



WETA SEX

fast and furious

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MAUD ISLAND



Love is a battlefield for weta, with males' sprinting and aggressive sword play deciding the winners in the search for a mate. By **Darryl Gwynne** and **Clint Kelly**.

Weta males – some with facial tusks and others with long blade-like jaws – are not sexy in the sense of being attractive. But in 1920, New Zealand entomologist George Hudson suggested that weta weaponry illustrated the Darwinian principle of sexual selection by improving male success in getting a mate.

Darwin and Hudson's work inspired us to study weta sex, and Maud Island, in the Marlborough Sounds, seemed the perfect location because representatives of three weta groups are abundant there. Sadly, this is not the case on New Zealand's mainland, where introduced predators have eradicated many species. Most large giant weta species survive today on conservation islands such as Maud.

Our studies have revealed the mating of various weta to be every bit as fascinating as their structural splendour. We have linked weta behaviour, structure and even their body size to Darwinian sexual selection.

Our main quarry on Maud Island was the Wellington tree weta, *Hemideina crassidens*, and the closely related Cook Strait giant weta, *Deinacrida rugosa*. We also studied a *Hemiandrus* ground weta, an unnamed species and one checking in at only 3 per cent of the weight of the giant weta that occasionally looms over it. Each of these species possesses an entirely different mating pattern, unlike their relatives, crickets and katydids, where typically the female homes in on the male's mating song because he provides a food-offering or the safety of a burrow. For weta, getting together is a silent endeavour, yet the key to understanding their variable mating still appears to be resources important to the female.

The mating biology of Wellington tree weta seems more akin to that of some mammals than insects because males defend harems. In Maud Island's woodland we found most harems in holes in mahoe trees. The most sought-after of these "galleries" are typically large with just one entrance. Each is guarded by a male with a big head equipped with mandible (jaw) swords sometimes as long as the rest of his body.

He faces inward to a cavity with up to a dozen females. Intruding rivals are confronted with the hind end of the harem master rather than his weapons. A fight starts when the resident is pulled out by his back legs. The rivals square off with jaws flared and the male with the smaller equipment scampers away. In more even matches a contest ensues where mandible-weapons are locked, twisted and pulled. Fights end when a loser is tossed from the tree. Unlucky losers can receive a crushed head or have a mandible snipped off by their opponent.

These observations suggested that male tree weta were vying for long-term control of a resource – the best galleries. We tested this idea by daily tracking down individually marked weta. Surprisingly, males stayed only about a day and a half, about half that of the females, though males will stay longer if a harem is large. A gallery is not a male's long-term home and fortress but instead appears to be a staging post hosting a series of itinerant and aggressive gigolos in search of receptive females.

A male appears to move on once he has mated with all the females. In an unconventional approach to mating, he unceremoniously hauls each female out of the gallery in much the same way as he would a rival. He attaches a sperm capsule to her, which, as in all weta, acts like a tiny turkey baster to inject sperm after the pair has separated. There is little opportunity for the female to reject his advances and his belligerent behaviour continues after copulation when he again grasps her with his mandibles and throws her from the tree.

This behaviour surprised us because other insect males stick by their mates to prevent matings with rivals. Evicting the female may have the same effect because the female can remove the sperm capsule prematurely if another male coming to the gallery attempts to mate. By ejecting his female, a male appears to reduce the risk of having the transfer of his sperm interrupted.

Worse than interrupted ejaculation is not mating at all – yet this would seem to be the fate of small-headed male

1 Wellington tree weta mating. Males defend harems, which is unusual behaviour for insects. Photo: Rod Morris

2 A female Cook Strait giant weta. Photo: Rob Suisted/www.naturespic.com

tree weta that prudently retreat from the weapons of larger opponents. As it turns out, though small-heads are ousted from the prime real estate, they can hole up with the occasional female in a narrow gallery safe from harassment by well-endowed competitors because a large set of head-gear cannot fit through the entrance. This and other evidence indicates that small-head males adopt a non-aggressive mating alternative to that of harem defence.

It was relatively straightforward to find groups of tree weta in galleries to study. However, giant weta were a very different story. We could easily spot these insect leviathans, but how were we to understand the process of sexual selection?

Occasionally we would see a solitary individual feeding on grass or a female laying eggs into the soil. On warm nights on the grasslands overlooking Maud Island's Home Bay, we had often observed a male at the heels of a lugubrious female. These suitors may have found their mates using scent, or pairs may have formed when boy-weta stumbled across girl-weta in the darkness. It appeared that sometime before dawn the two nestled down for a day-long liaison under whatever dry grass clump was close at hand. Given that the needs of the female – a refuge, food and a place to lay eggs – are widely dispersed, there was little benefit to males in aggressively defending these resources. But was there any rivalry among males? We addressed this by radio tracking uniquely marked individuals. The tiny transmitters we glued on to the thorax were not much of a burden for our supersized insects.

