

The Ghost of New Zealand

Bruce G. Marcot

On the North Island of New Zealand there resides a spectral figure with glowing red eyes: pūriri, the ghost moth. It is the country's largest moth, with the wingspan of some females exceeding five and a half inches (fourteen centimeters). Its scientific name, *Aenetus vire-scens*, reflects its most common color—green—but it comes in various shades of green, as well as yellow or pink. Its forewings are intricately marked with lacy patterns, sometimes darker than the wing color, sometimes paler. This striking and enigmatic creature has both ecological and cultural significance; it has several local names—including *pepetuna* and *mokoroa*—but it is best known as the pūriri moth. A nocturnal encounter with the ghost itself, combined with daytime encounters with evidence of its presence, led me on a journey of discovery regarding its unusual and most interesting life history.

This species is endemic to the central and northern sections of North

Island, in areas of mature forest vegetation. Let's begin in these forests, recounting the six distinct stages of the moth's life history. Egg laying typically occurs in late September or early October, when the adult females fly around the forest, randomly dispersing large numbers of small, round, yellowish eggs. The eggs usually fall to the ground and become part of the leaf litter, where they gradually turn black. An egg hatches within twelve to fourteen days, and the moth enters the litter-phase caterpillar stage. During this two-to-three-month period it feeds on nutrients within the ground litter layer, particularly on a range of fungal fruiting bodies. After its initial molt there, the caterpillar moves into the transfer-phase stage.

In its transfer-phase stage, the caterpillar crawls up a tree, where it digs a burrow into the trunk that angles slightly upward at first and then downward into the cambium. (In cross-section, it forms a distinctive "7" shape.) The



The pūriri moth caterpillar spends its first months in leaf litter on the forest floor. Photograph by dr_robert / CC BY 4.0.

pūriri is unique, the only truly wood-boring species of Lepidoptera. Its cavity opening is sealed with a membrane, an external sign of its presence, though one not always easy to see. The membrane is composed of silk webbing, detritus, and epiphytes, which together blend its appearance into that of the tree bark, helping the caterpillar avoid predation by parrots, particularly by the kākā (*Nestor meridionalis*), another endemic New Zealand species. Further, the membrane helps increase the temperature within the cavity, promoting more rapid growth of the larva.

This cavity becomes the home of the caterpillar in its tree-phase stage. It remains in the burrow for some time, feeding on the tree's cambium. Quite how long this stage lasts is uncertain. Various resources suggest that it ranges from one to four years, while others say four to six years or even more—an amazing period of isolation.

Ensnared within the cavity, the moth passes through several instars

until it eventually reaches the pupation stage, which lasts three months or so, and during which the caterpillar transforms to its adult form. This is then followed by the emergence stage, in which the pupa crawls back up the shaft it created within the tree cambium, and pushes through the membrane covering the opening. It exits the cavity in late afternoon or early evening, shedding its pupal skin at the opening and emerging as a winged adult.

Now that the long period of isolation is over, pūriri's remaining time is short. Adults have no functional mouthparts, so the free-flying adult stage during which they mate and breed lasts not much more than forty-eight hours. Little is known about how pairs find each other for mating, which apparently occurs after dark. One speculation is that males exude an attractant pheromone. Another is that emergence might be synchronized in such a way that by chance, in sheer numbers, mates find one another. If mating is successful, a



The dark pupal skin of a pūriri moth protrudes from the entrance to its tree cavity after the emergence of the flying adult. Photograph by Bruce G. Marcot.

female scatters up to two thousand eggs, thus completing the life cycle.

What, then, are the signs of pūriri in the forest? The adults are nocturnal, live for only a short span to mate and die, and occur in forest understory vegetation that is often dense, so encountering them is a rare event. The main signs are those tree cavities created during the tree-phase caterpillar stage, and it was cavities that I mostly found. But locating one with a fresh membrane cover signaling the presence of a dormant pupa is not a frequent occurrence. Typically one finds vacant cavities, many of which may have been at least partially healed over by subsequent tree growth.

In the tree-phase stage, the moths primarily inhabit understory native hardwood trees. These include the putaputawētā or marbleleaf (*Carpodetus serratus*), lacewood or ribbonwood (*Hoheria* spp.), mānuka (*Leptospermum scoparium*), and māhoe or whiteywood (*Melicytus ramiflorus*)—and in particular the moth’s namesake, the pūriri tree (*Vitex lucens*), also called New Zealand mahogany, teak, oak, or walnut (strictly all of these being misnomers). In general, the native forests used by the pūriri moth are diverse. For example, along the Waipapa Loop hiking trail—less than two miles long—in Pureora Forest, I cataloged at least six species of large overstory native trees (rimu, tōtara, miro, mataī, white pine, and celery pine) and several species of understory native hardwoods (dracophyllum, coprosmas, lancewood, and mountain tōtara), collectively forming a verdant, partially closed-canopy woodland.

