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Do plants really need insects or is it just vice versa?

A short history of insects and plants

An extract of a presentation to the Friends of Cranbourne Botanic Gardens, By Patrick Honan, November 2014

This is a complex question with a history of about 450 million years, so only a very broad, potted glossy overview is possible. Insects appeared about 50 million years after land plants, but the relationship really took off when flowering plants appeared about 100 million years ago.

Insects have utilised plants as a food source to the best of their abilities, and plants have done everything in their power to prevent being used.
Insects will cooperate with plants where it is in their interest, and vice versa, and as long as the reward is high enough.
In extreme cases this develops into an obligate mutualism, where a species of plant cannot survive without the continued existence of a species of insect, and vice versa.

Herbivory

More than half of all insect species are herbivorous, and there are more species of plant-eating insects than there are species of plants in the world. A single eucalypt tree may support more than 100 species of herbivorous insects.
Many insects are monophagous but some will feed on more than 150 plants species; however, ninety percent of all herbivorous insects feed on plant species within three plant families or fewer. In any given habitat, the amount of plant material eaten by insects is 3-4 times that eaten by mammals.

A female Goliath Stick Insect (*Eurycnema goliath*) tucking into a eucalypt leaf

Defences

Given the amount of plant material available on earth, it's no wonder it's such a heavily utilised resource. But a remarkable amount of it remains uneaten, due to:

- Plants being very low in protein – although some plants are up to 20% protein, much of it is not the right sort needed by animals, and insects are protein-rich;

- The majority of a plant is generally low in nitrogen – xylem is 0.05% and wood is 0.3% nitrogen (although new growth is generally high in nitrogen);
- Much of the plant is low in water (particularly bark, wood and seeds) and insects that feed on these must find other water sources;
- Cellulose is indigestible to all but a few insects (eg silverfish and termites);
- Silica in grasses is not only indigestible but wears down the mouthparts;
- Plants are low in sodium, requiring butterflies for example to find sodium elsewhere and concentrate it in their bodies
- Secondary defensive compounds (at least 100,000 different types), which can be antifeedants or feeding deterrents, or block an insect's ability to extract nutrients, or simply act as toxins.

A male Common Crow Butterfly (Euploea core) absorbing nutrients from animal dung

To help them digest the sea of plants amongst which they live, many insects support a range of gut flora or house micro-organisms (often in mycetomes on their bodies).

Defences by herbaceous plants

Short-lived herbaceous plants defend themselves against being eaten by apparency, or lack thereof. They are difficult to find and, once found, die back before the insects can build up a large enough population to take advantage of them. They are often pioneering after cyclones or fires, and then disappear, or grow rapidly from the base with a high tissue turnover, or contain silica (eg grasses).

Many use complex toxins (such as alkaloids and cyanogenic glucosides), and the rarest toxin is the most effective. If any particular compound becomes too common it will attract a larger number of specialists able to detoxify it, which is a disadvantage to the plant that produces it.

As a rule, generalist herbivores cannot live on these plants because it takes a specialist to adapt to the toxins, and specialists struggle because these plants can be hard to find and the specialist, by its nature, can feed on little else. Birdwing butterflies are a good example, feeding only on plants of the one genus (*Aristolochia*).

Wanderer Butterfly caterpillar (*Danaus plexippus*), also known as the Monarch, feeding on *Gomphocarpus cancellatus* (formerly *Asclepias rotundifolia*)

Many of the chemicals are not only toxic to the insects, but to the plants themselves, and so are localised in specialised glands or pockets. As a side issue, many insects that specialise on a toxic plant host adopt (sequester) the toxins and use them for their own defence (birdwings, Wanderers, sawfly larvae) or even as sex attractants, aggregation pheromones or moulting hormones.

In some cases, insects (eg arctiid moths) may use compounds (eg cardenolides) from plants of one family (eg Asclepiadaceae) for defences, and other compounds (eg pyrrolizidine alkaloids) from plants of another family (eg Boraginaceae) for aphrodisiacs and flight arrestants. Although this is rare.

Defences by large trees

Trees are large enough to support generations of insects, giving the insects time to adapt to the trees' toxins, and they often grow in forests where trees of the same species are readily available and cannot hide – they are highly apparent.

These trees don't rely so much on toxins, which may be overcome by the insects, but on digestibility-reducing compounds such as tannins and on gums and resins. Although not particularly toxic, they slow development, reduce the number of generations of insects possible over time, increase the insects' exposure to predators, and increase the energy required to consume the plant – about the equivalent of the energy required to find less apparent plants.

Trees in seasonal areas produce a flush of growth which, combined with the above compounds, overwhelm the insects with too much food to be consumed in one sitting.

Some trees, such as eucalypts, supplement their digestibility-reducing compounds with extra toxins in their young leaves, and reduce the ability of insects to adapt to these toxins by ensuring each tree produces a slightly different toxin through genetic heterogeneity (outcrossing). Genetic variation is extremely important, resulting in individuals with the same parents exhibiting widely different levels of insect resistance (eg Jarrah (*E.marginata*) to the Jarrah Leaf Miner (*Perthida glyphopa*)).

The level of toxicity in eucalypts, and the importance of coevolution, is demonstrated by the lack of introduced insect species that have adapted to them in Australia, and the dearth of insects that attack eucalypts overseas.

Eucalyptus Leaf Beetle larvae (*Paropsis* species) feeding on their favourite plant

Despite the toxicity of eucalypts, some groups such as leaf beetles (eg *Paropsis atomaria*) are completely immune, almost regardless of the level of compounds. The number of 'eucalypt' species in Australia (more than 400) is possibly due to the arms race between this group of trees and leaf beetles (Family Chrysomelidae).

Try going into a stand of eucalypts and finding a single leaf undamaged by insects – it's an exercises that can take a very long time. Many native insect species can defoliate and kill entire eucalypt forests, such as Spur-legged Stick Insects (*Didymuria violescens*), Jarrah Leafminers (*Perthida glyphopa*), sawflies (*Perga* species), Christmas Beetles (*Anoplognathus* species) and Eucalyptus Lerps (*Cardiaspina albitextura*). The grazing pressure is often such that competitive exclusion is prevented – no one species of eucalypt can dominate all others.

Christmas Beetle, *Anoplognathus* species

Eucalyptus Lerps (*Cardiaspina albitextura*), perhaps the best studied native insects in Australia

Acacias, probably older than eucalypts, are even more species rich with a wider array of defences (eg extra floral nectaries and myrmeconia), with very high levels of defensive tannins and gums.

Another method of defence is to attract the predators or parasites of herbivorous insects. Some plants do it through recruiting ants to defend their leaves (myrmeconia) or with extra floral nectaries.

Physical barriers such as waxes and hairs, especially hooked hairs that impale, or sticky hairs (glandular trichomes) or other substances that trap small insects tend to be present in lieu of toxins. And lignin, silica and corky tissue in the wood, or tough compounds in the leaves, may wear down insect mandibles.

<u>Communication</u>

When under attack, many of the defensive compounds produced by plants are highly volatile and are released into the air to be detected by other plants, which then begin producing defensive compounds of their own, in preparation for attack.

It's unlikely that the plant under attack is warning its nearby conspecifics or competitors – it's more likely that other plants are 'eavesdropping' and preparing their own defences in advance. These compounds are not always species- or even family-specific – a given plant will pick up on chemicals from a range of other plant species.

