THE OCCURRENCE AND CONSERVATION STATUS OF TASMANIAN *PTEROSTYLIS* (ORCHIDACEAE)

Jasmine K. Janes, Dorothy A. Steane & René E. Vaillancourt*

*School of Plant Science, University of Tasmania, GPO Box 252-55, Hobart, Tasmania 7001; *email: jkjanes@utas.edu.au*

SUMMARY

Orchids belong to one of the largest plant families present in Tasmania and yet they remain poorly researched. In Tasmania, *Pterostylis* R.Br. comprises about 37 terrestrial species, commonly called greenhoods. Little is understood about Tasmanian *Pterostylis* ecology and a recent assessment of species' abundances and distributions have not been conducted. Over a two year period known *Pterostylis* locations within mainland Tasmania, King Island and Flinders Island were visited for the purpose of collecting detailed data for species abundance, distribution and flowering. Several species within the genus *Pterostylis* are facing significant threats, and recommendations to prevent the decline of these species are provided.

INTRODUCTION

Orchids represent a large portion of the plants at risk within Australia, primarily because of the interactions between anthropogenic impact (Bates & Weber 1990; Lehnebach *et al*. 2005) and the complex biology of orchids (Coates *et al.* 2006).

Within the Orchidaceae, the Pterostylidinae is a relatively large Australasian subtribe containing over 200 species of terrestrial, tuberous geophytes commonly called greenhoods (Hoffman & Brown 1984, Jones & Clements 2002). The group has a broad latitudinal range and occupies a variety of habitats, encompassing coastal and alpine areas in tropical and temperate regions. However, the subtribe is most diverse within the Australian southeast temperate zone where the climate allows for distinct periods of growth, flowering and dormancy (Jones & Clements 2002).

As with other orchid subtribes, the Pterostylidinae are easily recognised as a group, although identification of species can be difficult due to both the lack of local experienced orchid taxonomists and repeated taxonomic revisions (Jones *et al*. 1999; Jones & Clements 2002). Consequently, 12 complexes or natural groups comprising the "alata", "barbata", "curta", "daintreana", "longifolia", "mutica", "nana", "parviflora", "recurva", "rufa", "sargentii" and "vittata" groups were recognised within a single genus, that of *Pterostylis* R.Br. (Jones & Clements 2002). In recent years the subtribe has been the subject of taxonomic confusion with up to 16 genera being recognised (Szlachetko 2001; Jones 2006) and then

informally dismissed. Currently, within Tasmania, the genus *Pterostylis* comprises 37 species, of which 11 species are endemic and 13 species are formally recognised as threatened (five of these are endemic).

The few terrestrial orchid studies that have been conducted in the southern hemisphere indicate that several key threats are affecting orchid populations. Habitat loss, changes in land use practices and habitat fragmentation (Jones 1998; Jones *et al*. 1999; Lehnebach *et al*. 2005; Coates *et al.* 2006; TSS 2006) are probably the most pressing issues. However, human induced changes in fire frequency (Jones *et al*. 1999; TSS 2006), introduced and invasive plant species (Jones *et al.* 1999), casual picking of flowers (Dockrill 1992; Jones *et al*. 1999), grazing and digging from animals (Jones *et al.* 1999), and the use of fungicides (Feuerherdt *et al.* 2005) are all potential threats to the current and future management of Tasmanian orchids.

A recent assessment of *Pterostylis* abundance and distribution within Tasmanian had not been conducted for some years and, at the commencement of this study, there had been no formal monitoring or systematic recording of orchid populations (TSS 2006). This study aimed to assess some of the existing recorded sites of *Pterostylis* species in Tasmania. Although it should be noted that a full-scale survey of all recorded *Pterostylis* sites within the time constraints allocated for field work was not possible, and two new species (*Pterostylis lustra* and *P.* X*ingens*) have been confirmed for Tasmania since completion. The information obtained from this study will update the State-maintained *Natural Values Atlas* database and can be used to review the current listing status of several threatened species and suggest recommendations for their management.

MATERIALS AND METHODS

Study area and nomenclature

Field locations for this study were located throughout Tasmania. In recent years, two major classifications have affected recognised taxa (Szlachetko 2001; Jones & Clements 2002) and there has been considerable confusion within Tasmania concerning *Pterostylis* nomenclature. For the purposes of this study, nomenclature will conform to that of Buchanan (2007) because it is the most widely used and accepted within Tasmania.

