PLANT GALLS: THE DIVERSE ABNORMAL GROWTHS ON PLANTS RESULTING FROM THEIR INTIMATE ASSOCIATIONS WITH PARASITIC ORGANISMS

Allan Wills

A recent Australian publication introducing the biology and ecology of insects that live in plant galls reveals the fascinating life of these organisms. The book *Life in a Gall* by Rosalind Blanche would make a handy addition to the reading list of anyone interested in the Australian bush. Its language and content are highly readable and it is extensively illustrated and informative to a broad range of readers. The book is divided into an introductory chapter and chapters covering the different kinds of gall-inducing insects and their plant hosts; the adaptations that these insects have for living in galls; the various kinds of enemies of these insects and the strategies involved in avoiding being eaten; chapters on the problems caused by galls when they become pests, and the benefits and ecosystem services provided by galls. Lastly is a chapter describing how to collect and study galls.

A casual inspection of just about any piece of bushland will reveal at least several different types of plant gall. This is because about 50% of gall-inducing insect species in Australia are associated with eucalypts and up to 18% of gall-inducing insect species are associated with acacia. These two plant taxa that are so characteristic of much of our vegetation occur extensively across Australia.

Many different organisms that parasitise plants induce alterations in the normal development of cell tissue that result in a fantastic array of different shaped growths on plants. These irregular growths are known as galls and result from either an increase in the size of affected plant cells or an increase in the number of cells. The organisms that induce galls include phytoplasmas, viruses, bacteria, fungi, nematodes and arthropods (e.g. mites, and insects such as thrips, wasps, flies and beetles).

No one really knows how the structure of galls is induced and regulated by the galling organisms, particularly the complex structures induced by insects. The gall itself is produced by the plant.

One simple way of classifying galls is based on their structure and shape:

- Modified or multiplied organs that are still recognisable: e.g. witches brooms and virescences such as Sheoak Witches Broom associated with a phytoplasma pathogen.

Irene Tallentire beside a gigantic Sheoak Witches Broom on Common Sheoak, Allocasuarina fraseriana, Gidgegannup
Photo: Penny Hussey

- Irregular, variable growths with mostly undifferentiated tissues such as tumours and cankers: e.g. galls induced by the acacia gall rust fungus *Uromycladium tepperianum*.

Fungal gall on Jam Wattle, York
Photo: Zara Kivell

- Complex and organised growth with layers of specialised tissues forming a novel structure on the plant. Within this group are the great variety of galls induced by nematodes, mites and insects.

There are a few problems with considering galls only by structure. Quite different organisms can induce superficially similar galls and closely related parasites can induce galls that are very different in form. The galls induced by particular insect species are usually characteristic of the insect species. In some cases, such as the scale insects of the genus *Apiomorpha*, males induce quite different galls to the female insects. In some other cases, the type of gall formed depends on the stage of the insect's life cycle.

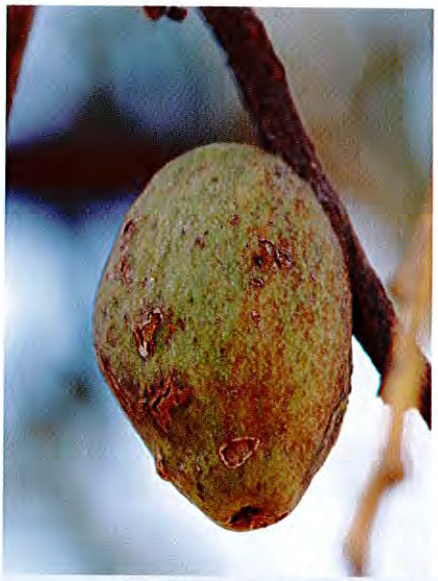
Which organism benefits from galling: insect or plant? An obvious benefit to gall-dwelling insects is that the plant provides a concentrated source of nutrients in the gall, and these are provided to the detriment of the plant. Also, flower bud and seed galling insects may reduce the reproductive potential of their hosts. However, some gall inducing fig wasps play an essential role in pollen transfer to the reproductive benefit of their plant hosts. Thus, galling insects that affect the reproductive potential of their hosts can have an effect on the composition of plant communities, and other organisms, including humans, which depend on plants affected by galls.