These compounds are also picked up by parasitic wasps and some insect predators, which use them to hone in one plant which support their host caterpillars.

For some time there has been evidence that plants communicate with each other through vibrations, nanochemical oscillations generated from within the cells. Again it's not so much communication with each other, but plants reacting to the presence or activities of other nearby plants. Recent evidence suggests the same mechanisms used to 'hear' vibrations are also designed to detect the sound of insects' chewing, which then primes the plant with defensive chemicals in preparation for attack. The same response occurs when researchers record and replay the sounds of caterpillars chewing even in the absence of the caterpillars themselves.

Leaf chewers

- Mouthparts point down, mandibles equipped with ridges to help with tearing and shredding;
- Problems caused: Reduce the leaf area available for photosynthesis, and sometimes cause defoliation leading to the death of a plant.

Tortoise Beetle (*Aspidomorpha deusta*) on a native *Ipomoea* species.

Leaf miners

- Mouthparts point forward rather than down, to give them a lower profile inside the leaf mines;
- Problems caused: Destroy leaf tissue and reduce the photosynthetic capabilities of individual leaves.

Sap suckers

- Mouthparts modified into a syringe;
- Two types of saliva – one is injected into the leaf and hardens to form a sheath around the entry hole, the other breaks down plant tissues;
- Mostly hemiptera – true bugs (aphids, cicadas, whitefly, planthoppers);
- Problems caused: May cause actively-growing shoots to wilt and die, premature ageing of leaves followed by leaf fall and reduce overall plant vigour.

An unidentified leaf-mining moth caterpillar

Gall makers

- Generate chemicals that cause the plants to produce hormones which change the growth of the leaf or stem, producing large and often bizarre growths that protect the insect and can also be diagnostic;
- The inside layer of the gall is made of protein- and carbohydrate-rich cells and the outer layer of thick-walled indigestible cells, making the inside highly nutritious and the outside protective;
- Include thrips, aphids, beetles (weevils), moths and, mostly, wasps and flies. About 70% of the gall making insects belong to Cecidomyidae (flies) and Cynipidae (wasps). A single oak tree overseas may be host to half a million cynipid gall wasps;
- Problems caused: Consume energy that would otherwise be available to the plant – generally not a major problem but some plant species can be destroyed by galls in some circumstances.

Seed eaters

- Seeds are high in fats and proteins, and are relatively easy to find by seed predators, particularly before being dispersed. Many seed predators are specialists, focusing on single species or a group of species, and often localised;
- One of the most effective plant defences against seed eaters is unpredictable seed set;
- Problems caused: Destroy the seed at any stage of development, including after being expelled by the plant, and reduce the number of offspring.

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Melbourne Urban Bioblitz
Fitzroy Gardens, Royal Park, Westgate Park

Wood borers

- Insects such as the introduced Sirex Woodwasp larvae bore into the heartwood and introduce a fungi (*Amylostereum areolatum*) into the tree to help digest cellulose;
- Jewel beetles lay their eggs newly killed wood, and zone in on heated trees during and after a bushfire. They can detect wood smoke and infrared radiation, but also bear heat sensing organs behind their second pair of legs, small pockets of water containing 70 sensillae. An oil fire in the US in 1925 attracted thousands of jewel beetles from more than 130km away;
- Problems caused: Interrupt or destroy the flow of nutrients through the tree, which can be exacerbated by fungal infections, and cause structural damage.

Wood-boring larval damage to a eucalypt trunk

Root feeders

- The effect of root feeders is often underestimated, their efficacy demonstrated by their success as biological control agents;
- Problems caused: Root feeders reduce a plant's ability to absorb water and in many species their ability to fix nitrogen. This often aids the effectiveness of foliage-feeders on the same plant, further damaging the plant.

Plants as insectivores

Four different designs are used:

- Sticky traps – eg *Byblis* and *Drosera*
- Steel traps (Venus fly trap-type) – eg *Aldrovanda vesiculosa*
- Mouse traps (a door opens when hairs are triggered and the insect is sucked into a bladder) – eg bladderworts such as *Utricularia*
- Pitfall traps – eg *Cephalotus follicularis* and *Nepenthes mirabilis*

Four families of plants in Australia feed on insects:

- Pitcher plants (Nepenthaceae)
- More Pitcher plants (Cephalotaceae)
- Sundews (Droseraceae)
- Bladderworts (Lentibulariaceae).

Additionally, at least one group of fungi (*Cordyceps*) kill burrowing insects.

A Hepialid caterpillar infected with Cordyceps species, from the Museum Victoria entomological collection.

Plants dispose of insects in other ways as well:

- Some plants, such as *Pisonia grandis*, have sticky seeds that trap and kill insects;
- *Lomatia* (Proteaceae) is bird-pollinated and apparently has toxic flowers that kill insects;
- The flowers of other plants, such as *Pterostylis* and *Asclepias*, appear to trap and even kill insects such as blowflies and Cabbage White Butterflies, but the purpose of this is unclear and perhaps accidental.

Ant plants

The best known ant plant is *Myrmecodia beccarii*, which houses the ant *Iridomyrmex cordatus*, in which the ants not so much protect the plant but produce nutrients in the chambers that are absorbed by the plant, normally growing in nutrient-poor soils.

The NQ rainforest tree *Endospermum formicarum* not only hosts the ant *Camponotus quadriceps*, but provides extra floral nectaries so that the ants never need to leave the tree. In return the ants protect the tree against both insects and vertebrate herbivores.

Australia doesn't have the swollen-thorn acacias of other continents, where the ants not only aggressively defend the tree but cut away encroaching plants, but some species of ants such as *Crematogaster* and *Myrmecorhynchus* do similar jobs in Australia.

Pollination

What is it?

Pollination in the classical sense involves an insect gathering pollen from the flower of one plant, then transferring it to the flower of another plant of the same species, thereby fertilising the flower, resulting in a seed(s). As a reward for this service, the flower provides nectar.

A daisy being pollinated by the Drone Fly (*Eristalis tenax*)

History

Many of the earliest gymno-sperms and angio-sperms were pollinated by beetles, probably incidentally as they moved from flower to flower seeking insect prey, and many of the most primitive groups are still pollinated by beetles today. The plants produced excess pollen, a caloric rewards for the pollinators, and only later did flowers begin producing nectar, encouraging the evolution of bees. The two Australian species of *Eupomatia* (and sole members of the Eupomatiaceae) are still pollinated by beetles in this way (*Ellechodes* weevils).

The two biggest groups of pollinators, Diptera (flies) and Hymenoptera (ants and wasps), evolved well before flowering plants appeared, but Lepidoptera (butterflies and moths) and Apoidea (bees) much later.

Today about 80% of plants are pollinated by insects (and the rest are mostly grasses (Poaceae) and conifers). Pollination by insects can be extremely wasteful, but generally not as wasteful as wind pollination.

As far as most insects are concerned, pollen gathering is irrelevant to them – they are simply after the nectar reward.

Plants offer the minimum reward that pollinators require to get the job done. Some plants attract generalist pollinators by producing masses of flowers and large quantities of nectar for a short period, with little guarantee that pollinators will visit other plants of the same species. Other plants can be inconspicuous and occur at low densities, producing small amounts of nectar of longer periods of time, if they are pollinated by specialists.

