# Wheatbelt Orchid Rescue Project

# Final Report 6

# Population Survey Data for Southern Populations of the Western Underground Orchid

# *(Rhizanthella gardneri)*

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ISBN: 978-1-74052-228-1

## Wheatbelt Orchid Rescue Project Final Reports

Brundrett M. 2011a. Wheatbelt Orchid Rescue Project Final Report 1. Objectives, Outcomes and Overall Conclusions. Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 1*

Brundrett M. 2011b. Wheatbelt Orchid Rescue Project Final Report 2. Population Size and Vital Statistics Data for the Granite Spider Orchid (*Caladenia graniticola*). Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 2*

Brundrett M. 2011c. Wheatbelt Orchid Rescue Project Final Report 3. Population Size and Vital Statistics Data for the Ballerina Orchid (*Caladenia melanema*). Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 3*

Brundrett M. 2011d. Wheatbelt Orchid Rescue Project Final Report 4. Population Size and Vital Statistics Data for the William's Spider Orchid (*Caladenia williamsiae*). Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 4*

Brundrett M. 2011e. Wheatbelt Orchid Rescue Project Final Report 5. Population Size and Vital Statistics Data for the lonely Hammer Orchid (*Drakaea isolata*). Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 5*

Brundrett M. 2011f. Wheatbelt Orchid Rescue Project Final Report 6. Population Survey Data for Southern Populations of the Western Underground Orchid (*Rhizanthella gardneri*). Wheatbelt Orchid Rescue Project, University of Western Australia. **This Report**

Brundrett M and Ager A. 2011. Wheatbelt Orchid Rescue Project Final Report 7. Seed Collecting, Soil Baiting and Propagation of Orchids. Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 7*

Brundrett M. 2011g. Wheatbelt Orchid Rescue Project Final Report 8. Translocation of Orchids in Wheatbelt Nature Reserves. Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 8*

**Citation of 2 or more Project Reports**
Brundrett M. 2011. *Wheatbelt Orchid Rescue Project: Case Studies of Collaborative Orchid Conservation in Western Australia.* University of Western Australia, Crawley, Western Australia.

**Note:** Appendix 1 contains location data for Declared Rare Flora that is not included in publicly available versions of this report.

## 1. Introduction and Objectives

The Wheatbelt Orchid Rescue (WOR) project is a Lotterywest funded collaboration between the Western Australian Native Orchid Study and Conservation Group (WANOSCG), the School of Plant Biology at the University of Western Australia (UWA), the Friends of Kings Park and the Department of Environment and Conservation (DEC). This project aims to help conserve Critically Endangered orchids in the Western Australian wheatbelt by obtaining knowledge required for sustainable management and directly contributing to recovery actions. Please refer to the first WOR report for further information.

Background information about the biology, ecology and classification of the underground orchid *(Rhizanthella gardneri)* is briefly summarised below. The current report primarily concerns southern populations of *R. gardneri* near Munglinup. Additional information is available from the Interim Recovery Plan (IRP) (Brown et al. 2003).

The underground orchid was first discovered by John Trott near Corrigin in 1928 and named by Richard Rogers in honour of Charles A. Gardner the Government Botanist of Western Australia. A few more locations were discovered between 1928 and 1959, but these habitats were cleared. Extensive surveys by WANOSCG from 1979 to 1985 found three new populations (Dixon and Pate 1984). John McGuiness discovered another on his family farm east of Esperance in 1979 (George 1980), which is now being conserved by the current owners. Recent sightings are summarised in Table 1.

*Rhizanthella gardneri* listed as Declared Rare Flora and ranked as Critically Endangered in Western Australia. This species is also ranked as Critically Endangered under the Commonwealth Environment Protection Biodiversity Conservation Act 1999 (www.environment.gov.au). The main threats listed in the IRP are little remaining habitat due to clearance for agriculture, gradual loss of remaining habitat (due to the decline of the associated *Melaleuca* species), poor recruitment, human impacts, drought and weeds (Brown et al. 2003).

**Table 1.** Numbers of underground orchids observed since 2000, with the approximate size of each habitat area. Designation of populations follows the Interim Recovery Plan (Brown et al. 2003), except where subpopulations are recognised. Data provided by Mark Brundrett, Andrew Brown, Andrew Batty, Jeremy Bougoure, Emma Adams and the IRP (M = major survey with additional help and time spent).

| Location / population | Area | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Northern** | | | | | | | | | | | |
| 1. Babakin | 9 ha | | 5 | 0 | 7 M | 14 | 0 | 0 | 1 | 10 | 15 |
| 2. West of Babakin | 4.5 ha | | 0 | 0 | 6 M | 10 | 1 | 1 | | 2 | 6 |
| 6. Kunjin | 9 ha | 1 | 11 M | 2 | | 5 | 0 | 0 | 0 | 3 | 2 |
| **B. Southern** | | | | | | | | | | | |
| 3. Oldfield River | 3 ha | 1 | 0 | 1 M | 3 | 1 | 1 | 26 M | 3 M | 2 | |
| 4a. Northwest of Munglinup | 2.5 ha | | | 3 | 4 M | 7 | 0 | 14 M | 2 M | 2 | |
| 4b | 0.25 ha | | | 0 | | | | 5 M | | | |
| 4c | 3.5 ha | 6 | 8 | 22 M | 2 | | | 4 | | | |
| 5 NW of Munglinup | | | | | | | | | | | |

## 2. Orchid and Habitat Characteristics

The western underground orchid (*Rhizanthella gardneri*) has many unique features. As its name suggests, it is fully subterranean and has no leaves and no other green parts (i.e. no chlorophyll).

