QUEENSLAND MUSEUM

INSECT AGENCY

look closer

Welcome to the Insect Agency

I'm Buzz the cicada and I'll be your guide through this facility. Here, we do important research on insects.

Our survival depends on these six-legged operatives of the animal kingdom. They keep ecosystems healthy, pollinate our crops, provide inspiration for new technologies and much more.

There are 1.25 million insects for every human on Earth, so we need lots of new investigators. We call them entomologists, scientists who unlock the secrets of the insect world. By the end of this tour, you'll be well equipped to work for our team. Are you ready for your briefing?

Queensland Museum

The Queensland Museum has a huge and amazing insect collection. Looking at every insect could keep you busy for a lifetime. Our collection contains almost 4 million specimens from all major groups of insects and their close relatives. Most are from Queensland and have been collected from diverse habitats throughout the state. Our collection contains dried specimens on insect pins or protected in paper envelopes, specimens mounted on microscope slides, and fluid-preserved specimens in jars of ethanol.

Even though we know a lot about Queensland's insects, most of our species are yet to be scientifically named. The Queensland Museum collection is filled with specimens of hundreds of new insect species. They are used by researchers all over Australia and throughout the world to describe and understand Queensland's diverse insect fauna.

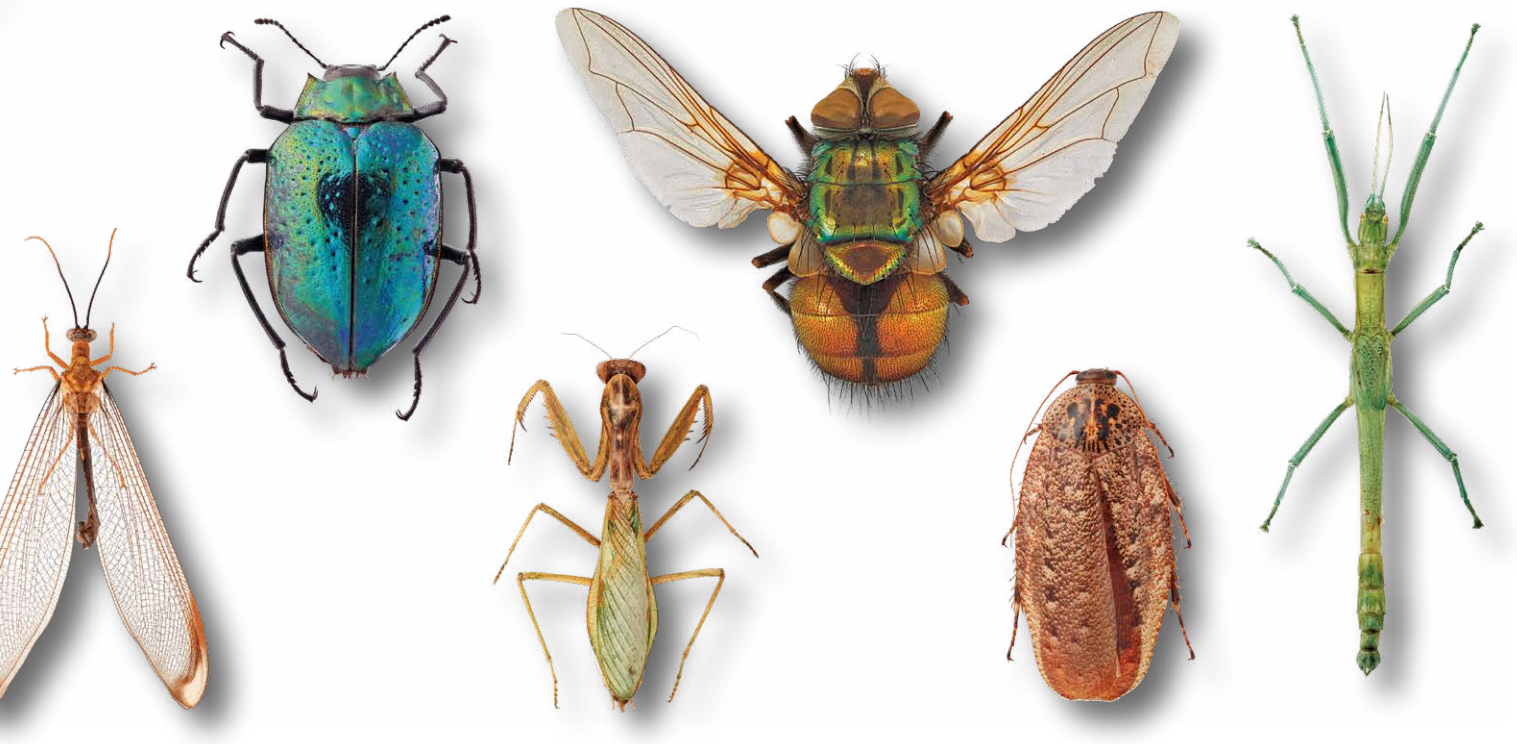
Centenary of the Entomological Society of Queensland (ESQ)

One hundred years ago, a group of entomologists formed the Entomological Society of Queensland, Australia's first society dedicated to studying insects. At the time, there were more entomologists in Queensland than in the rest of Australia combined, because of the enormous variety of insects that are found here. Queensland is Australia's most biodiverse state, meaning that Queensland has the greatest diversity of different species – not just insects, but also other animals and plants. Maintaining our biodiversity is very important for keeping our planet healthy.

