WESTERN AUSTRALIAN NATIVE ORCHIDS

"The masters of deceit"

by ANDREW P. BROWN

INTRODUCTION

With over 800 genera and 30,000 species, orchids are one of the worlds largest and most successful groups of plants. In fact they constitute about 10% of all flowering plants and many more still await discovery in areas where botanists have yet to explore. Although the greatest number of species occurs in the tropics, they are well represented throughout most regions and it is really only in the coldest and most arid places that orchids are not found. Australia has relatively few genera and species in comparison to many other places, but does contain over 115 genera and 800 species. The South-West of Western Australia has some 350 of these, many of which are unnamed.

WESTERN AUSTRALIAN ORCHIDS

Western Australian orchids occurs in two disjunct regions. Firstly there are some 12 or so species found in the tropical north, particularly in the area on and adjacent to the Mitchell Plateau. However, the second, and by far larger group, is found in the lower South-West. Here, species of orchid can be seen from near Shark Bay, South-east to Balladonia, and east in a narrow coastal strip to Eyre on the Great Australian Bight. Over this large area habitats range from high rainfall Jarrah, Marri and Karri forests, winter-wet swamps and coastal heath, to much lower rainfall inland Mallee woodlands, salt-lake margins and granite outcrops.

In Western Australia's mediterranean climate of cool, wet winters and hot, dry summers orchids largely grow and flower during the Autumn, Winter and Spring months. A few species do continue flowering into the summer, but with the exception of the Slipper Orchid *(Cryptostylis ovata)*, all die back to dormant tubers which resprout following the Autumn rains. The first to appear each year is the Leafless Spider Orchid *(Caladenia aphylla)* which begins flowering in March, while the last is the Mignonette Orchid *(Microtis media)*. Although the flowering of this species begins in November, it continues well into February.

Orchids found in Western Australia range in size from the dainty Dwarf Spider *(Caladenia bryceana)*, which grows to a mere 6 cm in height and has flowers just 2 cm across, to the tallest of all Western Australian orchids, the Tall Leek Orchid *(Prasophyllum regium)*. This species grows to well over 2 metres in height and has up to a hundred or more flowers, but like the Dwarf Spider these are tiny. Other species have large flowers up to 30 cm across and the variation in floral shape between species is enormous. Many are extremely attractive, but some of our orchids such as Greenhoods *(Pterostylis)* and the Hammer orchids *(Drakaea)* have flowers that are so bizarre that it is hard to imagine that is what they really are.

Like orchids elsewhere the Western Australian species have a number of special features which contribute to their success. All have numerous tiny seeds that can be dispersed widely by the wind. They also have a close tie with soil fungi that infect the germinating seed and provide a food source on which the young plant can grow, and they have an ability to thrive in harsh environments, either as herbs with underground tubers in semi-arid regions, or, as with some of the Kimberley species, perched on rock outcrops and trees in rainforests.

While some species such as Snail Orchid *(Pterostylis nana)* are able to multiply vegetatively (asexually) by producing two or more tubers each year, most like the White Spider Orchid *(Caladenia longicauda)* and rarely have more than a single replacement of the old tuber. They must instead rely upon seed dispersal as a means to increase their numbers and this dependance requires the flowers to be actively pollinated by insects or, in rare cases, by apomixis (self-pollination).

The paramount specialty of our orchids is therefore illustrated in their diverse flowers which have evolved with one aim in mind, and that is to manipulate insects in order to achieve pollination.

ORCHID POLLINATION

Without a doubt orchids are one of the most specialised groups of plants in the world and in order to achieve pollination the orchid flower has undergone a number of major adaptations. Unlike

most other plants, orchids have combined the pollen-bearing parts (anthers) and pollen-receiving parts (stigmas) into one central structure known as the collumn. Orchids also have all their pollen amassed into one or two large bundles, each of which can be transferred as a single unit. These become attached to the head, thorax or abdomen of a pollinating insect, in a position where they cannot be easily removed. If the pollen mass is then transferred to a receptive stigma of another flower an exceptionally large number of ovules will be fertilised at the same time. In contrast, most other plants require multiple pollination events to secure a similar amount of fertilisation.