Pollinator constancy

One problem faced by plants is ensuring that a visiting insect then takes its pollen to another member of the same plant species, rather than wasting pollen visiting a different plant species. And that the insect brings pollen from the same species when visiting that plant. This is known as pollinator constancy, and the consistency at which pollen is gathered can often be observed in European honeybees in the field.

Attracting pollinators

The colour, shape and aroma of the flower is generally designed solely to attract a specific group of insects, and nothing more. Many plants evolve a shape and colour of flower that is distinct from that of other plant species, resulting in a unique set of stimuli that encourages pollinators to visit other flowers of the same species (and therefore effect pollination).

You can tell what pollinates a plant by the flower morphology. Bees cannot see red very well, and so red flowers are usually pollinated by birds and butterflies. Many flowers have 'nectar guides' visible in the ultraviolet to attract bees.

Nectar feeders have mouthparts adapted to extracting nectar (eg a butterfly's proboscis), and plants have adapted methods of making sure pollen is deposited on the insects during the extraction process. Pollen feeders have chewing mouthparts that show no intention of spreading the pollen itself.

Pollination by a female Orchard Butterfly (Papilio aegeus)

Recent research suggests that flight by bees (particularly bumblebees) causes them to be positively electrically charged, and that when visiting a flower some of this charge is passed on to the flower. Plants are poor conductors, and some of this charge is retained by the flower, making them more attractive to bees and therefore encouraging further visits, reinforcing flower 'constancy'.

Pollen from a single plant species covers this European Honeybee (*Apis mellifera*)

Plants that use non-specialist pollinators may develop pollinia that are deposited on a specific site on the insect (eg *Asclepias*, *Stylidium*), different to sites used by other plant species on the same insect. Some orchids use 'lock and key' mechanisms to ensure only other members of the same species are pollinated.

Deception

Sometimes the relationship is not at all mutual. Plants that 'deceive' insects into pollination give no reward whatsoever. Some insects manage to retrieve nectar without gathering pollen and may even destroy the flower in the process.

Another method is to use insects that aren't pollinators at all, and therefore there is no danger of pollen being mixed up. Some Australian orchids (*Cryptosylis*, *Prasophyllum*, *Calochilus* and *Caladenia*) employ male ichneumonid wasps to copulate with them and in doing so transfer pollen. *Diuris* attracts male bees, *Spiculea* attracted male thynnid wasps, *Pterostylis* attract small flies, *Prasophyllum* attract staphylinids and chrysomelids, and *Microtis* attracts curculionids.

In Australia, Stylidium species range from hosting a wide array of pollinators to only male bombylid flies.
Stylidium have a pressure-sensitive brush-like stigma that springs against the insect's abdomen, picking up pollen grains, and anthers that bend inwards to attach more pollen.
Typically, these orchid flowers take 15 or more minutes to reset, ensuring the insect has moved on and therefore avoiding self-pollination.
Bucket orchids and the intricate traps they set to hold bees, only attaching a pollinium when the bee has found the final escape hatch
Euglossa orchid bees scraping off the surface of the flower and packing the powder into their bodies, an aphrodisiac that attracts females

Fig wasps

Female agaonid wasps are designed to squeeze into the small hole in the fig, often losing their wings and antennae in the process. The wasp lays eggs in the short female flowers, in which the wasp larvae develop. The fig then produces male flowers with anthers and pollen. Female wasps emerge as adults, mate with any males present (who then die), collect pollen and leave to enter the figs of other plants.

<u>Seed dispersal</u>

Many plant species produce seeds with highly nutritive structures (most commonly eliasomes) that are not used by the seed but collected by ants.

About 300 plant species around the world produce eliasomes for ants
In Australia about 1500 plant species in 87 genera and 24 families produce eliasomes, mostly in low nutrient habitats (mallee, scrubby woodlands and heath).
About 7% of the entire Australian plant fauna are myrmecochorous in this way.
The seeds themselves are impervious to ant mandibles, although scarification may stimulate germination. The eliasomes are eaten and the seeds either left underground (because the ants can't grip the seed without the eliasome) or scattered around the nest entrance, tucked away in cracks in the soil or under leaves to prevent other ants wasting time on them.

Conclusion

So to the question. Plants as a whole do need insects, and insects as a whole do need plants. As a group, their very survival depends on this.

However, some plants don't need insects and do everything within their power to avoid them.
Some insects can live without plants and in fact certain plants lead to their demise.
Some plants, such as Moreton Bay Figs, will die out when the last fig wasp dies.

In each case plants need insects as far as their interests dictate. They will reward insects for pollination services, for example, but only as much as is required to do the job. Insects will take from plants whatever they possibly can.
In many cases this can develop into a mutualism, even an obligate mutualism, but in all cases it's just plant-insect interactions.

The Patch Primary School

ESV End of Year excursion, December 2014

Meet your ESV Council

Linda Rogan
Editor, ESV

Photo: Peter Rogan

When did you join the ESV?
The first meeting I attended was a night for nature photographers, organised by Peter Marriott and Steve Curle. I came along to show a DVD of photos on Imperial Blue Butterflies (*Jalmenus evagoras*) and joined up within the year.

When did your interest start?
When I was six years old my friend's dad was an entomologist and I remember him taking the time to show us antlions.

Then I came to Australia from Oregon, US, in 1979 but didn't have a particular entomological interest then, only plants and especially native orchids. And then butterflies and bees caught my eye as pollinators. I retired from physiotherapy in 2002 and then had time to pursue my interest in nature.

For several years I walked past a group of *Jalmenus evagoras* every day in Greensborough, but it took a long time for me to notice them. I started photographing and researching them and even now I regularly monitor them.

Your main entomological interest?
Native bees, and the interaction between plants and their pollinators. I love to be out in the bush and whatever is happening at the time is what interests me most.

Through my interest in indigenous plants, my back garden in Greensborough is becoming a haven for insects, especially jewel beetles, weevils and lycid beetles. This year I've counted six species of jewel beetle, including *Castiarina erythroptera,* a lycid-mimic, as well as a possible species of lycid-mimicking weevil. Other jewel beetles in the garden include *C. rectifasciata, C. sexplagiata, C.*cf. *goodingi,* a lovely red and blue *C.* cf*. cruentata* and some tiny *Diphucrania* sp. There are also several species of native bees – the more I learn, the more I see. My backyard bee list includes *Amegilla cingulata*, *Lasioglossum lanarium*, *L. calophyllae*, *L. bicingulatum Euryglossa ephippiata*, *E. nigrocaerulea, Lipotriches australica*, *L. flavoviridis*, *Hylaeus quadriceps*, *H. ofarrelli, Homalictus punctatus, Exoneura ploratula, Megachile ferox,* so, lucky 13, so far! All species have been logged on BowerBird for ID.

Favourite insect group?
Bees, when available, and Dawson's Burrowing Bees (DBBs) (*Amegilla dawsoni*) in particular. The whole insect experience with DBBs in Carnarvon, WA, was special. I'd heard about them and had seen the David Attenborough footage, and knowing there is only a two-week window to see them, we visited a known spot near Carnarvon and there were the DBBs in huge numbers. The males were out searching the holes for females, and we stayed a couple of days to watch the whole story.

