Wheatbelt Orchid Rescue Project

Final Report No 3

Population Size and Vital Statistics Data for the Ballerina Orchid *(Caladenia melanema)*

Mark Brundrett

Wheatbelt Orchid Rescue

lotterywest supported

Our environment, our future
Department of Environment and Conservation

The University of Western Australia

Friends of Kings Park

W.A. Native Orchid Study & Conservation Group

Mark Brundrett
School of Plant Biology (M090)
The University of Western Australia
35 Stirling Highway
Crawley, 6009, Western Australia
E-mail: mark.brundrett@uwa.edu.au

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. **This Report**

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 Size and Vital Statistics Data for Southern Populations of the Western Underground Orchid (*Rhizanthella gardneri*). Wheatbelt Orchid Rescue Project, University of Western Australia. *Link 6*

Brundrett M and Ager E. 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

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 the rarest orchids in the Western Australian wheatbelt by obtaining knowledge required for sustainable management and directly contributing to recovery actions. Please refer to the WOR Report 1 for further information.

Information about the taxonomy, biology and ecology of the ballerina orchid *(Caladenia melanema)* is summarised below. An Interim Recovery Plan (IRP) has been prepared (DEC 2007). *Caladenia melanema* is 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 Ballerina Orchid has a very limited distribution in tall *Melaleuca lateriflora* dominated shrublands (Fig. 2) near salt-lakes between Lake Grace and Pingrup in the eastern wheatbelt of Western Australia. Until recently, the estimated total size of populations was about 300 individuals (Table 1). However, recent surveys coordinated by the WOR project have resulted in a greatly revised estimate of total population size (Table 3). Populations are listed in Tables 1 and 3, with locations in Appendix 1.

WANOSCG members and the author (MB) have discovered several new populations of ballerina orchids since the start of the WOR project (Tables 1 and 3). However, Population 2, discovered by Gary Brockman in 2008, is small and may consist primarily of hybrids, Population 3, discovered by Margaret Petrides in 2009, is on a very small area of grazed land and Population 4, discovered by Margaret Petrides and Mark Brundrett in 2010, requires further investigation. Consequently, the majority of known plants are still found in Population 1. In recent years, new sub-populations of population 1 have been discovered, but all occur within a few km within the same habitat area (Appendix 1). In contrast to these new populations, several older sub-populations of ballerina orchid have not been sited for a decade or more and are probably lost (1b in the road reserve and another location recorded in WAHerb). Designation of sub-population numbers in Tables 1 and 3 follows the order they were discovered and does not reflect positions within the reserve.

Table 1. Populations of *Caladenia melanema* (after DEC 2007). See Table 3 for current data on population 1. Populations 2-4 and subpopulations 1c-e (shaded) were discovered from 2007 to 2010. See Table 3 for current data on Population 1.

Population Number & Location	Land Status	Located	Number of plants	Current condition	Status and threats
1a NW of Pingrup	Nature Reserve	1985	14 – 300	Healthy	Grazing, salinity, accidental disturbance, weeds
1b NW of Pingrup	Road reserve	2000?	3-8		
1c NW of Pingrup	Nature reserve	2007		Healthy	
1d NW of Pingrup	Nature reserve	2007		Healthy	
1e NW of Pingrup	Nature reserve	2008		Healthy	
1f NW of Pingrup	Nature reserve	2010		Healthy	
2 SE of Pingrup	Nature reserve	2008	~10	Healthy	Possibly hybrids
3 N of Pingrup	Private property	2009	~20	Very poor	Very small area, grazed
4 S of Lake Grace	Nature reserve	2010	> 200	Healthy	Possibly hybrids requires survey

Figure 1. The ballerina orchid (*Caladenia melanema)*. **AG.** Habit. **B-E.** Characteristic dark trichomes on sepals and petals (arrow). **A-F.** Variations in flower colour. **CE.** Short dark hairs are more obvious on flower buds. **G**. Leaves occur in clumps resulting from clonal division.

2. Orchid and Habitat Characteristics

The ballerina orchid is a small clumping *Caladenia* species with whitish flowers that are characterised by a dense covering of dark trichomes on the sepals and petals of flowers (Fig. 1). It was known by its manuscript name in Hoffman and Brown (1992) before it was formally described in Hopper and Brown (2001). It is related to several other members of the *Caladenia filamentosa* complex with short petals and sepals, but its closest relatives tend to flower later or only occur near the coast (Hopper and Brown 2001). Most specimens of *Caladenia melanema* have very short trichomes on their sepals and petals (Fig. 1C), while other members of the complex usually have longer cylindrical trichomes.

Figure 2. Typical habitat of the ballerina orchid in open tall shrubland dominated by *Melaleuca lateriflora* (D) adjacent to saltlakes. In these habitats, *Caladenia melanema* occurs under or near shrubs while annual and perennial herbs typically occur between them.

The ballerina orchid typically grows under the canopy of *Melaleuca lateriflora* that grows in relatively pure stands in close proximity to saltlakes (Fig. 2.) Soil is sandy with a low clay content and a pH of about 6 (Table 2).

Table 2. Soil data for two *Caladenia melanema* population 1 habitats.

Site	**1**	**2**
pH	5.75	6.07
pH (CaCl2)	5.59	5.61
Salinity (ds/m)	31.5	156.2
clay %	0.4	3.3
silt %	0	1.4
Sand%	99	95
Classification	sand	sand

3. Population Surveys

Data presented below is summarised from surveys by the author (MB) and DEC staff from 2007 to 2010. Population 1c, discovered by Andrew Brown and Marie Edgley of DEC in 2007, consisted of 150 plants within a few square metres, but these were all grazed before flowering in 2008 and only 80 were located there in 2010. Figure 3 shows a second new subpopulation (1b) consisting of 4 plants discovered by WANOSCG members following the WOR *Drakaea isolata* survey in 2007. The author (MB) discovered a third new sub-population (1e) of 2 plants south of 1a in August 2008 and many more were found at this site in 2009 and 2010 (Table 3). Erica Shedley of DEC discovered several other sub populations in 2009 (f, g). All of these locations are in similar vegetation that occurs in a narrow band around salt lakes in the same lake system (Appendix 1).

Figure 3. WANOSCG members located a small new subpopulation (1d) in dense *Melaleuca lateriflora* shrubland in 2007.

There was a comprehensive 2-day survey of the population 1 area in 2010 by the author (MB), Kris Brooks (DEC Flora Conservation Officer), volunteers from WANOSCG (Margaret Petrides, Pam Goodman) and representatives of wheatbelt community groups (Jocelyn Ward from Nyabing and Lucy Skipsey from Pingrup). This survey resulted in updated counts of individuals and locations for all plants to allow more effective management and monitoring in the future (Table 3, Appendix 1). As shown in Figure 4, there was substantial variability in flower colours and plant heights with the new subpopulations. The occurrence of stunted plants seems to be linked to severe drought.

