FURTHER NOTES ON THE OCCURRENCE OF FAIRY LANTERNS *THISMIA RODWAYI* F. MUELL. (THISMIACEAE) IN TASMANIA: VEGETATION ASSOCIATIONS

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INTRODUCTION

The flowering plant *Thismia rodwayi* F. Muell. ('fairy lanterns' – Plate 1) belongs to the family Thismiaceae (Merckx et al. 2013). Thismiaceae have often been included in Burmanniaceae but molecular data indicates that the two families are not closely related (Merckx et al. 2006). Thismiaceae comprise about 63 species in five genera (Merckx et al. 2013). Most species occur in tropical rainforest, but a few occur in subtropical and temperate regions. *Thismia rodwayi* is such a temperate species. It was described in 1890 by Ferdinand von Mueller based on a specimen collected near Hobart, Tasmania, by Leonard Rodway (von Mueller 1890). The species has subsequently been found at several other localities in Tasmania, and is also known from Victoria, New South Wales, southern Queensland, and the north island of New Zealand (Jonker 1938; Roberts et al. 2003). In Tasmania *Thismia rodwayi* is presently listed as 'rare' under the Tasmanian *Threatened Species Protection Act 1995*.

Plate 1. *Thismia rodwayi* from near the Myrtle Gully track on the lower slopes of Mount Wellington

Like all species of Thismiaceae, *Thismia rodwayi* has a fully mycoheterotrophic mode of life: the plant is leafless and achlorophyllous, and obtains all of its nutrients and sugars from fungi. These fungi are obligate mycorrhizal partners of surrounding trees, from which sugars are obtained in exchange for mineral and water from the soil. Thus, *Thismia* ultimately obtains carbohydrates from surrounding trees through shared mycorrhizal fungi. Recently, the mycorrhizal fungus of two specimens of *Thismia rodwayi* from the Meander area in Tasmania was identified with molecular methods (Merckx et al. 2012). The detected fungus belongs to the *Glomus* Group A clade, which confirms earlier morphological observations that *Thismia rodwayi* exploits an arbuscular mycorrhizal fungus (McLennan 1957). Interestingly, the fungal DNA sequences that were obtained from several root segments of both specimens were all identical. This suggests that *Thismia rodwayi* plants, like many other mycoheterotrophic plants and generally unlike chlorophyllous plants, exhibit exceptional specificity towards their fungal associates (Bidartondo et al. 2002; Merckx & Bidartondo 2008).

Extreme mycorrhizal specificity may limit the occurrence of plant species, particularly if the associated mycorrhizal fungus is rare. A particular mycorrhizal fungus may only occur in a particular vegetation type, or may even show specificity towards a particular green plant species. This limits the distribution of the fungus and that of the mycoheterotrophic plant that needs this particular fungus to survive. Such an extremely specific three-partite relationship occurs, for example, between the underground orchid *Rhizanthella gardneri*, *Melaleuca* shrubs from the *Melaleuca uncinata* complex, and their shared ectomycorrhizal *Ceratobasidium* fungus (Bougoure et al. 2009). The potential fungus-plant specificity thus may explain the rarity of some plant species (Swarts & Dixon 2009), mycoheterotrophic plants in particular (see for example Hazard et al. 2012).

To investigate whether *Thismia rodwayi* has a tendency to co-occur with particular plant species, we analysed the vegetation community associated with *Thismia* plants that were sampled across its distribution range in Tasmania. The findings reported herein formed part of a broader study of mycoheterotrophic plants from around the world being undertaken by VM (and various colleagues): further results will be progressively published on both *Thismia rodwayi* and other species. The present paper "sets the scene" for the sampling regime for subsequent research findings on *Thismia rodwayi* in particular.

METHODS

In October and November of 2012 the authors systematically searched for *Thismia rodwayi* in Tasmania. Both known sites, based on records included in DPIPWE's *Natural Values Atlas* and described in TSS (2007), and potential sites, which included sites in similar vegetation close to known sites and parts of the State predicted to support the species (Wapstra et al. 2005), were surveyed. Searches primarily focused on wet sclerophyll forest, which is known to be the preferred habitat of *Thismia rodwayi* (Roberts et al. 2003; Wapstra et al. 2005). Wet sclerophyll forest is a common vegetation type in Tasmania and generally consists of a tall eucalypt overstorey, a secondary layer of soft broad-leaved shrubs and small trees such as *Olearia argophylla* ('musk daisybush', Asteraceae), *Bedfordia salicina* ('tasmanian blanketleaf', Asteraceae) and *Pomaderris apetala* ('common dogwood', Rhamnaceae), and a dense understorey of ferns. *Thismia rodway*i can only be detected during the flowering period, when small orange

flowers protrude from the forest floor (Plate 1). However, these flowers generally remain covered by leaf litter and are thus difficult to find. Therefore searches consisted of carefully removing leaf litter at potential *Thismia* patches as described by Wapstra et al. (2005).

