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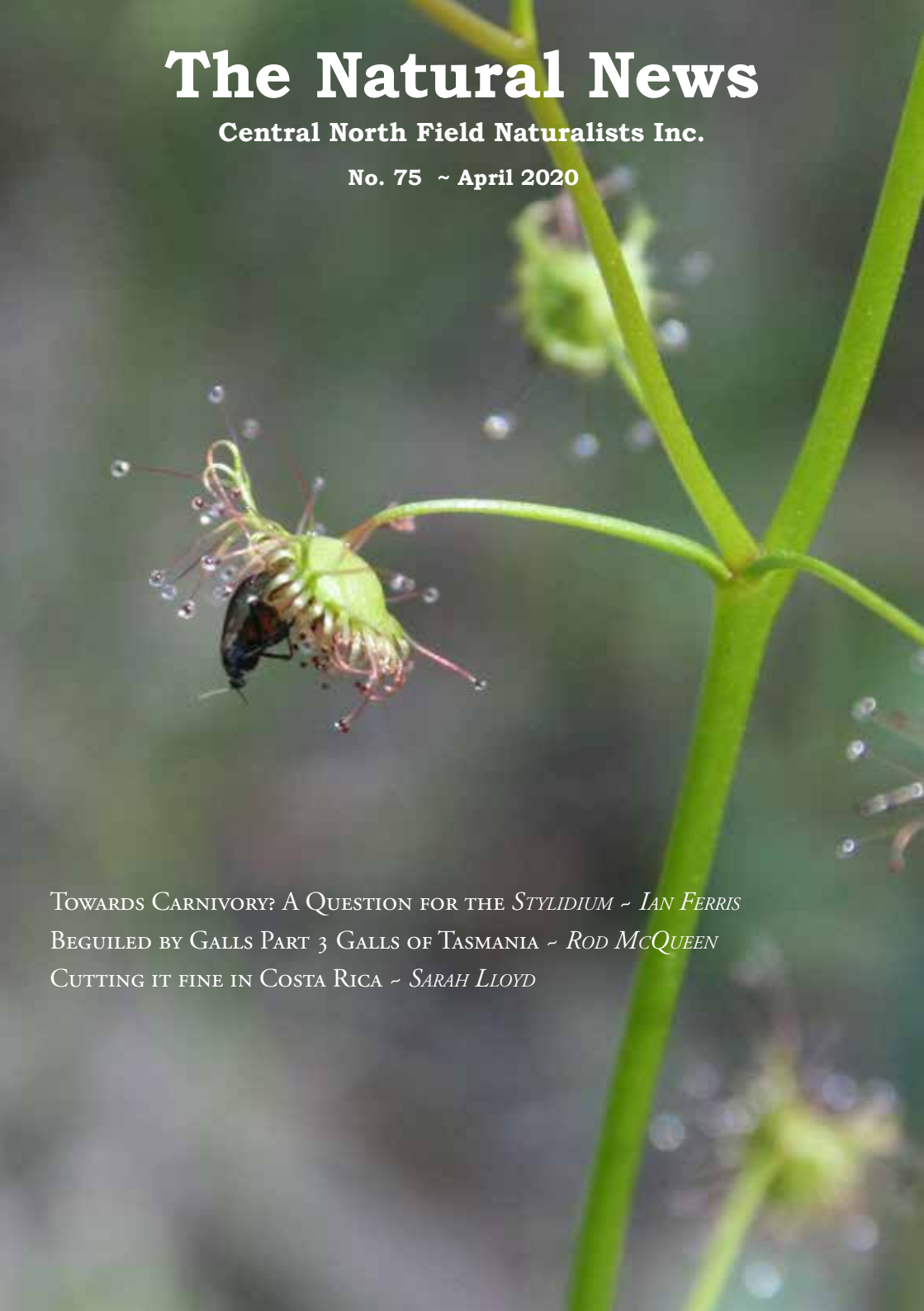

Towards Carnivory? A question for the *Stylidium*

Ian Ferris

During investigations into the *Drosera* species (Sundews) in northern Tasmania, references were found identifying *Stylidium* species (Triggerplants) as either carnivorous or "proto-carnivorous". These references (see below) have "triggered" a range of responses and the matter is not yet settled.

Carnivorous plants are those that capture insects or other small creatures, and gain some nutrients. Many other plants trap or kill insects, but carnivory is where the nutrient from the prey is consumed.