Data presented in Table 3 show that grazing impacts were widespread and substantial grazing was also observed to occur within fenced areas. Many plants showed signs of drought stress due to record low winter and spring rainfall (Fig. 6). The best flowering plants occurred in the southernmost subpopulation (1e), probably due to local variations in rainfall (Lucy Skipsey pers. comm.). It was also observed that flowering was best within cages. This suggests that small cages provided more protection than 5 m^2 enclosures, but the cause(s) of grazing are not known (there was no evidence of rabbit or kangaroo dung within fences).

Table 3. Survey results from 2010 by Kris Brooks and Mark Brundrett. Population 4 data is also included for comparison.

Subpopulation	1a trans*	1a other	1c	1d	1e	1f	1g	Total		Pop. 4
Flowering Plants	143	340	19		82	15	106	705		38
Non-flowering	434	102	31		162	71	132	932		130
Grazed	47	211	31		51	48	244	632		38
Total	624	653	81	4	295	134	482	2269		206

*trans = plants within 50 x 4 m transect area.

Figure 4. Ballerina orchid survey in 2010. **AG**. flowers protected in a cage **C**. Kris Books, Jocelyn Ward and Margaret Petrides during the survey. **DE**. Height variations. **E-H**. Colour variations.

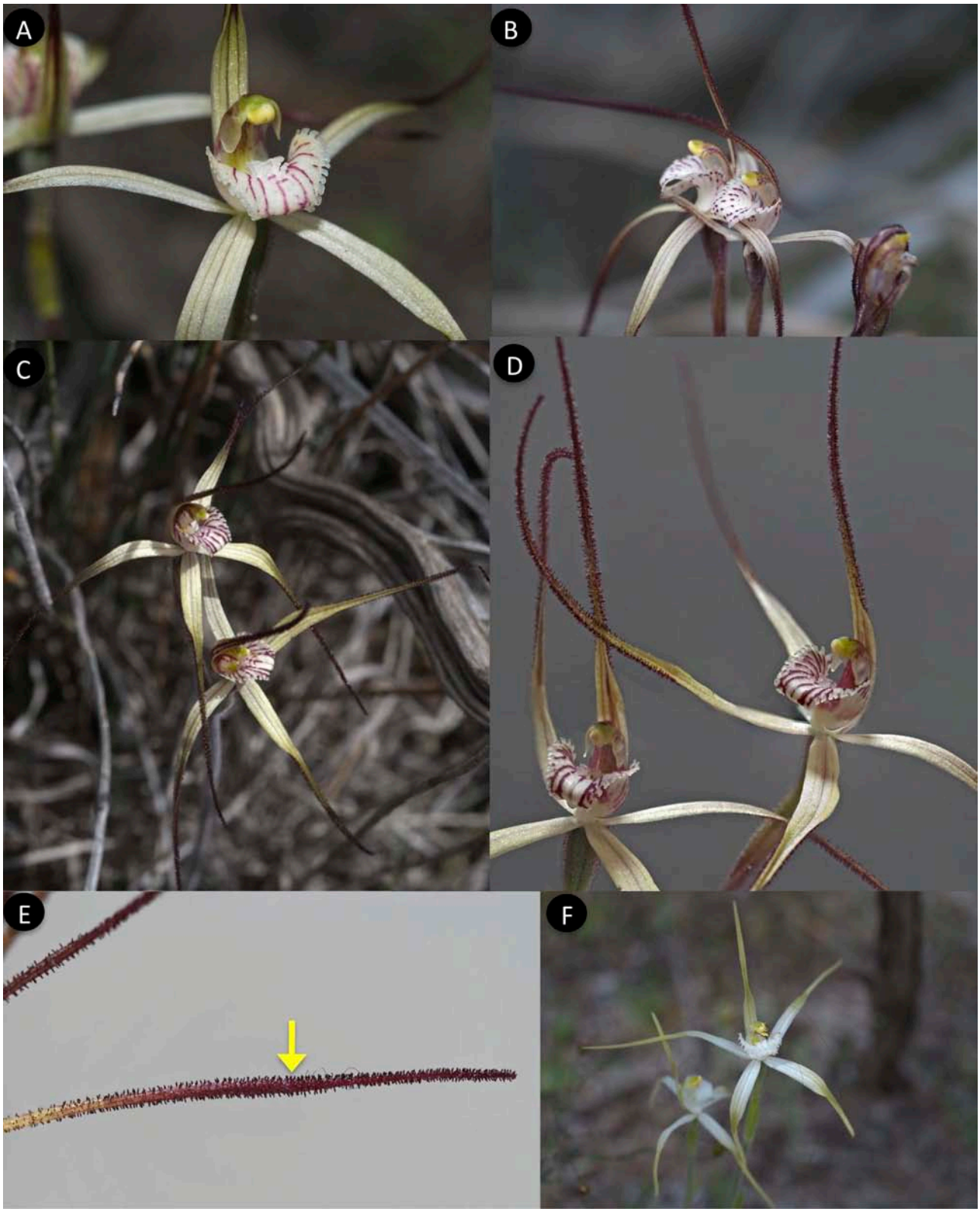

Figure 5. Atypical flowers from new populations. **ACD**. Flowers in population 3 and 4 that appear to be hybrids. **B.** Plants in population 4 are more typical looking. **DE**. Atypical flowers have relatively long trichomes on petals and sepals. **F**. A pale form of *Caladenia melanema* observed in Population 1 in 2010.

As shown in Figure 5, some or all of the plants growing in 2 small populations may be hybrids. Resolving if hybridisation with other *Caladenia* species has occurred in populations 2 and 4 and clarifying relationships between *C. melanema* and other similar species requires a genetics study.

4. Vital Statistics Data

A 50 m transect in population 1a was established by the WOR project in 2007 and recounted annually until 2010. This transect was visited in late August to assess flowering, grazing and preliminary seed set, with a later revisit to determine final seed set. This transect includes the two largest aggregations of plants, and was estimated to include ~70% of all known individuals of this species, initially, but this proportion has declined as more plants were discovered elsewhere in the same nature reserve.

As show by Figure 9, *C. melanema* plants were very densely aggregated at 2 points along the transect where clumps of plants are almost touching (between 2-15 m and 40-50 m). This made counting plants very difficult. Dense clumps of orchids result from clonal division by daughter tuber production next to the parent tuber, but these locations also seem to have been hotspots for reproduction from seed, resulting in new clumps of orchids. Each clump contained from 1-30 leaves and 1-14 flowers, with an average of 4.6 leaves and 2.5 flowers per clump in 2009 (Fig. 11). The highly aggregated distribution of this orchid in some areas may have long-term consequences for survival, due to more intense competition for resources and pollination, as is discussed in Section 8.