To ensure that cross-pollination occurs most flowering plants attract animals, birds or insects as agents for pollination, although wind is also used by some successful groups, such as grasses and the Australian Sheoaks.

The common approach offered to pollinators is to advertise food, either in the form of pollen or nectar or both. For example, honeybees visit flowers for nectar and in the process of obtaining it pollinate them. The nectar they collect is used to make food for their brood. Thus, both flowers and insects receive benefits from this interaction, and in the case of our own native insects the hum they produce around a flowering gum tree is familiar testimony to the success of this attraction process.

However, orchids, (and the Western Australian species are no exception) do not always provide what they promise and display a diversity of floral contrivances aimed at enticing insects to participate in the transfer of pollen. They often provide neither pollen nor nectar to the visiting insect and instead use other devious and deceptive means to entice their services. Over one third of all orchids (10,000 species) fall into this group. The methods they use provide a fascinating subject for study and have attracted the attention of meny eminent students of evolution. Charles Darwin, for instance, wrote a book about it, as did some of his contemporaries.

AUSTRALIAN POLLINATION STUDIES

In Australia a number of enthusiasts with an interest in our orchids, both last century and early this century, have done studies into their pollination. Observations of pollination events were made by pioneers such as Robert Fitzgerald in Sydney in the 1870's who is well-known for his perceptive studies into pollination of our Sun Orchids *(Thelymitra)*. Using jars to cover flowers. Fitzgerald demonstrated that, unlike most other orchids, many Sun Orchids were capable of pollination without insects. Following Fitzgerald, Oswald Sargent in Perth in the 1900's unwittingly observed the pseudo-copulatory pollination of the Dragon Orchid *(Caladenia barbarossa)* by a black wasp. This was followed by Edith Coleman's discovery in the 1930's of pseudocopulation in the Slipper Orchids *(Cryptostylis)*, thus putting Australia firmly on the map as a place where unusual and unique pollination systems occur. Rogers, also in the 1930's, described the pollination of the Blue Fairy Orchid *(Caladenia deformis)* by a bee *(Halictus subinclinans)* and in 1946 Fred Fordham gave an interesting description of the pollination of the Beard Orchid *(Calochilus campestris)* by a male Scollid Wasp. In recent years this research has enjoyed a resurgence of interest by workers such as Bates, Beardsell, Bernhardt, Calder, Clements, Dafni, Hutchinson, Jones, Peakall, Stoutamire, Williams and many others, resulting in a great deal of new understanding.

Never-the-less, little is known about the pollination systems of many of our orchids and there is still a great deal more research to be done.

Also worthy of future research is how much impact the European Honey Bee has on the successful pollination of our orchids. The animal is the wrong size and shape and, although it often removes pollinia, fails to deposit it in the right place. It may also compete with rare flower wasps and native bees for food, thus reducing the levels of pollination in the orchids serviced by these insects.

Additionally, very little is known about the insects themselves and this is yet another area of possible future study.

POLLINATION OF WESTERN AUSTRALIAN ORCHIDS

The Insects

A diverse group of South-West Australian insects pollinate orchid flowers. These include beetles, fungus gnats, midges, mosquitoes, flies, bees, wasps and flying ants. Although it would appear that bees are the most common pollen vector used by orchids, it is in the latter two groups that some of the closest ties between orchid and pollinator occur.

Flower wasps or Thynnids are especially important. The females are flightless and live underground for most of their lives. When ready to mate they emerge from the soil, climb up nearby vegetation, and advertise to males by then releasing a chemical attraction which blows downwind. The winged males rapidly respond by flying upwind in ever decreasing zig-zags toward the odour source. Females are clutched from above by the males and mating takes place in flight. The mated couple then fly to flowers where the male feeds on nectar and either regurgitates some for the female or backs around so that she can feed herself. After several such mating events, the female burrows underground in search of beetle larvae, which she subsequently paralises. She then lays her eggs beside this food source.

Flying ants are utilised by Hare Orchids *(Leporella fimbriata)* in the South-West. Emerging in

Autumn on warm still days, usually preceding the onset of a cold front, they fly for some distance in search of a suitable place to set up a colony. Having achieved this, the winged fertile males mate with the queen and eggs are laid.