Drosera species have glands called trichomes on at least some of their leaves and sometimes the stems. The trichomes produce a combination of shiny digestive fluids on a short stem. This attracts a variety of insects, which are trapped and then digested, with the plant absorbing some of the nutrients. This has developed because these plants survive in places with either very few nutrients or with acidic conditions that preclude nutrient uptake.

Drosera peltata P. Milner

Drosera species are keen to attract insects because they can consume them. Yet they also need to be pollinated successfully. This is achieved because most *Drosera* species have their flowers on long separate stems, well away from the trapping leaves.

Stylidium species in Australia, including our own common Triggerplant *Stylidium graminifolium*, have also developed trichomes which trap insects on their stems and sepals. Studies have indicated that in controlled conditions, the number of insects caught is similar in both genera. However, although chemical analysis of the fluid did confirm a digestive component, no evidence has been presented as to the nutrient value of this feature to the *Stylidium*, which would consume a significant part of the plant's energy and nutrient budget. There is discussion as to whether this development is a precursor to *Stylidium* becoming carnivorous; *Stylidium* species are often found in similar nutrient poor locations as *Drosera*.

It could be that the benefit to the *Stylidium* is a protective one. *Stylidium* have a feature that gives it the common name – Triggerplant. When a flying insect lands on the visually attractive and scented flower to get a nectar reward, the column holding the pollen snaps rapidly from its normal position, and strikes the insect. The pollen is showered onto the insect, to be carried away to another Triggerplant when it departs. Other insects, such as ants or crawling species, would also trigger the column, but might not take the pollen to another Triggerplant unless it was very close by. Therefore the plant gains advantage by preventing access to the flower to crawling insects by stopping them with a sticky minefield.

Stylidium graminifolium showing trichomes (glands) on their stems and sepals. I. Ferris

A cranefly (Tupilidae) stuck on the leaf of *Drosera peltata.* S. Lloyd

Other plants use spikes, hairs, or other means to protect their flowers.

It would seem that *Stylidium* and *Drosera* have developed similar trichomes, but for different reasons. In time, a *Stylidium* species might gain some advantage from the trapped insects, but that is possibly well into the evolutionary future.

There are many references, but these may pique your interest:

https://www.bionity.com/en/encyclopedia/Stylidium.html

https://legacy.carnivorousplants.org/cpn/articles/CPNv46n1p28_29.pdf

https://en.wikipedia.org/wiki/Protocarnivorous_plant

Drosera species usually have their flowers on long stems well away from their sticky leaves. This is one of the numerous species common in Western Australia's impoverished soils. S. Lloyd

Beguiled by galls, Part Three: Galls of Tasmania

Rod McQueen

The most recent attempt to compile a numerical, systematic list of Australian galling insects and their hosts that the author has found is Rosalind Blanche's 1995 thesis, "Factors Influencing the Diversity of Gall-forming Insect Species on Australian Plants". Though she developed a respectable database by scouring the literature and checking specimens held in major museums she was quick to point out that "the actual number of gall insect species and host plant genera could be much higher". In the 25 years since then, much more information has been published, rendering her lists outdated. But nobody has attempted a broad systematic revision so there is no check list of Tasmanian galling insects.

In Tasmania eucalypts and acacias are the chief host plants but there is less certainty about the galling insect fauna. Blanche's list of the insects that form galls on the twelve main eucalypt species includes: 33 scale insects (Coccoidea), 17 plant lice (Psylloidea), 4 wasps (Hymenoptera) and 3 gnats (Diptera). Whether this list is an accurate reflection of the relative abundance of galling orders on Tasmanian eucalypts will become more evident over time. It provides little insight into the many other genera of susceptible plants. So far it would seem that the Tasmanian gall fauna is completely lacking any aphid-, beetle-, sawfly- or lepidopteran-induced gallers.

Natalie Tapson, Horticultural Botanist at the Royal Tasmanian Botanical Gardens, lists the species most affected by galling in Tasmania:

Acacia melanoxylon, A. longifolia sophorae, A. mucronata, A. mearnsii, A. dealbata, Eucalyptus delagetensis, E. viminalis, E. obliqua, Leptosperum scoparium, L. glaucescens; Melaleuca pallida and *M. virens.*

All parts of eucalypts can be galled—roots, leaves, branches, stems, and flower buds—but acacias, melaleucas, and leptospermums support galls on fewer plant parts.