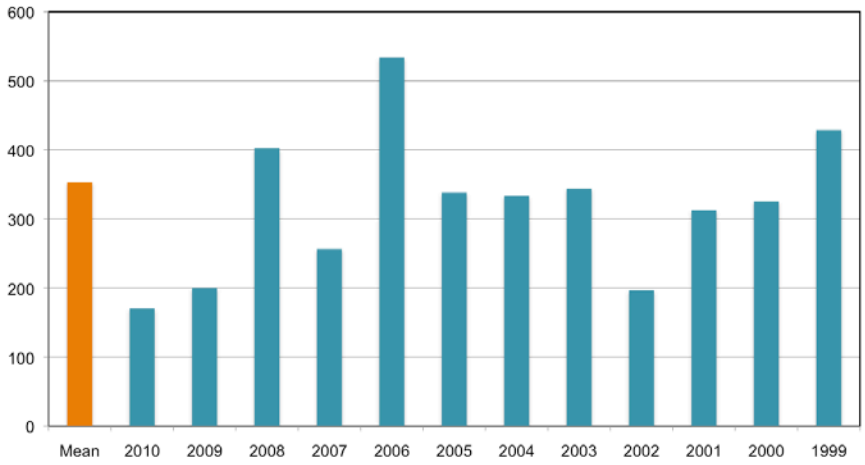

Figure 6A. Rainfall at Lake Grace the closest station to locations where *Caladenia melanema* occurs (Bureau of Meteorology, www.bom.gov.au). Rainfall in 2010 was only 48% of the long-term average and 2009 was also very dry.

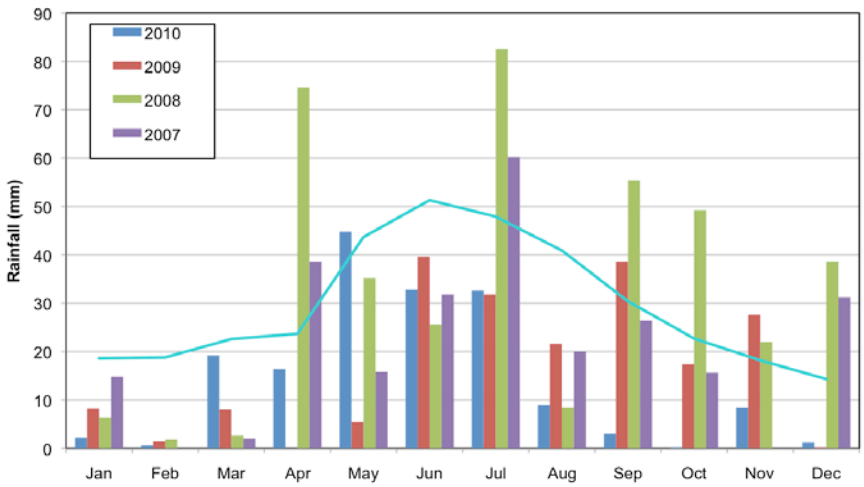

Figure 6B. Annual variations in monthly rainfall patterns over the past 4 years. There was severe late winter and spring drought in 2009 and 2010 (Bureau of Meteorology, www.bom.gov.au).

Figure 7. A. (left) Abundant flowering in a dense clump in 2008. **B.** (middle) Grazed leaves and flowers in 2008. **C.** (right) seed pods.

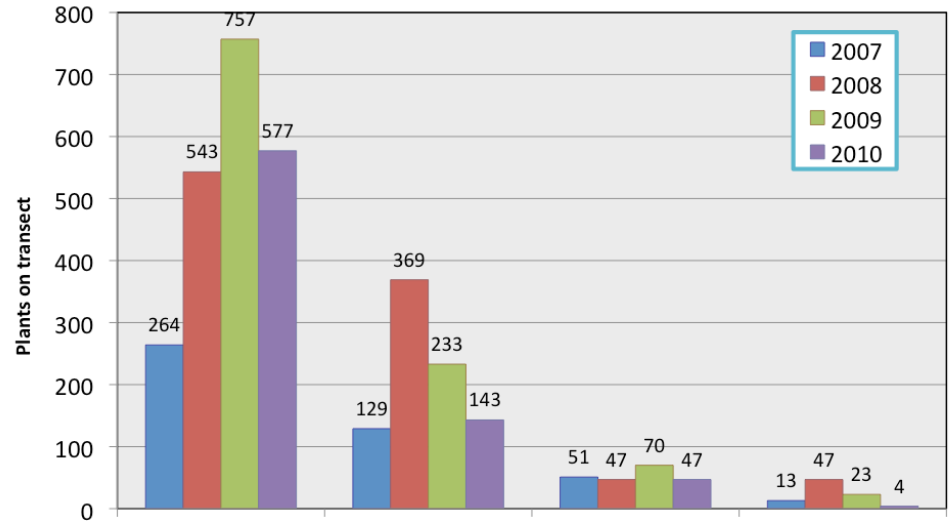

Figure 8. Seasonal variation in emergent plants, flowering, grazing and seed set along a 50 x 4 m transect.

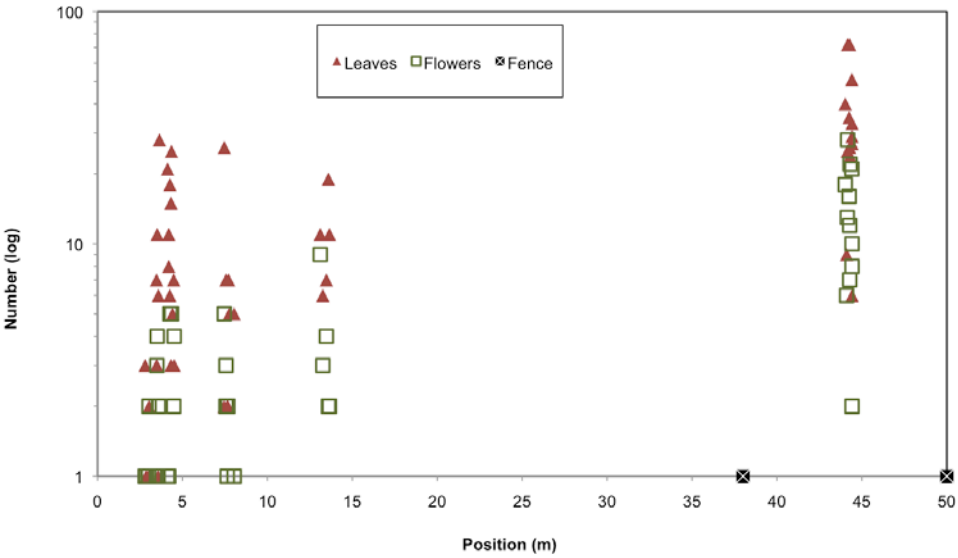

Figure 9. The relative position and density of leaves and flowers in clumps of *C. melanema* along the transect in 2009.