The Orchids

As mentioned before, Western Australian orchids use a variety of contrivances in order to attract pollinating insects. Some are no different to most other flowering plants in offering food to ...ential pollinators. However, many circumvent the system by providing neither nectar nor pollen. Instead, they engage in pretence and deception. There are flowers that resemble fungi, some that smell like rotten meat, others that have structures like pollen laden anthers of lillies and some flowers simply mimic other flowers to catch the odd unwary or inexperienced bee which is working the model plants for pollen or nectar. The masters of deception, however, are those orchids that deceive male wasps or flying ants by successfully emulating females of the insect species. This is done by emitting chemical attractants and also, occasionally, by visually resembling the female. This is an evolutionary theme that reaches its most diverse and sophisticated development in South-West Western Australia.

The main methods of attraction are as follows:

Orchids with nectar

There are several orchid groups in the South-West that offer nectar and attract a range of insects as pollinators. The two largest are the Leak Orchids *(Prasophyllum)* and Mignonette Orchids *(Microtis)*, both of which advertise their nectar by producing sweet floral fragrances and, in some species, colourful flowers.

Most Leek Orchids flower following summer fires and appear erect black or green stems amongst the blackened remains of associated burnt shrubs, It has been suggested that this form of camouflage has been developed in order to hide the plants from foraging animals. Unfortunately it does not appear to be very successful as many plants are eaten by Kangaroos and other animals. A typical example of *Prasophyllum* is the beautiful Fringed Leek Orchid *(Prasophyllum fimbria)*. Like others, it advertises the droplets of nectar found near the base of its brightly coloured labellum by its sweet floral scent. The flowers of both this and other species attract many nectar-feeding insects, including flies, beetles, bees and wasps. Many of which will pollinate the flowers.

Although smaller, Mignonette Orchids *(Microtis)* are similar to Leek Orchids. Favouring winter-wet habitats such as ephemeral swamps or moss swards on granite outcrops they often occur in large colonies, sometimes amounting to thousands of plants. The minute flowers of the Mignonette Orchids produce small quantities of nectar that attract tiny insects such as midges, ants and tiny bees. Interestingly, most species of Mignonette Orchid will self-pollinate if insects have not been active, thus it can be seen that they have the best of both worlds.

Also using nectar as an attractant are the Mosquito Orchids *(Cyrtostylis)*. These occur in cool, damp habitats and provide nectar for the small pollinating fungus gnats that are abundant where the orchids grow.

Other orchids which use nectar as an attractant are the Beak Orchids *(Lyperanthus)*, Bunny Orchids *(Eriochilus)*, Rabbit Orchids *(Leptoceras)* and some of the flower-like Spider Orchids *(Caladenia)*. Many of these are bee specialists.

Bee Specialists

Flower bees respond to certain fragrances and colours, and usually seek pollen and nectar from flowers. In fact a diverse array of South- Western orchids have flowers specially modified to attract bees as their major pollinators. Some fairy caladenias exemplify this specialization. The lip and column combine to form an open-mouthed tube that can be forced apart only by bees of the required size, shape and strength.

Bright Colours

Many insects, such as beetles and bees, are attracted to bright colours, a feature shown in several South-Western orchids. The intense yellow of the common Cowslip Orchid *(Caladenia flava)* and the bright pink of Fairy and Fan Orchids *(C. latifolia, C. reptans and C. nana)* are familiar sights in the Spring. These often produce massed displays, particularly in the season following summer fire. Obviously the insects are not overly particular as hybrids between these species are common producing a beautiful array of colours.

Sun Orchids *(Thelymitra)* are another genus with bright coloured flowers. Although it has been shown that some species are actually mimicking other flowers, the rich blues, yellows and pinks of most Sun Orchids are known to attract insect pollinators.

Mimicry

On first inspection, the intricate and delicate flowers of Donkey Orchids *(Diuris)* make little sense in terms of pollination. Neither perfume nor nectar are offered. When seen in the wild, however, it will be noticed that there is a close similarity between the central parts of the Donkey Orchid flowers (dorsal, sepal and labellum) and those of co-blooming peas such as *Daviesia, Pultenaea* and Isotropis. Studies have shown that bees regularly visiting pea flowers for their rich source of nectar occasionally explore the Donkey Orchid flower in the same way. One such visit is usually enough to remove pollinia and one more visit mistake in visiting a second Donkey Orchid ensures pollination. This is just one example of pollination by

food deception and is often referred to as "floral mimicry" because the orchid appears to mimic another flower.