When a *Thismia* plant was found the wider area (up to c. 300 m radius) was subsequently scanned for more plants, growing at least a few metres from each other. The search was stopped after five such plants were found (because only five individuals were required for DNA/fungal studies). For each *Thismia* plant we recorded all vascular plants roughly growing within a 3 m radius. It is important to note that what we assign here as a *Thismia* 'plant' may refer to an individual or a cluster of multiple *Thismia rodwayi* flowers found within close proximity (e.g. within c. 10 cm). In the latter case subsequent dissection of the root system often revealed that the flowers emerged from unlinked root systems, and thus are part of different *Thismia rodwayi* individuals.

To compare the species diversity of green plants growing close to *Thismia* between the sites we calculated Jaccard distances using the R package 'vegan' (Oksanen et al. 2012). Jaccard distances (measurements of dissimilarity) were used to cluster sites based on their species similarity.

RESULTS & DISCUSSION

We recorded *Thismia rodwayi* from ten different sites, listed here as 'TAS1' to 'TAS10' (Table 1, Figure 1). No major range extensions were made. However, an additional site on each of the Forestier and Tasman peninsulas, and an additional site near each of the previously known Franklin, South Sister and Warners Sugarloaf locations, were recorded. In addition to the ten sites sampled as part of the present study, a single *Thismia* flower was observed near the Myrtle Gully track on the lower slopes of Mount Wellington (Plate 1) – this locality has not been included in vegetation analyses presented herein (single plant only).

Figure 1. Map of Tasmania showing the location of the sites where *Thismia rodwayi* was sampled as part of the present study

Potential sites where no *Thismia* was found included South Bruny Island, Maria Island, Tooms White Gum Forest Reserve, Mount Arthur, Mount Barrow, Holwell Gorge and Notley Gorge. The failure to find *Thismia* at these sites is no proof of its absence. In fact, the species has been previously observed at Mount Arthur (late 1960s) and Holwell Gorge (2009).

At sites where *Thismia rodwayi* was found it generally took less than 15 minutes to locate five plants that were several metres apart. When this was achieved the formal search was stopped to undertake sampling, but it is possible that at these sites many tens or even hundreds of plants were present, based on informal cursory searches. For example, over 50 flowers were detected in less than 1 hour of searching across approximately 1 ha at the

Table 1. Site information

Site name	Location	Coordinates	Elevation (m a.s.l.)	Number of *Thismia*[1]
TAS1	Sandspit River, Wielangta State Forest	-42° 42' 42.52"N 147° 50' 29.86"E	220	>5
TAS2	Hylands Road, Forestier Peninsula	-42° 56' 7.06"N 147° 54' 9.83E"	195	>5
TAS3	Edwards Road, west of Huon River	-43° 4' 21.20"N 146° 48' 33.29E"	90	>5
TAS4	Pirates Road, Tasman Peninsula	-43° 3' 3.00"N 147° 54' 26.66"E	340	>5
TAS5	Hills Road, Franklin	-43° 5' 15.64"N 146° 58' 34.09"E	410	1
TAS6	New Road, west of Franklin	-43° 4' 35.63"N 146° 56' 33.72"E	450	>5
TAS7	Styx Valley	-42° 45' 54.40"N 146° 47' 3.75"E	265	4
TAS8	South Sister, north of St Marys	-41° 32' 34.12"N 148° 10' 23.19"E	605	5
TAS9	Meander (Warners Sugarloaf North)	-41° 40' 27.42"N 146° 38' 37.01"E	435	>5
TAS10	Meander (Warners Sugarloaf South)	-41° 40' 31.94"N 146° 38' 27.29"E	435	>5

[1] this refers to a clump of *Thismia* plants, which may contain a single or many plants (see text)

Sandspit River site, and similarly high numbers were detected at the Warners Sugarloaf North site in less than 15 minutes of searching less than 0.5 ha. Only at TAS5 could we find just a single clump of *Thismia* (3 flowers) – this is one of the most anthropogenically disturbed sites ever recorded for the species with introduced *Rubus* sp. ('blackberry') and *Pinus radiata* ('radiata pine') present nearby. We also failed to detect a fifth plant at TAS7 (Styx), although potential habitat was widespread and seemingly ideal.

