# Hammer orchids

## with a waspish attraction

A study of Western Australia's hammer orchids has led to some exciting discoveries about their taxonomy and unusual methods of pollination. This knowledge is proving valuable in the development of strategies aimed at protecting these unusual plants, some of which are threatened with extinction.

by Andrew Brown, Stephen Hopper and Joanna Moore

Well known for being spectacular or unusual, orchids are one of the largest of all plant families, making up about 10 per cent of the world's plant species. They are varied, complex and engage the eye of many bushwalking wildflower enthusiasts.

Although a myriad of floral forms are known among the orchids, without a doubt the orchid genus that exhibits one of the most bizarre adaptations is the Western Australian genus *Drakaea*—the hammer orchids.

## The hammer orchids

Named from the type species *Drakaea elastica* by John Lindley in 1839 in honour of the accomplished botanical artist Sarah Anne Drake, *Drakaea* is a genus of 10 species characterised by small, fleshy, heart-shaped leaves, thin wiry stems and solitary flowers, each with a hinged insect-like labellum (lip). This latter feature leads to their common name, with the lip imagined as the head of the hammer and the arm the handle.

Hammer orchids are among some 400 orchid species found in Western Australia and, like the majority, are endemic to the south-west between Kalbarri and Israelite Bay. Most species are found in deep sandy soils and all favour open areas, meaning they are often seen along old tracks and around the margins of sand pits. A keen eye is required to observe hammer orchids because, while they are sometimes locally common, they are small and have dull colouration. Hammer orchids can be found in flower between August and November with the majority of species flowering between September and October.

## Confused taxonomic history

The taxonomic history of the hammer orchids has been one of dispute and confusion from the time the genus was first named in the nineteenth century. When first described, just one species, *Drakaea elastica*, was recognised by English botanist John Lindley. James Drummond, a botanist and plant collector with a special interest in orchids and who collected the type specimens of *D. elastica*, was surprised by this, as two species were plainly evident around Perth and he had sent them separately bundled to Lindley's herbarium. However, the two species had been mistakenly pasted together on the same sheet. When he realised the mistake, Drummond named them *D. livida* and *D. lucida*. So for more than a century, the name *D. elastica* was applied to the wrong species—the common warty hammer orchid now known as Drummond's *D. livida*.

A long and complicated series of contributions to the genus followed, involving the discovery of new species, numerous new descriptions, misnamings and renamings. By the 1980s four species had been named—the glossy-leafed hammer orchid (*D. elastica*), warty hammer orchid (*D. livida*), king-in-his-carriage orchid (*D. glyptodon*) and narrow-lipped hammer orchid (*D. thynniphila*).

## First modern-day study

The most recent chapter in the hammer orchid story—a taxonomic review of the genus carried out over 25 years—is a particularly exciting one. The study is the first based on modern collections and field data and recognises 10 species within the *Drakaea* genus, including the description of six new species. Official naming of the new hammer orchids took place in 2007 in a paper written by Stephen Hopper and Andrew Brown published in *Australian Systematic Botany*. It bases its taxonomy in part on the perceptions of wasps!

