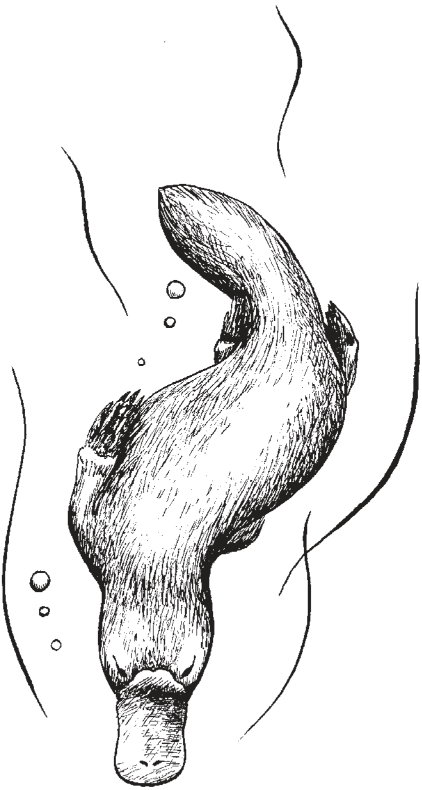
THE TASMANIAN NATURALIST

Number 140
2018



Published by the
Tasmanian Field Naturalists Club Inc.

VOLUME 140 (2018) **ISSN 0819-6826**

TFNC

The Tasmanian Naturalist

Contents

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Published annually by the Tasmanian Field Naturalists Club Inc., GPO Box 68, Hobart, Tasmania 7001

Printed by Monotone Art Printers using 100 gsm Digital Satin paper.

Distribution and ecology of the silky snail *Exquisitiropa agnewi* (Legrand, 1871)

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Abstract

The silky snail *Exquisitiropa agnewi* (Legrand, 1871) has only been reliably recorded from the eastern and southern slopes and summit area of kunanyi/ Mt Wellington near Hobart, Tasmania. All accurately localised records have been on dolerite substrates at altitudes above 550 metres, and evidence concerning possible historic presence at lower altitudes is inconclusive. This paper presents data from records since 1990, including a total of 34 specimens. The species lives in rocky habitats, frequently around the edges of dolerite talus fields. Although the species' known range is entirely reserved, and the species does not appear to be at a high risk of extinction, it can be locally affected by track construction and other local land clearances, and may be vulnerable to major fires.

Introduction

Tasmania has a very diverse fauna of small land snails in the family Charopidae. Bonham (2003) recognised 66 species; about two-thirds of these are undescribed. However, based on further field collections and subsequent unpublished studies by the author, the true number is likely to be at least twice as many. By comparison Victoria has a recorded fauna of 30 described and about 25 known undescribed species.

Much of the diversity of undescribed Tasmanian species appears to be concentrated in a small number of genera (especially *Bonhamaropa* Stanisic, 2018 and *Scelidoropa* Hyman and Stanisic, 2010, and also *Tasmathera* Bonham, 2018, *Gadaropa* Stanisic, 2018 and *Stenacapha* Smith and Kershaw, 1985). However, the fauna also includes several species, some of which are very localised, that appear to belong to monotypic genera.

One of the earliest of these localised species to be discovered was the silky snail, *Exquisitiropa agnewi* (Legrand, 1871), which has only ever been reliably recorded on the slopes of kunanyi/ Mt Wellington. It is one of the eight Tasmanian land snail species listed as threatened on the schedules of the Tasmanian Threatened Species Protection Act 1995. The natural history and conservation status of most of the other species has been documented in detail either in published papers or in substantial reports, but this has not yet been the case for *E. agnewi*. This paper provides all available information regarding the species' recorded distribution and ecology.

Identification

Adult shells of *E. agnewi* (Plates 1-4) range from 3.8 - 5.1 mm wide at 4.25-4.75 whorls. The spire is slightly elevated, and the umbilicus is wide (diameter/umbilicus width ratio (D/U) 2.9 - 3.5). The distinguishing character of the species is its teleoconch sculpture of extremely fine, densely packed radial ribs (several hundred on the body whorl).

Under SEM (Plate 5) these appear as sharp thin blades of somewhat variable height and spacing. Low spiral cords also occur on the teleoconch (adult sculpture) but their prominence varies between specimens and they are not always visible on the dorsal surface even at 60x magnification. This spiral sculpture is often most prominent around the umbilicus. The protoconch sculpture was described as "smooth, granular" by Smith and Kershaw (1979) but actually consists of about 30 densely packed, low irregular spiral cords, which in places can lose form (perhaps as a result of damage) (Plate 6). Low irregular radial ridges and troughs can also be present on the protoconch, but not as a defined sculptural feature.

Plate 1. Dead shell of *E. agnewi.* Lost World, 24 Jan 2001 Shell width: 4.0 mm.

Plate 2. Dead shell of *E. agnewi.*

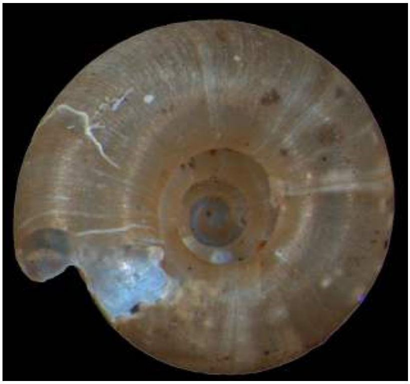

Plate 3. Dead shell of *E. agnewi.*

Plate 4. Live animal of *E. agnewi.* Milles Track, 8 Sep 2007 . Shell width: approx 4.5 mm

Photograph: Geoff Fenton.

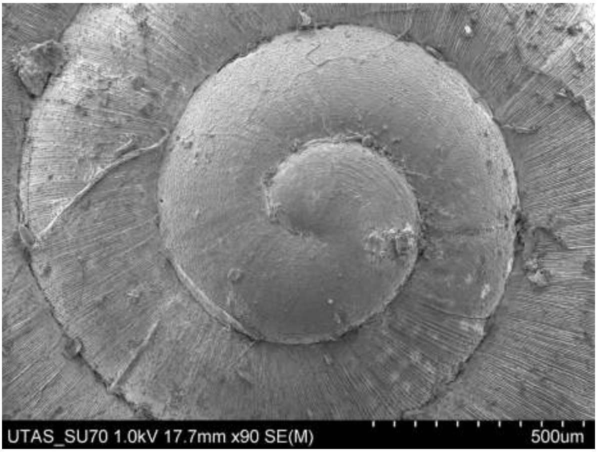

Plate 5. SEM of *E. agnewi* sculpture showing protoconch and early teleoconch. Lost World, 24 Jan 2001.

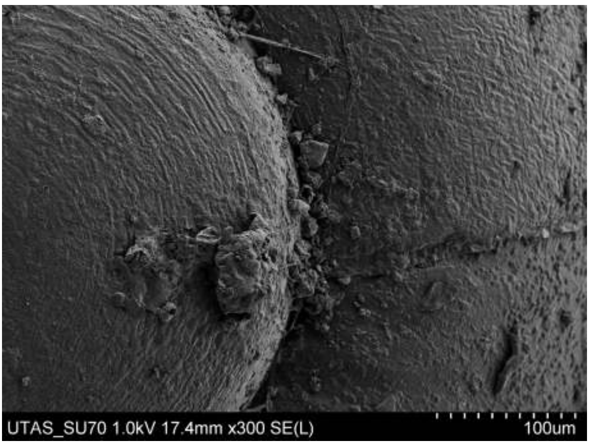

Plate 6. SEM of *E. agnewi* protoconch sculpture showing low irregular spiral cords and loss of form of cords on right. Lost World, 24 Jan 2001.