South-Western Australia has an unusually high number of blue-flowered herbs and shrubs, most of which attract bees as pollinators. These flowers are mimicked superbly by some species of Sun Orchid *(Thelymitra)*. The nectarless Scented Sun Orchid *(Thelymitra macrophylla)*, for instance, has a prominent yellow apex to the collumn which bees appear to mistake for the bright yellow pollen-producing anthers of our native lillies. Bees are known to collect pollen from these lillies by a special mechanism called "buzz pollination", achieved by vibrating their wings to release pollen from the flowers anthers. Occasionally these bees mistake a Sun Orchid for an associated lilly and, in an attempt to buzz the false pollen, inadvertantly pollinate the flower. Other Sun Orchids including the spectacular Queen of Sheba *(Thelymitra variegata)*, which resembles the Star of Bethlehem *(Calextasia cyanea)*, the Blue Lady Orchid *(T. crinita)* which is a close match for the Native Iris *(Orthrosanthus laxus)*, and the Lemon-scented Sun Orchid *(T. antennifera)*, also have elaborate processes on their columns that resemble anthers or pollen masses. Bees are deceived by these and in their frustrated attempts to glean pollen, often pick up or deposit real pollinia.

Another orchid group that has evolved elaborate structures which resemble anthers are the Enamel Orchids *(Elythanthera)*. Found only in Western Australia both the Purple Enamel *(Elythanthera brunonis)* and the Pink Enamel *(E. emarginata)* have brightly coloured glistening flowers that contain enlarged structures at the base of their much reduced labellum. As with the Sun Orchids these attract native bees and appear to be mimicking similar looking buzz-pollinated flowers found in Fringe Lillies *(Thysanotus)*, native Tomatoes *(Solanum)* and several other groups.

Pseudopollen

Pollen is used by many plants as a food reward to attract insects, however, none of the orchids found in Western Australia are known to provide pollen as a legitimate food. Some, instead, produce a mealy substance known as "pseudopollen". Leek Orchids for instance, offer nectar but also have labella which contain false pollen on which insects can often be seen feeding. Interestingly, these orchids may also be mimicking the erect flower spikes of Blackboys *(Xanthorrhoea)*. These are like Leek Orchids in that they appear in the season following fire. A similar range of nectar-seeking insects visit both and this would appear to be a case of a plant offering nectar, but also indulging in deception and mimicry.

The Potato Orchid *(Gastrodia sesmoides)* is a saprophyte and as such has no green colouration. It therefore cannot photosynthesise, and instead derives all the nutrients it needs from a fungus that has infected its swollen rhizome-like tuberoid. During the early Summer its inconspicuous bell-shaped flowers can be seen in the higher rainfall forest areas of the lower South-West. On the lip of each flower is produced a fine sugary substance which bees, having entered the flower, proceed to scratch. They are known to place this "pseudo-pollen" on their hind legs together with real pollen gathered from other plant species and in so doing inadvertantly remove pollinia from the anther and/or deposit it on the stigma.

Fungus mimics

The dank floor of South-West Australia's forests or the sodden margins of swamp are the home of the inconspicuous Helmet Orchids *(Corybas)*. Fungus gnats appear to be attracted to these orchids, probably due to their fungus-like odour and dull purple and brown colouration. This combination may well deceive the gnat into perceiving the orchid flower as a fungal fruiting body and on visiting the flower they achieve pollination. An amazing transformation then takes place. Once the tiny ground-hugging flowers are pollinated they are rapidly pushed skywards for up to 30 or more centimetres by the elongated stem. When the pod ripens this results in a more effective dispersal of the seed by wind, which is an important consideration for inhabitats of still forest floors.

Spider Orchids

Many Spider Orchids *(Caladenia)* offer neither nectar nor pollen, nor do they contain false anthers, pseudopollen or mimic other flowers. However, they do attract a large range of insect pollinators such as flies, beetles, hoverflies, bees and wasps. This group of orchids have flowers with elongated wispy floral segments that are covered in glandular hairs and are known to emit various scents ranging from sweet and fragrant to obnoxious, the latter often like rotting meat. It would appear that insects are attracted by these odours.