Examples of plants, flowers and seed capsules are shown in Figure 1. Each inflorescence has up to 100 small, inward facing, reddish-coloured flowers, spirally arranged on a flattened disc. Inflorescences vary from 1 to 4 cm in width and are enclosed by a chamber formed by overlapping ~1 cm wide by 3 to 5 cm long bracts that hold back the soil. These bracts are white, pink or red, becoming darker with age and light exposure. Bracts form a chamber over the flowers, leaving only a small opening close to the soil surface (Fig. 1A), but they spring open once flowers are excavated (Fig. 1BC). Most photos of the underground orchid show excavated flowers with the bracts spread open, which is not the natural situation. Inflorescences exposed to allow counting during surveys are re-covered with soil by pressing the bracts into position to re-form the soil-free chamber over the flowers.

*Rhizanthella gardneri* is known from two areas in the central and south-eastern wheatbelt about 300 km apart; (i) The Munglinup - Oldfield River area and (ii) the Corrigin - Babakin area (Brown et al. 2003). In the Corrigin - Babakin area *R. gardneri* grows in association with *Melaleuca scalena* while in the Munglinup - Oldfield River area it grows with *M. uncinata* and *M. hamata* (Bougoure et al. 2008). These broom bush honeymyrtle species were previously all known as *M. uncinata* (Craven et al. 2004). In both areas *R. gardneri* grows with a specific mycorrhizal fungus that forms a three-way relationship with broom bush and *Rhizanthella* (Mursidawati 2004, Bougoure et al. 2009, 2010). This unique orchid is easy to identify, if located, but very hard to find in the wild due to its subterranean habit.

The western underground orchid flowers from May to June in northern areas and from June to July in southern areas. Pollinated flowers produce a berry-like fleshy fruit, which are indehiscent at maturity and contain 20 to 150 seeds. The fruit mature in October or November and contain seeds which are much larger than those of other orchids (about 1 mm, see Fig. 12). It is believed that small animals disperse the fleshy fruit, but this has not been confirmed and may no longer occur.

The western underground orchid has only been found growing within a few cm of mature broom bush honeymyrtle *(Melaleuca uncinata* complex) in undisturbed mature thickets. These habitats have nutrient-poor, gritty, sandy clay or sandy loam soils over clay subsoil. The orchid has a tuber 10-30 cm below the surface and it flowers under the soil surface and the litter layer.

As explained in Section 5, the underground orchid is fully dependent on a symbiotic mycorrhizal fungus in the *Rhizoctonia* group for its nutrition. The microscopic fungal filaments (hyphae) are thought to provide plants with essential nutrients. However, the underground orchid has a parasitic relationship with this fungus, which in turn is dependant on its primary relationship (ectomycorrhizal) with the roots of the broom bush shrubs. This highly specific 3-way relationship (broom bush-fungus-orchid) explains why the underground orchid only occurs under broom bush and cannot be cultivated like other terrestrial orchids.


**Figure 1.** Inflorescences and flowers of the western underground orchid. **A**. Inflorescences are subterranean but the tips of bracts may protrude into the soil litter layer. **B-E**. Inflorescences with spirally arranged flowers within pale bracts. **D.** Single flower. **F**. Rhizomes. **G**. Seed capsules.


**Figure 2.** Habitat photos. **A.** *Rhizanthella gardneri* most often occurs in dense pure stands of broom bush (*Melaleuca scalena* in this case). **B**. Broom bush plant with fruit. **C**. Broom bush (*Melaleuca hamata*) is present in a mixed stand with other shrubs and trees at another site. **D**. Broom bush inflorescence and seed capsules.

## 3. Population Surveys

**3A. Surveys from 2000 to 2006**

Surveys of all known populations were undertaken by DEC, UWA, Botanic Gardens and Parks Authority (BGPA) staff and volunteers in 2001, 2002, 2004, 2005, 2006 (Fig. 3). Larger surveys were organized as part of the WOR project in 2007 and 2008 with assistance of volunteers from WANOSCG (see Section 3 below). The main objective of surveys was to confirm the health of known *Rhizanthella gardneri* populations with minimal impacts to their habitats and define habitat areas.

Data from surveys of all known habitats of the western underground orchid are included in Table 1. In many cases, few or no plants were discovered due to dry conditions and the extreme difficulty of locating subterranean inflorescences of this orchid.

The first recent major survey of southern populations was held over 3 days in July 2004 was led by staff of the UWA, BGPA and DEC Esperance with assistance by volunteers (Preston and Brundrett 2004). This resulted in the discovery of 50 flowers on about 40 flowering plants at the southern sites near Munglinup. This was the first major underground orchid flowering event that has been observed in over 20 years and resulted in a much clearer understanding of the size of habitat areas. Population 5 could not be relocated and has not been observed in recent years, despite several surveys. It is believed that the occurrence of several hot fires within a few years has severely impacted on this habitat and it may no longer be suitable for *Rhizanthella gardneri*.

**Figure 3.** Surveys of the southern underground orchid were conducted by DEC, BGPA and UWA staff and volunteers in 2003 and 2004 provided a comprehensive study of the distribution of *Rhizanthella* in habitats near Munglinup (Left –Ross Brockway volunteer, Right – Emma Adams DEC).

**Figure 4.** WANOSCG volunteers contributing to surveys of northern populations of the underground orchid near Babakin in June 2007.