Shells are dark greyish yellow to pale brown, and are semi-translucent while the snail is alive. The living animal visible through the shell is colourful - reddish brown to coffee-brown with patches of black, white and yellow or orange. Live specimens when found in daytime are often dormant or sluggishly active and there are no photos of fully emerged live specimens crawling.

Dead shells become more opaque and whiten, often fading to a creamy-white colour. Dead shells are often found in very poor condition - crumpled, fragmentary or partly embedded in soil and plant roots.

The common name "silky snail" derives from Brazier's description of the shell (in Legrand (1871b) as "having a silky appearance". Stanisic *et al.* (2018) rendered this as "silky pinwheel snail" for consistency with the book's common names for other Charopidae.

History

Published descriptions and reallocations of *E. agnewi* and its synonyms are as follows:

Helix (Discus) agnewi (Legrand, 1871a) sp 27

Helix (Pitys) petterdi (Legrand, 1871b) sp 67

Helix (Pitys) peroni (Legrand, 1871b) footnote to sp 67 [*nomen nudum*]

Helix (   ) petterdi – Petterd, 1879 [no subgenus, *agnewi* incorrectly considered junior synonym]

Flammulina agnewi - Petterd and Hedley, 1909

Roblinella agnewi – Iredale, 1937

Exquisitiropa agnewi - Stanisic, 2018

Early material of *E. agnewi* was collected by William Franklin Petterd and described and illustrated as *Helix (Discus) agnewi* in Legrand (1871a), with type locality "Springs, Mt Wellington - *Petterd*". The name is conventionally credited to Legrand although the description was written by James Cox.

Legrand (1871b) also included the name *Helix (Pitys) petterdi* with the description and notes attributed to William Brazier. Brazier's notes stated "I have received this species very often named as *H. Legrandi* with other shells from Tasmania." The locality was given as "Huon Road, near Hobart Town - *Petterd*".

Petterd (1879) incorrectly gave *H. petterdi* as the senior name and noted the species as present at "Huon Road, and the lower portion of Mount Wellington, on the ground in damp places." Petterd also noted "Its most important character is the extreme fineness of the satiny-like striae" and stated "I have met with it only at the locality given, where it is anything but plentiful".

Bonham (2003) rejected *H. petterdi* as a synonym of *H. agnewi* without stating reasons, but this arose as a misinterpretation of antiquated measurement units. Brazier *in* Legrand (1871 - 2nd edition) stated that the species had dimensions of "*Diameter, maj. 2 lines ; min 1 3/4 ; alt. 1 line.*" Several versions of the unit "line" existed in European science at the time (see for example von Hayek 1973). For all those that were slightly larger than 2 mm, the measurements given by Brazier are consistent with the senior name.

The most likely explanation for the two names *agnewi* and *petterdi* is that Petterd sent material to both Cox and Brazier, who each described the species unaware of the other's efforts. Legrand then published both descriptions without realising they referred to the same thing.

Probably, Petterd collected the species intermittently in low numbers on his many collecting visits to kunanyi/Mt Wellington, and Brazier's "very often" was a slight exaggeration. In all, fourteen nineteenth-century specimens are held in museum collections (Bonham 2003). Most of these are in a single lot, but this does not necessarily show that Petterd discovered any hotspot for the species. Some remarkably large Petterd lots of various charopids occur in museum collections, and in the absence of specific dating on the original labels it is possible that he amalgamated samples from the same locality across multiple dates.

The species was placed in the genus *Roblinella* by Iredale (1937) and has long been known as *Roblinella agnewi*, but has also long been known to not even resemble that genus. Stanisic (2018) placed it in the new monotypic genus *Exquisitiropa*.

After Petterd's collections in the late 19th century, there were no reliable records until 1990. While there were a few claimed records in this time, those that were supported by specimens proved to be mis-idenfications (for instance of *Archiropa architectonica*). A record by May (1923) from Esperance is unsupported by known specimens

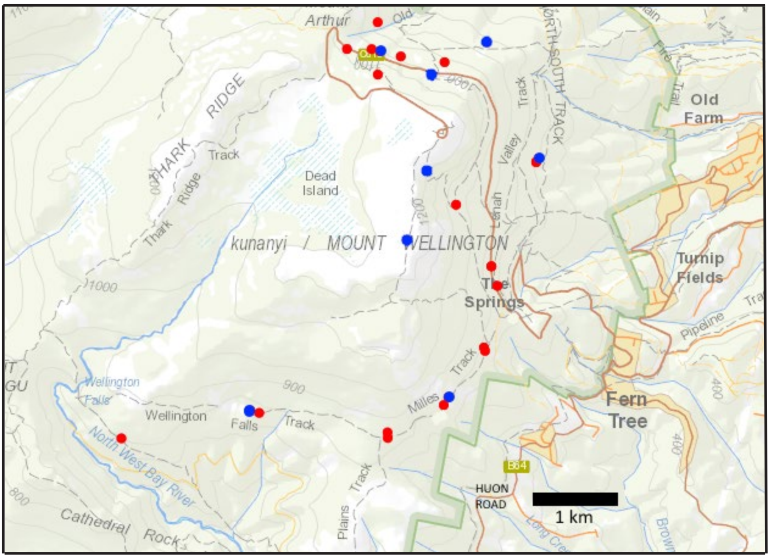

Figure 1: Map of records of silky snail *Exquisitiropa agnewi* since 1990. Blue circles: records including live specimens, red circles: dead shells only. Source map from Natural Values Atlas, modified to remove mis-located duplicates.

and is assumed to have been one of the superficially similar species. A copy of Petterd (1879) scanned by the Biodiversity Heritage Library and available online has handwritten notes, possibly by Petterd himself, referring to a claimed record from the Upper Nile River near Ben Lomond. This is likely to have been an undescribed species allied to *"Thryasona" marchianae* and collected in large numbers by the author and Craig Reid on Fishers Tier in 2004.

Modern records

A full list of the modern records is given in Appendix 1, and records are mapped in Figure 1. From 1990 onwards, there have been 24 records of the species, including a total of eight live and 26 dead specimens. Eight of the records resulted from commissioned surveys for the species, mostly during environmental impact assessments for walking or biking track proposals. The remainder were voluntary searches. Of the latter, in most cases *E. agnewi* was either the target species or one of a number of target species, but there were also some general land snail searches on which *E. agnewi* was not expected to be found.

Despite this degree of searching concentrated on one species, *E. agnewi* has accounted for only about 3% of native land snail specimen records within its range (author's records). Most records have been of single specimens (usually dead), with one record of seven specimens within about 20 metres of each other. Five of those seven were within 20 cm of each other in dry litter under one small rock overhang, but these included four dead shells in various states of decay. This cluster might therefore have been partly a result of preservation conditions rather than unusual local abundance.