Study species

Pterostylis species found at given sites throughout the January 2005 to August 2007 periods were identified to species level. Representative flowering individuals were lodged with the Tasmanian Herbarium (HO), where the identification was confirmed. All records were forwarded to the Threatened Species Section at the

Department of Primary Industries and Water in Tasmania (DPIW) for entry into the *Natural Values Atlas* (NVA) database.

Using previously recorded orchid sightings in the NVA as a guide, the State was divided into six regions: northwest, northeast, southeast, central, King Island and Flinders Island. This site selection strategy ensured that species with widespread distributions were represented at least once in each region and species restricted to one or two regions were represented at least twice in each region. Sites that contained more than one species in each region were preferentially selected to reduce travel time. As a result, some species may be under-represented while others may appear more common. Using the NVA as a guide, a total of 91 previously recorded *Pterostylis* sites were selected, on the basis that the observation was made in 1995 or later.

RESULTS

Twenty four of the 35 Tasmanian *Pterostylis* species sought were successfully located and identified in this study (Table 1). *P. melagramma* was the most common species (14 sites), closely followed by *P. parviflora* (11 sites) and *P. pedoglossa* (10 sites). Ten species, *P. alata*, *P. aphylla*, *P. atrans*, *P. commutata*, *P. cucullata*, *P. foliata*, *P. sanguinea*, *P. scabrida*, *P. squamata* and *P. tunstallii* were found at only one site each (Table 1). Four of these species (*P. alata*, *P. aphylla*, *P. commutata* and *P. scabrida*) are endemic, with *P. commutata* recognised legislatively as the most threatened. *P. aphylla* was the least frequently recorded of these four endemic species, with only seven individuals recorded from Bluff Hill Point (Table 1). A further four species (*P. cucullata*, *P. sanguinea*, *P. squamata* and *P. tunstallii*) from single sites are not endemic but their conservation status is listed as threatened. Both *P. sanguinea* and *P. squamata* populations had fewer than 10 individuals and *P. tunstallii* populations on Flinders Island comprised 28 individuals. In contrast, *P. cucullata* had the most individuals out of the single-site species located (Table 1).

Four other threatened species, *P. ziegeleri*, *P. pratensis*, *P. grandiflora* and *P. atriola*, were successfully located. *P. ziegeleri* was recorded in relatively high numbers from South Arm and Ross (Table 1), while *P. pratensis* was recorded from two sites in relatively low numbers and was the only species found to inhabit alpine grassland (Table 1). The two confirmed locations of *P. atriola* (Snug Tiers and Wielangta) had relatively small populations (Table 1). *Pterostylis grandiflora* was identified from a relatively large population at Hazards Beach, although it varied considerably in terms of the number of emergent and flowering individuals over three years (Table 1). Between 2005 and 2006 there was a 79% decrease in the number of emergent *P. grandiflora* individuals (i.e. those with a visible rosette or flower). The number of emergent individuals increased in 2007, but remained 6% lower than in 2005.

Table 1. *Pterostylis* sites and abundances found during the study Regions: Central Plateau (C), Flinders Island (FI), King Island (KI), North East (NE), North West (NW), South East (SE). Vegetation Types: alpine grassland (AGL), *Callitris* forest (CAL), coastal heath (CH), grassland (GL), dry sclerophyll (DS), dry sclerophyll-coastal heath (DS-CH), dry sclerophyll sedgeland (DS-S), tea-tree scrub (TTS), wet sclerophyll (WS).