**3B. Major Survey of Potential Habitats near Munglinup in July 2008**

In July 2008, Mark Brundrett (WOR), Emma Adams (DEC Flora Conservation Officer, Esperance) and Andrew Brown (DEC Species and Communities Branch) led a survey with WANOSCG volunteers. The main purpose of this 3-day survey was to accurately determine the size of habitats where *R. gardneri* occurs near Munglinup (see Appendix 1). Locations near Munglinup were selected using satellite imagery and aerial photos provided by Graham Behn (DEC and CSIRO). Some areas required access through farmland with landowner permission. There was an excellent turnout with 12- 30 WANOSCG members attending each day (see Fig. 5).

Surveys of remnant vegetation along a 15 km stretch of the Oldfield River in the vicinity of population 3 did not locate new populations, but several area of broom bush shrubland which were potential habitat were located. Exceptionally dry conditions in the region in 2008 (100 mm to June) may explain why very few underground orchid flowers were found at the Oldfield river site (over 30 people searching for 2 hours found 1 plant), but it certainly rained when we were there. In contrast the underground orchid was flowering well at population 4, only about 15 km away, where we observed over 25 inflorescences. Despite the dry conditions, most other wintering flowering orchids in the Munglinup area were observed to flower in 2008 (Table 2).

**Table 2.** Winter flowering orchids from the Munglinup area.

| ***Latin name*** | **Common name** |
|---|---|
| *Pterostylis* sp. | Shell orchid (close to *P. aspera*) |
| *Pterostylis vittata* | Greenhood |
| *Pterostylis* sp. | Hairy stem snail orchid |
| *Diuris* sp. *(aff. pulchella)* | Donkey orchid (widespread) |
| *Pterostylis allantoidea* | Shy greenhood (leaves only) |
| *Pterostylis* sp. | South coastal snail orchid |
| *Pterostylis rogersii* | Curl-tongue shell orchid |
| *Eriochilus scaber ssp. scaber* | Pink bunny orchid (leaves only) |
| *Caladenia* sp. *(aff. hiemalis)* | South coast early spider orchid |
| *Rhizanthella gardneri* | Underground orchid |
| *Corybas limpidus* | Crystal helmet orchid |

**Figure 5A.** Six adjacent underground orchid inflorescences observed in 2008. It is rare to find multiple inflorescences in one spot.

**Figure 5B.** Volunteers from WANOSCG who attended underground orchid surveys in the Munglinup area over 3 days in July 2008.

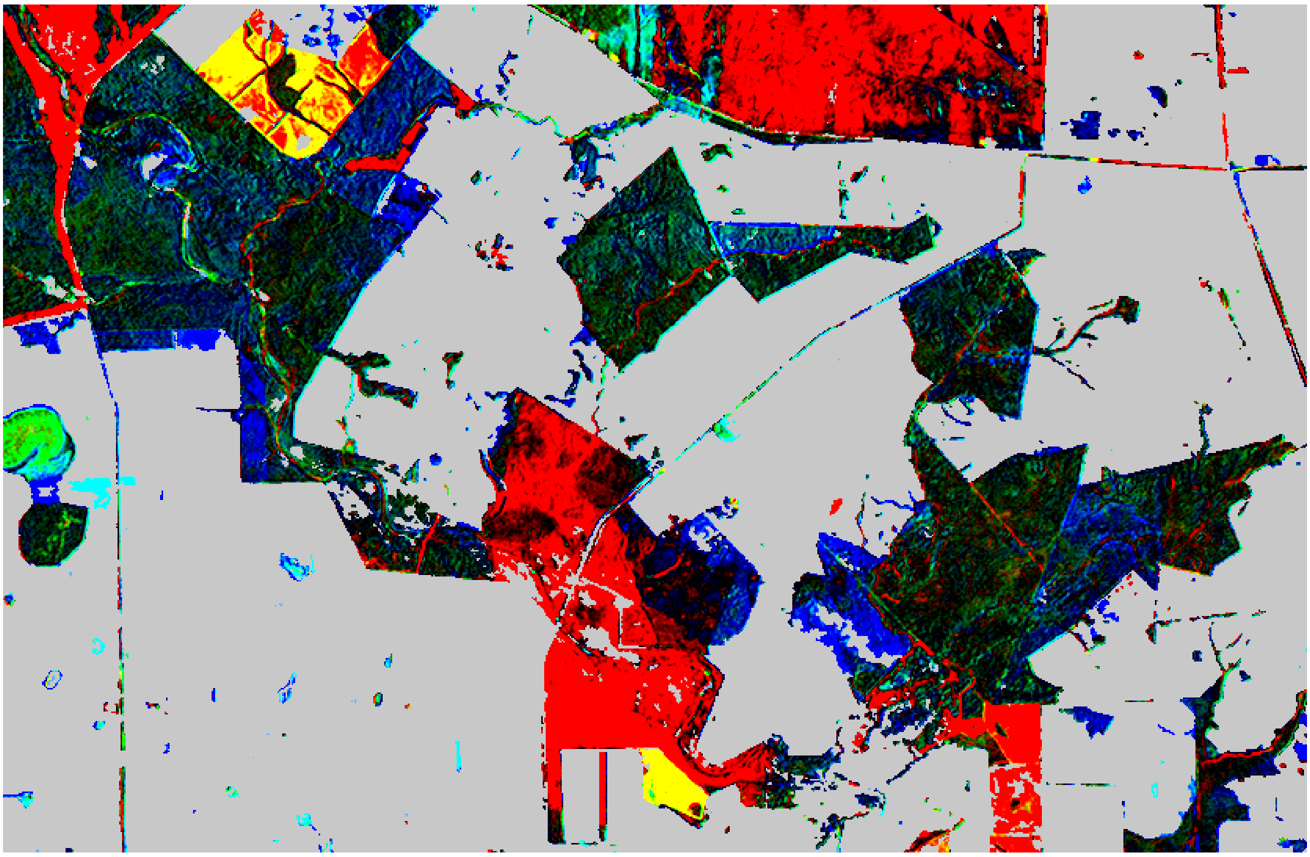


**Figure 6.** Composite image of vegetation along the Oldfield River and its tributaries near Munglinup. Manipulated Landsat satellite imagery shows healthy vegetation (green), recent fire impacts (red), recovery after older fires (blue) and vegetation loss (yellow). Image by Graham Behn, DEC.