The most notable aspect of the modern records is that none of them have come from closed wet forest, despite a large amount of searching in closed wet forests within and around the species' known range. Habitats where the snail has been found include sparsely vegetated dolerite boulder fields, rocky subalpine woodlands and wet scrub (Plate 8), and rocky areas in alpine scrub and heathland (Plate 9).

Plate 7. *E. agnewi* habitat in damp drainage line on dolerite blockfield, Hunters Track (720 m), 2 June 2017.

Further, the species has never yet been recorded at surface level in the treeless interior of the largest boulder fields (there has been no known searching for land snails in cavities well below surface level). It tends to occur in smaller blockfields and scree slopes, or in the semi-open sparsely wooded sections of larger boulder fields. Often there is some shrub cover of *Bedfordia salicina* (Labill.) DC., *Olearia viscosa* (Labill.) Benth. and other damp to wet forest shrubs. One specimen was found in a narrow line of wet scrub on a drainage line through a larger area of sparsely-wooded boulder field (Plate 7).

Most *E. agnewi* specimens found have been under rocks or in litter in small rock overhangs. The few found in leaf litter or moss have been associated with rocks.

Plate 8. *E. agnewi* habitat in subalpine woodland and scrub, below Pinnacle Road between Big Bend and Chalet (1035 m), 3 June 2017.

Plate 9. *E. agnewi* habitat in subalpine woodland and scrub, below Pinnacle Road between Big Bend and Chalet (1035 m), 3 June 2017.

The species is more likely to be found in damp areas with a well-developed moss or lichen cover on the dolerite rocks.

E. agnewi appears to occur more reliably in some areas than others. All four serious searches on Milles Track have been successful, but there were several failed searches along the seemingly similar Organ Pipes Track before one dead shell was finally found there. It has never been recorded in the Neika area, including searches following the Pipeline Track west and then north from Neika for up to 4 km. This is despite at least 15 hours of searching in this area, most of it targeted at this species. It has, however, been found once near Wellington Falls.

There has been very little searching west of the species' known range. A one-day survey covering Mt Connection and Collins Bonnet was unsuccessful and there have been two failed searches around the summit of Collins Cap. However, there is a very large amount of unsearched habitat in the western Wellington Range. There are also some habitat types that have not been searched within the species' known range, such as the cliff faces of the Organ Pipes and also cavities deep below surface level within boulder fields.

Most of the modern sites have no known fires since the major 1967 bushfire. However, in 2000 a fire burnt areas around Hunters Track and below Pinnacle Road near the Chalet. During a survey in 2017, the species was found (including one live specimen) in some areas that had been affected by this fire.

Discussion

The species' extent of occurrence is at least 14 km^2, based on the minimum convex polygon of the modern records. However, the actual extent of occurrence is likely to be at least slightly larger given the lack of surveying in some areas, and could be much larger. The species' area of occupancy within its proven extent of occurrence is difficult to estimate. Only relatively small areas within the polygon appear clearly unsuitable based on aerial photography (including some small areas of closed wet forest and also the swamps surrounding Dead Island) but occupancy appears to be patchy on a finer scale.

Assuming that Petterd's early "Huon Road" locality is genuine, the lack of recent records from the Neika area presents a puzzle. The presence or absence of the species in this area is significant because the dolerite near Neika is separated from the dolerite that includes the Organ Pipes by an area of Triassic sandstone, from which the species has not been recorded. The shortest distance between Huon Road and a confirmed record is 1.4 km and the shortest distance to apparently suitable habitat that is connected to areas with proven records is 750 m. Possible explanations for the failure to so far replicate the "Huon Road" record include:

- Petterd's locality description may have been inexact. Some area easily accessible from Huon Road but somewhat further up the mountain slopes may have been considered part of the "Huon Road" locality. This said, in discussing another species Petterd does distinguish a gully between Huon Road and the Springs from either locality.

- The species may have been present closer to Huon Road than recent records but have been eradicated by subsequent fires or vegetation change.

- The species may still be present in the broader "Huon Road" area but may be more localised or scarce than in Petterd's time.

- The species may have been only locally present at a site that has yet to be rediscovered.

Conservation status and management

E. agnewi is currently listed as Rare on the schedules of the Tasmanian *Threatened Species Protection Act* 1995. It is also listed as Vulnerable (category D2) on the IUCN Red List, but the listing has not been reviewed since 2000.

The known range of *E. agnewi* is entirely reserved within Wellington Park. The species was considered to be at long-term risk from climate change because it was believed to occupy a narrow altitude range (Bonham 2000) but further finds have showed the species to have an altitude range of at least 675 metres. There is no reliable evidence that the species has suffered any historic population decline (although this depends on the perhaps unsolvable mystery of Petterd's Huon Road record).

The species has not become any more difficult to find since the first modern record in 1990.

Populations of the snail may be affected by walking track and, increasingly, mountain bike track, constructions. Proposed tracks often result in surveys being conducted. Where the species is found, tracks may be rerouted to avoid impacts on apparently localised populations, or construction techniques avoiding the use of gravel fills may be preferred to maintain habitat for the species. Land clearance within the species' habitat (for instance the currently proposed building of cable car infrastructure and a tower near the summit) is likely to eradicate the species from areas cleared or built over, but will not necessarily affect it beyond that.

Predatory *Oxychilus* snails are a major threat to charopids in the kunanyi/Mt Wellington foothills, but there are no confirmed records of the genus within the range of *E. agnewi*. Exotic slugs including *Arion intermedius* Normand 1852, *Deroceras reticulatum* (Muller 1774) and *Lehmannia nyctelia* (Bourguignat 1861) are present in parts of the species' range and were very common around Hunters Track following the 2000 fire, but there is no evidence that they have affected *E. agnewi*.

The species' fire sensitivity is unclear, but it should be assumed on a precautionary basis that it is sensitive to major fires. Fire-sensitivity could explain why at lower altitudes (where such fires as do occur in closed forests would tend to be major high-temperature fires) it has so far been found mostly in boulder fields and screes, while at higher altitudes it occurs more generally in rocky areas. Also, if the species were particularly well-adapted to boulder field environments it might occur at surface level in the treeless interiors of the larger boulder fields, but this, so far, does not appear to be the case. However, there may be other explanations for these apparent patterns, which in any case are based on only a small number of records.

Overall, while *E. agnewi* is apparently localised and uncommon and has a degree of specialisation in its habitat requirements, it does not appear to be at a high level of extinction risk. Its retention on the state list is appropriate on current evidence but this might cease to be the case if it is found to be much more widespread through the Wellington Range.

Acknowledgements

My thanks to all who have provided transport on trips on which this species was recorded. Karsten Goemann (UTAS) provided assistance with SEM imaging.

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Appendix 1. Records of silky snail *Exquisitiropa agnewi* since 1990. All records by K. Bonham, except 26 Oct 2010 by K. Bonham and C. Hawkins.