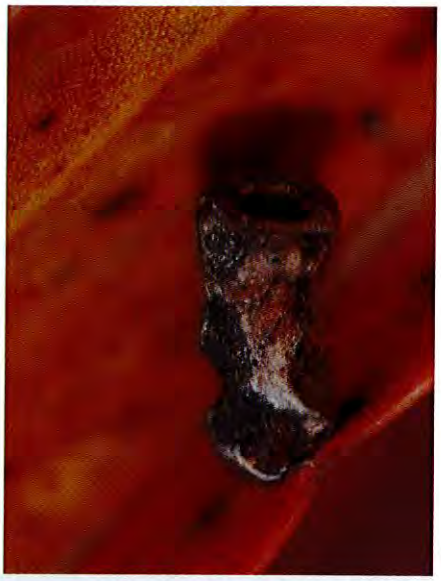
What kinds of insects induce galls on plants and what plants are galled? An amazing variety of insects and plant hosts! The insects include bugs (such as psyllids, scale insects and whiteflies), wasps, thrips, flies, beetles and even moths. Generally each species of galling insect has a

continued on page 12

continued from page 11

Plant galls





Believe it or not, these galls are made by the same species, the scale insect Apiomorpha, *growing on Tuart. On the left is the gall made by the female, on a twig, or the right the much smaller gall made by the male, growing on a leaf, Trigg. Photo: Allan Wills*

narrow range of only one or two plant host species.

While the chapter on the taxonomy of gall inducers and their hosts is a well illustrated synopsis of insect and host taxa, the high level of host specificity of gall inducers means its strength is not as a 'What gall is that?' identification handbook. Rather, it is a prelude to the subsequent chapter that reveals the fascinating adaptations of the insects to their life mode and to overcoming the problems of dispersing and finding the right plant and site for producing a gall, and successfully reproducing. For example, among most galling scale insect species it is the immature insect stage that is the dispersal stage to new gall sites. This nymphal stage is usually limited to crawling, which is a restricted means of dispersal. One group of scale insects has solved this problem through a difference in the rate at which males and females mature. The males mature faster than the females and the immature females hitch a ride on the elongated abdomens of their winged adult brothers to new sites suitable for initiating galls.

The way insects feed within the gall is determined by the kind of insect inducing the gall. The enclosed insects may have mouthparts which allow direct chewing of plant cells (wasp, beetle, moth and some fly larvae), or feeding by sucking the contents of plant cells by piercing mouthparts (psyllid and scale insect nymphs). Feeding by the larvae of the gall midge *Asphondylia floriformis* (tiny flies) involves wounding and chewing of the tissue of the host plant Beaded Glasswort (*Sarcocornia quinqueflora*) to induce gall formation followed by feeding on the layer of fungus that develops on the interior walls of the gall. Newly emerged adult females carry spores of the fungus to new gall sites where the female lays her eggs. In a later chapter, the ecological importance of this and another species of gall midge is revealed. Seeds of the *Sarcocornia* host are a food source for the threatened orange-bellied parrot. These parrots migrate from Tasmania to coastal salt marshes in Victoria where they overwinter and feed on the beaded glasswort. Galling affects seed production and should the amount of galling increase there is potential for this to contribute to a decline in parrot populations.

Two examples of the problems caused by galls are of relevance to Western Australia. In natural stands of the Scarlet Banksia (*Banksia coccinea*) the gall inducing midge *Dasineura banksiae* causes galls on the underside of leaves. While these may be of trivial importance in wild populations, this banksia is cultivated commercially for its prized red inflorescences. The presence of galls renders the flower stems unsuitable for the fresh flower trade. The affected leaves can be removed but the stems are suitable only for the dried flower trade resulting in diminished financial returns.