The Entomological Society of Queensland is still going strong, and this exhibition is part of their 100th birthday celebrations. The society welcomes anyone with an interest in insects. It holds monthly meetings with guest speakers and has its own journal, The Australian Entomologist.

What is an entomologist?

Before we continue, let me tell you about what entomologists do. The one thing we have in common is a fascination for insects. We are scientists dedicated to uncovering the secrets of the insect world. The types of research we do is nearly as varied as the insects themselves and there's still so much to learn.



INSECT BODIES

First, let's identify our target.

Insects come in so many different shapes and sizes that it's hard to believe they are all part of the same team. A dragonfly, a stick insect, a beetle and a flea all look very different, but their bodies are all put together the same way.

Here are some things that all insects have in common:

- Unlike humans, insects have their skeleton on the outside of their bodies.
- Called an exoskeleton, it works like a suit of armour. It can be very thick and hard, or thin and flexible.
- Insects have a segmented body, which is divided into three parts – a head, a thorax, and an abdomen.
- The head has a pair of compound eyes, a pair of antennae, and a set of mouthparts for eating.
- The thorax is made up of three segments, each with a pair of jointed legs – that's six legs in total. If there are more than six legs, you have an imposter!
- Most adult insects also have wings on their thorax – usually two pairs, but some insects only have one pair, and others have no wings at all. So don't be fooled – wings are optional extras!
- The abdomen is where you'll find the structures that enable mating or egg laying, often near the tip.

EYES

Insect eyes are very different to ours. Instead of a single lens, insects have compound eyes made up of many tiny units, each with its own lens. Insect vision isn't as sharp as ours, but their eyes can process images much faster, making them ideal for tracking moving objects. Check out these operatives and their special skills.

Super sight

NAME

Big-headed Fly, Family *Pipunculidae*

SUPER ANATOMY

Eyes with almost 360-degree vision

SUPER SKILL

Many insects can see forwards, backwards and sideways all at the same time because the tiny lenses in their compound eyes point in almost every direction. The eyes of this big-headed fly are so large that there's barely room for anything else on its head.

Double vision

NAME

Whirlygig Beetle, *Macrogyrus oblongus*

SUPER ANATOMY

Eyes divided in two

SUPER SKILL

Whirlygig beetles have double vision because each eye is divided into two parts – one for seeing above the water, and one for seeing below. When skimming across the water, they search for prey on the surface using their above-water eyes and scan for predators with their below-water eyes.

> **ASSIGNMENT:**
> How do you think humans could use this double vision technology?

Insect eyelashes

NAME

Tangle-veined Fly, *Trichophthalma laetilinea*

SUPER ANATOMY

Eyes with tiny hairs between the individual lenses

SUPER SKILL

The first part of the scientific name of this fly literally means ‘hairy eyes’. The hairs keep dust particles away from their eyes while they fly. Insects don’t have eyelids, so they can’t close their eyes to stop dust landing on them.

ANTENNAE

Smell is a very important sense for most insects. Detecting chemical odours helps them find food, a mate and a good place to lay their eggs. Most insects detect odours using their antennae. These important body parts are packed with tiny receptors that can ‘smell’ chemicals in the air and on surfaces, or detect vibrations, sounds or changes in pressure. Most insect antennae look like thin threads, but others are all kinds of shapes.

Mozzies with super hearing

NAME

Male Giant Mosquito, *Toxorynchites speciosus*

SUPER ANATOMY

Bushy antennae with tufts of long, fine hairs

SUPER SKILL

Male mosquitoes use their antennae to find a mate. The long hairs on their antennae are sensitive to soundwaves moving through the air and are finetuned to the buzz of females of their own. This means they can find them in a crowd of other mozzies – even if they're 10 metres away. That's better than a secret handshake!

Super-sensitive perfume detectors

NAME

Male Emperor Gum Moth, *Toxorynchites speciosus*

SUPER ANATOMY

Feathery antennae with lots of long side branches

SUPER SKILL

The antennae of male emperor gum moths can detect the chemical perfume released by the female when she is ready to mate. The male can pick up tiny amounts of the smell wafting through the air and follows these chemical clues until he finds the female. That's some treasure hunt!

Ant antennae

NAME

Spider Ant, *Leptomyrmex rothneyi*

SUPER ANATOMY

Taste-tester antennae

SUPER SKILL

Ants have elbow-shaped antennae that can ‘taste’ chemicals all around them – on the ground, on objects, or even on other ants. When two ants meet, a quick ‘lick’ with their antennae tells them whether they have met a friend from the same nest, or an enemy from a different one.

> **ASSIGNMENT:**
> Next time you’re outside, have a close look at an ant as it walks. It will be constantly tapping its antennae to the ground, tasting the environment. Would this be a useful skill for humans?