Cockroaches also hold a fascination for me but I haven't got far with them. Most of my interest is opportunistic and beetles often catch my eye. Jewel beetles in particular, and most especially *Castiarina*.

A Blue-banded Bee *Amegillla cingulata* on Magenta Storksbill *Pelargonium rodneyanum*.
Photo: Linda Rogan

For me, entomology is all about learning and I have the special pleasure of finding creatures that I haven't seen before nearly every time I go hunting with my camera. Occasionally the things I find and photograph are of interest to the experts as well and this is the biggest reward for me. When I can learn a bit about the ecology of the creature this is even better. An example of this would be the photo of the Calothamnus bee, *Euhesma Euhesma tubulifera*, which has extended mouthparts, longer than its body and feed only on Calothamnus. Ken Walker has used this photo on several occasions. This might be my single favourite creature photo but the *Amegilla dawsoni* experience is still absolute tops. I can't really talk about photographic forays without mentioning that my husband Peter shares the general interest in nature enough to accompany me on these trips, offering essential support in so many ways.

A 'Sweat Bee' *Lasioglossum bicingulata* on White Tea-tree *Kunzea ericoides*
Photo: Linda Rogan

Are there entomologists you find inspiring?
I've read a lot of E.O. Wilson's work. His early writings were inspirational, as well as the artwork that's included in some of his books. He writes accessibly and it isn't all about ants. The internet and photography has allowed me to go from casual interest to delving deeper and encountering more interesting entomological writers.

As Editor of the ESV Bulletin, what makes a good article?
Those that tell a bit of a story, not just strictly taxonomy or research. That's just my personal preference. As editor I learn a lot on the job, and good photos contribute a lot to an article. Hearing about the experience of collecting insects, or hearing about the stories of the insects themselves, is most rewarding. Concise articles are also a good thing, but they shouldn't leave out the human aspect.

What's the best thing about being Editor?
I'm in contact with so many knowledgeable people, much more so than I would be otherwise. It gives me learning opportunities and although I still feel like a neophyte, it's good fun.

What do you think could work better?
Dichotomous keys totally lose me – keys are written by people who don't need them for people who can't use them, according to Ken Walker. Keys with a visual aspect, especially good photographs, are much more useful.

The Halictid Bee *Lipotriches flavoviridis* on Flax Lily *Dianella* species.
Photo: Linda Rogan

Any advice for the young entomologist?
The way I enjoy entomology is to follow my interest and passion. The lucky person is the one who finds a way to turn their passion into a living. I admire those with dedication and energy, such as the moth collectors, who put so much effort and long hours into their work. But I'm happy following my own passions.

Articles of interest

Year in review: Insect, bird evolution revisited

Genetic analyses produce new family trees

By Susan Milius
Science News: Magazine of the Society for Science and the Public, December 2014

Biologists in 2014 saw what an astronomical amount of data could do for evolutionary questions — and what it couldn't.
Bernhard Misof of the Zoological Research Museum Alexander Koenig in Bonn, Germany, and 100 coauthors, published an evolutionary family tree of insects and close relatives based on the subset of some 1,478 genes shared by 144 kinds of organisms.

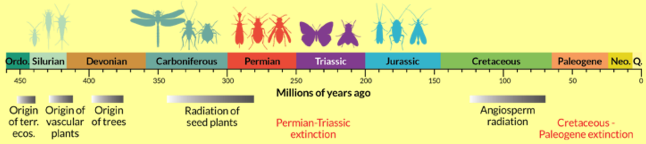
This project, called 1KITE (for 1,000 Insect Transcriptome Evolution), arranged branches on the new tree in ways that looked familiar, but details of certain insect orders differed. Project coleader Karl Kjer of Rutgers University says he has abandoned some of his earlier ideas on branches near the base of the tree as a result of the findings. And Kevin Johnson of the Illinois Natural History Survey in Champaign is rethinking whether the parasitic lifestyle really did evolve twice in Psocodea louse history, as he and colleagues had proposed.

Louse history still poses questions. The new tree puts the origins of parasitic lice at about 53 million years ago, well after dinosaurs died out. Vincent Smith of the Natural History Museum in London, who has proposed that lice nipped dinosaurs, points out that the new study still has considerable uncertainty in its time estimates for louse ancestors.

Another ambitious project redrew the bird genealogical tree based on the full genomes for 48 bird species. Published in December, this work, like the insect family tree, received funding from the Chinese genetic institute BGI.

New insect timeline

The earliest insects may have arisen as long ago as 479 million years, says a new study. Insects first took flight about 406 million years ago, as plants developed their vascular plumbing and expanded into the air too. Silhouettes show when ancestors of some major living orders of insects likely first started on their distinctive evolutionary paths. (From earliest, on left: springtails; jumping bristletails; silverfish; dragonflies and damselflies; crickets and katydids; bugs, cicadas and plant lice; snakeflies; beetles; sawflies, wasps bees and ants; moths and butterflies; true flies; caddisflies; cockroaches; and scorpionflies.)



Credit: 1KITE, adapted by M. Atarod

New York: where the streets are paved with hot dogs, donuts, burgers … and hungry insects

By Mike Jeffries
The Conversation, December 2014

If you don't finish it the ants will.

New York is one of many cities whose mythical allure claims that the streets are paved with gold. Sadly, you are more likely to be treading on – or at least wading through – the remains of burgers, hot dogs, sweets, cookies, fries and more unmentionable sources of nutrients. Yet in among all that detritus is an awful lot of energy, a resource that could underpin a complex ecosystem.

Food webs are a staple of ecology research, but usually explored in rain forests and coral reefs, ponds and savannahs. However a team at North Carolina State University has recently turned its attention to the much more dangerous terrain of Manhattan to find out if the insects living on and under the streets clear up a significant amount of the food litter – and whether the diversity of species makes any difference. Their results are published in the journal Global Change Biology.

The precise relationship between resources and the diversity of flora and fauna in ecosystems has been the subject of intense research ever since the coming of the word "biodiversity" in the late 1980s. Ecologists were challenged to explain the role of species: does it matter how many there are, does the number of species affect the way ecosystems work, what do all these species do for us?

All this activity drives the natural ecosystems which keep us alive. Ecosystems are more productive, efficient and resilient the more species they contain, perhaps because different species carry out complementary roles or, however unwittingly, benefit the activities of others.

The North Carolina team set out to test whether the diversity of invertebrate street life affected the removal of food that had suffered "improper disposal" (a charming politeness runs through the whole study) in the parks and elongated traffic islands of Manhattan.

To audit the pavement biodiversity, the team collected insects from among the leaf litter, with additional forays into other areas in search of ants. The rate of food clear-up was measured by putting out potato chips, cookies and hot dogs and seeing how much was left the following day.

The trap is set.
Photo by Youngsteadt et al

Some of the food was protected by wire mesh, others not – so that larger creatures such as rats and pigeons could get in too, to allow for their impact. The precise brands of crisp, cookie and hot dog are detailed, each cut up into more appetising chunks.

This is important, allowing experimental replication with street food around the world. For example in Britain the late-night kebab might be a significant bio-geographical variation. The rate of food clear-up was compared to the overall diversity of invertebrates and the precise mix of species. Sadly, nowhere do the team members outline how they explained any of their activity to passing policemen.