The Spider Orchids provide some useful intermediate stages in the development towards the sexual deception of male wasps and nowhere else in the world can the evolution of this remarkable system be better documented.

Interestingly, a group of flower spiders have specialised in using the Spider Orchid flowers as traps for unwary prey. Beautifully camouflaged to look like the anther at the top of the column, the spiders often capture insects attracted to the flower.

Sexual Deception and Pseudocopulation

The attraction of male insects to flowers under sexually false pretences, often termed pseudo-copulation, is used by several South-Western orchid groups, the flowers of which share certain characteristics. Their colours, for instance, are usually dull shades of green, yellow and maroon

and they are usually, but not always, odourless to humans. However, all produce powerful chemical lures that are irrestistable to male pollinating insects. These "sex-pheromones" appear to be especially active on still, warm days, particularly from late morning to mid-afternoons. Orchids found in these groups are often small and easily overlooked as they blend remarkably well into the dull background. Many also have a flexible labellum that is attached to the flower by a narrow claw and resembles a small insect.

The Dragon Orchids *(Caladenia barbarossa)* are a superb example as they have an insectiform lip that closely matches the size, shape and texture of a female flower wasp. The males of these non-social wasps of the family Tiphiidae, sub family Thynninae zigzag upwind to the flower then attempt to pick up the decoy and fly off with it, but are thwarted as the hinged lip throws them over against the column during their frustrated lift-off.

Like the Dragon Orchids, Hammer Orchids *(Drakaea)* are masters of deception. There are about eight species found in the South-West of Western Australia and their inconspicuous odourless flowers are living examples of extreme specialisation. These flowers are invariably solitary on top of a thin wiry stem and are reduced to mere remnants of their colourful counterparts seen in genera such as *Caladenia*. The biggest and most conspicuous part of the Hammer Orchid flower is its lip, which resembles to a remarkable degree a female flower wasp. Pollination is achieved by sexual deception of the male wasp, which is flung over and upside down against the column when it attempts to fly off with the female decoy. Each species of Hammer Orchid is pollinated by a different species of wasp and therefore illustrates one of the most specialised relationships between pollinator and plant known to occur in Australia.

In several Spider Orchids *(Caladenia)* the calli along the centre of the lip have become aggregated and modified to the point where they resemble a female mimic (at least to a wasp). The Arrowsmith Spider Orchid *(C. creba)*, for instance, is known to attract a large yellow-banded Thynnid wasp which attempts to mate with the dark band of glandular calli found along the centre of its labellum. However, some species are much less modified but still manage to achieve this deception. It has been noticed that most Spider Orchids which use sexual deception have clubbed petals or sepals (osmophores) which appear to be the source of the sexually attractive pheromone. The Fringed Mantis Orchid *(C. falcata)* is a good example of an orchid which uses this method. Attraction can be demonstrated by removing the clubs then exposing them to a wasp population seperately from the remainder of the flower. When this has been done it has been demonstrated that wasps will visit the clubs in preference to the remainder of the flower.

Yet another group of orchids that use sexual deception are the Flying Ducks *(Paracaleana)*. But these go one step further in having a sensitive labellum that is similar to that of the Triggerplants *(Stylidium)*, in being capable of movement on mechanical contact. A female decoy is formed by the lip and is attached to the inverted winged column by an elangated springy claw. On contact with the female decoy both the male wasp and lip are swung down into the pouch formed by the column wings. It takes a wasp a considerable amount of exertion to back-peddle out of the trap and in doing so it removes pollinia in the process. The flower subsequently resets itself to the firing position over a period of several minutes.

The tiny Elbow Orchid *(Spiculea ciliata)* is bizarre even by orchid standards. Although sending up its stem during late Spring, it does not begin to flower until the moss swards, in which it grows, dry out prior to the long hot Summer. Under these rather harsh conditions the orchid dies at its base but is able to support the flowers and developing seed pods with water and nutrients stored in its thickened fleshy stem. Each plant has up to seven flowers with hinged insectiform labella and curiously shaped column wings. When small male flower wasps, attracted to the female decoy, attempt to fly away with it they are momentarily trapped by the collumn wings, thus depositing or removing pollen.