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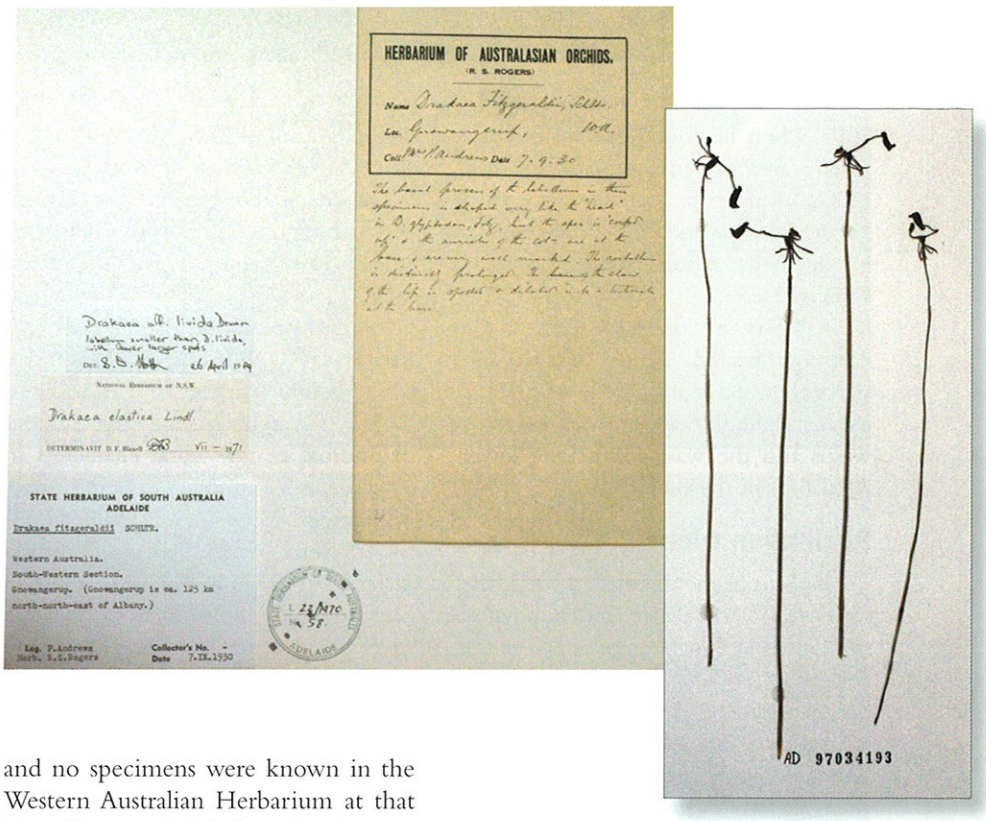
**Main** Wasp with warty hammer orchid.
*Photo – Babs and Bert Wells/DEC*

**Left** Kneeling hammer orchid.
*Photo – Andrew Brown/DEC*

The review began following a mapping program undertaken in the early 1980s by Stephen Hopper when at the former Department of Fisheries and Wildlife, the precursor to the Department of Conservation and Land Management, now the Department of Environment and Conservation (DEC), in collaboration with knowledgeable locals. The program was aimed at determining the taxonomic and conservation status of orchids. Through the program and follow-up research it became evident that despite the great amount of interest shown by numerous botanists and orchid enthusiasts over many years, undescribed taxa of *Drakaea* still existed. Six new species were subsequently recognised.

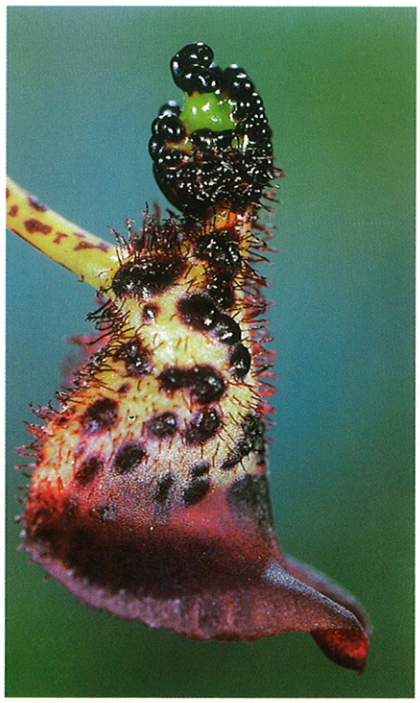
By 1992, five of the six new species had been identified. These were the kneeling hammer orchid (*D. concolor*), late hammer orchid (*D. confluens*), slender hammer orchid (*D. gracilis*), lonely hammer orchid (*D. isolata*) and dwarf hammer orchid (*D. micrantha*).

The sixth new species—the lost hammer orchid (*D. andrewsiae*)—was recognised only as the taxonomic review of the genus was finalised. Although photographs of the lost hammer orchid were taken in the early 1980s, no plants had been located and no specimens were known in the Western Australian Herbarium at that time. However, in 2004 a collection was discovered at the Adelaide Herbarium that had been made by Mrs P. Andrews from Gnowangerup in September 1930, and this was able to be used as the type collection. Subsequently, the prominent Western Australian orchidologist Garry Brockman took a photo of the species in September




**Top** The only known recent photograph of the lost hammer orchid.
*Photo – Garry Brockman*

**Above and above right** Type sheet and specimens of the lost hammer orchid collected by Mrs P. Andrews in 1930.
*Photos – Bill Barker/State Herbarium of South Australia*



**Above** Warty hammer orchid.

**Left** Late hammer orchid.
*Photos – Babs and Bert Wells/DEC*

2004 when he found two plants in a weedy area of remnant bushland east of Gnowangerup. Searches since then have failed to find the species, but it is hoped that it still exists in bushland somewhere.