Pavement ant: a hot dog's worst nightmare. AntWeb, CC BY

The speed with which food was removed proved startling. In the first run of the experiment using small chunks of food, 59% was gone within 24 hours. A second run using larger portions resulted in a 32% loss within a day. Whole cookies and chips … gone, chunks of hot dog … vanished.

The insect life on the traffic islands consumed supplies two to three times faster than the inhabitants of the parks. Life in the fast lane perhaps, or maybe the park life was more used to ice creams and sandwiches. In either locality, hot dogs were preferred to the light snacks.

In total the insects from the medians and traffic islands of two long Manhattan streets – Broadway and West St – could remove the equivalent of 600,000 potato chips per year. This could become a standard measure of invertebrate junk food ecosystem services.

The overall conclusion is that our invertebrate neighbours in the city make a notable contribution to the removal of litter. However the food clear-up was not affected by the diversity of species. More important was the presence of one species of ant, the perfectly named pavement ant, *Tetramorium caespitum*. Two to three times more food was removed where these particular ants were present.

There is something particularly pleasing about it being the pavement ant. Not just the name; this ant is not a native New Yorker, but an immigrant from over a century ago, probably coming from Europe to the Big Apple.

Urban wildlife is often rather overlooked as a sorry mix of second-rate left-over habitats and dodgy aliens. However the city represents a whole new habitat, likely to become ever more widespread; a zoopolis, with a distinct and fascinating ecology. Where the streets are paved with last night's food, these ants have certainly found their niche.

Clever bee-brain lets the insects see the big picture

By Bridie Smith
Science Editor, The Age, December 2014

Having a bee-brain isn't such a bad thing, as it turns out. Australian and French scientists have found that the insect is the only species other than humans capable of seeing the big picture as well as the detail in their environment.

Essentially the findings show the humble honey bee can see both the forest and the trees, a skill which not even primates can boast.

Published in the journal *Proceedings of the Royal Society B*, the results have implications for artificial intelligence.

Associate Professor Adrian Dyer with his honeybees at Melbourne University.
Photo: Simon O'Dwyer

"This is a complete change in our thinking of how brains process visual information," said associate professor Adrian Dyer from RMIT University, a co-author of the paper.

With under 1 million neurons, a bee's brain has less neurons than a human retina. But Professor Dyer said this made it the perfect model for studying information processing at its most basic level.

European Honeybee (*Apis mellifera*)

"In the 1970s we saw (Star Wars robot) C-3P0 walking around and interacting with very complex things," Professor Dyer said. "But the reality is that if we think of where robots have come in the last 20, 30 or 40 years it is remarkably disappointing."

What has been holding things back is working out how to enable robots to process the complex visual information in their environment. "Machine vision is capable of seeing the local information, or the trees, but it can't stitch it together properly to see the global information, or the forest, to know how to interact with the environment," Professor Dyer said.

Conducted over four years, the honeybee study provides great insights into the minimal neural requirements for global processing. It also proves high-level cortical processing isn't essential, meaning that the bee-brain could be a model replicated artificially.

To study the way the honeybee processes visual cues in their environment, researchers from RMIT, Monash University and the University of Toulouse watched as individual bees were released in a Y-shaped maze.

After travelling up the stem and reaching the intersection, the bees were faced with a choice of pattern at the end of each corridor. Each pattern contained both global information (from a distance the pattern formed a square or triangle) and local information (shapes within the pattern were circles and diamonds).

In subsequent tests, patterns were changed so that local and global information was swapped. The results showed the bees returned the patterns with the original global information.

It's not the first time the bee brain has proved more adept than its size might suggest. A decade ago, experiments showed bees could recognise faces. Bees, when rewarded, have also been shown to be able to learn tasks in a matter of hours.

Viewpoint: Insect Swarms Go Critical

By Hugues Chaté and Miguel A. Muñoz
Physics, Journal of the American Physical Society, December 2014

The seemingly erratic motion of insects in a swarm exhibits the correlated behavior of particles near the critical point of a phase transition.

Scientists capture video of swarming midges.
Photo: Andrea Cavagna/University "La Sapienza" of Rome

Scientists have found tantalizing evidence that diverse biological systems, including the human brain, gene expression networks, bird flocks, and fish schools, behave as though they are near the "critical point" of a phase transition, like correlated spins in a magnet on the verge of ordering. In flocks of starlings, for example, the velocity fluctuations of two distant birds mutually influence each other. Such "scale-free" correlations, which occur on all possible length scales in the flock, are a hallmark of criticality. The idea that biological systems could be described by the physics of phase transitions is exciting, as it could point to a common organizing principle in the evolution of seemingly different biological structures. But direct evidence for this idea, which first emerged two decades ago, remains relatively scarce. Now, a statistical study of insect swarms by Alessandro Attanasi and his colleagues at the University "La Sapienza" of Rome in Italy provides new evidence in support of this picture. The researchers used video to track the trajectories of hundreds of swarming midges (a type of small fly commonly found in cities). By analyzing the statistical properties of trajectories in swarms of different sizes, they show that midges exhibit the same scale-free correlations as flocking starlings, and argue that the swarms appear to always be poised at a critical point.

In statistical physics, the critical point on a phase diagram often separates an ordered phase from a disordered phase. For a biological system, being at such a point could have certain advantages: If the system is too ordered, it cannot adapt or respond to change in its environment; if it is too disordered, the response may not be strong enough. At a critical point, a small action by one or a few individuals in the group, such as responding to a predator, can ripple to distant neighbors thanks to long-range correlations. But before scientists can think about how and why biological systems might have evolved to be critical, more evidence that this actually happens is needed.

In their new work, Attanasi and his colleagues set out to the parks of Rome to record high-speed videos of swarms of midges native to the area. The movies, taken from three different viewpoints against a dark screen, were then processed to locate each midge and reconstruct its trajectory. The largest dataset followed 600 midges flying for ten seconds.

Unlike graceful birds traveling in a flock, insects in a swarm tend to just hover over a spot on the ground (such as still water.) But the analysis of Attanasi *et al.* reveals that the seemingly disorganized swarms have some sophisticated features. For each swarm, the authors calculated, from the midge trajectories, the correlation length of velocity fluctuations, which they define as the characteristic distance beyond which midge-midge correlations decay below a given threshold. They define the average distance between nearest-neighbor midges as the "control parameter"—akin to temperature or pressure in a true phase transition, except that its value cannot be changed for a given swarm. They also calculate a susceptibility that, in qualitative terms, measures the total correlation between insects.

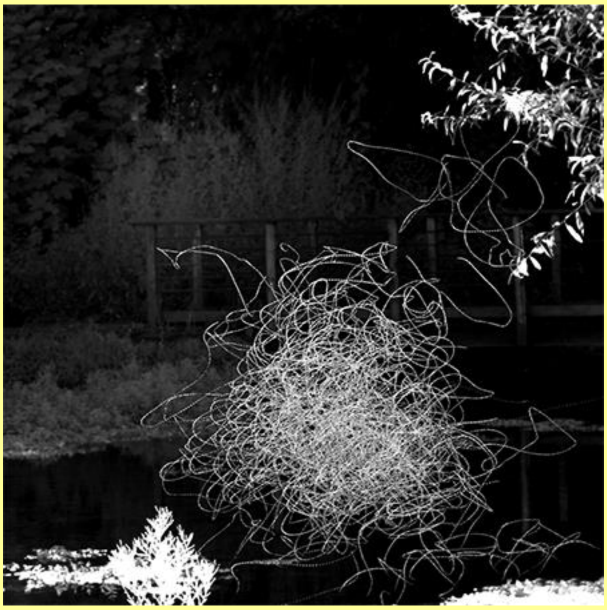
Their analysis shows that the correlation length and the magnitude of the susceptibility grow with the number of insects in the swarm, while the spacing between midges decreases.