MOUTHPARTS

Most insects feed with a set of mouthparts that chew solid food. Within these mouthparts is a set of toothed jaws called mandibles – and these can sometimes look pretty crazy. Not all mandibles are used for feeding. Some are used as weapons. Scientists have observed that many insects have graduated from eating solids to sucking up liquids such as nectar, plant sap, or the pre-digested soupy insides of their prey.

Jaws of steel

NAME

Wallace's Longicorn Beetle, *Batocera wallacei*

SUPER ANATOMY

Powerful chewing mandibles

SUPER SKILL

Warning! This operative is armed and dangerous. The longicorn beetle's massive jaws look like something you might use to cut sheet metal, but it uses them for chewing through wood. Don't try to pick one up if you want to keep your fingers.

The fastest jaws in the west?

NAME

Dracula Ant, *Mystrium camillae*

SUPER ANATOMY

Super-fast snapping mandibles

SUPER SKILL

Dracula ant jaws can snap shut at a speed of 320 kilometres per hour, so stand back! This ant uses its jaws to tear apart other insects that attack its colony.

Totally tubular, dude!

NAME

Vine Hawk-moth, *Hippotion celerio*

SUPER ANATOMY

A long, hollow, coiled proboscis

SUPER SKILL

Hawk-moths can sip nectar from flowers while hovering in flight. This is because they have a very long proboscis. In fact, a hawk-moth from Madagascar holds the record for the longest proboscis in the world – 28.5 cm long! Being able to refuel on the go is a great skill for any operative in the field. When they're not feeding, the proboscis is tucked safely away in a tight coil under the head.

LEGS

Insect legs are like the attachments of a Swiss Army knife. Standard legs are for walking or running, but there are fancy 'upgrades' for all sorts of tasks – toothed grabbers to capture prey, flattened oars for swimming, and muscly legs for jumping. These operatives have all been upgraded.

ASSIGNMENT:

Next time you're outside, have a close look at an ant as it walks. It will be constantly tapping its antennae to the ground, tasting the environment. Would this be a useful skill for humans?

Holy mole cricket, Batman!

NAME

Mole Cricket, *Gryllotalpa* sp.

SUPER ANATOMY

Shovel-like front legs

SUPER SKILL

Mole crickets have powerful, shovel-like front legs for excavating underground burrows – just like the mammals they are named after. This operative is a little eccentric, but he gets the job done.

Fearsome front legs

NAME

Hooded Horror Mantid, *Tamolania atricoxis*

SUPER ANATOMY

Spiny front legs for grasping and holding prey

SUPER SKILL

The hooded horror mantid has special front legs that strike out at super speed to grab its prey. The victim is held tight between two rows of spines with no hope of escape.

Backstroking backswimmers

NAME

Backswimmer, *Anisops* sp.

SUPER ANATOMY

Long, oar-like hind legs

SUPER SKILL

Backswimmers use their long hind legs to swim backstroke upside down. These underwater bugs are like miniature row boats propelling themselves through water. You may have already seen one in a swimming pool or a lake.

WINGS

Insects did something very special 400 million years ago – they evolved wings. Being able to fly is a game-changing superpower. However, only adult insects can fly. Most have two pairs of wings, and a few have one pair. Some insects lost their wings altogether or never had them in the first place, but it hasn't held them back from completing their missions!

Two wings not four

NAME

Cranefly, *Leptotarsus regificus*

SUPER ANATOMY

Rear wings converted to gyroscopes

SUPER SKILL

Like all true flies, craneflies use only their front pair of wings to fly. Their rear pair are tiny dumbbell-shaped organs called halteres. These act like gyroscopes and are packed with sensory organs that tell the fly where its body is in space as it flies.

A double cloak of invisibility

NAME

Saturniid moth, *Syntherata escarlata*

SUPER ANATOMY

Wings covered in double camouflage scales

SUPER SKILL

The scales on this moth form camouflage patterns that hide it from hungry birds during the day and absorb the ultrasonic calls of hunting bats at night. This makes it almost invisible to both types of predators – a real-life invisibility cloak!

Origami wings

NAME

Rove beetle, *Actinus imperialis*

SUPER ANATOMY

Intricately folded hind wings

SUPER SKILL

Rove beetles can secretly tuck their large hind wings under their tiny front wings by folding them origami style. It's a bit like having an aeroplane in your pocket. All beetles have two pairs of wings. The rear ones are for flying and the front ones are thick protective covers.

ABDOMEN

The insect abdomen is basically a tube of segments laid end to end – think of a column of Lego blocks. Most of the digestive system and reproductive organs are inside. Adult insects never have legs on their abdomen but many insect larvae, such as caterpillars, have fleshly leg-like structures called prolegs. Many female insects have a special egg-laying device called an ovipositor near the tip of their abdomen. Also at the tip, there is often a pair of sensory structures called cerci.

Boom box butts

NAME

Double Drummer Cicada, *Thopha saccata*

SUPER ANATOMY

Sound-producing abdomen

SUPER SKILL

Male double drummer cicadas make sound by quickly buckling plates on their abdomen. Cicadas are the loudest insects. Some can pump out more than 100 decibels of sound at close range. That's louder than a lawnmower! When they cluster together on trees, the wall of noise is loud enough to confuse their enemies and send them packing!

