycetophilidae), which inhabit damp, shady crevices, stream banks, tunnels and caves throughout the country, often forming quite impressive displays with their myriad twinkling lights. At Waitomo they occur in particularly large num-

bers in the Glow-worm Grotto because of the ideal environmental conditions and the plentiful food supply. Although the complete life cycle of the insect is passed inside caves, the glow-worm may be regarded as a troglone, or accidental guest.

One of the most peculiar features of *A. luminosa* is the feeding habits of the larva. The larva is narrow, elongated, segmented, semi-transparent, with a horny head which bears a pair of biting jaws. Behind the jaws are a pair of mucus glands. The larva builds itself a hollow, tubular nest of mucus and silk, in which it suspends itself from the shelf or ceiling above by a number of fine silk threads. The nest is very plastic, and enables the larva to glide rapidly backwards and forwards at will. From the nest it lets down up to 70 strings of sticky droplets known as "fishing-lines". Depending on environmental conditions and the size of the larva, fishing-lines vary in length from under half an inch to up to 20 inches, and are used by the larva to catch prey. They are remarkable for their great tensile strength, and are formed in a peculiar manner. Each consists of a long thread of silk, which bears at regular intervals a series of mucus droplets giving the appearance of a string of beads. The larva is able to break through the nest at any point along its length to let down or haul up fishing-lines. The fishing-lines are very delicate and so close together that even the slightest air current may cause the sticky threads to become entangled, so that the larva is constantly repairing its snare. In the bush and along stream banks these threads are usually very short. Their greatest length is reached in certain areas inside caves, due to the relatively calm conditions there.

At Waitomo, glow-worms feed chiefly on midges which breed in the water and mud-banks beneath them, but they are also cannibalistic, both on other larvae and on the adult flies. In the darkness, midges are attracted by the light emitted from the last abdominal segment of the larva, and fly upwards to become ensnared in the fishing-lines. The larva then moves to the appropriate fishing-line and, leaning out of its nest, hauls up the thread to which the midge is attached until it reaches its prey, which it immediately eats, discarding the remains. The hungrier a glow-worm is, the more brightly it will glow.

Cannibalism is of fairly common occurrence. Larvae are not necessarily confined to their nests, but often move about for considerable distances over the substratum seeking a site for a new nest. Thus two larvae may lie close together, or may approach each other and build nests within striking distance of each other. Then they lean partly out of their nests and snap at each others' heads with their jaws, each trying to pull the other out of its nest. While fighting continues each larva glows brilliantly, and it is comparatively easy to pick out a pair of fighting larvae in the darkness because of the intensity of colour and brightness of their lights. Occasionally a larva might fall out of its nest to the mud bank below, where it will continue to glow. Sometimes, when a larva is eaten, its light organ is discarded, and this also will continue to glow for some considerable time.

The life history is passed in four stages—egg, larva, pupa and adult fly. The eggs are laid in large numbers directly on to the walls of the cave. After about a three-week period they hatch into tiny larvae, which immediately emit a bright light; indeed, were it not for their light, they would be very difficult to find. They spread out over the roof of the cave and immediately commence building nests and letting down fishing-lines. These larvae grow over a period of several months till they reach

a length of about one and a half inches.

When about to pupate, the larva shrinks in size and becomes translucent. It removes the fishing-lines and braces of its nest. Then it shreds its larval skin and develops into a pupa three-quarters of an inch in length, which is suspended vertically by a long cord from its point of attachment on the ceiling to the region of the thorax. This cord appears to be formed from the larval nest and its supports. The pupal stage lasts for about twelve days. During this period there is a complete breaking down and building up of the tissues inside the pupa to form the adult fly.

In the pupal stage sexual differences become apparent. The female pupa is larger and stouter than the male, and possesses two prominent papillae at the rear end of the abdomen. In the male these papillae are much smaller. Both male and female pupae glow throughout all stages of their development. As in the larva, the luminous organ is situated in the last abdominal segment. The light is just as bright as that emitted by the larva, but is intermittent. In the female pupa the light appears to be connected with the attraction of male flies to the pupa. When the female pupa is gently touched the light flashes on immediately for a few seconds, and then goes out again. On several occasions two or three male flies have been observed attached to a female pupa which is glowing brightly.

