Australia's Amazing Insects

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Arriving in Australia for the first time many years ago as a young entomologist, I felt like a kid stepping into a giant candy shop. Astonishing creatures lurked and scuttled all around me, most of them still entirely unstudied by entomologists, and many still lacking even a scientific name. I could not wait to start exploring this mysterious micro-world.

Having devoted the past eighteen years to the study of Australia's native insects, I continue to be amazed and surprised by Australia's insect biodiversity. Although often overlooked because of their small size, these wonderful, complex animals have enormous importance for Australian ecosystems. They also offer valuable opportunities for scientific discovery.

In virtually every terrestrial and freshwater ecosystem, insects form an essential part of food webs and play important roles in many ecological interactions. While we might often wish for some insects (like mosquitos or bush flies) to disappear, many other animals feed on insects, and many plants – including some of our key crops – rely on them for pollination. If insects were to disappear, many ecosystems would surely be altered beyond recognition or would collapse entirely.

For example, flies provide food for small birds, mammals, lizards, and frogs, while tiny, stingless native bees pollinate many native plants. Ants – diverse and ubiquitous throughout Australia – hunt other small animals and clean up carrion. Termites (which are tiny, social cockroaches) break down vast quantities of dead wood. Leaf-eating insects like caterpillars process mega-tons of vegetation every day, and tiny springtails and midges teem in the soil.

Insects also have great practical importance. Insect pollinators play vital roles in modern crop production. But insects themselves have provided an important food source for Indigenous Australians for thousands of years, and some insects (like mealworm beetles and soldier flies) have the potential to provide a sustainable source of food for the world's growing population today. Insects could even help us deal with waste: some beetles and moths can digest materials like Styrofoam and cellulose and have the potential to play an essential role in the recycling of these materials.

While the ecological and economic importance of insects are difficult to overstate, so is their scientific importance. Most people do not realise how much of what we know about biology comes from research on insects. The tiny vinegar fly (*Drosophila melanogaster*) has been the workhorse of genetics for over

Top left: Large Neriid males (*Telostylinus angusticollis*) are very aggressive and sometimes engage in fierce battles for control of territories on rotting tree bark. The males strike each other with their elongated antennae, heads, and forelegs. Image: Russell Bonduriansky.

Top right: A different Neriid species occurs in far-north Queensland, where they breed on rotting fruit. This *Telostylinus lineolatus* pair is mating on a flower. Image: Russell Bonduriansky.

A remarkably camouflaged female leaf insect (*Phyllium monteithi*), native to the Far North Queensland rainforest. Image: Russell Bonduriansky.

a century and continues to yield new insights into how genes work. Research on *Drosophila* has revealed that all complex animals – a group that includes insects and ourselves – develop and function in much the same way. The same genes initiate the development of complex organs like eyes and brains and shape many aspects of the body structure in both insects and mammals – a legacy of our shared evolutionary history. Consequently, research on insects can tell us a great deal about ourselves.

But while all complex animals are similar in many ways, some species are beneficial for research on specific questions because of their unique ecology, physiology or behaviour, and a reason why Australian insects are so valuable to science.

For example, Australia has many native species of *Drosophila*. Several of these provide important insights into genetic variation and evolution in natural populations, including the potential for wild animals to adapt to climate change. Australian insects have also yielded surprising and counter-intuitive observations and provided textbook examples of important biological principles.

Take the jewel beetle (*Julodimorpha saundersii*), native to parts of the outback and coastal Western Australia. Male jewel beetles are irresistibly attracted to discarded beer bottles, whose colour and shape resemble (to the eye of a male beetle) an enormous, super-fecund female. This odd behaviour has provided an iconic example of a super-stimulus.

Neriid flies (*Telostylinus angusticollis*) aggregate and breed on rotting tree bark in coastal New South Wales and southern Queensland. These flies can also be spotted on compost in urban backyards. Image: Russell Bonduriansky.