**3C. Additional Surveys 2007-2010.**

In 2007 WOR & DEC staff visited sites to confirm the health of *R. gardneri* populations near Munglinup and to support research by Jeremy Bougoure a PhD student (see Section 5). In July 2009 northern boundaries of unallocated crown land along the Oldfield River were surveyed (Emma Adams, Julie Patten, Andrew Brown, MB). Only a small area of suitable habitat was located. In July 2010 a survey of the southern boundary of Oldfield River was also conducted by Emma Adam, MB, Andrew Brown, Erica Shedley. The main area of population 3 only revealed 1 flowering plant in 2010, perhaps because the soils as very dry.

Vegetation along the Oldfield River was generally in excellent condition, but a large section could not be assessed as it had recently been burnt (Fig. 6). The majority of habitats surveyed were not suitable for underground orchids, but 6 areas of potential new habitat were discovered (Appendix 1). A proposal to include a substantial part of the areas we surveyed into a nature reserve being prepared by DEC is strongly supported by information from this survey.

**3D. Northern Populations**

This report primarily concerns southern populations of the underground orchid and only a brief summary of the status northern populations is provided here. Canopy decline in broom bush has been observed in some areas, especially in population 2 and 6 (Fig. 10A). This seemed to be linked to periods of severe drought in recent years. In these sites the area of suitable habitat has decreased and this trend requires further monitoring. A large area in population 2 has been fenced, primarily to reduce grazing and assist regeneration of broom-bush seedlings (Fig. 10B). A permanent display on the underground orchid at the Babakin townsite in 2004 was prepared by the author (MB) and Mark Brown of Bruce Rock Landcare Group (Fig. 10CD).

## 4. Population Size and Dynamics

The survey data summarised above cannot be used to provide estimates of population sizes, since it is probable that even on good years only a small fraction of underground orchid plants flower. We do not know the ratio of flowering to non-flowering plants for the underground orchid, so observations cannot be extrapolated to estimate the size of populations. It is also very difficult to locate flowering plants so survey effort and the experience of searchers helps to determine numbers observed. It is also likely that rainfall or other climatic factors influences flowering intensity, as explained below.

Climatic factors, especially rainfall, were expected to be a strong determinant on flowering (Fig. 7). However the relationship between flowering and rainfall (monthly rainfall totals or months of drought preceding flowering) is complicated by substantial variations in flowering between sites. For example a group of 30 volunteers only discovered one plant in population 3 near the Oldfield River in 2008, where a smaller group found 26 inflorescences in 2004, but population 4 flowered well on both years. Flowering variability may reflect variations in rainfall between the 2 sites which are 15 km apart (and one is much closer to the Bureau of Meteorology weather station). Figure 8 shows that flowering may be good in years with both atypically wet or dry periods. June rainfall had the strongest correlation with flowering (Fig. 9). This may suggest that flowers can develop rapidly after rainfall, as most were observed in June or July.

Due to is subterranean habit, the underground orchid may be relatively unaffected by drought. However, it is likely that drought has indirect impacts on underground orchids due to reduced productivity of broom bush host plants and their associated fungus and/or through loss of litter from the soil surface. There is evidence that drought has degraded on the habitat of northern populations of *R. gardneri* in the past decade, but populations near Munglinup seem to be relatively unaffected. Baseline data on litter and soil from sites where *Rhizanthella gardneri* occurs have been published by Bougoure et al. (2008) and can be used to monitor changes in site productivity over time.

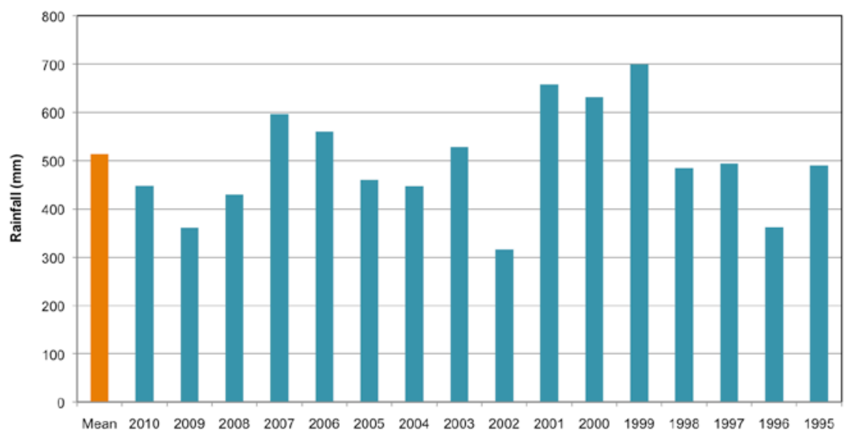



**Figure 7A.** Rainfall at Munglinup the closest station to locations where *Rhizanthella gardneri* occurs (Bureau of Meteorology, www.bom.gov.au).