Attanasi *et al.* interpret their data using the so-called Vicsek model, which, in simple terms, attempts to model collective motion by assuming that an individual in a group essentially follows the trajectory of its neighbors, with some deviations modeled as "noise." In this model, a phase transition from an ordered "flocking state" to a disordered one occurs when the noise rises above a certain level. Now, in theory, true criticality only occurs in infinite systems, a criterion effectively fulfilled by magnets and other solids, since the number of elements they contain are on the scale of Avogadro's number. Biological groups, on the other hand, are typically much smaller, and their critical points are smeared out over an extended transition region. Attanasi *et al.* show that the variation with swarm size of the quantities they measure is, as expected in the Vicsek model for finite-size systems, sitting near the maximally correlated point of their transition region. In particular, midges seem to regulate their average distance—or, conversely, swarms regulate their population—so as to function at maximal possible criticality.

Attanasi *et al.*'s attractive message is that biological groups, such as swarms, coordinate their behavior so as to optimize the ability to react collectively (e.g., to avoid predators or to attract sexual partners). Their observations, in fact, provide stronger evidence in support of criticality in animal groups than the scale-free correlations found in more ordered groups like starling flocks: Because starlings "pick" a direction, they represent a system in which rotational symmetry has been broken, and in such systems, scale-free correlations occur even away from the critical point.

One weakness of Attanasi *et al.*'s data, however, is that they only allow comparisons of swarms that differ in number by an order of magnitude. This difference is too small to ensure the reported size effects are evidence of criticality. Larger groups will have to be analyzed in the future. A more controlled environment might help too, although recent laboratory experiments on swarms of fewer than 50 midges don't indicate critical behavior, which may signal that it arises only in "natural conditions".

The criticality hypothesis has gained considerable popularity and empirical support in the field of neuroscience. Researchers have discovered critical-like neuronal avalanches and evidence that the background dynamics of the brain has features of criticality. Similarly, empirical evidence suggests that genetic regulatory networks might also operate at criticality. A "critical" brain could have several functional advantages, such as enhanced response to stimuli, the ability to exist in many states, and optimal transmission and storage of information. Bolstering this idea, researchers have argued that complex computations can only be performed by "machines" operating at criticality.



Detailed trajectories of midges in a swarm.
Photo: Andrea Cavagna/University "La Sapienza" of Rome

In these examples and the work by Attanasi *et al*, however, we are left with the challenge of understanding *how* a biological system arrives and stays at criticality. While magnets only exhibit critical behavior at a very precise temperature, animal groups and neurons seem to operate generically near critical points. So why is critical behavior so ubiquitous in nature?

One popular proposal from the 1980s is "self-organized criticality" (SOC), a collection of simple models and mechanisms aimed at offering a common explanation for why earthquakes, avalanches of flux lines in superconductors and solar flares are generically scale invariant. SOC models have been extended to biological systems, and not without reason: the critical avalanches observed in neuronal activity, for example, are reminiscent of earthquakes. But the SOC picture isn't entirely satisfactory because it ignores functional aspects of biological systems. An alternative, and more biologically centered, proposal suggests living systems can, by virtue of their need to have both an accurate and flexible understanding of each other, adapt spontaneously towards a critical state. Criticality that emerges in this way may, at larger time scales, provide an optimal trade-off between robustness and evolvability.

It would be nice to see all the pieces of evidence crystalizing into a robust theory of criticality in biological systems. Extracting quantities like the order parameter, correlation lengths and susceptibilities from real systems is essential to point scientists towards the right model. As beautifully shown by Attanasi *et al.*, unsuspecting midges could help a lot!

Curious Scientific Names Can Make Insects Famous

By Eduardo Faúndez
Entomology Today, December 2014

Scientific names — at least for plants and animals — are Latinized words, and the Latin language was selected for the naming of new organisms because it's a dead tongue.

Thestral incognitus, named after the Thestrals in the Harry Potter saga.

Why choose a dead tongue? Here's why: 1) A dead tongue is neutral because no one speaks it as their native language, and therefore no one gets any kind of linguistic advantage, and 2) a dead tongue does not evolve over time, which is a very important characteristic if we want the naming of species to be organized and stable.

Many scientific names refer to characteristics of the organisms they are describing. For example, greenish species are usually called *"virens"* or *"viridulus,"* which means green in Latin. Several insects and crustaceans have names like *longiconis* in reference to their long antennae, because "longi" means long and "cornis" means horn.

Other organisms are named after the places where they were collected, which is why many species are called *"americanus"* or *"texanus"* or *"braziliensis."*

An organism can also be named after people. In fact, you can even tell if it was named after a man or a woman. Names that are based on men end in "i" or "oi." On the other hand, names that are based on women end in "ae." That's why there are lots of names like *"isabellae"* or *"paulae"* or *"rileyi"* or *"smithi."*

Some organisms are even named after fictional characters. For example, a beetle called *Agathidium vaderi* was named after Darth Vader from *Star Wars*. In fact, there's also a wasp — *Polemistus vaderi* — that was named after Vader, and it's joined by two other characters in the same genus: *Polemistus chewbacca* and *Polemistus yoda*.

There are tons of curious names in taxonomy. The cartoon character SpongeBob SquarePants has a species of fungus named after him: *Spongiforma squarepantsii*. A spider called *Walckenaeria pinocchio* was named after the Disney character Pinocchio, and a little wasp called *Tinkerbella nana* was named after Tinker Bell. More recently, a horse fly was named after the singer Beyonce, a grasshopper was named after Mexican singer Lila Downs, and an aquatic mite was named after Jennifer Lopez.

The number of curious names is incredible, and the best compilation of them is probably the Curious Taxonomy Website, which is run by Mark Isaac.

Why do researchers use curious names?
This year I actually named an insect after a character in the Harry Potter saga. My colleagues from the Insect Systematics Lab at North Dakota State University and I described some new species of Heteroptera. One of our bugs came from Chile, my home country. It was found in an area of the country that is pretty well-collected, where we observed thousands of specimens, but only a few of this new species and genus. Something about these bugs made it difficult for people to see them easily, which reminded me of

the Thestrals, a breed of winged horses with skeletal bodies from the Harry Potter books. Additionally, our bug has ivory carinae which resemble the skeletal bodies of the Thestrals, which led us to name the bug *Thestral incognitus* Faúndez & Rider, 2014.

Our article was published in the journal *Zootaxa*, and I was surprised to see it make the news worldwide. Then again, I wanted people to be aware of this species because we need more fresh specimens for molecular studies. Now that lots of people know about *Thestral incognitus*, we hope that someone will see one and will post photos on the Internet so we can get more precise collection data.