Pollination by ants is an extremely rare occurance anywhere in the world. A few species of Mignonette Orchid *(Microtis)* are known to be pollinated by ants, but pollination by sexual deceit of male flying ants is unique to the Australian Hare Orchid *(Leporella fimbriata)*. The single species of this genus is unusual in that it flowers in Autumn, however, this makes sense when you consider that it is this time of year when flying ants swarm. These primitive ants *(Myrmecia urens)* are in search of a queen with which to mate and start a new colony. On nearing the flower of a Hare Orchid they act in a similar way to male flower wasps on other species of orchid by being initially attracted by a chemical lure (sex pheromone). However, unlike the male flower wasps, they first land on the plant's stem rather than the flower, then climb upwards, align themselves sideways accross the lip for a few minutes, and squirm their way out, picking up pollinia as they do.

Commonly known as Flower Wasps, the large, colouful Scollid Wasps *(Campsomeris)* appear to be attracted to the wonderfully ornamented labellum of the Beard Orchids *(Calochilus)*. It is believed that they are lured by pheromones emitted by the flower and, in their attempt to mate, inadvertantly pollinate the orchid. Interestingly these orchids are also capable of self-pollination should the insects not be active.

But perhaps the most well documented case of an orchid using pseudocopulation as a method of achieving pollination is in the Slipper Orchids *(Cryptostylis)*. So convincing is their attraction to male Ichneumon wasps *(Lissopimpla excelsa)* that copulation is attempted and sperm packets are ejected into the orchid. The rather un-flowerlike flowers resemble a dead fleshy leaf on which the male wasps alight upside down and attempt to copulate. Pollinia are then picked up and deposited on the stigma this way.

Species in other genera such as *Pterostylis, Genoplesium* and *Thelymitra* have evolved their own methods of successful pollination by sexual deceit.

Greenhoods

Greenhoods *(Pterostylis)* are one of the largest genera of Australian terrestrial orchids. All have their petals and sepals fused into a hood which encloses the column. As with the Flying Duck Orchid *(Paracaleana)* the often protruding labellum, in most species, is sensitive to the touch, springing upwards to trap against the column any insect which alights on it. These are usually tiny midges or mosquitoes, which reasons currently unknown to us, are attracted to the flower. They can escape only by crawling upwards, first past the stigma on which they deposit any pollen that has already adhered to them, then past the anther from which they remove a new load of pollen. They finally emerge from the flower by passing out through the cavity at the top.

The Underground Orchid

The Underground Orchid *(Rhizanthella gardnerii)* is one of Western Australia's botanical marvels, as it germinates, grows, flowers and fruits entirely underground. Although, recent studies have shed new understanding about this remarkable plant, its pollination remains largely a mystery. When flowering, the plant forms a crack in the soil surface and a range of insects including minute flies, wasps and termites have been seen leaving the tulip-like head with pollinia attached.

Self-pollination

Some South-Western orchids have foregon the use of insects to transfer pollen and instea achieve self-pollination (autogamy) by a proces involving the anther collapsing onto the stigma In fact, some orchids such as the Slender Sur Orchid *(Thelymitra pauciflora)* often do not ever bother to open. However, most species that self-pollinate are also visited by insects and only resort to self-pollination when insects are not active. Self-pollination is especially common in the Beard Orchids *(Calochilus)* and some Sun Orchids *(Thelymitra)*, but also occurs in a smattering of species throughout many genera.

Some orchids have taken this process one step further and are able to produce seed without any sexual union taking place. This is known as apomixis and several species of Microtis, such as Dark Mignonette Orchid *(M. orbicularis)*, use this method. Plants resulting from apoximis are genetically identical to the parent and are often quite abundant as they usually produce large amounts of seed. They are thought to use this method because cross-pollination is likely to fail in the absence of appropriate insects or because of severe or unstable environmental conditions. Although a short-term advantage in that large numbers of plants are produced that are well adapted to local conditions the long-term disadvantage is that the entire population may be wiped out if environmental conditions change, since there are no variants which may be able to survive.

FINAL REMARKS

Well, there you have it. Orchids may not always deliver what they promise, and in fact they may at times be quite deceitful, but the devious methods they use to achieve pollination makes a fascinating story. A story that we are only just beginning to understand.

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