Galling insects are eaten by some birds including some parrots whose strong bills are capable of cracking open galls. The gut contents of Swift Parrots sometimes include the pupae of gall-inducing fergusoninid flies. Sarah Lloyd describes observations of Green Rosellas at Birralee:

> Last week I added another couple of ingredients to their diet: the invertebrates that are responsible for the galls on eucalypts and dogwoods. In early November numerous eucalypt leaves with bright red spherical galls fall from the canopy. Many … have exit holes from where the responsible invertebrate has vacated … other galls are either intact or they've been split by the parrots to access the tiny invertebrate within, an achievement that requires considerable force.

Here is a brief but patchy overview of Tasmania's gall fauna.

Stem gall of *Apiomorpha conica* on *Eucalyptus*. Lyn Cook.

Scale insects — Hemiptera: Coccoidea

Around 80% of scale insect galls are found on stems, leaves and flower buds of *Eucalyptus* and other Myrtaceae despite this plant family comprising less than 10% of the species diversity of the Australian flora.

Tasmania has three species of the flamboyant genus *Apiomorpha — A. conica, A. strombylosa* and *A. munita munita*, all of which occur on eucalypts.

Sheoaks (*Allocasuarina*) host the scale insects *Cylindrococcus spiniferus* and *C. casuarinae*. *C. spiniferus* exhibits dimorphism (see Part Two), a relatively rare phenomenon among galling insects with only a few cases known in Tasmania. Females form stem rosette galls up to 32 mm long which are often mistaken for fruit, while male galls up to 17 mm long are slenderer. Both are usually located on the same stem. Crawlers (free-living, first-instar nymphs) are dark red then turn orange after moulting in the developing gall to second-instar nymphs. At maturity, winged males depart in spring and summer to hunt for females. Females can remain in the gall and continue to produce nymphs for up to two years.

Dimorphism is also known in *Eremococcus turbinatus*, a common scale insect gall on terminal leaf buds of common tea-tree *Leptospermum scoparium*. This species is endemic to the east coast of Australia, including Tasmania. Adult females are legless and remain forever doomed to life in the near dark. Holes in the base of the galls allow males to enter to mate and offspring to leave.

Eremococcus turbinatus galls on *Leptospermum*. The hole in the base allows males in to mate and offspring to leave. Lyn Cook

One specimen of the widespread genus *Tanyscela* has been collected from an unidentified eucalypt near Dover. *Tanyscelis verrucula* females produce nipple-like galls around 4–9 mm long on stem, leaf petiole or midrib. Males induce 2–5 mm long cylindrical galls on stems and leaves.

Psyllids — Hemiptera:Psylloidea

Psyllids (see Part Two), often called "jumping plant lice", have about 380 described species in Australia. Of the approximately seventy genera, three—*Glycaspis, Trioza* and *Schedotrioza*—contain galling species. Newly hatched nymphs are less than a millimetre long.

A UTAS study from 1979–1982 describes an unidentified species of psyllid that induces simple pit, or pouch galls, which form a depression in one side of actively growing leaves, on three *Eucalyptus* species (*pulchella*, *obliqua*, *regnans*). Two species of predacious mites were found to opportunistically exploit the gall tissue but played no part in its formation. Larvae of one species of tortricid moth were also found to feed on the gall tissue. Investigators found that if for any reason (such as drought conditions) the gall was vacated by the nymph, the leaf produced abnormal "eruptive" growths about 2 mm in length. Though designated as an emergent gall in the literature, these are in reality a pathological phenomenon, similar to witches' brooms.

Trioza is a genus of worldwide distribution, many of which induce galls on a broad range of non-eucalypt plants. The Australian fauna includes six described and some undescribed

species (pers. comm., Gary Taylor). Tasmania has one undescribed species found on pinkwood, *Beyeria viscosa* (Euphorbiaceae).

Trioza gall on *Beyeria viscosa* 3-4 mm. Rod McQueen

Trioza nymph. Rod McQueen

Dr. Gary Taylor, University of Adelaide says of the other two genera, "The genus *Glycaspis* has about 140 species, mostly lerp-formers and all on eucalypts. Of these about 20 form galls, of which three occur in Tasmania. The genus *Schedotrioza* has 12 species, all gall formers on eucalypts, of which four occur in Tasmania".

Species of *Schedotrioza* form "apple" galls on the leaves of *Eucalyptus amygdalina, E. obliqua* and *E. sieberi*. The nymphs are completely enclosed and depend on the splitting of the galls to emerge.