EASTING	NORTHING	LOCATION	DATE	LIVE	DEAD	ALT (m)	Microhabitat
518612	5251982	Lost World Track	24/1/ 2001	0	2	900	Rock (1), grassy litter in rock overhang (1)
519228	5251384	Chalet	10/3/1990	1	0	1010	Litter of Centropappus brunonis
518612	5251382	Panorama Track	4/1/2004	0	1	1140	Rock
520531	5250399	North-South track	1/11/2005	1	6	570	Rocks (2) and dry litter in rock overhang (5)
520526	5250353	North-South track	26/10/2010	0	1	570	Rock
519172	5250279	Zig Zag Track	8 /12/2010	1	0	1220	Small pile of rocks
519508	5249889	Organ Pipes Track	14/10/2015	0	1	950	Rock
519912	5249182	Lenah Valley Track	9/7/2000	0	1	730	Rock
519980	5248957	Lenah Valley Track	14/3/2002	0	2	715	Small rocks in stack around large boulder
519823	5248252	Milles Track	16/12/1992	0	1	770	Rock
519836	5248214	Milles Track	17/10/1998	0	2	760	Small rocks
519412	5247683	Milles Track	4/12/1993	0	1	800	Litter of Pomaderris apetala
519359	5247594	Milles Track	8/9/2007	1	1	800	Rocks
517137	5247540	Milles Track	8/9/2007	0	1	770	Rock
517238	5247510	Milles Track	8/9/2007	1	0	775	Litter between rocks
515653	5247223	Wellington Falls track	2/1/2008	0	1	800	Rock
518715	5247220	Milles Track	16/12/1992	0	1	850	Not recorded
519865	5251752	Near Hunters Track	2/6/2017	1	0	720	Litter on rock
518258	5251676	Near Big Bend	19/12/2016	0	1	1080	Small rocks
518541	5251674	Between Chalet and Big Bend	3/6/2017	0	1	1035	Rock
518635	5251648	Between Chalet and Big Bend	3/6/ 2017	1	0	1025	Rock
518877	5251589	Between Chalet and Big Bend	3/6/ 2017	0	1	980	Rock
519380	5251522	Near Hunters Track	2/6/ 2017	0	1	915	Rock
518941	5249486	South Wellington	15/10/2014	1	0	1245	Moss around rocks

Paradise Plains – ecological succession in full swing

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Introduction

The Paradise Plains Reserve, which is south of Ringarooma and adjoins Mathinna Plain in north-eastern Tasmania, covers an area of about 440 ha. A sub-alpine environment, it is about 900 metres above sea level. This reserve has not only been a personal source of fascination, but has also attracted attention from many scientists studying the effects of Aboriginal burning and the recent contraction of grassland areas since burning ceased. The area is a mosaic of vegetation communities, including eucalypt forest, rainforest, scrub, *Gymnoschoenus* sedgelands, grassland and *Sphagnum* peatlands.

Sphagnum peatland at Paradise Plains

Ten years ago, along with many other members of the North-Eastern Tasmanian Field Naturalists Club, I stood on the edge of a most amazing piece of *Sphagnum* peatland at Paradise Plains. We looked in through the trees and saw the ground covered with rounded hummocks that resembled a pale green and orange-green doona. In the hollows around the edges of the mounds were marked trails made by marsupials. There was a very strict protocol about our movements—we had to step only in these trails around the edge of the peatland, so we did not leave our mark on this extremely fragile environment.

What makes this site so unusual is that over the top of these rolling pillows of pure *Sphagnum* moss is a forest with three storeys. The under-storey consists of celery top pine, *Phyllocladus asplenifolius*, some 3–6 metres tall. The next storey consists of woolly tea trees, *Leptospermum lanigerum,* up to 20 metres tall. Finally, there is the occasional *Nothofagus cunninghamii,* which provides the very top canopy.

This was a unique experience for every member of our group, because there is so little of this type of *Sphagnum* peatland remaining undisturbed in Tasmania. This patch of *Sphagnum* bog is protected because of its uniqueness as a site of floral significance. It is also naturally sheltered in the extreme. Indeed, despite my best efforts, recent attempts to find this patch to take photographs for this article failed.

Plate 1. This is the closest the author came to finding the pure Celery top – *Sphagnum* peatlands described above. This Sphagnum community consists of woolly teatree – native pepper – gahnia.

Bog mosses in Tasmania

The bog mosses, or mires as they are sometimes referred to, make up such a small part of the Tasmanian landscape that they are ecologically unique. In total, they cover barely 1300 ha, which is only 0.0015% of the area of Tasmania.

Most of the peatland community types are poorly preserved. In times past, sites were destroyed because of lack of knowledge of their importance, with many being decimated by grazing, and other areas being harvested for the horticultural industry. Typical clearing activities—such as happened at one site in the north-east near the Ralph Falls car park—disturb and degrade these sensitive peatlands, where even alterations to drainage and sediment flow can lead to destruction.

Thirteen *Sphagnum* community types are identified and described by Harris and Kitchener (2005) most occurring at altitudes in the range 600–1300 m. *Sphagnum* community types include heath and sedge peatlands, montane and snow-patch moss beds, and habitats including blackwood, sassafras, melaleuca and/or celery top pine. The one I've just referred to at Paradise Plains is known as Celery Top Pine – *Sphagnum* Peatland. It is number 7 in the list of 13 and described by Harris and Kitchener as:

> *Dominated by celery top pine with cheese-berry, bottlebrush or native pepper common. Found in NE.............*
> *..................Celery top pine–Sphagnum peatlands (Group 7)*

Peatlands in Tasmania

Sphagnum is strongly associated with waterlogged sites, high rainfall and low evaporation, and with peat formation. Though quoting rainfalls can be a tricky business in these days of climate change, it would be safe to say the Paradise Plains area receives somewhere in the range 1000–2000 mm of precipitation per annum. The estimated mean annual temperature at Tasmanian *Sphagnum* peatland sites is between 5.7ºC and 8.6 ºC. At such low temperatures, low evaporation rates are a certainty.

Peat, which can be several metres deep, comprises a layer of dead material from bog plants. Peat often contains important palaeoecological information such as vegetational sequences, climatic conditions and fire histories. It has been concluded after the measurement of many pillows of *Sphagnum* that the size of the pillows is closely related to the depth of the peat. The rate of peat formation is variable, but peat typically forms at a rate of approximately 2 centimetres per century. The deepest peats in Tasmania, some of which are in excess of 3 m deep, indicate considerable antiquity. For example, radiocarbon dating of peat from a mire at the Walls of Jerusalem suggest that peat accumulation began there some 8000 years ago. (Whinam 1990)

Some *Sphagnum* mires have formed in places where drainage is slowed or blocked. The constant exposure to moisture, moderate aeration and minimal nutrient input seem necessary to their formation. It's obvious that this is the case at Paradise Plains. Because of the highly acidic nature of *Sphagnum* - the pH of Tasmanian *Sphagnum* peatlands is

Plate 2. A sphagnum mound measuring about 60 cm in height at Blue Tier.

in the range 3.5 - 4.5 and because the high water-table promotes low oxygen levels, the fungi and bacteria which would otherwise decompose the dead plant material are not present, allowing the peat to build up. Coincidentally, many of the sites where mires have formed in Tasmania were in formerly glaciated areas such as the Central Highlands. On the Blue Tier, there are excellent examples of tussock-*Sphagnum*-mire communities which developed along the streams after the burning of the rainforest for tin mining.