As part of the revision of the hammer orchid genus, many field surveys were conducted and these explored the interaction between male wasps and the wasp-mimicking lower petal (lip) of the orchids.

## Pollination tricks

It has been discovered that the lip of many orchids takes on physical similarities to female wasps to enable the orchids to attract male wasps for cross pollination. This biologically complex adaptation is repeated in several Western Australian orchid genera but nowhere to the remarkable degree as in the hammer orchids where the significantly enlarged and highly modified lip or labellum actually resembles an insect more than it does a petal.

Although the function of the insect-like lip of hammer orchids drew speculative comment as early as 1951, a full understanding of its role in attracting pollinating insects did not begin until male thynnid wasps were seen visiting flowers of the common warty hammer orchid in the Darling Scarp east of the Perth suburb of Kelmscott in the early 1970s.

American pollination ecologist Professor Warren Stoutamire was visiting Australia at the time, conducting fieldwork on the function of unusual or rare floral characters in orchid species aimed at enticing insect pollinators. Warren was told about the thynnid wasps visiting common warty hammer orchid flowers. This led him to study other hammer orchid species and resulted in his publication of illustrations and descriptions of the mechanisms used by the hammer orchids for pollination.

Understanding the mating behaviour of thynnid wasps is integral to understanding how hammer orchid flowers are pollinated. The female thynnid wasp is flightless so when it is ready to mate, it climbs up low vegetation and releases a pheromone (a sexually attracting odour). The stingless winged male thynnid wasp detects the pheromone and zigzags upwind to find its source.

Once the male wasp locates the much smaller female it picks the female up and they mate in flight. The male immediately flies to a source of nectar so they can share a nuptial dinner before decoupling. The female thynnid wasp then drops to the ground and burrows below to find beetle larvae, which it renders immobile with its sting before laying eggs on the victim.

## Sexual confusion

It has been established that hammer orchid flowers emit an aerially transported chemical that mimics the pheromone of the female thynnid wasps. The male thynnid wasp, when picking up the orchid's deceptive scent, behaves as if it had located a receptive female wasp—it heads towards the source.

The hammer orchid's wasp-like lip sits at the end of an intricately constructed hinged attachment. When the male thynnid wasp finds what it perceives to be a pheromone-releasing female wasp, it grasps the female and tries to fly away to mate. But instead, the male and the lip arc forwards with the wasp's momentum—made possible by the hinged attachment—until its

**Above** A thynnid wasp flies up to a slender hammer orchid flower, attracted by its appearance and scent.

**Right** The wasp grasps the female wasp-mimicking lip, hoping to mate.

**Below right** It then arcs forward, colliding with the orchid's column.
*Photos – Babs and Bert Wells/DEC*

back collides with the orchid's column (a structure within the orchid flower).

During this process—and as the baffled wasp probably tries to work out what has gone wrong—the male's upper thorax (the middle section of its body) comes into contact with the stigma and anther (the top part of the orchid's column). This is what the orchid needs for pollination to occur. The wasp may pick up some pollinia (pollen packets) on its thorax or, if it already has some on it from a previous visit to another hammer orchid, some may rub against the stigma.

## A specific attraction

Building on the work of previous researchers, a study was conducted into which thynnid wasps were attracted to which hammer orchids. To do this, sets of different species of hammer orchid flowers were set up in vials of water in areas of bushland where male thynnid wasps were known to be active. The wasps could then be watched to see how they interacted with the flower baits.

**Above** Eight of the 10 known species of hammer orchid.
*Photo – Stephen Hopper*

**Right** Leaves of the dwarf hammer orchid.

**Far right** Searching for rare hammer orchids.
*Photos – Andrew Brown/DEC*

The study established that the thynnid wasps that pollinate hammer orchids display species-specificity. This means when given a choice, each species of wasp is selective in which species of hammer orchid it attempts to mate with. The conservation of the thynnid wasps is therefore important to the conservation of the orchids.

The actions of the wasps provided evidence that the subtle floral differences between the hammer orchids warranted naming several new species. This explains the assertion that the new hammer orchid taxonomy is based in part on the perceptions of the wasps.

## Fungal association

Even if the pollination process goes smoothly and the orchid's pollen grains grow down into the plant's ovary where they develop into a mature seed, seed germination is not guaranteed. Orchid seeds are among the smallest plant seeds and this means they are unable to germinate and grow on their own, as they lack the necessary nutrient store.