Species	Date	Location	Reg-ion	Veget-ation type	No. indivi-duals	No. flowers
P. alata	2/7/07	South Arm	SE	CH	37	24
P. aphylla	28/11/05	Bluff Hill Point	NE	TTS	7	3
P. atrans	6/2/06	Snug Tiers	SE	DS	1	1
P. atriola	20/3/05	Tooms White Gum*	NE	WS	1	3
P. atriola	6/2/06	Snug Tiers	SE	DS-S	31	41
P. atriola	9/3/06	Wielangta Forest	SE	DS	18	31
P. commutata	8/12/05	Ross	NE	GL	11	6
P. concinna	2/7/07	South Arm	SE	CH	96	18
P. concinna	2/8/07	Strzelecki NP	FI	TTS	18	18
P. concinna	3/8/07	Vinegar Hill	FI	DS	372	372
P. cucullata	10/11/05	King Island	KI	TTS	224	68
P. ziegeleri	10/10/05	Ross	NE	GL	81	294
P. ziegeleri	20/10/05	South Arm	SE	GL	423	286
P. decurva	8/2/05	Mt Wellington	SE	WS	137	14
P. decurva	19/1/06	Mt Barrow	NE	WS	5	2
P. decurva	6/2/06	Snug Tiers	SE	DS	1	1
P. decurva	28/2/06	Mt Wellington	SE	WS	39	30
P. foliata	1/12/05	Mt Wellington	SE	WS	104	31
P. grandiflora	26/3/05	Hazards Beach (1)	NE	CH	266	8
P. grandiflora	13/4/06	Hazards Beach (1)	NE	CH	56	2
P. grandiflora	18/5/07	Narawntapu NP	NE	WS	1	1
P. grandiflora	26/5/07	Hazards Beach (1)	NE	CH	100	13
P. melagramma	28/8/05	Hobart	SE	DS-S	50	138
P. melagramma	28/8/05	Mt Nelson	SE	DS	30	311
P. melagramma	29/8/05	South Arm	SE	DS-S	16	186
P. melagramma	25/9/05	Hartz Mountains	SE	WS	40	23
P. melagramma	19/10/05	Bruny Island	SE	WS	8	24
P. melagramma	19/1/06	Mt Barrow	NE	WS	3	3
P. melagramma	9/4/06	Lake Leake Rd	NE	DS	1	1
P. melagramma	27/9/06	Mt Wellington	SE	WS	178	742
P. melagramma	5/10/06	Risdon	SE	DS	6	8
P. melagramma	9/10/06	Police Point	SE	DS	22	
P. melagramma	20/7/07	Tooms Reserve	NE	WS	20	
P. melagramma	20/7/07	Tooms Reserve	NE	DS	8	

Species	Date	Location	Region	Vegetation type	No. individuals	No. flowers
P. melagramma	25/7/07	Waterfall Bay	SE	WS	12	
P. melagramma	2/8/07	Strzelecki NP (1)	FI	TTS	7	
P. melagramma	2/8/07	Strzelecki NP (2)	FI	TTS	18	
P. melagramma	2/8/07	Strzelecki NP (3)	FI	TTS	16	
P. melagramma	3/8/07	Vinegar Hill	FI	DS	19	
P. nutans	18/9/05	Rokeby	SE	DS	27	
P. nutans	3/11/05	Flinders Island	FI	CAL	9	
P. parviflora	25/3/05	Bruny Island	SE	CH	19	
P. parviflora	26/3/05	Hazards Beach (1)	NE	CH	18	
P. parviflora	3/4/05	M Rd, Forestry	NE	DS	35	
P. parviflora	17/3/06	Huon Rd	SE	DS	43	
P. parviflora	6/4/06	Bruny Island	SE	CH	26	
P. parviflora	9/4/06	Lake Leake Rd	NE	DS	1	
P. parviflora	12/5/06	Adventure Bay	NW	CH	8	
P. parviflora	13/4/06	Hazards Beach (2)	NE	CH	58	
P. parviflora	20/4/06	Peter Murrell Reserve	SE	CH	1	
P. parviflora	11/5/06	Bluff Hill Point	NW	TTS	98	
P. parviflora	12/5/06	Mt William	NE	TTS	16	
P. parviflora	13/5/06	Eddystone Point	NE	DS-CH	38	
P. pedoglossa	20/3/05	Lake Leake Rd	NE	DS	4	
P. pedoglossa	25/3/05	Bruny Island	SE	CH	22	
P. pedoglossa	26/3/05	Hazards Beach	NE	CH	4	
P. pedoglossa	2/4/05	Waterfall Bay	SE	DS	8	
P. pedoglossa	6/4/06	Bruny Island	SE	CH	19	
P. pedoglossa	9/4/06	Lake Leake Rd	NE	DS	119	
P. pedoglossa	12/4/06	Sisters Hills	NW	CH	10	
P. pedoglossa	12/4/06	Adventure Bay	NW	CH	8	
P. pedoglossa	11/5/06	Bluff Hill Point	NW	TTS	8	
P. pedoglossa	13/5/06	Eddystone Point	NE	DS-CH	2	
P. pedoglossa	25/9/05	Hartz Mountains	SE	WS	49	
P. pedoglossa	3/11/05	Flinders Island	FI	CAL	4	
P. pratensis	2/12/05	Liawenee	C	AGL	35	243
P. pratensis	2/12/05	Miena	C	AGL	12	87
P. sanguinea	2/8/07	Strzelecki NP	FI	TTS	2	2
P. scabrida	8/12/05	Mt Wellington	SE	WS	36	25
P. stenochila	6/7/06	South Arm	SE	DS-CH	14	42
P. stenochila	20/7/07	Lake Leake	NE	DS	3	3
P. stenochila	21/8/07	Epping Forest	NE	DS	12	34