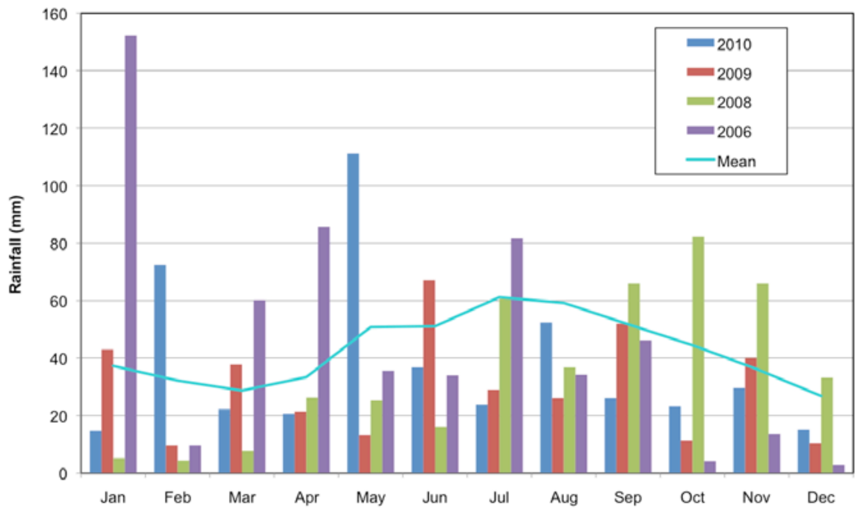



**Figure 7B.** Annual variations in monthly rainfall patterns over the 4 years of the WOR project (Bureau of Meteorology, www.bom.gov.au).

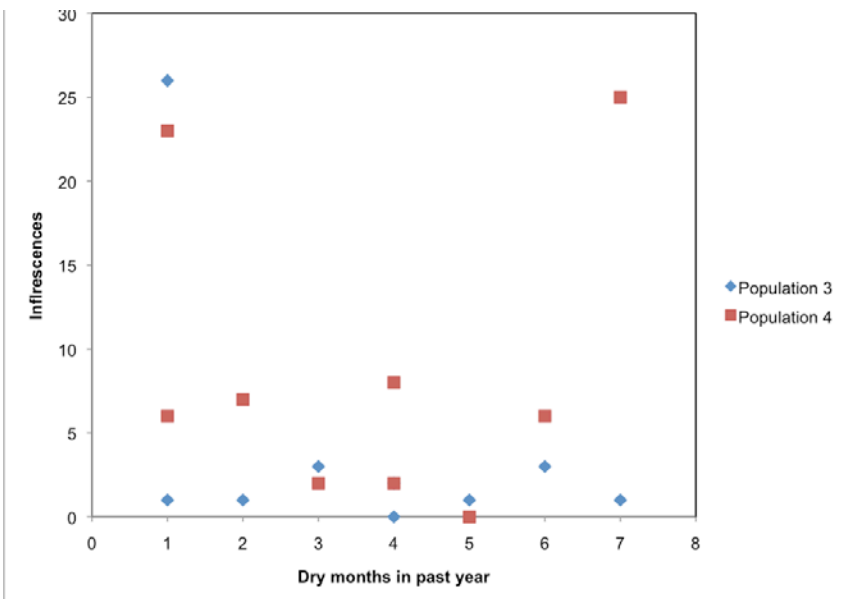



**Figure 8.** Relationship between June rainfall and emergent plant numbers for 2 *Rhizanthella gardneri* populations near Munglinup. Rainfall data from the Bureau of Meteorology (www.bom.gov.au). Population size data from the WOR project and the IRP (Brown et al. 2003).

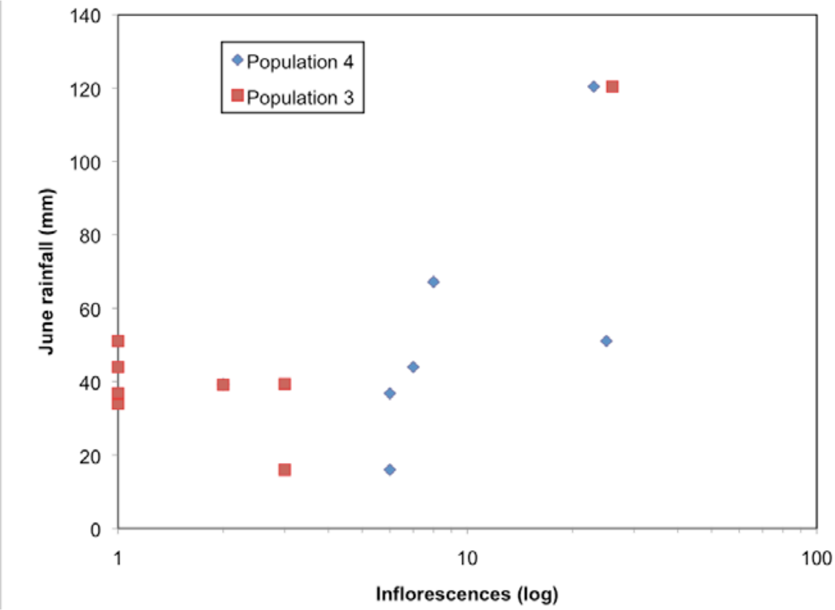



**Figure 9.** June rainfall (Bureau of Meteorology, www.bom.gov.au) was more highly correlated with flowering of the underground orchid near Munglinup than any other month.


**Figure 10A.** Severe canopy decline in part of population 2 north of Corrigin. **B.** Large fenced area in Population 6 near Corrigin. **CD.** Information display explaining the biology and ecology of underground orchids erected in Babakin in 2004.