Moth caterpillars beware!

NAME

Giant Wood Moth Parasitic Wasp, *Virgulibracon endoxylaphagus*

SUPER ANATOMY

Very long, egg-laying drill

SUPER SKILL

This female wasp reaches the best place to lay her eggs by drilling through the wood of gum trees using her amazingly long egg-laying tube – a process that can take hours. She lays her eggs inside Giant Wood Moth caterpillars that live in tunnels deep within gum trees. When the eggs hatch, the wasp larvae feed on the caterpillar eventually killing it. What sneaky sabotage!

Cockroach motion detectors

NAME

Australian Cockroach, *Periplaneta australasiae*

SUPER ANATOMY

Wind-sensitive hairs

SUPER SKILL

The Australian cockroach has a sensory superpower at the tip of its abdomen. It's a pair of structures called cerci that have fine hairs that are sensitive to air currents. The puff of air created by opening a door is their cue to skiddoo. Now you know why these operatives always know when you're coming!

INSECT PLANET

Now, let's get down to business. These buzzing, flying, swimming and crawling critters are everywhere – in jaw-dropping numbers and species, and in a mindboggling variety of shapes and sizes.

More insects live on Earth than any other kind of animal – 5 to 10 million different insect species. We think there are about 10 quintillion (1 000 000 000 000 000 000) individual insects on the planet at any given time! So, really, we're living on their planet.

Our mission here at the Insect Agency is to identify and understand as many of them as possible. Even though some may look a bit alien, these six-legged superheroes have been quietly working hard for the planet for hundreds of millions of years.

Beetles, more beetles, and even more beetles

Beetles are the most diverse group of special operatives – I mean insects – in the world. Almost half the world's named insects are beetles. That's about 400,000 different species,

some as small as a third of a millimetre, and others as big as 19 centimetres. Australia has more than 25,000 beetle species that we've named so far.

Here's a selection of beetles from around the world. What differences can you see between them?

Biodiversity in the 'burbs

Not all our insect operatives live in lush, tropical rainforests. Many prefer other environments – even deserts and busy cities. Over 60 species of ants alone were found in one Brisbane garden. If you look closely, you'll spot dozens or possibly hundreds of insects working hard in your backyard or local park. How many can you find?

Why are there so many insects in Queensland?

Many of the insect operatives we research work in Queensland. This is because it's a big state, and it offers them many of their favourite habitats. Almost three-quarters of Australia's 450 or so butterfly species live here. Many of these operatives enjoy the rainforest lifestyle that Queensland offers.

INSECT SUPERPOWERS

One of the most fascinating types of research we do at the Insect Agency is to look at how insect superpowers could be used in other ways. Our teams have spent many years studying our operatives' remarkable abilities. Now some scientists are copying insect superpowers (we don't think they mind) in order to develop new technologies and solve design challenges in the human world. This type of research is called 'biomimicry'.

DRUGS FROM BUGS

NAME

Mottled Cup Moth Caterpillar, *Doratifera vulnerans*

LOCATION

Northern and eastern Australia and south-west Western Australia

SUPERPOWER

Stinging spines armed with complex venom

BIOLOGICAL CHALLENGE

Staying safe while feeding and exposed on a leaf

POTENTIAL APPLICATION

Special properties in venom to make medicine

This brightly coloured caterpillar is prepared for chemical warfare. It protects itself from predators with clusters of short, hollow spines that inject a stinging venom. Researchers at the University of Queensland in Brisbane have found that the venom is made up of 151 different toxins. Some of these toxins may have antibacterial properties or the ability to kill parasites in cattle.

ANTIBACTERIAL INSECT WINGS

NAME

Clanger Cicada,
Psaltoda claripennis

LOCATION

Eastern Queensland and
north-east New South Wales

SUPERPOWER

Bacteria-killing wings

BIOLOGICAL CHALLENGE

Preventing bacteria and microbes from fouling their wings

POTENTIAL APPLICATION

Making antibacterial surfaces

Have you ever looked closely at a cicada's wing? They may look smooth, but they are covered by a vast carpet of blunt spikes called nanopillars. The spikes are about 200 nanometres high. A nanometre is one billionth of a metre, and 200 nanometres would be about 1/500th of the thickness of a sheet of paper. When bacteria settle on the wings, the nanopillars pull the cells apart, breaking their membranes and killing them.

A team of scientists at RMIT University in Melbourne have managed to 3D-print similar bacteria-killing nanopillars onto the surface of plastic. Antibacterial plastic packaging will stop food from going bad and make it last longer on the shelf.

SUPER-VISUAL TRACKING

NAME

Tau Emerald Dragonfly, *Hemicordulia tau*

LOCATION

Occurs throughout Australia, except in the far north

SUPERPOWER

Rapid visual processing system for tracking moving objects

BIOLOGICAL CHALLENGE

Tracking and catching flying insect prey

POTENTIAL APPLICATION

Visual navigation systems for autonomous drones and robots

Dragonflies are some of our most deadly operatives. They can pluck flying insects out of mid-air. They are highly efficient hunters that catch their prey nearly 100% of the time.