Species	Date	Location	Region	Vegetation type	No. individuals	No. flowers
P. squamata	5/2/06	Dolphin Sands	NE	DS-S	8	14
P. tasmanica	19/10/05	Bruny Island	SE	CH	1	1
P. tasmanica	7/11/05	King Island	KI	CH	16	9
P. tunstallii	2/8/07	Strzelecki NP (1)	FI	TTS	28	32
P. tunstallii	2/8/07	Strzelecki NP (2)	FI	TTS	9	13
P. tunstallii	2/8/07	Strzelecki NP (3)	FI	TTS	11	26
P. williamsonii	29/8/05	South Arm	SE	DS-S	19	186
P. williamsonii	28/8/05	Mt Nelson	SE	DS	28	261
P. williamsonii	27/8/06	Risdon	SE	DS	11	27
P. williamsonii	20/7/07	Tooms Reserve	NE	DS	11	11
P. williamsonii	2/8/07	Strzelecki NP (1)	FI	TTS	14	16
P. williamsonii	2/8/07	Strzelecki NP (2)	FI	TTS	8	15
P. williamsonii	2/8/07	Strzelecki NP (3)	FI	TTS	22	39

Seven of the *Pterostylis* species found are endemic to Tasmania: *P. aphylla*, *P. atriola*, *P. commutata*, *P. pratensis*, *P. scabrida*, *P. stenochila* and *P. williamsonii* (Table 1). As previously mentioned, several of these species were identified from single sites (Table 1). All other *Pterostylis* species found (Table 1) are considered common within Tasmania and Australia (Jones *et al.* 1999; Jones 2006a), although the number of sites and population sizes for each species varied considerably.

Several locations of *Pterostylis* species that had been lodged with DPIW were visited throughout the study but neither flowering individuals nor sterile rosettes were found at any of the nine sites (Table 2).

Orchid species can remain dormant for several years thus, it is impossible to determine if these populations were absent due to decline or dormancy. Several of the species that were not observed at previously recorded locations are threatened (*P. falcata*, *P. sanguinea* and *P. squamata*). *Pterostylis dubia*, a Tasmanian endemic, was not found in 1996 at several of the sites that had been lodged most recently with the NVA (Table 2). Five species, *P. alata*, *P. concinna*, *P. parviflora*, *P. pedoglossa* and *P. tasmanica*, were identified from other sites around Tasmania and are not listed legislatively (Table 2). *P. plumosa* and *P. uliginosa* are not cited on the TSPA or EBPCA, however neither sterile rosettes nor flowering individuals were found at several of the sites most recently lodged with DPIW (Table 2). Five species, *P. curta*, *P. mutica*, *P. nana*, *P. rubenachii* and *P. wapstrarum* were not sought actively due to time constraints.

Table 2. *Pterostylis* species locations that were unoccupied at the date of survey. Note that this does not necessarily indicate absence of the species, merely that species were not located at the given time.