In total we recorded 31 different vascular plant species growing in close proximity to *Thismia* plants (Figure 2). *Pomaderris apetala*, *Coprosma quadrifida* ('native currant', Rubiaceae) and *Beyeria viscosa* ('pinkwood', Euphorbiaceae) were most commonly encountered. Nearly all *Thismia* plants recorded were growing in proximity of *Pomaderris apetala*. Only near two *Thismia* plants was *Pomaderris apetala* not present: the single plant found at TAS5, and a *Thismia* at TAS7. However, in both of these plots, *Coprosma quadrifida* was present, which is the second most common plant found near *Thismia* plants (Figure 2).

Interestingly, *Pomaderris apetala* was recently found to associate with ectomycorrhizal fungi (Tedersoo et al. 2008). However, it is not uncommon for

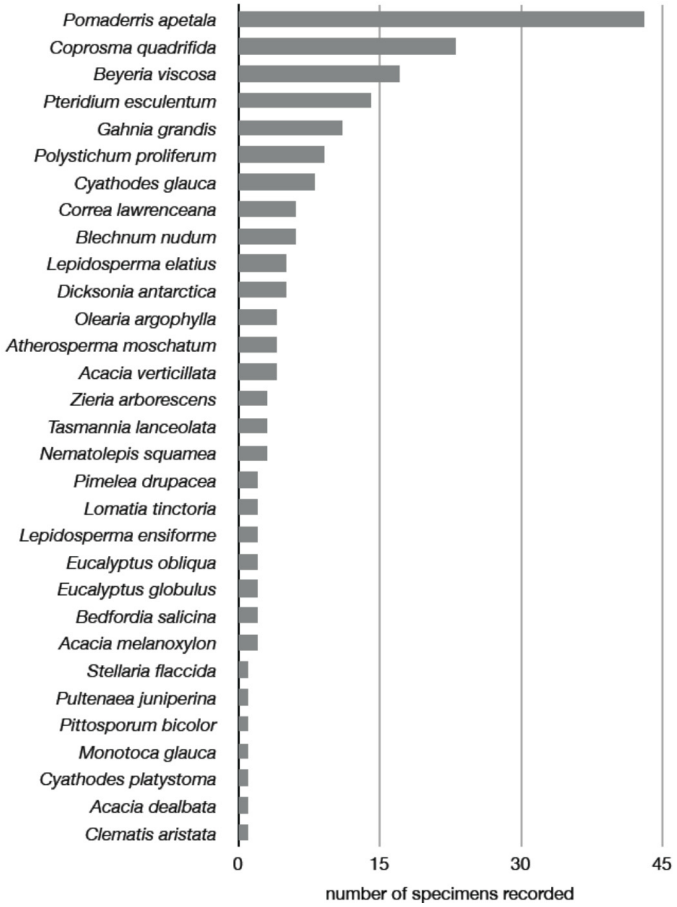

Figure 2. List of vascular plants species recorded growing in close proximity to *Thismia rodwayi* (bars represent the number of times each species was recorded growing near sampled individuals of *Thismia rodwayi*)

ectomycorrhizal plants to form arbuscular mycorrhizas as well (Smith & Read 2008). Thus this does not exclude the possibility that *Pomaderris apetala* is linked to the arbuscular mycorrhizal fungus *Thismia* is using to grow. Similarly, species of *Eucalyptus* and *Acacia* can form both ecto- and arbuscular mycorrhizas (Smith & Read 2008) and thus may be symbiotic with the *Glomus* fungus *Thismia* is using as well. All other species recorded at the *Thismia* sites are likely exclusively arbuscular mycorrhizal (Wang & Qiu 2006) and are thus also potential hosts for the arbuscular mycorrhizal fungus that is targeted by *Thismia*.