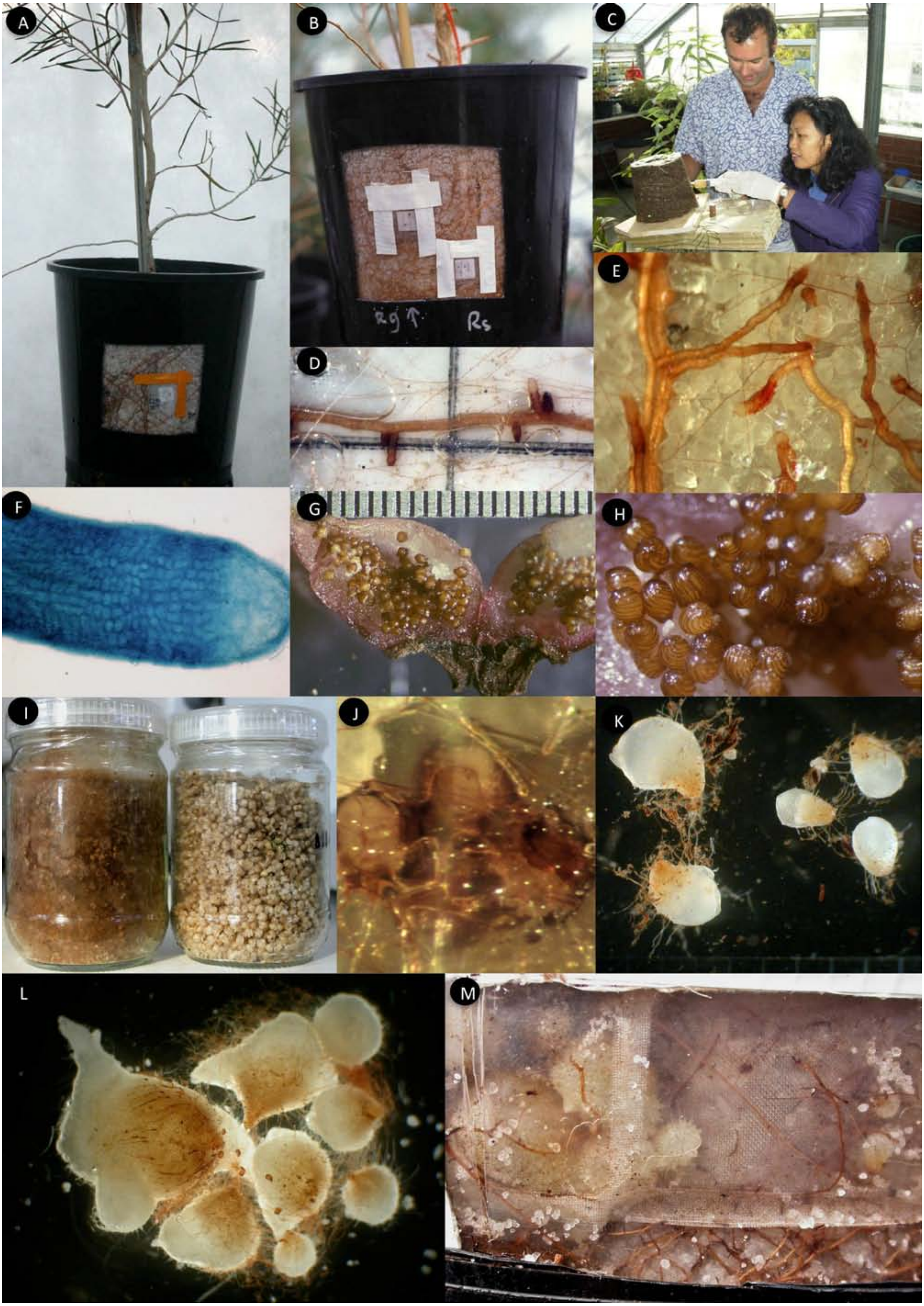
## 5. Pollination

The most frequent floral visitor in underground orchids is the small fly shown in Figure 11. This is a small phorid fly, also known as a “hunchback fly” (*Megaslia* sp.) that was identified as the pollinator of *Rhizanthella gardneri* by George & Cooke (1981). Despite its small size, this insect has been recorded in photographs and movies of *Rhizanthella gardneri* and several were captured in an insect trap by MB in 2007 (photographs and observations provided by J, Cooke, MB, Wayne Merritt, Andrew Brown, Jeremy Bougoure and Sasumu Yamaguchi). Small fungus feeding insects are known to pollinate other winter flowering orchids such as *Pterostylis* (Brundrett 2007).

Pollination by small files is also supported by structure of *R. gardneri* inflorescences, where flowers occur in a protected underground chamber enclosed by bracts with a narrow opening near the soil surface that would exclude large insects. Presumably, phorid flies encounter the underground orchid while foraging through litter in search for fungi to feed on, but it is not known if they are attracted by a specific pheromone of more general fungus-like odour.

It is also possible that *Rhizanthella gardneri* flowers are capable of self-pollination (pollen was observed to have fallen onto the stigma in some microscope images of flowers), but this requires further investigation.


**Figure 11.** Phorid flies (*Megaselia* sp.) with *Rhizanthella gardneri* pollen attached to their backs after emergence from an inflorescence of the underground orchid. Photos by Wayne Merritt.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## 6. Research on the Underground Orchid

Initial investigations of the underground orchids ecology and WANOSCG surveys to discover new habitats are summarised by Dixon and Pate (1984). Jack Warcup first grew and flowered the western underground orchid in pots of broom bush using fungi and seed from WA (Warcup 1985).