Species	Date	Location
P. alata	19/6/05	Duck Bay
P. alata	19/6/06	Boronia Hill
P. alata	27/6/06	Avoca
P. concinna	19/6/06	Boronia Hill
P. dubia	26/2/06	Lake Fenton
P. dubia	28/2/06	Mt Wellington
P. falcata	19/1/05	Mt Barrow
P. falcata	19/1/06	Mt Barrow
P. furcata	28/1/05	Woods Lake
P. furcata	28/1/05	Interlaken Rd
P. furcata	10/12/05	Woods Lake
P. furcata	10/12/05	Interlaken Rd
P. furcata	7/2/06	Woods Lake
P. furcata	7/2/06	Interlaken Rd
P. furcata	23/2/06	Woods Lake
P. furcata	23/2/06	Interlaken Rd
P. parviflora	12/4/05	Lime Bay
P. pedoglossa	12/4/05	Lime Bay
P. plumosa	28/10/05	Lime Bay
P. plumosa	12/11/05	Blackmans Bay
P. plumosa	12/11/06	Blackmans Bay
P. plumosa	27/11/05	Narawntapu NP
P. sanguinea	26/7/05	Cape Portland
P. sanguinea	14/8/06	Cape Portland
P. squamata	20/1/06	Avoca
P. squamata	31/1/06	Cleveland
P. squamata	31/1/06	Avoca
P. squamata	31/1/06	Ross
P. tasmanica	28/10/05	Lime Bay
P. uliginosa	3/1/06	Southport
P. uliginosa	15/1/06	Freycinet

DISCUSSION

The status of Pterostylis *species in Tasmania*

The majority of *Pterostylis* species were located using relatively recent records from the DPIW NVA, a State database in which any registered user can record

sightings of species. Several new species locations were discovered as a result of this study and were added to the NVA. Some species appeared to be far less common than suggested by previous records, and some were not located at relatively recently recorded sites (1995 onwards). These results confirm that our information about *Pterostylis* species' distributions and demographics is somewhat outdated and suggest that several species' listings should be revised.

Based on the observations from this study, there are several species that are not currently listed under the TSPA that warrant further investigation and possible consideration for listing. For example, *P. sanguinea* and *P. squamata* were located during this study as single populations, each consisting of fewer than 10 individuals. Several other recently recorded sites were devoid of the species, suggesting that these species may be in decline. The most critical case is *P. commutata*, which is currently considered one of the most threatened orchid species in Tasmania. *P. commutata* was identified from a single site comprising only 11 individuals and there have only been three recorded sightings of this species in the last 13 years, none of which came from formally protected areas.

To manage and conserve *Pterostylis*, and other orchid species, effectively it is essential to collect information relating to population biology and habitat requirements. It is imperative that long-term studies commence that monitor and investigate the life-history stages of those species most at risk. However, short-term management strategies that maximise the growth and reproduction of existing populations should begin immediately.

Short-term management strategies for Pterostylis *species*

Annual mowing has been shown to maintain orchid population numbers and lead to increased leaf area by limiting shoot competition with other species (Coates *et al*. 2006; Janečková *et al*. 2006). Furthermore, limited competition allows for resources to be allocated to growth, and a large total size was identified as crucial for the long-term survival and increased reproductive fitness of the North American *Cleistes bifaria* and European *Himantoglossum hircinum* terrestrial orchids (Gregg & Kéry 2006; Pfiefer *et al.* 2006). Consequently, a regular regime of mowing after capsule ripening and seed dispersal may be beneficial to the growth, seed set and survival of grassland and coastal *Pterostylis* species because dense ground cover is often present in these communities.

Fire can promote flowering in orchid populations. For example, *Corybas carsei*, *Prasophyllum* aff. *patens*, *Thelymitra cyanea* and *Pterostylis paludosa* in New Zealand, *Thelymitra epipactoides*, *Pterostylis gibbosa* and *Prasophyllum correctum* in south-eastern Australia (Calder *et al.* 1989, Goldman & Orzell 2000; Visman 2000; Norton & De Lange 2003; Coates *et al.* 2006) showed significant increase in population numbers after fire. Furthermore, fires at two year intervals

resulted in an increase in the numbers of 23 orchid species from south-western Australia (Grant & Koch 2003), while intervals of three years increased the number of *Prasophyllum correctum* individuals by 5% and increased the number of plants that remained reproductive the following season by 6% (Coates *et al*. 2006). In Tasmania, coastal heath, grassland and dry sclerophyll habitats traditionally have high fire frequencies (Jackson 1968). Thus, a regular fire regime would be beneficial for most *Pterostylis* populations in these vegetation types. Populations of species, such as *P. decurva,* that occur in wet sclerophyll forests would not benefit from such a management choice because these habitats naturally have a longer interval between fires (Jackson 1968) and develop a thicker layer of litter that may be required for fungal relationships.