The key to their success is their vision. They process images much faster than we can, and they can focus on a single moving object while ignoring all other distractions. When hunting among a swarm of prey, they 'lock' onto one target like it's the only one that exists. Scientists at the University of Adelaide copied the dragonfly's visual tracking ability to develop much faster and better ways to control autonomous drones.


0.5 mm

PHYSICS OF BUTTERFLY COLOURS

NAME

Ulysses Blue Butterfly,
Papilio ulysses

LOCATION

North-eastern Queensland, New Guinea, Solomon Islands, Indonesia

SUPERPOWER

Light-absorbing, ultra-black wing scales

BIOLOGICAL CHALLENGE

Making the bright blue colours stand out

POTENTIAL APPLICATION

Making cheaper and better solar panels

Male Ulysses Blue butterflies have intense blue patches on their wings and have always been one of our better-looking operatives. The colour is produced by the special microscopic structure of thousands of overlapping scales that reflect blue light. The blue areas appear brighter because they are surrounded by velvety, ultra-black patches. The scales in these patches are black but also have a distinct microscopic structure that helps them absorb light. Copying the structure of these scales may provide cheaper and better light-absorbing surfaces for solar panels.

SPECIAL OPERATIONS

Now that you've met some of our operatives and know how to identify them, it's time to enter the Special Operations Headquarters of the Insect Agency.

Here you'll find case files revealing what various insects are doing while we're not watching – the secret missions I've mentioned. We've uncovered some amazingly useful things that insects do to keep ecosystems healthy. In fact, our planet would be doomed without these tiny cleaning, greening, feeding machines!

Feeding the Planet

What would you say if I told you that insects are a tasty snack? Many animals – including spiders, scorpions, centipedes, freshwater fish, frogs, reptiles, birds and mammals – eat insects. In fact, some animals feed on almost nothing but insects. We call these insect-feeding specialists 'insectivores'.

By being eaten and eating so much themselves, insects are the glue that holds food webs together. They eat dead vegetation and animals, fungi, plants, and even each other.

Here at the Insect Agency, we've started looking at insects a little differently. Have you ever tried a salted cricket? Our researchers love them for morning tea.

FEEDING HUMANS

For some, the thought of eating insects is gross, but people have been doing it for as long as humans have lived on Earth. Around the world, two billion people in 130 countries eat insects. Don't worry; eating insects won't stop them from doing their valuable work. Remember, there are quintillions of them!

TRADITIONAL FOOD SOURCES

First Nations people used their traditional knowledge of insects to access important food sources. More than 60 insect species have been documented as traditional foods for Indigenous Australians.

Bogong Moth *Agrotis infusa*

Each year Bogong moths migrate to the high country of the Australian Alps and cluster in their millions in caves and rock crevices. Aboriginal groups gathered in the mountains to feast on the moths, which are a good source of fat and protein despite being only about the size of a peanut. Various methods are used to prepare the moths, including cooking them in a fire and eating them whole, grinding roasted moths into a paste (which could then be smoked and preserved), or turning them into cakes.

However, the number of Bogong moths has declined over the past 40 years – partly due to humans using more chemicals that are harmful to insects. But other factors, such as climate change, light pollution from our cities, drought, and introduced predators like foxes and pigs also contribute. There are signs

that moth populations are recovering, but these insects face an uncertain future unless we look after them and their habitats.

Yeperenye caterpillar, *Hyles livornicoides*

Before Europeans arrived on this continent, Yeperenye (pronounced yep-a-ren-ya) caterpillars were an important food source for the Arrernte people of central Australia. They buried the insides of the caterpillar in the ground and then cooked the rest of the body in a fire before eating them. The caterpillar is the larval stage of a species of hawk-moth. The Yeperenye caterpillar is sacred and is the most important ancestral being for the Arrernte people.

Stingless Sugarbag Bee, *Tetragonula carbonaria*

The name ‘sugarbag’ refers to several species of Australian native bees. But unlike some bees, sugarbag bees don’t sting. They make their hives (or nests) in the hollows of gum trees, in rock crevices, or in the ground. The honey they make inside the hive is highly prized by First Nations people, and the method of locating the hives – tapping trees to see if they are hollow or listening for a buzzing sound – is told in Dreaming stories, songs and ceremonies. Sugarbag honey can also be used medicinally as an antiseptic, eye wash, or to treat skin problems.

BUG APPÉTIT

The number of people on Earth keeps getting higher and higher, which means we need more food to feed us all. So, one of our tasks at the Insect Agency is to look at finding sustainable food for everyone.

Perhaps eating insects is the answer – after all, they're full of protein, and they need less land, energy and water to grow than other types of food.

Not convinced? Think of it this way – do you like lobsters, prawns and crabs? These are all types of crustaceans. Insects are basically a group of crustaceans that successfully colonised the land. Maybe we just need to think of insects as land lobsters.

So are you ready to crunch on a cricket? Or munch on a mealworm? Many people are. In fact, more than half the people surveyed by RMIT University in Melbourne said they would be likely to eat insects in the future.