Geraldton wax (*Chamelaucium uncinatum*) is also grown commercially for the fresh flower trade. The native chalcidoid wasp

continued on page 13

Bud galls, causative organisms unknown. Left: Coastal Daisy (Olearia axillaris). *Photo: Allan Wills Right: Jam Wattle* (Acacia acuminata), *York Photo: Zara Kivell*

continued from page 12

Plant galls

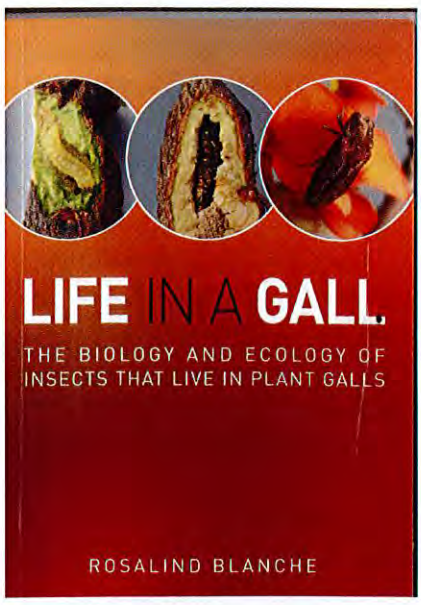
Dasineura banksiae *galls on Scarlet Banksia. Photo: Sylvia Leighton*

Oncastichus goughi induces galls on the new stems and leaves of this plant. The presence of galls results in deformed branching patterns which degrade the suitability of affected plants for the fresh flower and nursery trade. The wasp has spread to Israel and California where it is considered a pest.

Gall enemies range from predation by parrots, tiny wasp parasitoids, inquiline species which cohabit the galls with the gall inducing species, and kleptoparasitic species which steal the gall from the gall-inducing species. Against these enemies, gall-inducing insects employ an equally diverse array of strategies. Perhaps one of the most interesting defences briefly touched on by the author is the antibacterial secretions of gall inducing thrips.

Galls are not all bad news! When species are introduced either deliberately or accidently to new countries outside their endemic range they often proliferate because they have left their enemies behind. Galls have potential for use in biocontrol of invasive plant species. One of the best known examples of this is the use in South Africa of the flower galling chalcidoid wasps *Trichilogaster acaciaelongifoliae* and *T. signiventris* to reduce environmental damage caused by the introduced Australian wattles *Acacia longifolia* and *A. pycnantha*. Of local interest in the book too is a section dealing with the potential of two gall midge species *Dasineura strobilus* and *D. tomentosa* as biocontrol agents of coastal tea tree which is a woody weed species in WA.

After obtaining the required permission appropriate to the area intended for survey for galls, how do we know what kind of insect is present inside the gall we have found? Well, the equipment needed for collecting galls and studying galls, such as secateurs for snipping the galls from vegetation and paper bags for specimens, is quite simple, as detailed in the book, and can be found in most households. Collected specimens can be dissected to extract insects from the galls, or the galls can be kept in ventilated containers such as glass jars with tissue covers to rear specimens to adult stages. Identifying what has been collected usually requires viewing the insect specimens by magnification and reference to a good information source such as the two volumes of *Insects of Australia*. But don't despair if you have no access to these, there are lots of keen entomological groups out there on the internet who can provide help and advice on identification. A local group is the WA Insect Study Society who are contactable via their website: museum.wa.gov.au/waiss/



Life in a Gall
Rosalind Blanche
Pub: CSIRO

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A CUCKOO BEE

Shown here is a Waroona Cuckoo Bee (*Thyreus waroonensis*) visiting *Boronia dichotoma*, a spring-flowering perennial often seen on winter-wet flats on the Swan Coastal Plain.

The female cuckoo bee requires a 'host' and uses the nest of another native bee, the Blue-banded Bee (*Amegilla chlorocyanea*) to lay her eggs. The cuckoo bee larvae hatch first, then destroy their host's brood and take over the food supply inside the chamber. To sleep at night, male cuckoo bees attach themselves to a stem or leaf by their jaws only.

The bee is found throughout Australa and it will visit a variety of flowers, including eucalypts and grasses.

Heather Adamson