Heavy grazing by vertebrates can cause a severe reduction in photosynthetic area, which can in turn inhibit orchid flowering and emergence (Coates *et al.* 2006). Orchids may eventually die because of a reduction in stored carbon required for flowering in subsequent years (Gregg 2004). As a result, the growth and reproductive success of heavily grazed orchids may be reduced greatly. Gregg (2004) found that moderately grazed populations of *Cypripedium reginae* recovered significantly faster than heavily grazed populations in terms of flowering and plant size. Light grazing has been shown to benefit populations of *Pterostylis gibbosa* by increasing light levels and allowing for increased growth in areas with dense cover (National Parks and Wildlife Services 2002). *Pterosytlis* species occurring in dense vegetation types such as grassland and sedgeland that require frequent disturbance would most likely flourish under managed light grazing. Accordingly, some populations in areas that are grazed heavily may benefit from exclosures.

Management strategies for Pterostylis commutata

This study has identified *Pterostylis commutata* as one of the State's most threatened orchids (Plate 1). The species was identified from a single location (an unprotected tourist attraction), although it has been sighted at two more grassland sites within the central east area of Tasmania. 'The Midlands' central graben is situated in rain-shadow from the west of the State and the east (Jackson 1999). As a result, evaporation greatly exceeds precipitation and the Midlands are regularly subject to drought conditions. Stochastic events, such as lengthy drought periods, accidental trampling from tourists, grazing from herbivores and occasional picking could potentially decimate the populations.

To combat trampling and grazing a temporary exclusion fence at the tourist accessible site should be erected during emergence and flowering. An exclusion fence would significantly reduce herbivory of rosettes, and damage from trampling, while still promoting healthy growth of the grassland area if combined with light mowing. It may also deter collection and picking while increasing public

awareness of the species' plight. This in turn could prevent the theft of individuals once collectors realise that the flowers are small, cultivation is exceedingly difficult and the species is deciduous.

Plate 1. Grassland habitat of *Pterostylis commutata* at the Tunbridge Township Lagoon Nature Reserve. This site also supports other threatened plants including orchids such as *Prasophyllum tunbridgense* (inset photo of *P. commutata* by Peter Tonelli).

Occasional supplementary watering may also benefit *P. commutata* populations. It has been noted that orchid tubers in Western Australia are frequently subject to soil temperatures over 30ºC and periods of 4-5 months without rainfall (Tieu *et al*. 2001). Occasional summer rainfall can increase orchid survivorship by reducing the stressful effects of drought (Batty *et al.* 2006; Scade *et al*. 2006). Hence, supplementary watering throughout the summer period may increase seedling establishment and reduce overall mortality.

Hand-pollination has been shown to be effective in increasing orchid population sizes abroad. The average fruit set level for European deceptive orchids is 27.7% (Neiland & Wilcock 1998); the average fruit set for *Pogonia japonica* in Japan is 20% (Matsui *et al*. 2001) and *Pterostylis gibbosa* averaged between 5-19% in Australia (NPWS 2002). No hand pollination trials were conducted on *P. gibbosa*, although the rate of fruit set in *Pogonia japonica* increased to 80% (Matsui *et al*. 2001) when outcrossing by hand pollination was introduced. Consequently, hand pollinating to increase seed set may lead to a larger population size which will further increase recruitment and establishment rates within *P. commutata* populations.

Thus, hand pollinating in conjunction with temporary exclusion fences, light mowing, artificial watering and consistent monitoring may aid in maintaining – and potentially increasing – *P. commutata* populations in the wild, until such a time as the other actions outlined in the Tasmanian *Orchid Recovery Plan*, particularly *ex situ* cultivation and mycorrhizal investigations, can begin.

CONCLUSION

This study aimed to assess the distribution of *Pterostylis* species and provide an updated account of abundance and occurrence throughout Tasmania. The results indicate that our current knowledge of *Pterostylis* ecology and distribution is limited and outdated. Several species that were thought previously to be abundant and widespread appear to have declined in the past decade. Consequently, a more active approach in surveying and recording species should be implemented and several short-term management strategies are recommended to ensure the continued survival of threatened populations until the Tasmanian *Orchid Recovery Plan* (TSS 2006) comes into full effect. The results and recommendations from this study will assist in formulating long-term management plans that ensure the survival of several orchid species.