CLEANING THE PLANET

Recycling is very important to the Insect Agency, and insects are some of the best recyclers around. Our research field agents have discovered that a large group of insects break down plant and animal matter because they feed on dead wood, dead bodies and dung. But insects do far more than just keep the place tidy. They also release and recycle nutrients in their food, making these nutrients available to plants and other animals. Take note, recruits – our insect cleaners are little marvels!

DEAD WOOD

Decomposing dead wood is tough, but thankfully some insects are really good at it. Wood is made of complex molecules that are difficult to break down. In some environments, it can take more than 100 years for fallen trees to decay. The rotting process is often kickstarted by fungi, but many insects help break down dead logs, branches and twigs.

Termites

Termites get a bad rap because they eat the wood in our homes – but they are only doing what comes naturally. Instead, let's look at some of the positive things they do.

Many termite species have microorganisms in their gut that produce the enzymes that allow them to digest wood. Some termites can even produce the enzymes themselves.

Although many people think of these insects as home wreckers, Insect Agency researchers have uncovered their role as homemakers for our native animals. In eucalypt forests, termites hollow out trees that are then used by reptiles,

mammals and nesting birds. Some native kingfishers and parrots build their nests inside termite mounds, both on the ground and up high in the canopy.

Wood cockroaches and family beetles

Have you ever walked past a large rotting log in the rainforest? It doesn't look like much is happening, but inside there might be families of insects breaking it down from within. Even in moist rainforests, logs take years to decompose – plenty of time for colonies of wood cockroaches and family beetles to thrive in their assignment.

CLEANING UP THE DEAD

We should be grateful to insects for cleaning up the bodies of dead animals. Otherwise, we'd have a very smelly planet. At the slightest whiff of decay, insects are on the job.

The first ones to turn up are blow flies and flesh flies, whose maggots thrive in the early 'liquid' phase of decay. As the carcass begins to dry out, a series of different flies, beetles and moths move in. The last to arrive are the insects that feed on dried-out skin.

This predictable sequence allows special entomologists, called forensic entomologists, to estimate a body's time of death. Insect missions have all sorts of applications for us. This is just one reason why we study them.

First on the scene: blow flies and flesh flies

Flies are the first insects to arrive at a carcass. Their antennae are super sensitive, picking up the odour of gases released by bacteria that have started to break down the body. They lay lots of eggs that hatch into fast-growing maggots. The body becomes a writhing mass of maggots living in a sea of their own digestive juices.

Cheese Skipper, *Piophila casei*

As the body dries out, a cheesy odour wafts from the carcass during the later stages of decomposition. Cheese flies are attracted to the smell, and their small maggots feed on what flesh remains. In some parts of the world, cheese fly maggots are intentionally added to cheese to create a pungent delicacy.

Hide Beetles, *Dermestes* species

Hide beetles are late-arriving species whose larvae feed on tougher parts of the body, like the skin and tendons, as it dries out. Natural history museums often keep colonies of hide beetles to help them clean up skeletons.

DUNG

Poop. Many animals just drop it and leave...and someone has to clean it up. Our specialist operatives known as dung beetles are some of our hardest workers. They don't actually eat the dung, but they do enjoy sucking up its juices. They also use dung as food for their larvae. Female dung beetles roll balls of dung and lay an egg inside each one. The balls are then buried in the soil or stashed in grass clumps. Once again, what's good for the beetle is good for the earth. Dung beetles help the soil by burying nutritious poo and aerating it with their burrowing. Australia has almost 400 different species of native dung beetles. In fact, Queensland Museum has the world's best collection.

Onthophagus muticus

Dung beetles love fresh dung and want to be first at the poo pile. A few species, such as *Onthophagus muticus*, have an unusual strategy. These beetles have special claws that allow them to hang onto the hairs around the butt of kangaroos and wallabies. As soon as these animals poo, the beetles let go and drop to the ground with it.

Onthophagus dandalu

These brightly coloured dung beetles are especially attracted to dog poo in suburban areas. How wonderful! They help keep our backyards free of doggy doo. In open forests, these dung beetles also use and bury native mammal dung.

GREENING THE PLANET

It's true that some of our insect operatives eat plants – you might have seen caterpillars munching through leaves and, of course, caterpillars grow up to be butterflies and moths.

But plenty of other insects help plants grow. For example, burrowing insects improve soil for plants by making it crumbly, which allows water to seep through more easily. Some insects kill plant-eating insects, helping to keep their populations down. Then there are the insects with a very intimate relationship with plants – the seed spreaders and pollinators.

POLLINATION

Did you know that without insects there would be no chocolate? That's right. Insects pollinate the cocoa bean flower, meaning that they take pollen between flowers so that the plants can make seeds and reproduce.

In fact, many of our food crops rely on insects to pollinate their flowers, including fruit and nut trees, berries and vegetables. If all the insect pollinators disappeared, we wouldn't have much variety in our diet, and we would struggle to produce enough food for everyone.

Therefore, we need to make sure that nothing stands in the way of these operatives completing their assignments.

BEES

Pollination is such an important job for some of our insects – especially bees. Bees are some of the most efficient pollinators of flowers. They are very hairy operatives, which is quite useful as pollen grains stick to them easily. They gather up the pollen with comb-like structures on their legs. Most bees will then carry the pollen to the nest on their back legs, although some will store it underneath their abdomen, and others swallow it and store it in their gut.