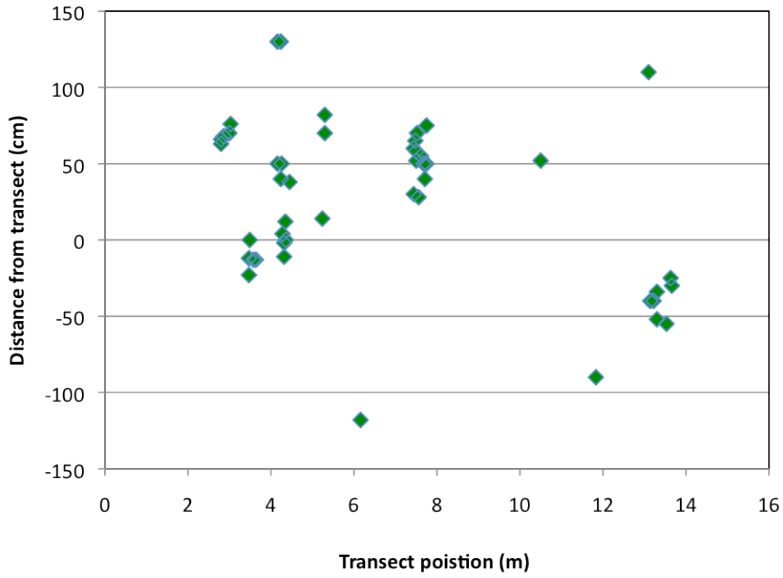

Figure 10. The distribution of clumps of ballerina orchids was highly aggregated into zones where competition for resources may be considerable. Only the first 15 m of the transect is shown. Note that the vertical scale is much finer than the x-axis scale.

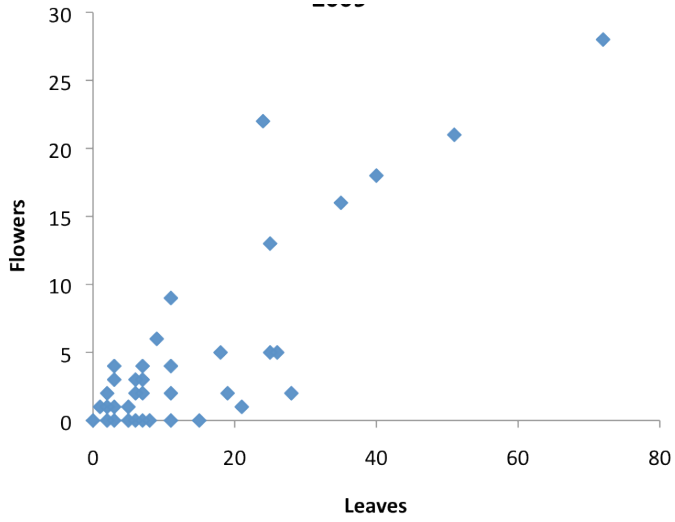

Figure 11. The relationship between numbers of leaves and flowers in clumps of *C. melanema* in 2009.

5. Population Size and Dynamics

Rainfall patterns shown in Figure 6 differ substantially from long-term averages, especially in 2009 and 2010. The first 3 months were very dry in 2007 and 2008 and there was a substantial rainfall deficit in winter which was followed by a wet spring in 2008 but not 2007. Exceptionally good flowering in August 2008 may have been the consequence of heavy rainfall in April and July (Fig. 6B). When data from all years is compared, there was a weak correlation between winter rainfall and number of plants observed in population 1a (Fig. 12). The exceptional increase in abundance observed in 2008 and 2009, in comparison to earlier years, reflects increases in numbers of clumps and their size. Figure 13 provides strong evidence that the size of the main population of *C. melanema* (1a) is increasing in numbers, although it should be noted that all 5 values over 300 relate to years of the WOR project when surveys may have been more thorough. The trend in Figure 13 also results, in part, from decreased grazing within the enclosure after 2008. Results of the 2010 survey of other parts of population 1 also provide strong evidence the entire population is growing (Section 2).

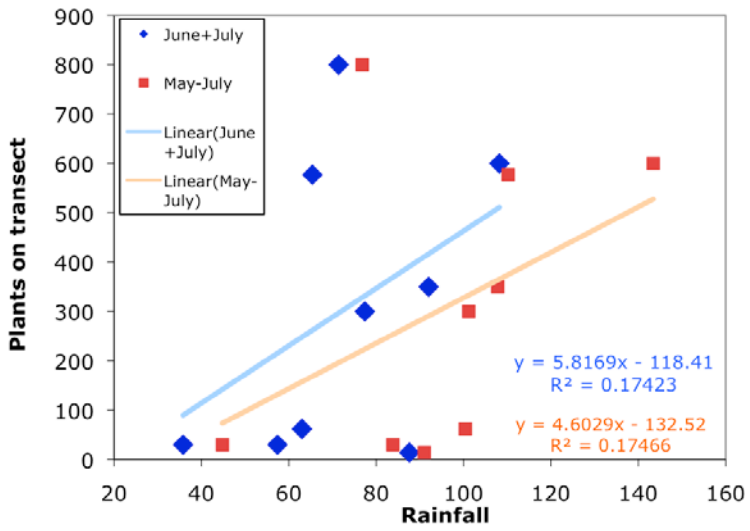

Figure 12. Relationship between rainfall and emergent plant numbers for *C. melanema* in population 1a over 10 years. There seems to be a weak correlation with June + July or May + June + July rainfall and plant numbers. However, this relationship is primarily due to population growth over time. Rainfall data for Lake Grace are from the Bureau of Meteorology (www.bom.gov.au). Population size data from the IRP (DEC 2007) and this report.