Sofi Mursidawati, a MSc student at UWA and Kings Park, published a thesis into the role of mycorrhizal fungi in nutrient supply and habitat specificity associated with the orchid - fungus - *Melaleuca* relationship, that is available via the UWA library (Mursidawati 2004). *Rhizanthella* seeds were germinated in the glasshouse at Kings Park by Sofi Mursidawati, Andrew Batty and Mark Brundrett in 2004 using window pots containing *Melaleuca* sp. inoculated with fungi isolated from *R. gardneri* (Fig. 12). Sofi was also able to confirm the role of a particular fungus in seed germination and growth. She also studied the nutritional requirements of the fungus causing tripartite mycorrhizal associations with *Melaleuca* spp. and *R. gardneri* and the nature of mycorrhizal associations in *Melaleuca* roots (Fig. 12).

Jeremy Bougoure, a PhD student in the Ecosystem Research Group at the UWA completed a thesis on the underground orchid in 2009. A paper describing its habitat requirements was published in the Australian Journal of Botany (Bougoure et al. 2008). Jeremy has fully resolved the identity of the fungus developed DNA probes to detect this fungus in soils (Bougoure et al. 2009). Orchid seeds were also used as baits to study *in situ* germination of the underground orchid (placed in mesh pouches in soil), but germination rates were very low, despite supplemental watering using an irrigation system. Jeremy also used stable isotopes to measure *Melaleuca* - *Rhizanthella* nutrient transfer following experimental synthesise of the association (Bougoure et al. 2010). Detailed measurement of carbon and nitrogen fluxes confirmed the *Rhizanthella* is dependent on fungus-mediated carbon transfer from *Melaleuca* and also obtained nitrogen from soil organic matter via the fungus. He precisely characterised the nature of the symbiotic interface within *R. gardneri*. His research is available in electronic form as a thesis (Bougoure 2009) and 2 further publications are being prepared.

Scientists at the University of Western Australia have also investigated the chloroplast genome of the western underground orchid (*Rhizanthella gardneri*) through a research collaboration between the Plant Energy Biology Centre of Excellence (Etienne Delannoy and Ian Small) and the WOR project (Mark Brundrett). This project was partially funded by the Faculty of Natural Science and Agriculture at UWA. Major outcomes include documenting the loss of photosynthesis genes from this orchid to determine the minimum set of genes in non-photosynthetic plants (Delannoy et al. 2011). DNA sequences of *Rhizanthella* also provided valuable data on the phylogeny of underground orchids and genetic diversity between populations.

Other research on *R. gardneri* includes confirming that seed and fungi are viable after cryostorage (-196 °C), so can be stored for future propagation attempts (Andrew Batty pers. comm.). Seed has been collected from several habitats for storage at Kings Park. Fungal isolated from *Rhizanthella gardneri* and *R. slateri* are also included in this collection.

**Figure 12** (Facing page). **AB.** Window pots used to raise underground orchids. **C**. Inoculating *Melaleuca* plants with a fungus from *Rhizanthella*. **DEF.** Mycorrhizal roots of *Melaleuca* sp. inoculated with this fungus. **GH**. Capsule and seeds of *Rhizanthella gardneri.* **I.** Fungus inoculum produced on millet seed. **J-M.** Stages of underground orchid seed germination in window pots. Seedlings vary in size from 0.2 mm (J) to 25 mm long (M).

## 7. Conclusions and Recommendations

1. The total size of all populations of the western underground orchid may be less than 50 mature individuals (Brown et al. 2003). However, this may be an underestimate since flowering plants are hard to detect and the ratio between flowering and non-flowering plants is unknown.
2. Rhizomes of the underground orchid are capable of vegetative division, so it is likely that plants located with a few meters are the same individual or closely related. Consequently, a population genetics study is required to determine the size of individuals of this species and the number present at each location.
3. Sub-optimal rainfall conditions on many of the years when surveys occurred influenced the outcomes of surveys as plants were more difficult to find on some years than others.
4. Despite the high degree of difficulty in finding flowering plants of *Rhizanthella gardneri*, observations over a decade coupled with high-resolution aerial photography and on-the-ground observations of vegetation allowed us to define the areas occupied by this orchid (Appendix 1). However, due to the low frequency of flowering and difficulty locating flowering plants, it is fairly likely that *R. gardneri* also occurs outside the Core Habitat areas in Appendix 1.
5. Research on the underground orchid at the University of Western Australia and Kings Park has focused on the diversity of the orchid and its fungal partners and the nature of the tripartite symbiotic association (Section 7). Techniques for growth of the underground orchid in tripartite associations with broom bush and a shared mycorrhizal fungus have been developed. Seeds and fungi have been collected and their viability demonstrated.
6. Additional research is required to understand pollination, seed dispersal and population genetics of the underground orchid.
7. There has not been a full recovery plan prepared for the underground orchid. Future plans should focus on sustainable site management and reintroduction of propagated seedlings to new field sites, now that it is possible to propagate *R. gardneri* (Section 5).
8. One potential objective of translocations into new sites would be to allow viewing of orchids without damage to natural populations. The underground orchid is one of the most beautiful, strange and iconic orchid species in the world and has already become a focus of ecotourism.
9. Northern populations of *R. gardneri* seem to have been severely affected drought resulting in a major reduction in observed numbers of flowering plants. Most of the habitats in which the underground orchid occurs near Munglinup are in good condition, but one has been severely affected by fire (Population 5).
10. There is no requirement for weed management for the underground orchid at present.
11. This report identifies Core Habitat and Critical Habitat areas, as defined below, for this species that should be included in a fire management plan and any other relevant management plans.
12. *Population 4, which is on private property*, is *most important Core Habitat area for* Rhizanthella gardneri *as it contains the highest density of inflorescences of this species observed in recent years within a small area (~6 ha).*
13. *Population 3 is near the Oldfield River is the second most important Core Habitat area for* Rhizanthella gardneri *as it contains the greatest number of known plants for this species observed in recent years within a small area (15 ha).*
14. Critical Habitat areas for *Rhizanthella gardneri* would be all areas of vegetation containing broom bush, especially in relatively dense stands, and buffer areas within 500 m of them within the area where it occurs. This essentially consists of all remnant vegetation along the Oldfield River and its tributaries near Munglinup. These areas include Unallocated Crown Land and privately owned areas and some of these areas are subject to a nature reserve proposal.