Then there is the mountain katydid (*Acripeza reticulata*). This species has an amazing startle display that has become a key example of anti-predator behaviour. Research by Kate Umbers and colleagues at Western Sydney University is exploring the evolution and ecology of this strategy.

Or consider the tiny Zeuss bug (*Phoreticovelia disparata*) of far-north Queensland. In many insect species, males attract females with 'nuptial gifts' of food, such as nutritious glandular secretions or prey items. But Zeuss bugs have furnished the only known example of a role reversal involving a nuptial gift from females to males. Research on the evolution of such unusual behaviours and reproductive strategies can yield insights that would otherwise be difficult to achieve.

In my lab at the University of New South Wales, my students and I study a large, beautiful insect – the stilt-legged fly (*Telostylinus angusticollis*). This species (a member of the family Neriidae) is native to coastal New South Wales and southern Queensland and very common in and around Sydney. It naturally aggregates and breeds on the rotting bark of *Acacia longifolia* trees and the introduced 'coral tree', but it can also be seen on compost in urban backyards. Despite its abundance and large body size, almost nothing was known about its biology until we began to study it.

Neriid flies turned out to be extremely useful for understanding how environmental factors such as diet can influence development. The flies' growth

Several male stick insects (*Megacrania batesii*) jostling for position around a female on a *Pandanus* sp. host plant in Far North Queensland. Image: Russell Bonduriansky.

Native *Drosophila* aggregating on *Pandanus* sp. fruit keys in far-north Queensland. A much larger Neriid fly (*Telostylinus lineolatus*) towers above them. Image: Russell Bonduriansky.

A stick insect is individually marked as part of a mark-recapture study. Image: Russell Bonduriansky.

Male Neriid flies (*Telostylinus angusticollis*) compete over a female as she lays eggs into tree bark in Sydney. Image: Russell Bonduriansky.

A stick insect (*Megacrania batesii*) with an engorged biting midge on its thorax. Image: Russell Bonduriansky.

rate, the development of sex-specific traits (such as the enlarged heads, antennae and forelegs used by males as weapons in their spectacular battles over territory), their behaviour, and even their rate of ageing, are all strongly influenced by their early-life nutritional environment. We also discovered that some of these environmental effects are transmitted across generations via effects on offspring development, providing new insights into trait inheritance.

We have recently started working on another fascinating group – the Australian stick and leaf insects (Phasmatodea). These large, spectacular insects are hyper-diverse and ecologically important in Australia, but surprisingly little research has been done on this group. Indeed, Australia's largest stick insect – the Gargantuan stick insect (*Ctenomorpha gargantua*), which grows to well over a half-meter in length – was only recognised and named by entomologists a few years ago. My students and I are using other (slightly more compact) stick insect species to research their unusual reproductive biology. Many stick insects belong to the tiny minority of animals endowed with the ability to switch between sexual and asexual reproduction (parthenogenesis). We are exploring the evolutionary and ecological implications of this unique ability.

So much is left to discover. I run an undergraduate course on evolution, where students carry out small research projects on locally abundant organisms at the University of New South Wales's Smith's Lake Field Station in Myall Lakes National Park. Even within the scope of an undergraduate project, students often discover entirely new behaviours and lifestyles among the insects, spiders, snails, and plants at the Station.

But there is also much cause for concern. Many people assume that insect populations are so vast that human activities rarely threaten them. Yet, troubling data suggests that many insect populations are experiencing a rapid decline. Even extremely abundant insects, like the Bogong moth (*Agrotis infusa*), can succumb rapidly to anthropogenic environmental change. But some insects have very restricted ranges and small population sizes, making them especially vulnerable to extinction as a result of climate change, pollution, habitat destruction, or over-collecting. Tragically, some insects are disappearing even before anyone has had a chance to learn about their unique biology. Because very few insect species are monitored, we do not even know what we are losing.

There is an urgent need to learn more about Australia's native insects, monitor their populations, and include insects in conservation strategies. Insects are a natural resource that we cannot afford to lose.