Sendra & Ortuño (2007) wrote about the issue of curious names and how they are celebrated by some and discouraged by others. In any case, these names get people talking about the new species, and they may even capture the attention of administrators who are in charge of providing funds to study biodiversity, which is often left behind other disciplines.

Whether you like them or not, curious names have a long history — *Coleopterodes liliputianum* was named in 1864 after characters from *Gulliver's Travels* — and these names will continue to be used in the future because there are millions of species left to describe. Taxonomists who love their work want the world to know about all of the diversity out there. In my opinion, curious names are powerful tools that can be used by taxonomists for extension purposes.

ESV upcoming events

General meetings are held at the Melbourne Museum Discovery Centre Seminar Room, at 7.45pm, on the third Tuesday of every second month.

Members and guests are welcome to join us at Michelinos Trattoria Restaurant in Carlton at 6pm.

Tuesday 20 January 2015
Council meeting

Tuesday 17 February 2015
Susan Lengyel, Urban Ecology Coordinator, City of Melbourne – Summary of the Melbourne Urban Bioblitz 2014
Dr Elena Ivanova, Swinburne University of Technology – Nanopillars of cicadas and dragonflies

Tuesday 17 March 2015
Council meeting

Tuesday 21 April 2015
AGM and Julie Whitfield, Amaryllis Environmental – Butterfly conservation and the Eltham Copper

Tuesday 19 May 2015
Council meeting

Tuesday 16 June 2015
Members' night

Tuesday 21 July 2015
Council meeting

Tuesday 18 August 2015
ESV excursion

Tuesday 15 September 2015
Council meeting

Tuesday 20 October 2015
Members' night

Tuesday 17 November 2015
Council meeting

December 2015 (date TBA)
Christmas gathering

Around the societies

Entomological Society of Qld

Nine general meetings per year on the second Tuesday of the respective month.
Meetings are held at the Ecosciences Precinct, Boggo Road, Dutton Park, Qld
k.ebert@uq.edu.au

Tuesday 9 March 2015 – Dr Bill Palmer, AGM and Presidential Address.

Society for Insect Studies

10 February 2015 – Dieter Hochuli, Wildlife versus The City

Australian Entomological Society

Celebrating 50 years

Greeting cards by artists from Wildlife and Botanical Artists Inc.
Cards are $5 each or set of 6 for $25

Bright bugs coins for sale
Bright bugs set of 6 coins now available from the Australian mint.
http://www.austentsoc.org.au/AES/Home

Butterfly Conservation South Australia

Public Talks Program
First Tuesday of the month, March to November at 6.15pm for a 6.30pm start.
At the Clarence Park Community Centre
72-74 East Avenue, Black Forest.
Bus route W91/W90: stop 10.
Noarlunga Train service: Clarence Park Station.
Glenelg Tram: Forestville stop 4, 9min walk south.
Entry by donation (minimum of $2).
Bring supper to share, tea/coffee will be supplied.
At the start of each meeting a ten minute presentation on a 'Butterfly of the Month' will be given by a BCSA committee member.

The first public talk will be on Tuesday 3rd March at 6.30 when Dan Duval from SA Seed Conservation Centre based at the Botanic Gardens will provide a fascinating insight to the SA Seedbank project.

Australian Entomological Society

Dear Victorian AES members,
Just a brief note before the Christmas/ New Year break. News articles for the first issue of Myrmecia, 2015 will need to be submitted by Friday, 9th January 2015. If you have any highlights of 2014, new projects, project updates, photographs or anything else you would like to share with society please let me know as it would be great to hear from you.
Merry Christmas and a Happy New Year to all!!
Looking forward to hearing from you in 2015
.Best wishes,
Linda Semeraro.

ESV newsletter goes global

The Entomological Society of Victoria newsletter is now sent to more than 80 entomological societies around the world, including

- Entomological Society of New Zealand;
- Royal Entomological Society (UK);
- Austrian Entomological Society;
- Vermont Entomological Society (USA);
- Entomological Society of South Africa;
- Israel Society of Entomology;
- Connecticut Entomological Society (USA);
- Entomological Society of British Columbia (Canada);
- Societas Europaea Lepidopterologica (Germany);
- Kansas Entomological Society (USA);
- Maine Entomological Society (USA);

amongst many others.

As usual, if you would like to contribute, or to communicate with other societies around the world, please contact the editor Patrick Honan.

In addition, if you would like to keep up with overseas societies' activities, please contact Patrick Honan for details.

Can you help?

From Janine Schneiders

Just wondering if you were able to identify this nest - we have a heap of them in our back yard (Geelong Victoria), and with both pets and children, were wondering if I should be worried for them depending on what hatches? It is soft, spongy, dusty looking (dirt?) not sure if it is weblike or silky, and comes in all sizes.

There are heaps of them, they seem to have appeared over just a few days - some smaller, and some over 10 cm in width.

Please contact Steve Curle (steve@scurle.com) or Patrick Honan (phonan@museum.vic.gov.au) if you can help.

Gippsland Lakes Bioscan
With Museum Victoria











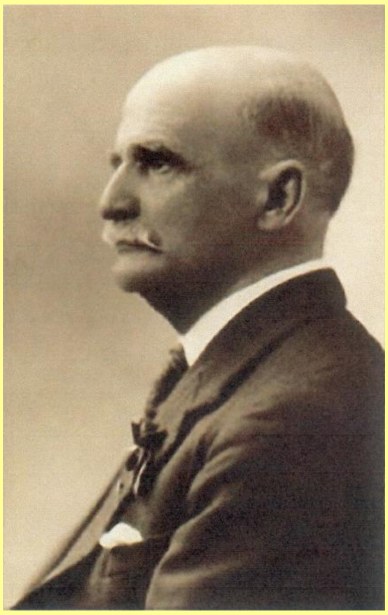


Prominent entomologists

An occasional series on early entomologists

Walter William Froggatt
1858-1937

Although better known for his work in New South Wales and Queensland, W.W. Froggatt was born in Blackwood, Victoria, in June 1858. His parents, originally from Yorkshire, moved the family to Bendigo where Froggatt was educated and was encouraged by his friend and bush naturalist, Richard Nancarrow, to study nature.

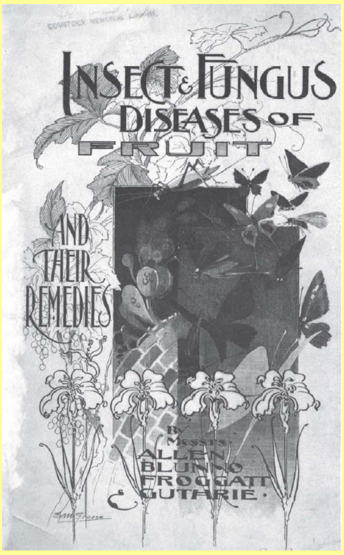


Walter Wilson Froggatt in his later years. Photo: Sydney Morning Herald.

After several years on the land, Froggatt moved in 1880 to the goldfields around Milparinka, NSW, and to the Flinders River, Qld, sending specimens to Ferdinand Mueller and Charles French. He had a general interest in all natural history but entomology in particular, and with Mueller's assistance was appointed entomologist and special zoological collector as well as taxidermist to the 1885 Royal Geographical Society's New Guinea Expedition.