15. Populations in the Munglinup region are about 15 km apart and connected by vegetation along the Oldfield River and its tributaries. The majority of vegetation in this area is not suitable habitat for *R. gardneri*, but 6 other areas of potential habitat were identified within the vegetation corridor along the Oldfield River (Appendix 1). Even if these areas are not currently occupied by *R. gardneri*, it is quite likely that they were occupied in the past or may be in the future. Thus, all of the native vegetation along the Oldfield River near Munglinup should be considered as Critical Habitat of the species, by providing both present and future habitat areas with intact connectivity and buffers around core habitat areas.
16. Core Habit areas, as identified in Appendix 1, should be protected from fire. It seems likely that *Rhizanthella gardneri* populations are adversely affected by fire (as was the case for Population 5). This species also seems to grow best in areas with deep leaf litter.
17. It is recommended that the known and potential habitats along the Oldfield River be protected within an A Class Nature Reserve that includes all UCL vegetation between West Point Road and the South Coast Highway.
18. Population 4 on private property needs to be protected in collaboration with the landowners.
19. The WOR project, in collaboration with DEC and research scientists at UWA and King Park, has successfully addressed all 15 of the recommendations in the IRP (DEC 2007), but some recovery actions are ongoing (Table 3).
20. This report includes data and management recommendations that should be included in revisions of the IRP.

***Definitions***

**Critical habitat** is identified as being habitat essential for the survival of a listed threatened species or community. Habitat means the biophysical medium or media: (a) occupied (continuously, periodically or occasionally) by an organism or group of organisms; or (b) once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reintroduced. (*Environment Protection and Biodiversity Conservation Act 1999*).

**Core Habitat**, as defined in this report, is the most essential area (s) for survival of the species as it contains the highest concentrations of and/or the majority of currently known individuals. This is the area where the species is most vulnerable to threats such as disturbance causing changes to associated vegetation. This area is the highest priority for protective or remedial actions in the case of fire, weed outbreaks, animal grazing etc. Multiple separate areas, if defined, should be ranked in order of importance.

## 8. Acknowledgements

The Wheatbelt Orchid Rescue Project was funded primarily by Lotterywest. Mark Brundrett, Andrew Batty, Ryan Butler, Emma Adams, Sofi Mersidawati and Andrew Brown had key roles in earlier surveys and were assisted by volunteers from BGPA and UWA including Margaret Collins, Grant Wells, Val Preston and Ross Brockway. Recent surveys have involved Mark Brundrett, Andrew Brown, Emma Adams and Jeremy Bougoure and others. Ruther Kirchner provided site access and valuable information. Valuable assistance was also provided by the managers of Munglinup Beach Resort. I would especially like to thank the WANOSCG volunteers who attended the major survey in 2008. This was a major commitment due to the large distances they travelled (Munglinup is over 600 km from Perth).

**Table 3.** Summary of Interim Recovery Plan objectives (Brown et al. 2003) relative to WOR project outcomes and recommended future actions.

| Action | WOR Project | Future Objectives |
|---|---|---|
| Coordinate recovery actions | Attendance of recovery team meetings and coordination with DEC and community groups | |
| Liaise with land managers and achieve long-term protection of habitat | Contributed to nature reserve proposal | Formalise protection of important population on private land |
| Monitor populations | Monitoring data from 2001 to 2010 presented here | Ongoing |
| Collect seed and mycorrhizal fungi from all populations and develop suitable long-term storage protocols | Seed and fungi collected stored and viability tested. Germination protocols developed. | Assess the need for translocation and if deemed necessary develop a translocation proposal |
| Obtain biological and ecological information | Permanent plots established to monitor habitat (Bougoure et al. 2008). Nutritional studies (Bougoure et al. 2009, 2010). | Further studies needed to monitor habitat viability, pollination, dispersal, etc. |
| Population genetics | Detailed genetics study (Delannoy et al. 2011). | Further studies required to determine population size and diversity. |
| In situ seed germination | In situ germination was found to be of limited effectiveness (Bougoure 2008) | |
| Conduct further surveys | Surveys from 2001 to 2010 summarised here | Additional potential habitat areas may be identified |
| Develop and implement a translocation proposal | Protocols for propagation developed and tested | Develop proposal |
| Conduct research into the reasons for habitat degradation | Habitat study completed and published (Bougoure et al. 2008) | Further studies required to ensure habitats are sustainable |
| Develop and implement a fire management strategy | Critical habitat areas mapped (this report) | Develop fire management plan |
| Undertake weed control | Not identified as a major risk | |
| Rehabilitate habitat | Some habitat decline noted | Further habitat management may be required |
| Promote awareness | Presentations and permanent display in Babakin (press release in Feb 2011). | Additional articles and website (in development) |
| Review the need for a full Recovery Plan and prepare if necessary | Major issues that require action have been identified in this report | Prepare plan |

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