Adult *Schedotrioza* from Geeveston. Bodylength approx. 2.5 mm. Tony D., Bowerbird

Wasp gallers

Chalcid wasps form galls in the stems, leaves and flower buds of *Eucalyptus* and in the flower buds of *Acacia*. Woody green galls about 10 mm in diameter caused by the chalcid wasp *Trichilogaster trilineata* are common in the flower heads of silver wattle *A. dealbata*. Perhaps the most conspicuous of all Tasmanian gall associations is that between a congener of this wasp, T. *acaciaelongifoliae,* and the coastal wattle, *Acacia longifolia sophorae,* "Christmas ball" galls familiar to anybody who has visited a northern Tasmanian beach. Females mate and oviposit in flower buds immediately after chewing their way out of the gall; they die

within a couple of days. Eggs remain dormant in the buds until the next spring when feeding by the hatched larvae in the axils of the developing flowers leads to the formation of spherical galls. Since more than one egg is laid in the same inflorescence, numerous galls develop simultaneously, coalescing as they do so and producing a large cluster with up to 24 chambers. Normal flower development comes to a grinding halt, and even neighbouring flowers die back. This arrangement may be unique among galling insects in that some galls hold separate chambers for males and females — a round, central female chamber and a smaller, peripheral, oval chamber, perpendicular to the female, containing a male grub!

In 2008, an outbreak of damaging twig and branch galls struck introduced Tasmanian blue gums (*Eucalyptus globulus*) in California. The culprit turned out to be a new chalcid wasp of the genus *Selitrichodes*. It was described and given the name *S. globulus*. So far, it has not been found in Australia, but is "certainly Australian in origin". So, keep your eyes peeled for swollen twigs on blue gums and you may become world famous.

On a recent visit to Devils Gullet, some conspicuous, 5–10 mm, shiny stem galls were seen on an immature *Eucalyptus coccifera*. Dr Gary Taylor confirmed that it was a chalcid wasp gall based on the numerous chambers, and the features of the larvae.

Cut open Chalcid wasp gall from *E. coccifera*. Two larvae visible. Rod McQueen

Parasitoids and hyperparasitoids

Tasmania has its fair share of wasps that do not induce galls themselves but make havoc of those that do. The Mercury, Nov 16, 1942, makes this observation: "Gall-makers are numerous, and were it not for the tiny wasps that keep a check on them by application of their ovipositors, which leads to baby wasps usurping the galls, the forests would be overrun with them, and trees would suffer on a wide scale" (Nature Notes: Insect Gall-makers).

A common genus of tiny Tasmanian gall parasitoids (2–3 mm long) is *Megastigmus*, the members of which seem to restrict their depredations to galls on eucalypts. At least five species are known throughout Tasmania concentrated on flower and bud galls induced by *Fergusonina* and *Apiomorpha* species. *Megastigmus iamenus* has been reared from at least two *Apiomorpha* galls and other globular eucalypt galls. The ovipositor of this species is as long as the body. *Megastigmus tasmaniensis* has been reared from bud galls on *Eucalyptus obliqua. Megastigmus fuscicornis* is found in various leaf galls on eucalypts.

Dipteran gallers

Galling dipterans affect the stems, leaves and flower buds of numerous genera of plants.

The *Fergusonina-Fergusobia*, fly-nematode association is the only known case of **obligate mutualism** between insects and nematodes. These pairs exhibit extremely high host specificity, though they are found on a wide range of myrtaceous host genera. In this case it is the nematode rather than the maggot that "irritates" the host into gall formation. Only one such association has been found in Tasmania involving the endemic species *Fergusonina tasmaniensis* that causes galls in the terminal leaf buds of the snow gum, *Eucalyptus pauciflora*.

They are probably many undiscovered

Asphondylia floriformis galls on glasswort shoots. David Tng

instances of infestation by gall midges (Cecidomyiidae) in Tasmania. One established association is that between the midge *Dasineura tomentosa* and the coastal tea tree, *Leptospermum laevigatum*, in north-east Tasmania whose galls look like Camellia flower buds. Pupation occurs inside the gall.

A small number of species of *Asphondylia* form galls on two species in salt marshes commonly known as glassworts or samphire. These plants are characterized by growth that resembles upright strings of beads. Spherical galls form on the "leaves" or are mere swellings of the leaves, but *A. floriformis* induces a complex structure of tightly overlapping scales on beaded glasswort *Sarcocornia quinqeflora*, described as "superficially resembling flowers" by Winifred Curtis. Some mid-nineteenth century Herbarium specimens of infected glassworts have accompanying notes indicating that the collector mistook the galls for floral parts, not surprising as the true flowers consist of small, inconspicuous "tassels".