Sphagnum species in Tasmania

All *Sphagnum* peatlands contain one or more species of *Sphagnum* moss. It seems that particular species or suites of species are associated with a particular nutrient status and acidity. There are five true *Sphagnum* species (i.e. mosses belonging to the genus *Sphagnum*) in Tasmania, plus a distantly related species that was formerly considered to belong to the *Sphagnum* genus *(Ambuchanania leucobryoides*, formerly *Sphagnum leucobryoides*). The five Tasmanian species are: *Sphagnum fuscovinosum, S. cristatum, S. australe, S. falcatulum and S. novo-zelandicum. (Flora Technical Note No. 6)*

Sphagnum cristatum is the most common species in Tasmania. This moss is distinctive due to the spongy texture of the moss tendrils. The plant consists of a main stem that is sometimes quite hard, with short clusters of branches arranged along its length and forming a mop-like head. When these stems are growing densely together in a hummock, only the mop-tops are visible. The growth rate of *Sphagnum cristatum* varies in Tasmania depending on altitude and aspect (especially shelter from the weather). At a site at Mt. Field (altitude 950 m) the growth rate was measured at 0.4 cm/year, whereas at a sheltered site in Central Tasmania (altitude 530 m), the rate was 4.2 cm/year. (Whinam 1990)

As to whether or not grazing by marsupials occurs, huge numbers of droppings are seen on the tracks around the edges and sometimes on the pillows, but no evidence of actual grazing has been detected. However, plant species growing in the mounds are often grazed, thus reducing the competition between these species and *Sphagnum* for light.

Sphagnum has an extremely high water-holding capacity—it can contain up to 15 times its weight in water, making it a useful commodity in the nursery industry. It is favoured by orchid growers and is often used to wrap rose and fruit tree rootstock for transportation. Harvesting occurs on a very small scale and is closely monitored. Very little peat mining occurs in Tasmania.

Other species on the plain

In another site at the edge of the plain, a stand of *Eucalyptus delegatensis* includes some impressive trees, one of which is about 400 years old, with an area of rainforest adjacent.

The open area nearby includes more *Sphagnum* moss, referred to as *tussock sphagnum* which is growing along the banks of Newitts Creek, from which it receives its moisture. Less than a metre wide and only a few centimetres deep in summer, this creek winds its way tortuously across the plains until it eventually connects with the South Esk River. Some of the bolster *Sphagnum* mounds on its bank are being overgrown by rainforest scrub species such as *Richea scoparia*. Away from the creek are the remains of the *Poa* grasslands.

Plate 3. Sphagnum mounds alongside the creek being overgrown by rainforest scrub species.

Plate 4. A stand of ancient *Eucalyptus delegatensis,* with a sharp transition to rainforest seen alongside.

Plate 5. Sphagnum lining the banks of Newitts Creek, Paradise Plains. The remains of the *Poa* grasslands can be seen in the background.

Effects of human activity

The reason this open area is of interest is that it resulted from human activity. Bowman *et al*. (2012) describe this area as just one part of a 'matrix of vegetation which has long puzzled ecologists'.

Fragments of charred myrtle and celery top pine found on this part of Paradise Plains indicate that rainforest originally covered this area. It has been confirmed that in areas with altitude above about 800 m, rainforest is replaced with grassland when burned, rather than prickly shrubs and bracken. Archaeological studies have shown that areas such as these were used by Aborigines as summer hunting grounds. The firing was used to promote growth of fresh vegetation, thereby attracting game that could be hunted (Ellis 1984).

Although these fires would have been controlled so as not to destroy the environment the Aboriginals depended on for survival, it is clear that extensive fires did occur by accident during hot dry years. Evidence for this is present in the form of fire scars of various ages. Following their creation, these plains were a passage-way for members of the Ben Lomond tribe as they travelled to meet the more easterly tribes to barter and exchange goods. Indications are that the firing was continuous for 4000 years or more, and a sharp boundary was kept between the grasslands and the rainforest and eucalypt forest.

Effects of cessation of firing

Since the firing ceased, following displacement of the Aboriginals by European settlers, there has been a steady expansion of forests into the treeless parts of the plains. Bowman *et al*. (2012) compared three sites in Tasmania—one in the quartzite dominated landscapes of South West Tasmania, one on the basalt plateau at Surrey Hills in the North west,

Plate 6. Remaining Poa grassland and sedgelands with *Leptospermum lanigerum* establishing as a result of the cessation of Aboriginal burning. Paradise Plains.

and a third site at Paradise Plains, where the substrate is granite. The rates of expansion of forest and subsequent loss of *Poa* grasslands since the cessation of Aboriginal fire management has been greatest here on the granitic substrates of Paradise Plains. This has happened by a process of margin increase, mostly by *Leptospermum lanigerum*. It seems that the leptospermums act as pioneers to facilitate the establishment of eucalypt and rainforest seedlings. The re-growth of rainforest species happens in the core forest behind the *Leptospermum* expansion.

Methods of study to gather this information have included examination of fossil pollen and use of Tauber pollen traps, tree ring counts and carbon dating. These have indicated a rapid growth of rainforest understorey, and at the same time an equally dramatic decline of the eucalypt over-storey. Bowman *et al.* (2012) analysed historical aerial photography sequences to chart the changes in grassland and sedgeland areas. As a result they were able to calculate the proportion of *Poa* grasslands and *Gymnoschoenus* sedgelands that changed to forest in the time between photos.

All around the *Sphagnum* bogs of Paradise Plains the rainforest is beginning to recolonise and looks set to complete the process begun more than 5000 years ago. In the celery top - *Sphagnum* forest, it is estimated that over a period of many centuries, the celery tops will naturally displace the tea-trees, and in turn will be displaced by myrtles as the dominant climax species. Out on the plain, the rainforest will eventually take over the grasslands and grow up to the edges of the creek.

So, this isn't the final chapter in this story; an ecological succession is in full swing in this region, albeit in slow motion.

Acknowledgements

I would like to acknowledge David Bowman *et al.*, Robert Ellis, Jennifer Whinam and Ian Thomas, whose writings have informed and fuelled my enthusiasm for this investigation.

In particular, Jennie Whinam, a specialist in *Sphagnum* ecology, has been instrumental in increasing the knowledge and improving the preservation status of peatlands in Tasmania since the late 1980s.

I also acknowledge the assistance I received from Chris Forbes-Ewan on formatting and style issues relating to this article.

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Novel host associations for the fungus beetles *Cnecosa insueta* and *Thallis vinula* (Coleoptera: Erotylidae: Erotylinae) in Tasmania

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Abstract

Novel basidiocarp hosts in the fungal families Fomitopsidaceae and Polyporaceae are documented for two Tasmanian species of fungus beetle (Erotylidae). Large aggregations of *Cnecosa insueta* (Crotch) were found feeding on *Neolentiporus maculatissimus* (Lloyd) Rajchenb and *Thallis vinula* (Erichson) on *Ryvardenia campyla* (Berk.) Rajchenb. Field observations of both beetles and hosts are documented.