Froggatt's part in the trip was so successful he was employed as a collector by Sir William John Macleay, who also proposed him for membership of the Linnean Society of NSW. He remained on the council for 39 years, serving as President from 1911-13, and later becoming a member and then Fellow of the Linnean Society of London.

From 1886-88, Froggatt travelled through the wilder parts of North Queensland and the Kimberley region of WA, collecting for Macleay in remote areas and leading the life of the adventurer-collector. He went to England to gain experience in museums and universities, and in 1889 was appointed assistant at the Sydney Technological Museum, then in 1896 appointed Entomologist in the Department of Mines and Agriculture, making him more or less the 'Government Entomologist'. His research and observations resulted in the publication of almost 400 papers in the *Proceedings of the Linnean Society*, the *Australian Forestry Journal* and the *Agricultural Gazette of NSW*.



Insect and Fungus Diseases of Fruit, one of the many publications of Froggatt's during his productive career.

Froggatt's research often focussed on pest species, beginning with coconut palm pests in the Solomon Islands, then travelling overseas in 1907-08 on behalf of the Victorian, NSW, Qld and SA Governments to investigate pest species at their origins, particularly fruit flies.

Froggatt is best known these days for his widespread patronymic in species names, but is still familiar to many amateur naturalists for his landmark popular books: *Australian Insects* in 1907, *Forest Insects of Australia* in 1923 and *Forest Insects and Timber Borers* (1927).

Although now very difficult to obtain, *Forest Insects of Australia* is still an important reference and did much to popularise Australian insects.

He spent much of his life collecting in the field, for museums, other institutes or private collectors. Travelling alone either on foot or horseback, he collected thousands of specimens that are now distributed in museums around the world, many of which are type specimens.

In 1923 Froggatt retired from the Department of Agriculture but took up a position as Forest Entomologist with the Forestry Commission in NSW. He retired from there in 1927 and sold his insect collection to the CSIRO, where it remains an invaluable resource on forest insects.

Froggatt did much to popularise natural history in general and entomology in particular, being a founding or council member of a number of naturalists' and preservation societies, such as the Wildlife Preservation Society of Australia and the Australian National Research Council.

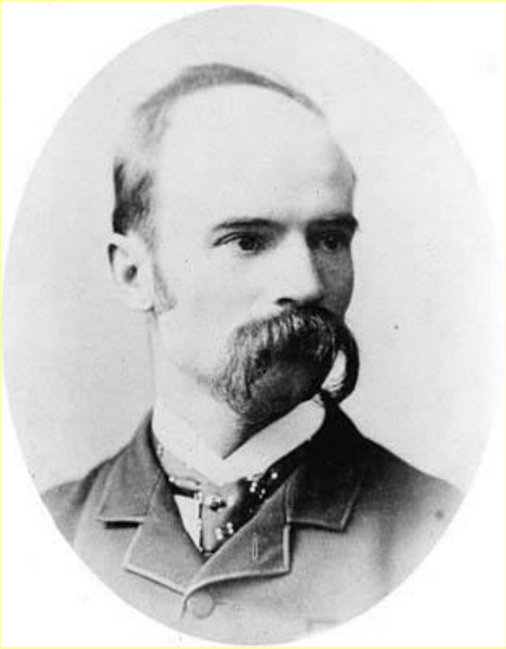
He also wrote nature books aimed at children, as well as newspaper articles and stories in the *Australian Naturalist*. He died in Sydney on 18 March 1937, and in 1938 a memorial was unveiled at Balls Head in North Sydney, commemorating Froggatt's interest in the local environment and its rehabilitation. His son John went on to become a notable entomologist in Papua New Guinea, and daughter Gladys wrote the World of Little Lives in 1916.

But the name Froggatt lives on, and is very familiar to most Victorian and Australian naturalists as more than 18 species of plants and animals have been named after him.

The insects include:

- several ant species (*Anonychomyrma froggatti, Camponotus froggatti*, *Myrmecia froggatti, Adlerzia froggatti, Stigmacros froggatti* and *Liomyrmex froggatti*, *Solenopsis froggatti, Leptomyrmex froggatti* as well as *Froggattella kirbii* and *F.latispina*);
- beetles such as the Ground Beetle *Notonomus froggatti*, Tiger Beetle *Cicindela froggatti*, the Kurrajong Pod Beetle *Australaethina froggatti* and Stag Beetle *Ceratognathus froggatti*;
- bugs such as the Apple Leafhopper (*Edwardsiana froggatti*) and the well-named cicada Maroon Clicker (*Kobonga froggatti*);
- booklouse *Austropsocus froggatti*;
- thrip *Haplothrips froggatti*;
- fruit fly *Bactrocera froggatti*;
- and the eulophid wasp *Aprostocetus froggatti*.

But perhaps the two best known insect species are the Moreton Bay Fig Wasp (*Pleistodontes froggatti*) and the Eucalyptus Leaf-blister Sawfly (*Phylacteophaga froggatti*), both species very familiar to Victorian insect enthusiasts.



His name also appears regularly, sometimes bracketed, after genera such as *Pseudopsylla* and *Glyptotermes*. And Froggatt's Bendigo childhood is commemorated by the Kamarooka Mallee (*Eucalyptus froggatti*).

Upcoming conferences

Society of Systematic Biology Conference
Location: Guaruja, Brazil
Date: 26-30 June 2015
Contact: http://systbio.org/

XVIII. International Plant Protection Congress (IPPC) 2015
Mission possible: food for all through appropriate plant protection
www.ippc2015.de
Free University Berlin
14195 Berlin-Dahlem/Germany
24-27 August 2015

Entomological Society of America
The ESA will co-locate their Annual Meeting with the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America in Minneapolis, Minnesota, November 15-18, 2015.

Addendum

Following the brief article in the last ESV Newsletter regarding George Vernon Hudson and the origin of daylight saving time, Ted Edwards filled out a few more entomological-related details:

George Vernon Hudson, second from left.

George Vernon Hudson (20 April 1867, London to 5 April 1946, Karori, New Zealand) worked as a clerk, rising to a high position in the Post Office in Wellington. Entomologically his principal interest was in Lepidoptera on which he wrote several important books but he also wrote books on Neuroptera and Coleoptera. More relevant to the daylight saving story was that he was an enthusiastic amateur astronomer in which field he made several discoveries. It is as an astronomer as well as an entomologist that the daylight saving idea germinated. Indeed astronomy was sufficiently important to him that he named his daughter Stella.

Stella's son, George William Gibbs, took over his grandfather's mantle and has produced outstanding work on Lepidoptera particularly on the "jaw-moths" (Micropterigidae). He recently reviewed the Australian micropterigids and last June published a landmark revision of the New Zealand species in the "Fauna of New Zealand" series. He has also published on the New Zealand glow worms. George is currently a Senior Research Associate of the Victoria University, Wellington.

A page from Hudson's 1898 book New Zealand Moths and Butterflies.

On her father's death, Stella privately published his latest unpublished manuscripts as Hudson, G.V. 1950."Fragments of New Zealand Entomology", Wellington, which includes a list of his publications. A google search will turn up obituaries and the entry on him in the "Dictionary of New Zealand Biography".

Ted Edwards
CSIRO

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	Steve Curle

Contributions to the ESV newsletter are always welcome.
Contact the President, Patrick Honan, at phonan@museum.vic.gov.au