Most *Asphondylia* have a single larva per gall, but *A. peelei* on *Tecticornia arbuscula* is noted for its multiple larval chambers. Larvae of all *Asphondylia* species feed on fungi growing in the chamber with the result that these galls do not need the nutritive layer found in other galls. The associated fungus has been identified as *Botryosphaeria dothidea*, a species that causes cankers on a wide variety of trees and shrubs. *Asphondylia* larvae metamorphose within the gall then escape through the apex of the gall leaving the **exuvia** lodged in the exit hole.

One major challenge facing these midges is to collect **conidia** of the fungus with which they associate. Newly emerging females are clean, so they must get the fungus from elsewhere, something that is not fully understood. Part of the mystery is hinted at by observations of another *Asphondylia* species, and the structure of the female abdomen, a large ventral pouch between the seventh and eighth abdominal segments where, it is believed, she stores fungal conidia. Beginning at sunset, newly emerged females repeatedly fly downwards, thrust their ovipositor into the soil then fly back upwards. Many of these flies never attempt to oviposit suggesting that the females scoop up spores when they thrust their ovipositors into the soil with those that don't oviposit having failed to find and gather the necessary conidia. Next time you stroll among glassworts, try to imagine the backstory of frenetic activity behind the galls you find. Better still, perhaps you could try to find active midges.

Thrips

While many thrips species create domiciles by gluing or sewing phyllodes together, barely a handful of thrips galls have been documented from Tasmania.

Oncothrips rodwayi, the only gall-inducing thrips on *Acacia* species in temperate climates, induces 10-15 mm long and 7-10 mm deep purse-shaped pouches on blackwood, *Acacia melanoxylon*. Galls contain around 37 individuals at maturity. These galls are always founded by females which lay numerous eggs in rapid succession. The time taken from egg-laying through feeding, pupation and **eclosion** of the foundress is about six weeks, after which the foundress dies and the offspring mate with siblings, escape and disperse.

Common boobialla (*Myoporum insulare*) is frequently galled by Klambothrips species in coastal south-east Australia, probably including Tasmania. Leaves are curled and distorted. (See photo, Part One.)

Conclusion

If you can accept the assertion that to learn everything there is to know about galls would take a few lifetimes, you can appreciate that this series of articles has barely scratched the surface and has by necessity made numerous generalities all of which have many exceptions; every theme is embroidered with countless nuances. We wait with bated breath for someone to produce a GallFlip. Please. Anyone?

Glossary

Conidia: an asexual, non-motile spore of a fungus.

Eclosion: The emergence of an adult insect from a pupal case or an insect larva from an egg.

Exuvia: the cast or sloughed skin of an animal, especially of an insect larva or pupa (known as the "exoskeleton").

Obligate mutualism: a mutualistic association in which neither organism can survive without the other.

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Trichilogaster acaciaelongifoliae adult. WaspWeb: Hymenoptera of the Afrotropical region. URL: www.waspweb.org. van Noort

Cutting it fine in Costa Rica

Sarah Lloyd

The opportunity to attend the International Congress on the Systematics and Ecology of Myxomycetes, (i.e. a slime mould conference) in Costa Rica in February 2020 was too good to pass up. Ron and I had always wanted to visit the country, not only because of its political system and lack of an army but also because of its diversity of landforms and associated flora and fauna—although tiny, Costa Rica has over 5% of the worlds biodiversity.

Leaving Tasmania just as a virus was beginning to wreak havoc across the planet was potentially riskier than we could ever have imagined. Ron had strong misgivings about going, but I was prepared to risk life and limb for myxos! We headed overseas on 22 February and during the following two weeks mingled with thousands of travellers at airports, cafes, restaurants and hotels.

During our final guided bird tour on 5 March, our guide seemed unconcerned about the spreading virus. At the time there was one confirmed case in Costa Rica; several weeks later a state of emergency was declared.

We grew ever more nervous each time we checked the news, fearing that we might not get home before borders were closed. It was with great relief that we returned to Tasmania on 13 March, one day before the 14 day quarantine for overseas travellers was recommended.

A more detailed account of our time in Costa Rica, the places we visited and the wildlife we observed will be distributed via email to members.

N.B. As advised in a recent email, all CNFN walks and other events have been cancelled until further notice due to Covid-19.

Collared Aracari

American Pygmy Kingfisher

Salamander

Chestnut-colored Woodpecker

Snowy Egret

Spectacled Caiman

Strawberry poison dart frog

Hummingbird

Whimbrel

Long-nosed bats

Gray-cowled Wood-Rail

White-throated Capuchin

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