Bees evolved to become vegetarian, using the pollen they gather from flowers to feed their larvae. There are around 20,000 species of bees worldwide and probably more than 2,000 Australian species. The Queensland Museum Network has one of the largest collections of Australian bees. They have thousands of specimens of hundreds of different species!

Black and Yellow Carpenter Bee, *Xylocopa aruana*
This is one of Australia's largest native bees. Like most of our native species, it is a solitary bee, meaning that it doesn't live in a hive. Instead, each female bee makes her own nest by tunnelling into soft wood or a plant stem. Some plants have flowers that need special buzz pollinators like carpenter bees.

The pollen is often held inside tubular structures that have an opening at one end. The female bee grabs onto the flower and vibrates her wing muscles, making a buzzing noise. This shakes the pollen grains loose.

Euryglossine Bee, *Euryglossa clypearis*

This is one of Australia's smallest native bees – only a couple of millimetres long. It belongs to a group of bees that are only found in Australia. Most bees in this group are pollinators of eucalypts and their relatives, plants in the family Myrtaceae. Some of them are so specialised that they only visit the flowers of one species of plant. Euryglossine bees swallow pollen and take it back to their nests. It's mixed with nectar and carried in a branch of their gut called a crop.

Leafcutter Bee, *Megachile macularis*

Leafcutter bees are often distinguishable by their yellow bellies. Females carry pollen back to their nest underneath their abdomen, attached to a thick layer of hairs. Leafcutter bees make their nests with pieces of soft leaves. They cut them out using their jaws, leaving neat oval and circular holes. Check the plants in your garden or park for their calling cards. They really like rosebushes.

ANTS SPREADING PLANTS

Spreading plant seeds is a key mission for some ants. More than 3,000 plant species have seeds designed to be spread by ants, and around half of them are from Australia.

These seeds are tempting to ants because they have a special fatty attachment on them called an elaiosome. Ants like to feed this fat to their larvae.

Ants carry the seed to their underground nest, chew off their reward and leave the seed underground, nicely planted in fertile soil and away from fire or animals who might eat it up.

ECOSYSTEM ENGINEERS

Ants and termites are highly specialised operatives. They are our ecosystem engineers. In hotter and drier climates, they're better than earthworms at helping soil become more fertile.

Ground-nesting ants and termites excavate large amounts of soil. Their underground tunnels aerate the soil and allow water to trickle down, which helps plants grow stronger.

Giant Bull Ant, *Myrmecia brevinoda*, nest

This huge 'sculpture' is an aluminium cast of the internal structure of the nest of the Giant Bull Ant, *Myrmecia brevinoda*. It shows the extent of the hidden underground earthworks performed by ants. A nest this size would be home to two to three thousand worker ants and a single queen. Workers of this species range from 13 to 36 mm in length – the largest are some of the longest ants in the world. But it's the smaller workers that would have done most of the digging to produce the subterranean tunnels and chambers.

MISSIONS

Mission 1

Too Much Poo

Bury more than 30 million tonnes of poo each year

Agent: Overseas dung beetles

Details:

About 50 years ago, Australia had a poo problem. More than 25 million cattle were leaving large, sloppy dung piles on pastures. This allowed lots of pest flies to breed. Unfortunately, our native dung beetles weren't up to the challenge of cleaning it up, so dung beetle species from overseas were brought in to assist. CSIRO led this spectacularly successful project from 1967 to 1985. Several introduced species of dung beetle settled into the Australian climate and got comfortable, and they now live in most parts of the continent. However, some areas didn't offer a suitable environment for these international operatives. So, in the last 10 years, a few extra dung beetle agents have come on board to fill in the gaps.

Mission 2

Seek and Destroy Invasive Weeds

Australia has a weed problem. About 15% of our plants have come from overseas, and around one quarter of those can seriously invade our natural environments. So, here at the Insect Agency, we carefully collect insects that are natural enemies of the target weed and release them to seek and destroy invasive plants. Over 200 biological control agents, most of them insects, have been released in Australia to control over 70 weed species. Unfortunately, only about a third of these weeds are successfully controlled, so there's more work to do.

> **ASSIGNMENT**
>
> Identify a weed in your backyard or local park. Research its natural enemy. What insect could best control it?

Case 1
The Original and Still the Best?

AGENT NAME

Cactoblastis Moth,

Cactoblastis cactorum

TARGET NAME

Prickly Pear, *Opuntia* species

BACKGROUND INFO

By the 1920s, prickly pear – a type of cactus that is a weed in Australia – had taken over more than 24 million hectares in New South Wales and Queensland. That's an area bigger than the whole of Victoria! Australia has no native cacti, so 'prickly pear' is actually a collective term used for several varieties of pest cacti that have been introduced from overseas – mostly a species called Opuntia. But pricky pear made the land unusable for farming or growing food, and many landowners simply walked away from their prickly properties.

SOLUTION

Cactoblastis Moth to the rescue. This South American moth was released in Australia in 1926 to help get rid of prickly pear. The moth's caterpillars feed on the fleshy pads inside the plant, preventing it from spreading. By 1933, these moths had cleared around 80% of the infested land in Queensland and 50–60% in New South Wales. This was one of the first and most successful examples in the world of insects fulfilling their special mission of biological weed control.