ACKNOWLEDGEMENTS

This research was funded by a Discovery grant (DPO557260) from the Australian Research Council, an Australian Postgraduate Award to the lead author and research funding from the Australian Systematic Botany Society (Hansjörg Eichler Scientific Research Fund). The authors thank Marco Duretto (Tasmanian Herbarium) and Hans Wapstra for identification confirmation. The authors are indebted to Dr Wendy Potts and Matthew Larcombe from the Threatened Species Section (Department Primary Industries and Water), and Dr. Mark Hovenden and Dr Greg Jordan from the School of Plant Science (University of Tasmania) for their assistance and support.

REFERENCES

Bates, R. & Weber, J.Z. (1990). *Orchids of South Australia*. A.B. Caudell Government Printer, Adelaide.

Batty, A.L., Brundrett, M., Dixon, K.W. & Sivasithamparam, K. (2006). *In situ* symbiotic seed germination and propogation of terrestrial orchid seedlings for establishment at field sites. *Australian Journal of Botany* 54: 375-381.

Buchanan, A.M. (2007). *A Census of the Vascular Plants of Tasmania and Index to* The Student's Flora of Tasmania. Tasmanian Herbarium Occasional Publication No. 7, Tasmanian Herbarium, Hobart. (2007 web edition as downloaded from http://www.tmag.tas.gov.au/Herbarium/TasVascPlants.pdf).

Calder, D.M., Cropper, S.C. & Tonkinson, D. (1989). The ecology of *Thelymitra epipactoides* F. Muell. (Orchidaceae) in Victoria, Australia, and the implications for management of the species. *Australian Journal of Botany* 37: 19-32.

Coates, F., Lunt, I.D. & Tremblay, R.T. (2006). Effects of disturbance on population dynamics of the threatened orhcid *Prasophyllum correctum* D.L. Jones and implications for grassland management in south-eastern Australia. *Biological Conservation* 129: 59-69.

Dockrill, A.W. (1992). *Australian Indigenous Orchids*. NSW, Surrey Beatty and Sons Pty Ltd.

Feuerherdt. L., Petit, S. & Jusaitis, M. (2005). Distribution of mycorrhizal fungus associated with the endangered pink-lipped spider orchid (*Arachnorchis* (syn. *Caladenia*) *behrii*) at Warren Conservation Park in South Australia. *New Zealand Journal of Botany* 43: 367-371.

Goldman, D.H. & Orzell, S.L. (2000). Morphological, geographical and ecological reevaluation of *Calopogan multiflorus* (Orchidaceae). *Lindleyana* 15: 237-251.

Grant, C. & Koch, J. (2003). Orchid species succession in rehabilitated bauxite mines in Western Australia. *Australian Journal of Botany* 51: 453-457.

Gregg, K.B. (2004). Recovery of showy lady's slippers *Cypripedium reginae* (Walter) from moderate and severe herbivory by white-tailed deer *Odocoiles virginianus* (Zimmerman). *Natural Areas Journal* 24: 232-241.

Gregg, K. & Kéry, M. (2006). Comparison of size vs. life-state classification in demographic models for the terrestrial orchid *Cleistes bifaria*. *Biological Conservation* 129: 50-58.

Hoffman, N. & Brown, A. (1996). *Orchids of South-West Australia.* University of Western Australia Press, Nedlands.

Jackson, W.D. (1968). Fire, air, water and earth – an elemental ecology of Tasmania. *Proceedings of the Ecological Society of Australia* 3: 9-16.

Jackson, W. (1999). The Tasmanian Environment. In: *Vegetation of Tasmania*. (Eds. J. Reid, R.S. Hill, M.J. Brown & M.J. Hovenden). Australian Biological Resources Study, Hobart.

Janečková, P., Wotavová, K., Shödelbauerová, I., Jersáková, J. & Kindlemann, P. (2006). Relative effects of management and environmental conditions on performance and survival of populations of a terrestrial orchid, *Dactylorhiza majalis*. *Biological Conservation* 129: 40-49.

Jones, D.L. (1998). Contributions to Tasmanian Orchidology. *Australian Orchid Research* 3: 1-224.