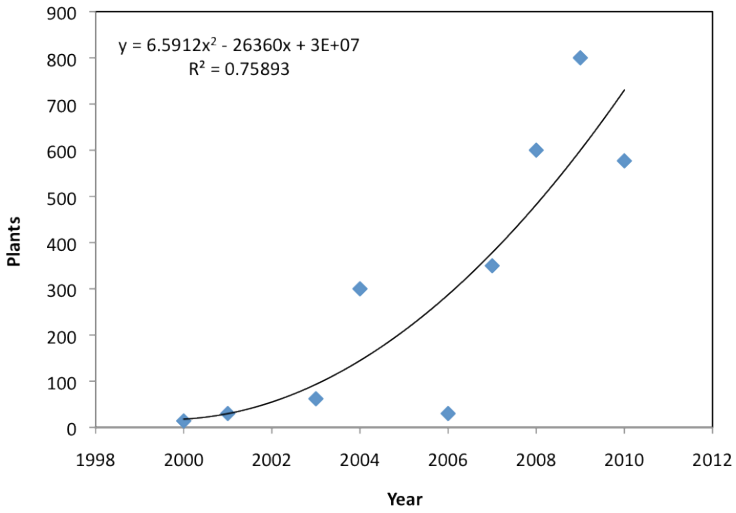

Figure 13. Increasing numbers of plants recorded for the entire 1a population (2000-2006) and for a 50 m transect (2007-2010) within the population.

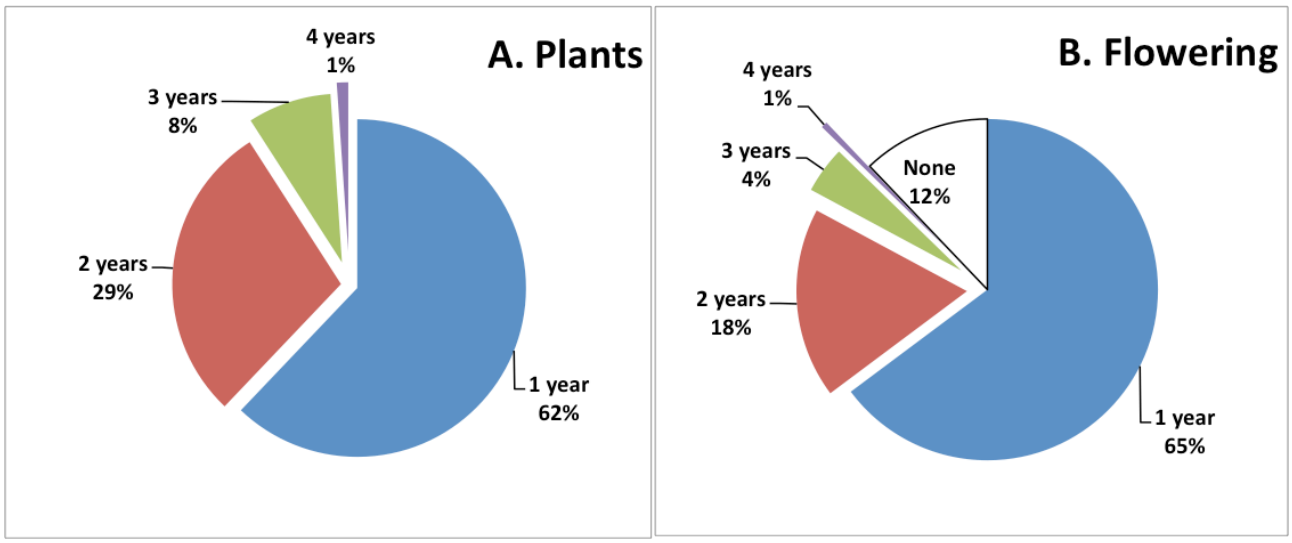

Figure 14AB. The proportion of *Caladenia melanema* plants that emerged (A) or flowered (B) on one or more years as determined by their position in a 15 x 4 m transect area.

Precise data on plant locations relative to the transect axis over 15 m (Fig. 10) allowed individual plants to be identified. This allowed the number of plants that emerged each year and how often they emerged or flowered over the 4 year period of observation to be determined (Fig. 14). The number of plants at unique locations was then summed to provide a preliminary estimate of population size along the transect (Table 4). Plants at the distal end (near 45 m) occur in such dense clumps they could not be used in the analysis.

Estimates of total population size and the proportion of plants that emerge, flower, set seed, or are grazed each year are provided in Table 4. On average 40% of plants emerged each year and 16% flowered, while seed set was a very low 2 % of all plants (dormant + emergent). These proportions are based on the assumption that plants emerging within 10 cm of the same position on different years were the same individual, but there may be even more dormant bulbs than indicated in Table 4. Underestimation of orchid numbers due to inaccuracy in measurements (due to stretching of tapes, etc) is unlikely to be a major factor since only the first 15 m of the transect was used in this analysis. The method used to estimate total individuals also assumes that plants live for a number of years and there is relatively little recruitment from seed each year, which is realistic since most newly observed plants were of flowering size.

If we assume that the estimate of 1350 plants on the transect is correct (Table 4), then an estimated total of between 4000 and 5500 plants for all of population 1 seems reasonable. This estimate results because about 50% of population 1a occurs on the transect and there are a similar number of plants in 1a as in the remaining 5 sub-populations combined (Fig. 15). Figure 15 also suggests that the proportion of flowering plants on the transect in 1a is lower than in other areas, perhaps due to overcrowding.

Table 4. Vital statistics data summary for *Caladenia melanema* from the transect. The estimated transect total is the sum of individuals that emerged at different positions on one or more years and the average annual % is based on this estimated total population.

Year	Leaves	Flowers	Seed set %	Grazed %
2007	264	129	10.1	39.5
2008	541	369	12.7	11.3
2009	757	233	9.9	30.0
2010	577	143	0.7	8.1
Average	*535.3*	*218.5*	*8.3*	*22.3*
Estimated transect total	1350			
Average annual % of total	**39.7**	**16.2**	**1.6**	**4.0**

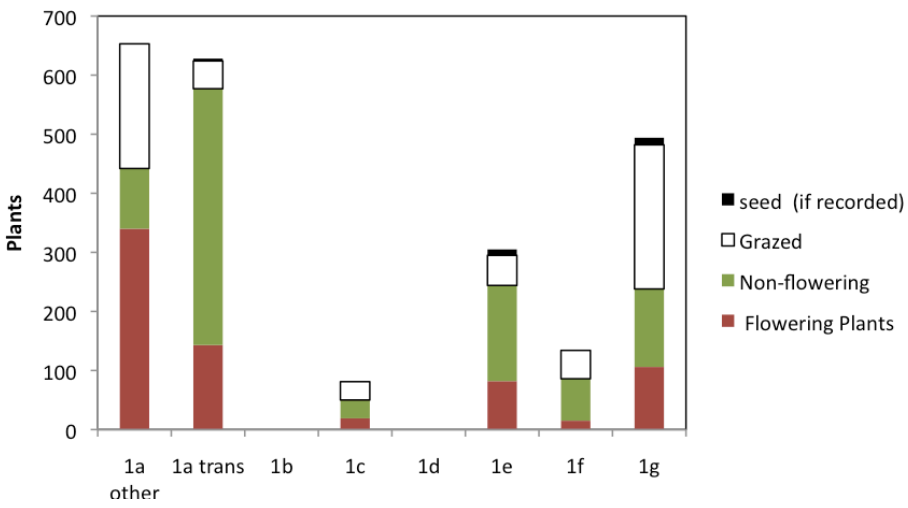

Figure 15. The numbers of plants in different subpopulations of Population 1 in 2010. The proportion of grazed and flowering plants and those with seeds are also shown.