The vacated tree cavities created by pūriri moths are occupied by some spiders and insects, particularly the tree



Old burrows are the most frequently encountered evidence of pūriri moths. Photograph by Gillian Candler / CC BY-NC 4.0.

wētā, a cricket-like New Zealand endemic, from which the tree name putaputawētā is derived. The cavities also may become prime real estate for other forest dwellers, in an interesting ecological parallel to other forests of the world where cavities that are created and abandoned by woodpeckers can then be used by invertebrates, small owls, squirrels, bluebirds, and many other species. As New Zealand has no native woodpeckers, the pūriri serves as an “ecological engineer,” a primary cavity excavator providing an element of habitat for other animals of the forest.

There is concern about the impacts of the moths on some tree plantations, because the cavities their caterpillars create reduce the soundness and value of the wood. Pūriri have been recorded causing damage to Australian blackwood (*Acacia melanoxylon*), which was introduced to New Zealand for its decorative lumber. Timber taken from infested trees often has defects caused by

the cavities or by the effects of secondary rot. Such damage has stifled the use of another tree, southern beech (*Nothofagus*), for plantation forestry on North Island. Pūriri have also used some fruit trees and poplars, but to a lesser extent. In general, though, the concern is minor for the moths in their tree-phase stage inhabiting commercially planted trees, and one study found no significant impact of the moth on its native namesake host, the pūriri tree.

Even if control of pūriri damage were needed, there would be no feasible

way to achieve it. Their sealed cavities thwart the use of sprays, so they would have to be individually located and injected with insecticide, making widespread control unworkable. Other exotic and invasive forest insect pests pose a greater hazard to plantation forestry in New Zealand, and are the more appropriate focus of regional and national biocontrol programs.

Moths are often pollinators, but given that adult pūriri are short-lived and have no mouthparts by which to feed, any incidental pollination func-



The pūriri moths burrow mainly into trees in the understory of mixed forests. The pūriri tree is a preferred home; this specimen has multiple cavities. Photograph by Jacqui Geux / CC BY 4.0.

tion seems highly unlikely. (Overall, the role and importance of moth pollinators in New Zealand is not well studied. Maybe we'll be surprised one day.)

Pepetuna, the most widely used alternate common name of pūriri, derives from the Māori phrase *pepe tuna* ("eel moth"). In a traditional practice, some Māori would extract caterpillars (which they refer to as *mokoroa*) by flooding their tree cavities with water, and then use them for eel bait or for food. Eels themselves sometimes feed on pūriri during the eels' migration to the sea between September and January, as they encounter the caterpillars on the flooded forest floor on rainy nights.

The pūriri moth plays an important role in traditional stories of the Māori people, who view it as a descendant of the god of the forest. Flying at dusk and at night, pūriri is considered to be a denizen of and a messenger from the world of spirits, or the spirit of an ancestor returning to visit its descendants. Interestingly, this parallels how nocturnal owls are viewed in some other cultures of the world as spiritual beings, messengers, and visitors. The Māori stories remind us to view ecosystems in a way that is far broader than can be captured in strict scientific description. They provide a basis for seeing the world through a socio-natural history perspective that values and honors even seldom-seen nocturnal life.

And my encounter with the ghost itself? On a late November evening, after discovering a number of tree cavities during the day, I made my way back to a field cabin at Pureora Forest Reserve in the company of a wonderful local biologist, Dr. Steven Pawson, associate professor at University of Canterbury. There,



With eyes that shine red in the darkness, the pūriri moth is a ghostly presence in a nighttime forest. Photograph by Emma & Tom / CC BY-NC 4.0.

in the deep dark of night, we called in a morepork owl (*Ninox novaeseelandiae*), another endemic New Zealand species and a known predator of the moth. And, as my host donned a headlamp, he was suddenly tagged on the head by a flying female pūriri, attracted to the light. This provided a most auspicious and fine ending to the day.

So it was that with my excursions into the forest world of the pūriri I came to appreciate its remarkable life history and its ecological and cultural roles, bringing home to me the wonderful spirit of the ghost moth of New Zealand.

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