Most terrestrial orchids require certain mycorrhizal fungi for seed germination and hammer orchids are no exception. The fungus also supplies the mature orchid plant with water and nutrients during its seasonal growing cycle. In the absence of this association the orchid would not be able to survive for long due to its poor photosynthetic capabilities and its lack of a normal root system. So the survival of hammer orchids not only relies on the wasp-assisted pollination process but also on a guarantee that the appropriate mycorrhizal fungus is present in the soil.

## Naturally rare

Hammer orchids are among the most endangered Western Australian orchids with six of the species now extremely rare in their natural habitat. The lost hammer orchid is not known to have any extant populations in the wild while the glossy-leafed hammer orchid is now confined to just a few areas of remnant bushland along the Swan Coastal Plain. Other rare species are the kneeling hammer orchid, late hammer orchid, lonely hammer orchid and dwarf hammer orchid.

While the Threatened status of the rare hammer orchids is largely due to past land clearance and ongoing threats such as rising saline water tables, weeds, inappropriate fire regimes and changes in hydrology, several hammer orchids appear to be naturally rare. The reasons are largely unknown and research is under way to determine the specific causes of rarity.

## Taking a closer look

Ryan Phillips, a PhD student at The University of Western Australia and the Botanic Gardens and Parks Authority, is undertaking research to better understand factors affecting the evolution and conservation of rare hammer orchid species. This research

**Right** Habitat of glossy-leafed hammer orchid.
*Photo – Andrew Brown*

**Below right** Wasp with narrow-lipped hammer orchid.
*Photo – Babs and Bert Wells/DEC*

will increase our knowledge of the orchids' biological and ecological requirements, including habitat requirements, fungal associations and the sexually deceived wasps that pollinate them. The research will yield important insights which will help in the future conservation of hammer orchids.

Ryan's research is currently focusing on the factors influencing rarity and the formation of new species in hammer orchids. By combining experimental baiting for pollinators (using flowers picked under a scientific collecting permit from DEC) and for mycorrhiza (using orchid seed baits), he hopes to determine the causes of rarity in all of the endangered hammer orchids.

A key early discovery is that there is considerable variation in the causes of rarity between different species of hammer orchid. For example, the dwarf hammer orchid has a widespread mycorrhizal fungus but its pollinator is extremely limited. At the other extreme, the kneeling hammer orchid has a widespread pollinator but is restricted by its own specific habitat requirements. An unexpected result is that all species enjoy a very high pollination rate—a sign of the effectiveness of sexual deception. It is hoped that this will enable a high survivorship of current populations.

## Conserving for the future

The conservation of the hammer orchids is an enduring concern and, in order to protect them, five of the 10 species are legally protected under the *Wildlife Conservation Act 1950* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. This highlights the ongoing need for active research and management to ensure the conservation of this unique part of Australia's orchid heritage.

In particular, surveys for the lost hammer orchid are urgently needed to establish its conservation status. So far, it has been recorded only three times from the Gnowangerup–Tunney district about 350 kilometres south-east of Perth and it has not been found in recent searches.

DEC staff have written interim recovery plans for the late and lonely hammer orchids and are updating a previously published plan for the glossy-leafed hammer orchid. These recovery plans outline the actions that are needed to urgently address the threatening processes most affecting the survival of these species and begin the recovery process. Many of the recovery actions have been implemented and with ongoing action it is hoped that the future of the rare hammer orchids is ensured.

Hopefully the bizarre flowers and behaviours of hammer orchids will continue to captivate us so we are inspired to keep learning about and protecting them well into the future.

Andrew Brown is the Threatened Flora Coordinator with the Department of Environment and Conservation (DEC). He is the honorary Curator of the Orchidaceae and Myoporaceae at the Western Australian Herbarium, a life member of the Western Australian Native Orchid Study and Conservation Group and has conducted more than 30 year's research into Western Australian orchids, including their biology, ecology, taxonomy and genetics. Andrew has collaborated in the description of 131 new Western Australian orchid taxa, including the six new hammer orchids included in this article.

Stephen Hopper became Director of the Royal Botanic Gardens at Kew in October 2006. He is an internationally recognised plant conservation biologist who collaborated in the discovery, classification and description of 300 new plant taxa and led the delivery of improvements to programs and infrastructure at WA's Kings Park to world-class standards. He is Visiting Professor at The University of Western Australia and the University of Reading, and is a Fellow of the Linnean Society.

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