Case 2
Unclogging the Waterways

AGENT NAME

Salvinia Weevil, *Cyrtobagus salviniae*

TARGET NAME

Salvinia, *Salvinia molesta*

BACKGROUND INFO

Salvinia (*Salvinia molesta*) is an aquatic fern that used to be a serious weed in Australia. It formed thick mats that covered lakes and slow rivers and caused problems for boats, farming, wildlife and flood prevention. It grows very fast and can double its weight in just two and a half days.

SOLUTION

CSIRO scientists searched in south-east Brazil, the native home of salvinia, for something to help control it. Three insects were brought back to Australia for testing, but the hero turned out to be a tiny black weevil, *Cyrtobagus salviniae*. This operative was first released in 1980 at Lake Moondara, near Mount Isa in north-west Queensland. Within 15 months, these weevils cleared a 400-hectare mat (that's more than 500 soccer fields!) of salvinia, reducing more than 50,000 tonnes of plants to just 1 tonne. Salvinia is no longer a problem in Australia, and this successful agent has now controlled the weed in at least 13 tropical countries.

Mission 3

Seek and destroy crop pests

Unfortunately, some of our insect operatives are hungry for our food crops, so we've had to recruit other insect agents to destroy them. They'll eat these hungry crop pests or secretly live inside them – infiltrating the group quite literally! These biological control agents may not always be able to bring these pests down by themselves, but they are an important part of a multipronged attack we call 'integrated pest management'.

Agent

Trichogramma pretiosum – tiny wasps that pack a punch

Some of our most specialised biocontrol operatives are miniscule wasps that are parasites of insect crop pests. The wasps lay eggs either on or in the bodies of the pests. Once the eggs hatch, the baby wasps eat these pests alive, sometimes from the inside. (Sorry, recruits – it's pretty gruesome. Some of these case files can be hard to look at.) *Trichogramma pretiosum* wasps attack moth eggs. These wasps are tiny – only half a millimetre long. We can breed masses of them and unleash 25,000 per hectare, killing pests and saving our crops.


5 mm

INSECT ACADEMY

Recruits, your briefing is over. Now that you've toured our facility, I hope you appreciate the valuable work our insect operatives do to keep humans and the planet healthy.

Our team of entomologists have been hard at work unravelling the secrets of the insect world. But there's so much more to learn. If you think you can handle the challenge, I invite you to join the *Insect Academy*.

Your mission, should you choose to accept it, is to apply your new skills to these training exercises.

Bug Builder

Design, customise and name your own insect creation. Bring it to life on the big screen and share it with your friends.

Insect Sorter

Hone your identification skills by separating out the insects and classifying them into their correct groups – we call them orders.

Acknowledgments

***Insect Agency* is supported by The Entomological Society of Queensland.**

All specimens part of the Queensland Museum collection with thanks to our donors.

Specimen photography by Geoff Thompson and Lily Kumpe. All other images by Queensland Museum unless otherwise credited.

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Exhibition Design: OP Designs
Graphic Design: Goldi
Editor: Writers Without Ink
Digital interactives: Inkahoots
Ant nest casting: Australian Ant Art (Dr Christopher East and Stephen East)
Traditional Food Sources research: Joshua Waters, DeadlyScience
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Dr Elena Ivanova (RMIT)
Professor Peter (Pete) Vukusic (University of Exeter, UK)

Vale

Dr Geoffrey Monteith (1942–2024)

Geoff Monteith was a giant of Australian entomology and one of Australia's greatest collectors. He added hundreds of thousands of specimens to the Queensland Museum's collections. No one has done more to document Queensland's diverse insect fauna, so it is fitting to honour him in *Insect Agency*.

Geoff's professional journey began at The University of Queensland, where he served as the curator of their insect collection from 1966 to 1978. Geoff then joined the Queensland Museum as Senior Curator of Lower Entomology, a position he held for 27 years. After his retirement in 2006, he continued to work as an Honorary, collecting and describing species new to science and publishing research until his health declined.

Geoff's research discussed the systematics of flat bugs, the biogeography of rainforest insects, the biology and taxonomy of dung beetles, plant-insect associations and the insect fauna of New Caledonia. Geoff amassed the largest collection of Australian native dung beetles in the world — over 100,000 specimens.

He extensively surveyed the rainforest-covered mountains of Queensland's Wet Tropics region. From 1979 to 1999, he surveyed 61 different mountain summits on more than 30 expeditions, discovering many hundreds of new species of insects and other invertebrates.

As a museum curator, Geoff was dedicated to sharing his vast entomological knowledge with the public, through museum displays, books and workshops. He led many display teams and was the driving force behind the display 'Living with Insects – Friends and Foes' in 1991.

Geoff's love of insects, nature, history and science pervaded his whole life, inspiring both young and old. His collections will continue to yield new species in the future and stand as a snapshot in time as the climate changes. Only a fraction of his vast knowledge was recorded — he is greatly missed.

Right antenna of a male Emperor gum moth, *Opodiphthera eucalypti*.

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