INTRODUCTION

More than 1500 species of the predominately tropical beetle family Erotylidae (fungus beetles) are known globally, with about 120 recorded from Australia (Lawrence & Slipinski 2013). Australian Erotylidae are mycophagous as larvae and adults, feeding within the fruiting bodies of both Agaricales and Aphyllophorales (mushrooms and bracket fungi; Hawkeswood 1986, 2003; Hawkeswood *et al.* 1997; Lawrence & Britton 1991; Lawrence & Slipinski 2013; Fearn 2017; Webb & Simpson 1991). Adult beetles range from 4-25 mm in length and are typically boldly coloured with red, orange and yellowish markings on a predominately black background. The biology and habits of most Australian species are poorly documented (Hawkeswood 2003), including the seven species recorded from Tasmania: *Cnecosa insueta* (Crotch), *Episcaphula australis* (Boisduval), *Thallis compta* (Erichson), *T. dentipes* (Blackburn), *T. femoralis* (Blackburn), *T. janthina* (Erichson) and *T. vinula* (Erichson).

Hawkeswood *et al.* (1997) provided a

review of host records for Australian Erotylidae including five of the Tasmanian species: *Cnecosa insueta* from *Hapalopilus* sp. and *Laetiporus portentosus* (Berk.) Rajchenb (as *Piptoporus portentosus*), *Episcaphula australis* from *Trametes coccinea* (Fr.) Hai J. Li & S. H. He (as *Pycnoporus coccineus*), *Leiotrametes lactinea* (Berk.) Welti & Courtec (as *Trametes lactinea*) as well as two unidentified *Polyporus* spp., *Thallis compta* from *Polyporus* sp., *Thallis janthina* from *P. portentosus* and *Thallis vinula* from *P. portentosus* and *Polyporus squamosus* (Huds.) Fr. However, the reference to *Polyporus squamosus* is most likely in error as it is a Northern Hemisphere taxon. It is possible that the very similar looking and native *Neolentiporus maculatissimus* was the polypore host in this instance. More recently, Bashford (2014) reared Tasmanian specimens of *T. femoralis* from *Ryvardenia campyla* and *Fuscoporia wahlbergii* (Fr.) D. A. Reid (as *Phellinus wahlbergii*) as well as *T. janthina* and *T. vinula* from *Ryvardenia cretacea* (Lloyd) Rajchenb, and Fearn (2017) reared *T. compta* from *Omphalotus nidiformis* (Berk.) O.K.Mill.

Cnecosa insueta is an aposematically coloured black and orange erotylid beetle ranging from 9-13 mm in length (Plate 1) occurring in eastern Australia (Atlas of Living Australia (ALA) 2018a; Hawkeswood *et al.* 1997) as well as northern and north eastern Tasmania. The low number of registered Tasmanian specimens in public collections (9) most likely reflects lack of collecting effort rather than an accurate reflection of the range or abundance of *C. insueta*. *Thallis vinula* (Plate 2) is common and widespread through coastal New South Wales and Victoria, south east South Australia and throughout Tasmania (ALA, 2018b).

Plate 1. Adult *Cnecosa insueta* (12 mm total length) on host *Neolentiporus maculatissimus* at Black River Siding, Wiltshire.

Photo: D. Maynard.

Field observations

Cnecosa insueta (Crotch 1876)

On 06/01/2018 the first author was conducting entomological field work in a highly degraded site that was once a rail siding on the Western Line at Black River, north west Tasmania (GDA94 356887mE 5477062mN). This 5 ha site is bounded by the Bass Highway to the north and Black River to the south. The site was surrounded by sapling regrowth of a range of native trees and shrubs common in the adjacent habitat. The disused rail line runs along the site's northern boundary, and a retaining wall constructed of large-diameter, untreated eucalypt trunks runs adjacent to this line, supporting the raised ex-industrial site. These eucalypt trunks were decomposing, and a large fruiting body (about 300 mm diameter) of *Neolentiporus maculatissimus* was growing on one of them (Plate 3). A large number of *C. insueta* (Plate 1), were living between the layers of the fruiting body, well back from the outer margin, near the moister, and presumably cooler, centre.

Forty-five specimens of *C. insueta* were collected and lodged in the entomological collection of the Queen Victoria Museum and Art Gallery (QVMAG)(QVM.2018.12.0136-0180).

Plate 2. Adult *Thallis vinula* from Trowutta Caves State Reserve, North West Tasmania. Photo: D. Maynard.

Thallis vinula (Erichson 1842)

On 27/01/2018 the first and second authors were conducting entomological field work in Trowutta Caves State Reserve, north west Tasmania (GDA94 340947mE 5451483mN) when a number of large fruiting bodies of *Ryvardenia campyla* were observed on a very large, decomposing *Nothofagus cunninghamii* log on the forest floor (Plate 4). The largest lobes were more than 300 mm across and the narrow spaces between lobe layers contained a range of small Coleoptera including *T. vinula*. Sixteen specimens were collected and lodged in the QVMAG entomological collection (QVM.2018.12.0490-0500 and 0746-0750); several portions of fruiting body were subsequently lodged with the State Herbarium after identification by the third author (HO 593125).

Polypore hosts

The two polypore species are not particularly rare in Tasmania (Gates & Ratkowsky, 2016). *Neolentiporus maculatissimus* appears to prefer an open habitat on substrates such as old bits of timber, e.g. railway sleepers, left lying around or logs alongside a track in wet sclerophyll forests. *Ryvardenia campyla* prefers a wetter habitat and is commonly found on logs of *Nothofagus cunninghamii* in rainforests, although not exclusively.

Records in the Atlas of Living Australia (ALA) show both species are widespread within Australia; *R. campyla* has been recorded in Tasmania, Victoria, New South Wales, Queensland and Western Australia (ALA, 2018c) and *N. maculatissimus* has been recorded from Tasmania, Victoria and New South Wales (ALA, 2018d). The two species also occur in New Zealand and the southern regions of Chile and Argentina (Patagonia), which may reflect our Gonwandan connections.

Both species cause a brown rot and have soft annual fruiting bodies, unlike the harder persisting brackets of polypores like *Fomes hemitephrus* (Berk.) Cooke and *Ganoderma australe* (Fr.) Pat., which are also common in Tasmanian forests and can last for many years.

Discussion

Given the concentration of adult Erotylidae on the fruiting bodies as described above, the authors suggest these observations and collections represent feeding and reproductive activities of both *C. insueta* and *T. vinula* on host species. The observations are consistent for both these species as well as other Australian Erotylidae on host fungi as described by Hawkeswood, (1986, 2003); Hawkeswood *et al.* (1997), Bashford (2014) and Fearn, (2017) where adults appear to be strongly attracted to the smell of recently emerged fruiting bodies for the purposes of feeding and mating.

Little is known about Tasmanian mycophagous insects and a great deal could be learned by collecting fruiting bodies and rearing out the associated insect species. We suggest following the successful guidelines of Bashford (2014) and Schigel (2008) for rearing fungivorous insects. It is important to lodge voucher specimens of both reared species and fungal hosts with recognised institutions (museums and herbariums) with as much associated information as possible.

Plate 3. Large fruiting body (c 300 mm diameter) of *Neolentiporus maculatissimus* growing from decomposing eucalypt log at Wiltshire, north west Tasmania. Photograph: D. Maynard.

Plate 4. Large fruiting bodies (largest lobes >300 mm diameter) of *Ryvardenia campyla* on decomposing *Nothofagus cunninghamii* log. Trowutta Caves State Reserve, North West Tasmania. Photograph: D. Maynard.