A large sex difference in size motivated our main hypothesis. Females of the Cook Strait giant weta weigh in at over 20 grams, twice that of males. The need for females

to be large to accommodate lots of eggs could not fully explain the extreme size difference. After all, in virtually all other weta the sexes are quite similar in overall body size. This led us to ponder whether, in contrast to the familiar Darwinian drama of heavyweights winning fights, small giant weta males had the advantage. Males do not defend resources so perhaps the best strategy is to scramble for mates, with lightweights favoured because they cover more ground.

Our test of this idea involved tracking down all tagged weta late each afternoon. We found many of them paired, nestled deep at the base of grass clumps where the male was spooned in beneath the female. We found that each pair had copulated frequently throughout the day – as revealed by the dozen or more empty sperm capsules dropped around them like condoms on a bedroom floor.

At this point we disrupted the love nest to measure the weta. Our recapture information showed that small males and those with long legs were covering more ground than their rivals. One bantamweight had legged it at least 100 metres in 24 hours – a marathon for a flightless insect. We found no association between female size and their nocturnal roaming distances. Most important was our finding that the distance males travelled was critical to their reproductive success. For success we had a better measure than simply the number of mating liaisons with different females. By counting the number of empty sperm capsules transferred in the day-long mating session we were able to relate male mobility directly to their insemination success; each inserted sperm capsule would have upped that male's contribution to the competitive mix of sperm from rivals already stored inside the female.

We know little about the mating habits of tusked weta, except that male tusks are used in fights in the endangered *Motuweta isolata*. There is some hope, however, on two fronts. First, a new species – *Motuweta riparia* – is now known. Near a pristine North Island forest stream we have found a healthy population that cries out for future study. *Motuweta isolata* has elaborate male tusks and enormous bulk. The only native survivors were on a tiny island in the Mercury group.

In 2002, one of us took part in a Department of Conservation search for this species. We found none and the outlook seemed grim because no individuals have since been found on the island. However, thanks to a captive rearing programme by DOC and release of this big tusked weta on to other islands in the Mercury group, the species now thrives. In 2002, it was a thrill to join in the discovery of the first hatchling tuskers on one of these other islands. So there is hope that healthy populations of *M. isolata* will eventually be restored to the New Zealand landscape and that future research will reveal this unique elephantine insect as another fine example illustrating the Darwinian mechanism of sexual selection.

Darryl Gwynne, University of Toronto, and his former PhD student Clint Kelly, now at Iowa State University, are professors of ecology and evolution. They have studied weta – and have been privileged to work on Maud Island/Te Hoiere – for the better part of the past decade while funded by The National Geographic Society and the Natural Sciences and Engineering Research Council of Canada.

Dinner date

Well over half of New Zealand's weta species are tiny *Hemiandrus*. These ground weta are virtually unknown compared with their larger and well-armed cousins but they have unique mating habits and structures that – as in other weta – are related to a resource important to females.

The newly mated *Hemiandrus* female grasps and eats a nutritious doughy mass that is ejaculated by her mate along with his sperm packet. The lack of this meal in our other weta is unusual as it is widespread in related insect families.

We discovered that, unlike most relatives, the male ground weta on Maud Island does not attach his nuptial gift to the sperm packet. Instead he places it partway up his partner's underside so she simply tucks her "chin" down to eat it.

The males of this and other ground weta advertise their offerings by tapping the abdomen on a leaf. After being attracted to this seismic signal, the female erects a bizarre appendage partway up her abdomen that functions as a secondary copulation site to which the male attaches while his genitals squeeze out the gooey gift. This abdominal appendage varies greatly between species: from a two-lobed structure in our Maud Island *Hemiandrus* to a bizarre, long elbowed device in the related *Hemiandrus pallitarsis*. Such species differences in female "secondary" organs is opposite to the familiar Darwinian pattern of species variation in male ornaments or armaments. Behavioural evidence such as a male ground weta rejecting a female after apparently assessing her abdominal ornament suggests that sexual selection of females has led to the evolution of these highly unusual structures.



Big, ugly and struggling

Large, flightless weta are walking meat pies for foraging introduced mammals such as rodents. Particularly vulnerable – to both predation and habitat change – are giant and tusked weta that live on the ground and use retreats in shallow burrows or low vegetation.

They have survived mainly on rodent-free offshore islands that have turned out to be valuable sources for successful translocation to other areas, especially islands. The first translocations involved Cook Strait giant weta that were moved from Mana Island to Maud Island in the 1970s and, more recently, in the Wellington area, to Mātiu-Somes Island and Karori sanctuary (Zealandia).

Mahoenui giant weta (*Deianacrida mahoenui*), were originally found in one small mainland area of goat-browsed dense gorse. Non-native gorse, ironically, protects weta from rodents. Translocations have produced healthy populations, including one on Mahurangi Island, off the Coromandel Peninsula. Since the first translocations in 2001, growing populations of Mercury Island tusked weta now exist on five Mercury islands. **F&B**

3 Darryl Gwynne radio tracks giant weta on Maud Island. Photo: Clint Kelly

4 A radio tag is attached to a giant weta on Maud Island. Photo: Clint Kelly

5 The radio tag is removed. Photo: Darryl Gwynne