Figure 16. A-E. Flies stuck in *Caladenia melanema* flowers. **FG.** This wasp (*Rhagigaster* sp.) is the most likely pollinator.

6. Pollination

Flies were common floral visitors of *C. melanema* in 2008 and 2010 and may have an adverse impact on pollination since they often became stuck in flowers resulting in blockage of the stigma (Fig. 16). These abundant flies seemed to be linked to unusually warm and dry winter weather, which has become more common in recent years and their impact requires further investigation. A thynnid wasp (*Rhagigaster* sp.) has been also observed to visit flowers and while much less common than the flies, is likely to be a successful pollinator (Fig. 16FG). A preliminary identification of this thynnid wasp was provided by Graham Brown and a specimen was submitted

to the WA museum. Pollination rates, while low are probably adequate (Table 4, Fig. 15), so pollinator limitations are of lesser importance to grazing impacts for this rare species, especially since a high proportion of developing seed-pods were eaten before maturity.

7. Long-term Habitat Viability

7.1. Salinity

Li et al. (2007) provide data on salt and conductivity levels in soils under different types of vegetation near salt lakes in the Chinocup Catchment area. They found that *Melaleuca lateriflora* often grew in soils with substantial levels of salinity. The salinity tolerance range for *M. lateriflora* is not known, but it can be assumed that this range also helps to determine the habitat of *C. melanema,* which occurs in the same soils, but may avoid the worst impacts of salinity by summer dormancy.

Land Monitor imagery available online is shown for the area between Lake Grace and Pingrup in Figure 17 below. The habitat of *C. melanema* is mapped as saline and vegetation density in the area appears to have declined substantially over the past 2 decades. The potential risks and impacts of rising saline groundwater in the habitat where *C. melanema* occurs require further investigation.

The WA Department of Agriculture and Food (DAFWA) have groundwater data for a number of locations in the Chinocup Catchment, but none are close to populations of the ballerina orchid. Their staff provided the following advice. According to Dr Paul Raper (Hydrologist, DAFWA Bunbury). The only bore located in relevant soil-landscape units is over 45 km north of population 1. The water level there is at about 1.5 m below ground & fluctuates seasonally, with an EC of 8,000 mS/m (i.e. 1.3 x sea water). According to Ruhi Ferdowsian (Hydrologist DAFWA Albany) the “target area has very high salinity risk. Groundwater is close to seawater salinity and wetlands have become discharge zones. Any valley floor and wetland that is surrounded by cleared agricultural land is a high salinity risk area.” He suggests we look elsewhere for areas with similar landforms that may be good candidates for translocation sites. However, areas that are unlikely to be effected by salinity could not be identified with vegetation that is suitable of *C. melanmea*.

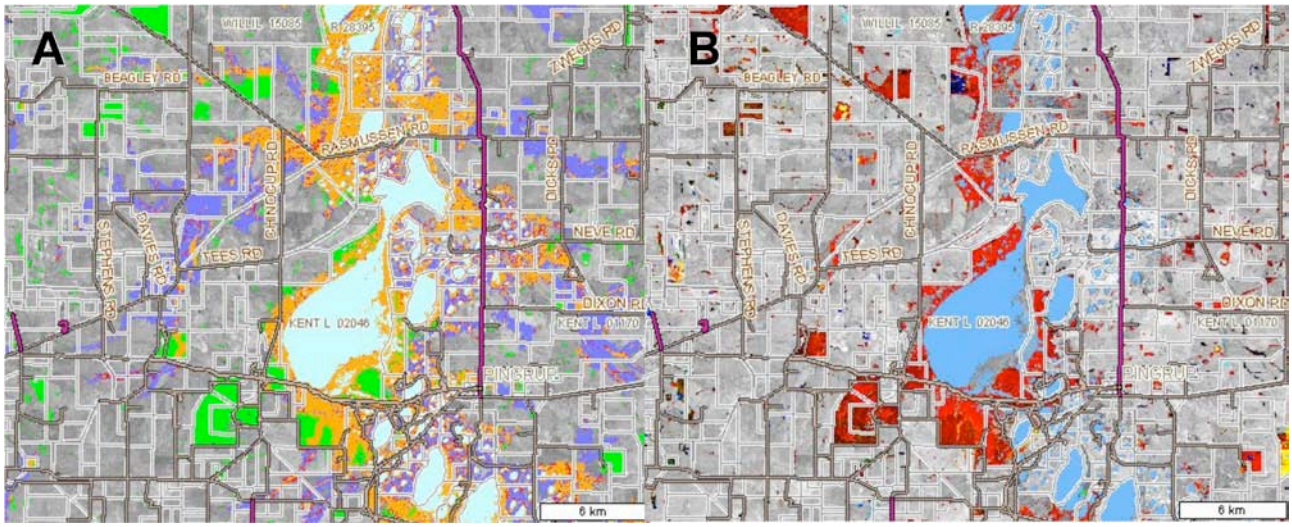

Figure 17. Land Monitor data for areas near Lake Grace and Pingrup (url: landmonitor.landgate.wa.gov.au). **A.** Salinity map (saline areas are orange, predicted salinity blue). **B.** Vegetation trends 1990-2008 (red = general declining trend in vegetation density over 1990-2008 period).

Figure 18. The relative position of ballerina orchid plants in Population 1 showing aggregation of plants into 6 subpopulations within a narrow Critical Habitat area 3 km long. Subpopulations are separated by small saltlakes (location imagery is only provided in Appendix 1).

Figure 19. The first fenced enclosure erected by DEC in 2007 to protect the ballerina orchid from grazing impacts is a direct result of data gathered by the WOR project. Four more fenced areas were installed to protect subpopulations of ballerina orchids in 2009.

7.2. Habitat Management

Critical Habitat for the ballerina orchid is confined to a small area in a chain of salt lakes. A substantial proportion of these orchids occur in one small Core Habitat area that is only about 150 x 80 m. This occurs within a larger surrounding area where 5 additional subpopulations occur in a strip of melaleuca woodland approximately 3 x 1 km in size (Fig. 18).