Acknowledgements

Special thanks to Chris Reid (Australian Museum) and Simon Grove (Tasmanian Museum and Art Gallery) for assistance with beetle identifications. Beetle specimens were collected under Department of Primary Industries, Parks, Water and Environment (DPIPWE) Permit Authority FA 1614.

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Exploitation of sapling *Banksia marginata* by *Cyrioides imperialis* (Fabricius 1801) (Coleoptera: Buprestidae) in Tasmania

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The impressive *Cyrioides imperialis* (Fabricius 1801), is a widespread jewel beetle species, occurring across the Australian east coastal region, including Tasmania. The common name, *Banksia* borer, implies it is host specific to this genus of Australian plants; species known to be visited by the beetle include *B. marginata*, *B. serrata*, *B. integrifolia* and *B. spinulosa*; Tepper (1887) reported the adults and larvae inhabiting *B. marginata* with adult activity around Christmas. More recently, records of the species utilizing *Leptospermum polygalifolium*, (= *L. flavescens*) (Williams 1977) and perhaps other *Leptospermum* spp. (Williams & Williams 1983) were reported in a review of larval host plants for the species by Hawkeswood (2007). In that same paper, *B. marginata*, *B. integrifolia* and *B. serrata* are listed as larval hosts, and Hawkeswood comments that the beetle is becoming less common, speculating this is possibly due to bushfire. The most detailed account of *C. imperialis* [as *Cyria*] includes illustrations of adult, larva and larval bore, provided by the Victorian Government entomologist French, who portrayed the species as a destructive pest and suggested it may destroy all the *Banksia* forests if not kept in check (French 1900). Here we present new information on the utilization of juvenile *B. marginata* as an important larval host plant.

A frequently encountered species, particularly along the Australian eastern sea-board, *C. imperialis* was once considered to be coastal in Tasmania, extending from Bruny Island, north along the east coast, and west along the north coast to Burnie (Cowie 2001). In 2014 the authors located a population of the species inland near Conara and another near Cleveland in 2015. Natural Values Database and Atlas of Living Australia searches revealed a previous record from the Epping Forest region in 2009 by S. Fearn. A further, most intriguing record was reported from the Lake Augusta area by J. Wood in 2009; at this altitude in Tasmania, (1140 m.a.s.l.) *B. marginata* occur as scattered alpine dwarves, often possessing large bulbous root boles. *Cyrioides imperialis* has also been recorded from similar elevations in the Blue Mountains, NSW. A study to ascertain the population density of

C. imperialis from the Tasmanian Central Highlands would be most interesting. *Banksia marginata* is widespread across Tasmania and given the diverse range of conditions from which the beetle is currently documented it is likely that *C. imperialis* has a much greater area of occupancy than previously assumed.

Although French (1900) illustrated the species, limited information is available on its biology. French noted oviposition occurred in the wood of *B. integrifolia*, where, after hatching, the larvae began feeding on the wood, tunneling into the tree, often descending 20-25 cm below ground level into the tap-root; one such observation was recorded in a "smaller *Banksia* bush". Only one observation of copulation has been published (Wilson 1977). References identifying larval host plants are limited; aside from French (1900), Hawkeswood (2007), reporting an observation from NSW, describes the position of an emergence hole in *Banksia serrata*, with a height of 6 m, stem diameter of 16 cm and an approximate age of 15-20 years. The distribution of *B. serrata* in Tasmania is limited to the coastal region of the central north-west; however, there are no confirmed records of its usage by the beetle in this State.

We have recorded abundant *C. imperialis* emergence holes in *B. marginata* regrowth saplings and established trees in dry *Eucalyptus amygdalina* forest at Cleveland in central Tasmania. Despite having multiple emergence holes, mature banksias in this area appear healthy and are obviously capable of sustaining successive generations of larval attack. However, this is not the case for small regrowth saplings, which, though seldom

Plate 1. *Cyrioides imperialis* emergence hole in *Banksia marginata*. Scale button 10 mm diameter.

having more than one emergence hole, usually die from the attention of the larva. Emergence holes in dead juvenile *B. marginata* plants have been recorded in stems of 45 mm diameter (measurements taken at the level of emergence); the smallest live tree bearing an emergence hole had a trunk diameter of 62 mm (Plate 1). In another live tree, forked at the ground, each branch bore an emergence hole at ground level, the stem diameters were 80 mm and 120 mm; in both instances the trees appeared healthy. Invariably, emergence holes in small trees were within 30 cm of ground level, the positioning of emergence is apparently haphazard and no preference of directional orientation of holes was evident.

Oviposition sites appear to be low on the stem, at or below the emergence hole, as dissection of several previously occupied root boles and stems revealed no larval excavation above this point. Examination of larval tunnels indicates that the larvae descend, usually into the root bole. Feeding is confined to the conductive tissue, which is reduced to frass packed into the wide shallow bore that is often only 3 mm deep and located immediately beneath the bark. Though larger trees are able to survive, small saplings are inevitably killed by the voracious larval feeding which effectively ring-barks the tree. The much flattened ultimate instar larva, which is usually curled inside the bore, possesses an enlarged pronotum 13 mm wide; the body is very slender with a total length of 55 mm (Plate 2).

The fully fed larva excavates a central frass-packed tunnel connected to the

Plate 2. *Cyrioides imperialis* ultimate instar larva, dorsal view.

pupal chamber (Plate 3) formed beneath the stem surface, leaving as little as 1 mm of intact bark covering the emergence site. Adult female *C. imperialis* average 30 mm in length, 12 mm width and body thickness of 10 mm, which parallels the average emergence hole dimensions of 13 x 11 mm.

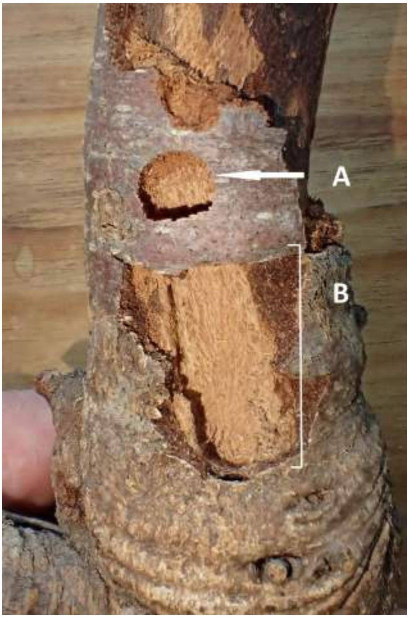

Plate 3. Male *Cyrioides imperialis* emergence hole (A) and exposed pupal chamber (B). Chamber dimensions 40 x 13 x 8 mm.

The larvae of the buprestid *Castiarina rudis* (Carter 1938) feed in *Orites revolutus*, as reported in Richards & Spencer (2017). The larval habits of this species are superficially similar to those of *C. imperialis*, including feeding in the root bole, the position of the emergence hole, which is mostly low on the stem, and larval occupation often causing death in smaller stems. Over the course of the current investigation many dead saplings were uprooted to establish the patterns and extent of larval occupation. Larval activity was confined to the bole of the tree, not extending into the larger roots and no evidence of subterranean emergence of *C. imperialis* was recorded, though beetle exit points were observed in several exposed living roots with diameters as small as 30 mm on mature trees. Saplings at the Cleveland location occur in thickets, despite no obvious signs of recent fire damage. *Cyrioides imperialis* appear to prefer the peripheral 2-3 m of these stands, since emergence holes were seldom seen deeper in the thickets. More beetle usage was apparent in the younger cohort of *B. marginata* trees with stem diameters under 12 cm, compared to mid-age regrowth of 20 - 25 cm diameter.