Jones, D. L. (2006). *A Complete Guide to the Native Orchids of Australia Including the Island Territories*, New Holland Publishers, Sydney.

Jones, D., Wapstra, H., Tonelli, P. & Harris, S. (1999). *The Orchids of Tasmania*. Melbourne University Press, Melbourne.

Jones, D.L. & Clements, M.A. (2002). A new classification of *Pterostylis* R.Br. (Orchidaceae). *Australian Orchid Research* 4: 64-124.

Lehnebach, C.A., Robertson, A.W. & Hedderley, D. (2005). Pollination studies of four New Zealand terrestrial orchids and the implications for their conservation. *New Zealand Journal of Botany* 43: 467-477.

Matsui, K., Ushimaru, A. & Fujita, N. (2001). Pollinator limitation in a deceptive orchid, *Pogonia japonica*, on a floating peat mat. *Plant Species Biology* 16: 231-235.

National Parks and Wildlife Service (NPWS) (2002). Pterostylis gibbosa *(R.Br.) Illawarra Greenhood Orchid Recovery Plan*. NSW National Parks and Wildlife Services, Hurstville.

Neiland, M.R. & Wilcock, C.C. (1998). Fruit set, nectar reward, and rarity in the Orchidaceae. *American Journal of Botany* 85: 1657-1671.

Norton, D.A. & De Lange, P.J. (2003). Fire and vegetation in a temperate peat bog: implications for the management of threatened species. *Conservation Biology* 17: 138-148.

Pfeifer, M., Heinrich, W. & Jetschke, G. (2006). Climate, size and flowering history determine flowering pattern of an orchid. *Botanical Journal of the Linnean Society* 151: 511-526.

Scade, A., Brundrett, M.C., Batty, A.L., Dixon, K.W. & Sivasithamparam, K. (2006). Survival of transplanted terrestrial orchid seedlings in urban bushland habitats with high or low weed cover. *Australian Journal of Botany* 54: 383-389.

Szlachetko, D.L. (2001). Genera et species orchadalium. *Polish Botanical Journal* 46: 11-26.

Threatened Species Section (TSS) (2006). *Flora Recovery Plan: Tasmanian Threatened Orchids 2006-2010*. Department of Primary Industries and Water, Hobart

Tieu, A., Dixon, K.W., Meney, K.A. & Sivasithamparam, K. (2001). Influence of soil burial and smoke germination patterns in seeds of selected Australian native plants. *Seed Science Research* 11: 69-76.

Visman, K.N. (2000). *The Effects of Fire on the Rare and Endangered Illawarra Greenhood Orchid,* Pterostylis gibbosa. Unpublished Honours thesis, University of Wollongong.

Note: grey-scale embedded images in this article are shown in full colour and enlarged in the central pages of this volume.

Appendix 1. A list of Tasmanian *Pterostylis* species, indicating endemism, State (TSPA) and national (EPBCA) conservation status.
TSPA: r = rare, v = vulnerable, e = endangered; EPBCA: VU = vulnerable, EN = endangered, CR = critically endangered

Species	Endemic	TSPA	EPBC	Suggested State Listing
P. alata	♦			
P. aphylla	♦			r-v
P. atrans				r
P. atriola	♦	e	EN	
P. commutata	♦	e	CR	
P. concinna				
P. cucullata		e	VU	v
P. curta				
P. decurva				
P. dubia	♦			r
P. falcata		r		e
P. foliata				
P. furcata	♦			r
P. grandiflora		r		v
P. X*ingens*				Not considered in present study as recognised as present in Tasmania only after study was completed (Jones 2006)
P. lustra				Not considered in present study as described after study was completed (Jones 2006)
P. melagramma				
P. mutica				
P. nana				
P. nutans				
P. parviflora				
P. pedunculata				
P. pedoglossa				
P. plumosa				r
P. pratensis	♦	v	VU	
P. rubenachii	♦	e	EN	
P. sanguinea		r		v
P. scabrida	♦			
P. squamata		r		v
P. stenochila	♦			r
P. tasmanica				
P. tunstallii		e		
P. uliginosa				Uncertain due to misidentification of several specimens of *P. aphylla*
P. wapstrarum	♦	e	CR	
P. williamsonii	♦			
P. ziegeleri	♦	v	EN	