A 10 x 10 m enclosure of 1 m high fencing was erected around the last 12 m of the monitoring transect in late 2007 when *C. melanema* plants were dormant (Fig. 19). This grazing enclosure was organised by Marie Edgley of DEC. It was observed that the majority of plants outside the enclosure were grazed after flowering in 2008 and all surviving seedpods in 1a were located in the enclosure. It was also observed that the type of grazing differed within the enclosure, where some flowers were eaten, but there was less grazing of entire plants. All but two of the plants in sub-population 1c (150 plants discovered in 2007) were severely grazed in 2008 resulting in loss of flowers and most of the leaf. Consequently, it was decided to increase grazing protection and 4 new enclosures were erected in subpopulations 1a, 1c, 1e and 1d by DEC in 2009 (organised by Erica Shedley). Grazing observations by the 2010 survey team indicate that fenced enclosures can reduce grazing, but do not eliminate it and it is not clear what the main cause(s) of grazing within enclosures are.

As explained in 7.1 above, there is evidence that the canopy of shrubs under which *C. melanema* grows has substantially declined in cover over the past 20 years (Fig. 17B). Since most *C. melanema* plants occur under the canopy of *Melaleuca lateriflora*, the long-term sustainability of these shrubs is likely to be critical for orchid populations. Recruitment of *M. lateriflora* seedlings has not been observed at the site and perhaps needs to be encouraged by grazing protection, or alternatively by planting seedlings raised in a nursery.

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. Conclusions and Recommendations

1. The WOR project increased community group involvement in orchid conservation both for rural residents who live near rare orchids and orchid enthusiasts who travelled from cities to attend rare orchid surveys. A major outcome of increasing public awareness and community group involvement in the wheatbelt resulted has been the discovery of several new populations of the ballerina orchid.
2. Three new populations were discovered from 2008-2010, but these are small compared to the original population (1). Additional survey work is required to determine the extent of Population 4 recently discovered 15 km north of any previously known plants. Several other areas with potentially similar habitats in this area should also be investigated.
3. Fieldwork revealed 4 new subpopulations (c-f) in Population 1 from 2007 to 2010. These are all within a few km of each other and seem to be of relatively recent origin (Appendix 1).
4. Concerning known subpopulations, 1b seems to no longer be extant (in its original location). As does a potential additional subpopulation east of 1b recorded in Florabase (Appendix 1).
5. This orchid also seems to have established a number of new subpopulations within the same 1 x 3 km Core Habitat area in the past decade, presumably by seed dispersal. These newer subpopulations seem to be gradually expanding in size.
6. It is likely that high plant abundance observed in wetter years such as 2008 and 2009 resulted from increased emergence of dormant tubers, but only long-term monitoring will allow more accurate estimates of population size and rates of increase to be obtained, since many *C. melanema* plants remain dormant even on years when conditions are favourable.
7. Data collected using permanent transects allowed flowering, seed-set and survival rates to be determined for the same plants each year. Four years of vital statistics data was sufficient to identify the major threats to orchids and provide a preliminary estimate of population size within a fixed area.
8. Grazing impacts were found to be the most serious immediate threat to the ballerina orchid in all sub-populations. Grazing was reduced but not eliminated within fenced enclosures erected by DEC in 2007 and 2009, so additional work is required to identify and control grazers.
9. There were adequate rates of pollination for *C. melanema*, but many fertilised flowers were grazed before seeds matured. A thynnid wasp pollinator has been tentatively identified, but has been observed very infrequently. The impact of flies on pollination should also be investigated further, as they are abundant on some years due to unseasonal in hot winter weather and become stuck in flowers, blocking the stigma.
10. Some weeds occur at the population 1 site, but there is little evidence of serious weed problems at this time.
11. Monitoring of the 50 m transect established in 2007 should continue to provide continuing information on population dynamics, seed set and grazing. Over longer timeframes, it should also allow the impact of climatic variability on population trends to be studied and help to determine the balance between recruitment and mortality for this species.
12. The use of small permanent tags that identify individual plants or clumps of plants should be investigated, as this may benefit future monitoring efforts.
13. Data on orchid emergence rates from a permanent transect was used in combination with survey data to provide a revised estimate for orchid numbers for all of Population 1. This estimate is 4000-5500 plants, or which 40% emerge each year on average. This is an order of magnitude larger than earlier estimates of population size provided in the IRP (DEC 2007) and is due to (i) the discovery of new sub-populations and (ii) a dramatic increase in the number of known plants in the main subpopulation (1a) over the past 4 years.
14. The highly aggregated distribution of individuals of this orchid suggests that it may already occupy most of its prime habitat (especially in Population 1a). Intense competition for resources

such as water, nutrients provided by mycorrhizal fungi, or pollinator visits is likely to occur in the few square metres where most plants occur. Such competition would be less severe in dry years when more plants remain dormant. It is possible that severe overcrowding (i.e. 300 plants within 1 m^2) could eventually lead to local extinctions of this species if resources become overly depleted.

15. The apparent overcrowding of plants in some patches provides an opportunity for recovery actions, as some of the excess dormant tubers could be moved elsewhere as a translocation trial. Excavating tubers within a patch at the end of the growing season would also allow the ratio of plants that emerge or remain dormant to be determined directly.
16. According to Andrew Brown (DEC), hybridisation seems to be an issue at 2 locations where some or all plants in small populations may be hybrids or a similar species (populations 3 and 5). Resolving this issue and the relationship between *C. melanema* and other similar species requires a genetics study. The WOR project has collected DNA samples that could be used for a preliminary analysis.
17. Groundwater salinity is a major problem with in the Chinocup Catchment and it is not yet clear what impact this will have on populations of this endangered orchid. It seems that associated vegetation has the capacity to tolerate soil salinity, but major changes to water tables will inevitably result in major impacts on vegetation. Groundwater monitoring bores should be used and soil tests conducted to establish baseline salinity data so changes can be monitored.
18. Land Monitor vegetation change imagery shows a substantial decline in cover for the entire area where *C. melanema* occurs and this requires further investigation. There is little evidence of recruitment of new *Melaleuca lateriflora* plants and it may be advantageous to plant some of these at the site, or create additional grazing enclosures for purposes of habitat improvement.
19. Seed baiting trials confirmed that seed collected from *C. melanema* and co-occurring common orchids is highly viable and some of the soils collected have compatible fungi that promote seed germination so are suitable for translocation of this orchid species (WOR Report 7).
20. Like many other rare species, the ballerina orchid has very specific habitat preferences and almost all known individuals occur in shrublands dominated by *Melaleuca lateriflora* near salt lakes. It is likely that this is partially due to the occurrence of a specific mycorrhizal fungus in these habitats. Additional research is required to develop an understanding of habitat specificity and to explain why some of the apparently suitable habitat is unoccupied. The role of mycorrhizal fungi in determining habitat preferences should also be investigated further. This requires identification and comparison of mycorrhizal fungi that associate with co-occurring orchids (Brundrett et al. 2003, Bonnardeaux et al. 2007).
21. As recommended in the IRP (DEC 2007), a translocation plan for *C. melanema* was developed and approved by the WOR project and DEC in 2009 (Brundrett and Edgley 2009). In addition to augmenting population sizes, a translocation trial was considered to be an appropriate means of investigating plant growth in areas of currently unoccupied habitat that appeared suitable. The propagation and translocation outcomes from the WOR project are presented in separate reports (WOR Reports 7 and 8).
22. Suitable areas for translocation outside of the reserve where this orchid already occurs could not be identified because the majority of this habitat type has been cleared, or severely degraded, or is at risk from salinity. However, further investigations should be conducted.
23. This report identifies Core Habitat and Critical Habitat areas, as defined above, for *C. melanema* that should be included in a fire management plan and any other relevant management plans (Appendix 1).
24. *In particular, Population 1a is the most important Core Habitat area as it contains about 50 % of all known plants of* C. melanema *within a very small area (2 ha).*