When the female fly emerges she is still glowing, and usually is fertilised immediately by one of the waiting males. If mating does not take place, the female flashes her light on and off till she succeeds in attracting a male fly to her. Only one mating takes place. After mating the female still continues to glow intermittently, while she flies about seeking a suitable place to lay her eggs. Once egg-laying commences female flies seldom luminesce. The length of life of the female fly is governed by the speed with which she lays her eggs, and can range from less than 24 hours up to 76 hours.

Male flies glow throughout the whole of their life, although not as brightly as the female. They tend to live longer, and are capable of fertilizing more than one female. They can survive up to four days.

The female fly of *Arachnocampa luminosa* is about three-quarters of an inch in length, with a wing span of four-fifths of an inch. It has a dark brown and white striped body and transparent veined wings. The male fly is slightly smaller. They are sluggish fliers and make a buzzing noise, but are seldom seen. In the caves at Waitomo the life cycle is continuous throughout the year.

The glow-worm's main predators are long-legged, small-bodied harvestmen, allied to spiders. There are a number of different species of these strange creatures living in caves as carnivorous scavengers. Two species have been observed feeding on glow-worms. One species attacks the larva and the other the adult fly. The moist conditions inside caves are ideally suited to encourage fungal growth, and several species of fungi attack the larval and pupal stages of the glow-worm. However, neither harvestmen nor fungi are real hazards to the glow-worm population.

Risk of floods and shortage of food supply at certain times of the year form a more serious problem at Waitomo. In the Glow-worm Grotto, the stream which flows through the cave brings in quantities of mud and debris with it, so that a series of mud banks form and gradually silt up the stream, causing flooding after heavy rain. On several occasions flood waters have risen to within about a foot of the roof,