The differences in species diversity between the *Thismia* sites are fairly small, resulting in low Jaccard distances (Table 2). The sites at New Road near Franklin (TAS5&6) were found to differ most from

Table 2. Jaccard distance between each pair of sites (the diagonal shows the total number of recorded vascular plant species for each site)

	TAS1	TAS2	TAS3	TAS4	TAS5	TAS6	TAS7	TAS8	TAS9	TAS10
TAS1	**10**	0.636	0.667	0.769	0.769	0.750	0.714	0.750	0.733	0.733
TAS2		**5**	0.625	0.778	0.900	0.846	0.700	0.750	0.833	0.833
TAS3			**6**	0.800	0.800	0.933	0.727	0.769	0.846	0.846
TAS4				**6**	0.909	0.769	0.600	0.857	0.750	0.750
TAS5					**6**	0.857	0.833	0.857	0.846	0.846
TAS6						**10**	0.800	0.889	0.733	0.813
TAS7							**8**	0.800	0.692	0.692
TAS8								**10**	0.733	0.538
TAS9									**9**	0.500
TAS10										**9**

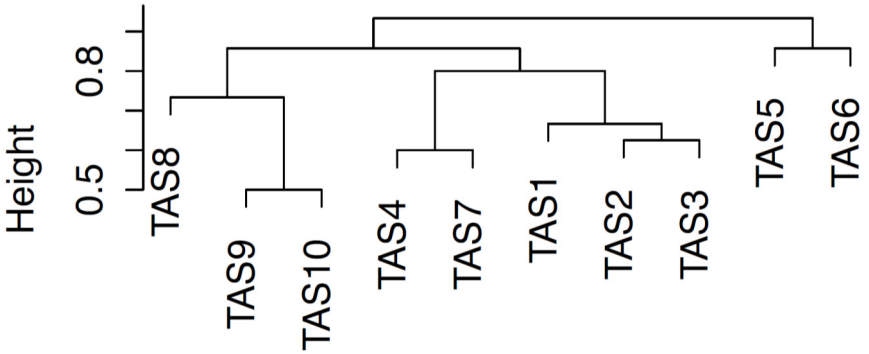

Figure 3. Hierarchical cluster plot of plant species similarity between the sites based on Jaccard distances

the other sites (Figure 3), mainly because these were the only sites where *Atherosperma moschatum* ('sassafras', Atherospermataceae), *Tasmannia lanceolata* ('native pepper', Winteraceae), and a few other species were recorded. The northern sites (TAS8 to TAS10) were also found to have very similar species diversity compared to the southern sites, mainly due to presence of *Blechnum nudum* ('fishbone waterfern', Blechnaceae), *Pimelea drupacea* ('cherry riceflower', Thymelaeaceae), *Polystichum proliferum* ('mother shieldfern', Dryopteridaceae) and the absence of *Beyeria viscosa*. These dissimilarities in diversity are thus mostly due to species that were only occasionally recorded (Figure 2), and it must be noted that the absence/presence of particular species at a site is relative: at some sites,

'absent' species were observed to occur in the wider area but not immediately close to the sampled individuals of *Thismia rodwayi*. This is particularly relevant for species of *Eucalyptus*. Thus, species diversity between *Thismia* sites is probably more similar than suggested by the Jaccard distances presented here.

Our observations indicate that *Thismia rodwayi* seems to have a strong preference for habitats that include *Coprosma quadrifida* and *Beyeria viscosa*, but particularly *Pomaderris apetala*, which is supported by previous studies (Roberts et al. 2003; Wapstra et al. 2005). However, none of these species have to be present for *Thismia* to occur. This suggests that *Thismia rodwayi* and its associated mycorrhizal fungus have a strong preference for a particular vegetation type, but not for specific plant species. This vegetation type, wet sclerophyll forest, is common in Tasmania and thus *Thismia rodwayi* may be quite common as well, as suggested by this and previous surveys (Roberts et al. 2003; Wapstra et al. 2005).

During our field study, genetic samples of the *Thismia* plants, their roots, and the roots of surrounding plants were sampled. In further research, these samples will be used to investigate the population genetics of the Tasmanian *Thismia* populations, patterns of mycorrhizal specificity, and the identity of the chlorophyllous species that are linked to the mycorrhizal network, with an emphasis on comparing the Tasmanian results to those obtained for sites sampled, or material obtained, from Victoria, New South Wales and New Zealand.

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