25. Critical Habitat areas for *Caladenia melanema* can be defined as all areas of *Melaleuca lateriflora* woodland adjacent to saltlakes and buffer areas within 500 m of them. These areas occur in several nature reserves and on private property.
26. Core Habitat and Critical Habitat areas ranked in order of priority from highest to lowest are; (1) the 10 x10 m enclosure in Population 1a, (2) Populations 1a in total, (3) Populations 1c-e, especially within the enclosures and (4) the entire Critical Habitat area.
27. The WOR project, in collaboration with DEC, has successfully addressed all 12 of the recommendations in the IRP (DEC 2007), but some are ongoing (Table 5).
28. This report includes data and management recommendations that should be included in revisions of the IRP.

9. Acknowledgements

The Wheatbelt Orchid Rescue Project was funded primarily by Lotterywest. Andrew Brown, Beth Laudon, Erica Shedley, Marie Edgley and Kris Brooks of DEC were major contributors to surveys and provided considerable expertise about populations of the ballerina orchid. Erica Shedley (DEC Flora Conservation Officers), volunteers from WANOSCG (Margaret Petrides, Pam Goodman) and representatives of wheatbelt community groups (Jocelyn Ward from Nyabing and Lucy Skipsey from Pingrup) also contributed to surveys. Phylis Robertson, Nur Koshkuson and Emily Ager also assisted with fieldwork. Ann and Barry Rick of Newdegate provided invaluable assistance, accommodation and advice. Grazing enclosures were organised by Marie Edgley and Erica Shedley of DEC. Margaret Petrides (WANOSCG) discovered two populations of the ballerina orchid in 2009 and 2010. Volunteers from WANOSCG helped discover a subpopulation of this orchid in 2007. Ruhi Ferdowsian and Dr Paul Raper of the WA Department of Agriculture and Food provided advice on salinity. Karen Clarke commented on the manuscript.

10. References

Bonnardeaux Y, Brundrett M, Batty A, Dixon K, Koch J, Sivasithamparam K. 2007. Diversity of mycorrhizal fungi of Western Australian terrestrial orchids: Compatibility webs, brief encounters, lasting relationships and alien invasions. *Mycological Research* **111:** 51-61.

Brundrett M, Edgley M. 2009. *Translocation Proposal Ballerina Orchid* Caladenia melanema *Hopper & A.P.Br. (Orchidaceae)*. Wheatbelt Orchid Rescue Project, University of Western Australia (13 pages).

Brundrett MC, Scade A, Batty AL, Dixon KW, Sivasithamparam K. 2003. Development of *in situ* and *ex situ* seed baiting techniques to detect mycorrhizal fungi from terrestrial orchid habitats. *Mycological Research* **107:** 1210-1220.

Department of Environment and Conservation. 2007. *Ballerina Orchid* (Caladenia melanema) *Interim Recovery Plan 2007-2012. Interim Recovery Plan No. 276.* Department of Environment and Conservation, Western Australia.

Hoffman N, Brown A. 1989. *Orchids of South-west Australia.* 1992. University of Western Australia Press, Nedlands.

Hopper SD, Brown AP. 2001. Contributions to Western Australian orchidology: 2. New taxa and circumscriptions in *Caladenia*. *Nuytsia* **14:** 27-308.

Li X, Rengel Z, Mapfumo E, Singh B-. 2007. Increase in pH stimulates mineralization of 'native' organic carbon and nitrogen in naturally salt-affected sandy soils. *Plant and Soil* **290:** 269–282.

Table 5. Recovery actions proposed in the Interim Recovery Plan for *Caladenia melanema* (DEC 2007) with relevant and planned outcomes of the WOR project.

Recovery Action	Priority	WOR Outcomes	Future Objectives
Coordinate recovery actions	High	Attendance of recovery team meetings	
Liaise with relevant land managers	High	Permits and permissions obtained	
Monitor populations	High	Monitoring with DEC (2007, 2008)	Monitoring should continue
Collect seed and other material to preserve genetic diversity	High	Seeds and fungi collected and viability tested. Seed baiting trails confirmed soil compatibility for seedlings.	Continue long term storage
Obtain biological and ecological information	High	Permanent transect established in 2007 and substantial new datasets obtained and evaluated (this report)	Additional information on pollination and genetics is required
Undertake weed control and follow-up with regular monitoring and additional control if required	High	Some hand weeding has occurred, but weed control is not considered a major issue at this time.	Monitoring should continue as weeds may become a more serious issue
*Measure and manage grazing impacts**		*5 fenced enclosures (DEC) have partially controlled grazing*	*Further monitoring may show additional measures are required.*
Promote awareness	High	Displays and presentations to community groups	Additional articles and website (in development)
Conduct further surveys	High	Comprehensive surveys of populations 1-3 completed. 3 new populations and 4 subpopulations discovered by DEC, WOR and WANOSCG volunteers	Comprehensive survey of a new population (4) required
Develop and implement a fire management strategy	High	Critical Habitat identified for inclusion in Fire Management Plan	Create or amend fire plans
Prepare a translocation proposal	High	Background data for proposal is summarised here. Proposal prepared, approved and implemented in 2009 and 2010 (WOR / DEC)	Further translocations may be advisable following assessment of results
Map habitat critical to the survival of *Caladenia melanema*	Moderate	Critical Habitat identified (Appendix 1 this report)	Critical Habitat map deployment (DEC)
Review the need for further recovery actions	High	Major issues that require action have been identified (grazing, habitat decline)	Investigating impacts of saline groundwater on vegetation should be a high priority

**Action missing from original table.*