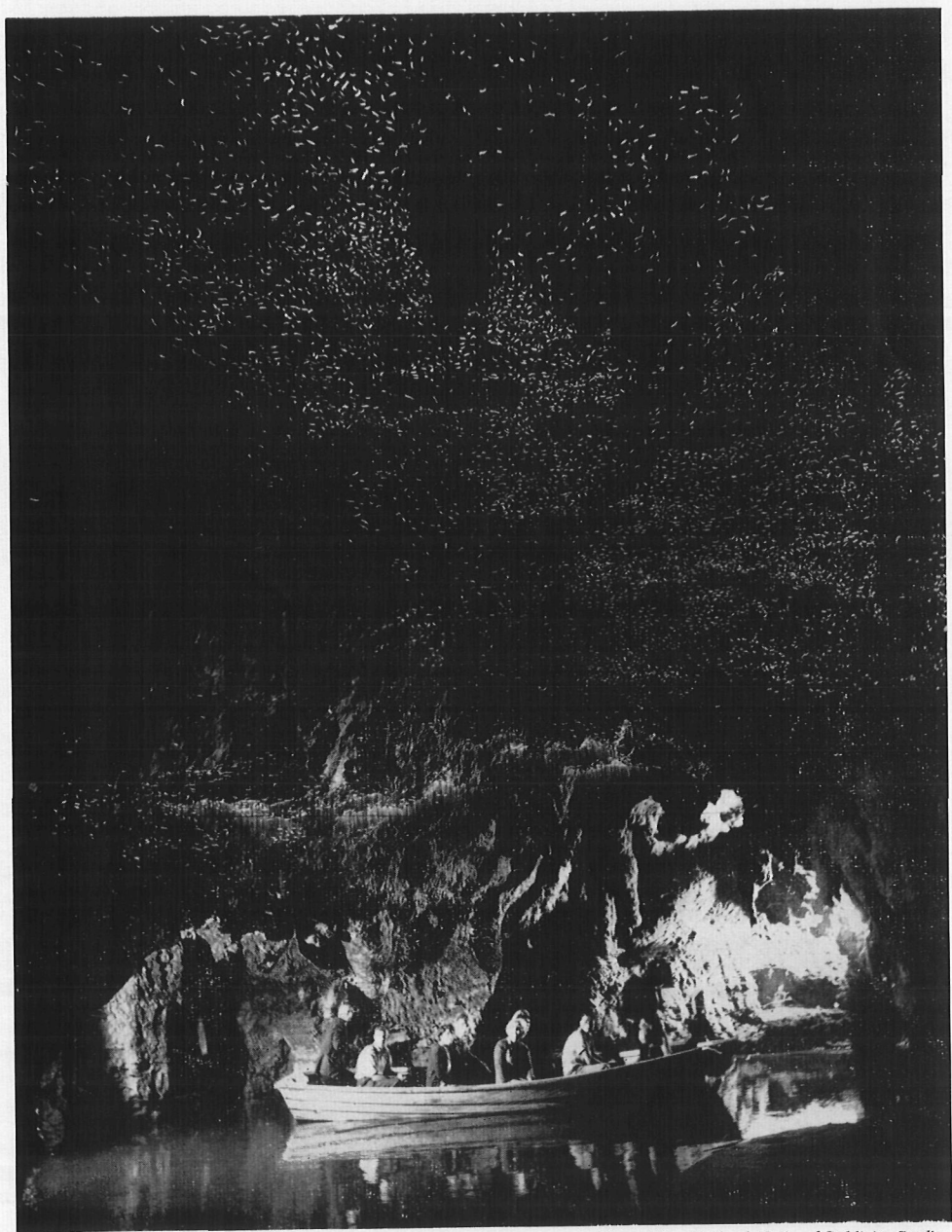


PLATE VI *Photo: New Zealand National Publicity Studios*
General view of Glow-worm Grotto in Waitomo Cave.

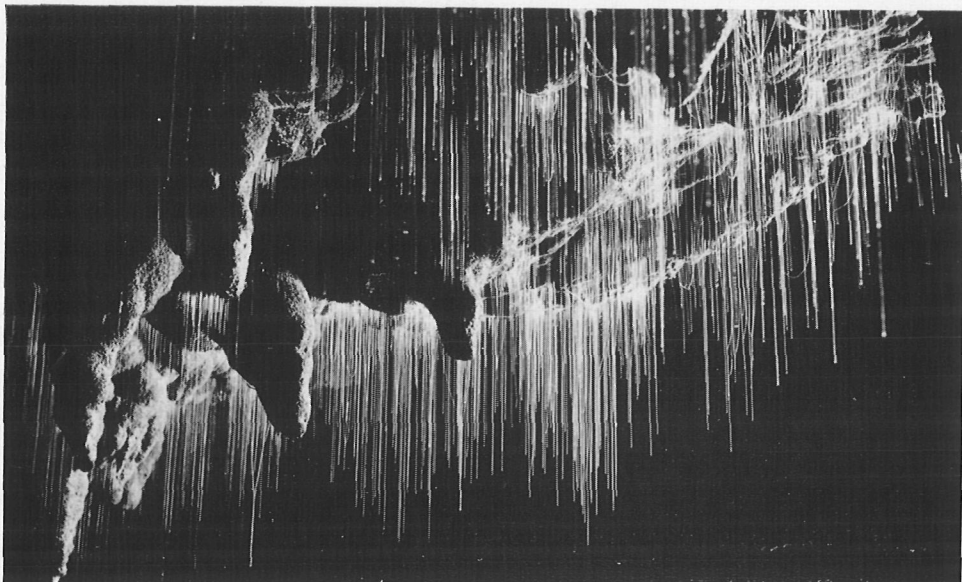


PLATE VIIA

Photo: New Zealand National Publicity Studios

Glutinous threads of the glow-worms in Waitomo Caves

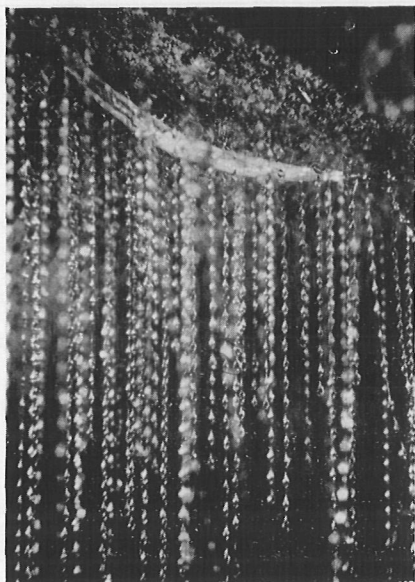


Photo: Transactions of the
Royal Society of New Zealand

PLATE VII B

A close-up of a glow-worm larva's nest and fishing lines. The larva is suspended from the wall of the Grotto, Waitomo Cave.

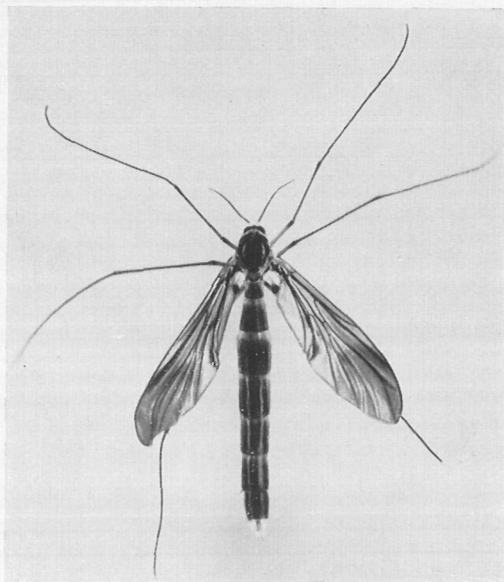


Photo: Transactions of the
Royal Society of New Zealand

PLATE VIIC

Female fly of *Aracnoscampa luminosa* (Skuse)
($\frac{3}{4}$ inch long). The light organ is glowing in
the anal segment.

and there has been fear that the entire glow-worm population would be washed away. Periodically this accumulation of silt has to be mechanically removed. Because of this, it has been suggested that portions of the formations should be removed so that the stream would have an uninterrupted passage through the cave, thus eliminating the formation of mud banks and all possibility of future flooding.

Whenever the mud banks are removed the size of the glow-worm population dramatically decreases. This is because the main food supply of the glow-worms—little midges whose larvae live in the mud—has been removed. If the mud were completely removed as suggested, the glow-worm population would probably almost entirely disappear. It is due to the ideal ecological conditions at Waitomo that the glow-worm display there is better than anywhere else in New Zealand.

Glow-worms also occur in Australia. They have been recorded from Queensland, New South Wales, Victoria and Tasmania. They are closely related to the New Zealand species, belonging to the same genus. The Tasmanian species, *Arachnocampa tasmaniensis* Ferguson, occurs in large numbers in the limestone caves at Ida Bay and also in the Maracoopa Caves. On the Australian mainland the species is so far undescribed. Its habitat is similar to that in New Zealand, but it is not very common in the bush, and seldom frequents caves or tunnels. Its general pattern of behaviour is similar to the New Zealand species.

The most interesting structure in the glow-worm is its light organ. This is formed from the dilated tips of the four excretory tubules, which are extensions of the alimentary canal. These lie within a layer of respiratory tissue that acts as a reflector. The anterior part of each tubule is concerned with excretion, while the posterior half forms the light organ. In no other known insect is the light organ formed from the excretory organ. The exact nature of the light still remains to be investigated, but the insect appears to be able to control it at will. Animal luminescence, or bioluminescence, has been recorded on many occasions, but no better example of this phenomenon can be given than that in the glow-worm.

This surely is one of the most fascinating members of New Zealand's insect fauna, and the beauty of its twinkling light is unrivalled by any other insect. To have seen these little insects in their underground habitat fighting for their daily existence is an experience that can never be forgotten. There is no comparable manifestation of Nature elsewhere in the world.