Captive reared adult *C. imperialis* emerged in December and January, while a fully hardened female imago was collected from the pupal chamber in December in the field (Plate 4). Cowie (2001) documents the adult flight period as occurring from December to March; specimens held in the authors' private collection were obtained between December and February. Adults are heavy, somewhat cumbersome fliers and only active in hot weather with little or no wind. Despite their apparently aposematic patterning the beetles are cryptic amongst the foliage and new growth of the food plant.

It is worth noting that not all dead *B. marginata* are populated by *C. imperialis* larvae. *Lamprima aurata* (Latreille 1817) has also been recorded in decaying roots and stems, however, this species is known to only utilize dead and decaying wood (Fearn 1996). Fruiting bodies of the saprotrophic fungus *Mycena clarkeana* (Grgurinovic 2003) were also occasionally found around the stem base of dead saplings, with or without beetle emergence holes. This fungus is not pathogenic and likely infiltrated the tree post-death (G. Gates pers. comm.).

Larvae of the large cerambycid beetle *Paroplites australis* (Erichson 1842) co-occur in *B. marginata* but display a preference for dead and dying mature trees. The emergence holes of this species may be found in the trunks of living trees, but the greatest abundance occurs where there is evidence of decay or a dead branch. Emergence holes of *P. australis* are ovoid, as opposed to the D-shaped holes of *C. imperialis*, measure up to 25 x 15 mm and are confined to the trunk and larger branches.

Emergence of adult *C. imperialis* occurs before the dead host tree loses its leaves. As noted above, larval feeding is restricted to the conductive tissue, and deeper excavation is only undertaken to provide a larger gallery leading to the pupal chamber. Excavation of the tree bole from which a male *C. imperialis* exited revealed that the larva utilized less than 20% of the available wood and feeding activity was confined to the sapwood immediately beneath the bark. This limited use of the wood resource suggests that the larval stage is relatively short, perhaps 1-2 years, which is probably similar to that of other buprestid species currently under investigation (Spencer and Richards unpub. data). *Cyrioides imperialis* is the largest jewel beetle in Tasmania, thus one might expect a protracted larval period and extensive use of the larval host plant. It is surprising to discover the small extent to which it excavates

Plate 4. Female *Cyrioides imperialis* imago emerging from exposed pupal chamber in *Banksia marginata* (inset), and fully emerged imago.

its host, suggesting that *B. marginata* is a particularly nutritious food plant. Although it is usually fatal to sapling *B. marginata*, multiple attacks on mature trees appears to have little or no effect, therefore, contrary to the concerns expressed by French (1900), the future of *B. marginata* would seem to be assured despite the attention of this magnificent beetle.

Acknowledgements

Sincere thanks to Dr. Genevieve Gates for advice and fungal identification, and to Jill Richards for her enthusiastic field assistance.

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When divine protection is not enough: extinction of *Lepidium hyssopifolium* Desv. (Brassicaceae) from Tasmanian cemeteries

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Abstract

Lepidium hyssopifolium is widespread in lowland parts of Tasmania, principally the Midlands, and Fingal and Derwent valleys. Within this range, the species is reported from four privately-owned cemeteries. Surveys in 2017 revealed that the species is now locally extinct at three of four of these cemeteries, only persisting at one location (Bothwell), where its survival is considered precarious. Removal of mature ornamental conifers is the most likely cause of the extinction of the species at two sites.

Introduction

Lepidium hyssopifolium Desv. is presently listed as endangered on both the Tasmanian *Threatened Species Protection Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. In Tasmania, the species has long been considered a "weedy native" (e.g. Kirkpatrick & Gilfedder 1998) because it appears to be restricted mainly to anthropogenic habitats. Most populations occur on road verges, usually associated with mature ornamental conifer trees, leading to some speculation that the species may be naturalised, not native (M. Wapstra in press). However, in the absence of unequivocal evidence for its naturalised versus native status, the species remains listed as endangered and should be managed as such.

The strongest "natural" habitat of *Lepidium hyssopifolium* is native grasslands and grassy woodlands, which have been extensively cleared in Tasmania (Kirkpatrick *et al.* 1995). Remnant grassy road verges, cemeteries and town parks may now represent a potentially important habitat for species in Tasmania. Indeed, in Kirkpatrick *et al.* (1988), the authors stated: "We have failed to find recently recorded populations of *Lepidium hyssopifolium*… All recent records of this species in Tasmania are from heavily modified roadsides. Its future in Tasmania depends on the reintroduction into places like the Domain, rather than reservation".

As part of a Statewide review of the populations of *Lepidium hyssopifolium* in Tasmania, primarily undertaken for the

Department of State Growth in relation to roadside populations, the author undertook database interrogations, collection examinations and field surveys. This included consideration of several cemetery occurrences, which are the subject of this paper. The broader distribution, habitat requirements and conservation status of the species will be considered in greater detail in a separate paper (M. Wapstra unpubl. data).

Methods

Three sources of records of *Lepidium hyssopifolium* were interrogated and reviewed to produce a complete list of all known locations of the species in Tasmania. These sources were: collections at the Tasmanian Herbarium (Tasmanian Museum & Art Gallery); DPIPWE's *Natural Values Atlas* database (NVA); and *Atlas of Living Australia* (ALA). These were filtered for the present paper to those records that coincide with cemeteries.

Field surveys were undertaken at four cemetery sites with reported occurrences of *Lepidium hyssopifolium*: (1) Bagdad; (2) Bothwell; (3) Lake River; and (4) Jericho. All accessible parts of the cemetery yard and verges were searched for evidence of *Lepidium hyssopifolium*. Where the species was detected, handheld GPS was used to record the point location of all individuals. Voucher specimens were collected under DPIPWE permits TFL 15280 and 17029 (in the name of Mark Wapstra) and lodged with the Tasmanian Herbarium (HO).

Results

Lepidium hyssopifolium has a widespread distribution in lowland parts of Tasmania, principally the Midlands, and Fingal and Derwent valleys (Figure 1). Within this range, the species is reported from four privately-owned cemeteries (Figure 2, Table 1).

Lepidium hyssopifolium is no longer present at three of the four cemeteries surveyed. The species only remains present at the Bothwell cemetery.

Plate 1. Previous habitat of *Lepidium hyssopifolium* at the Bagdad cemetery

Bagdad cemetery

This site is now privately-owned (that is, not church-owned) but the cemetery part of the title appears to remain open to the public. The site is a typical small cemetery with a small number of gravesites amongst bare ground and light "lawns" under mature *Pinus radiata* (Plate 1). The presumed location of the population of *Lepidium hyssopifolium* (and indeed *Lepidium pseudotasmanicum*, which was hitherto also considered a threatened species) was under the drip zone of the larger ornamental pine trees. No evidence of *Lepidium hyssopifolium*

Table 1. Details on cemeteries with records of *Lepidium hyssopifolium*

Site	Location	Details of records	Field survey date
1	**Bagdad** Uniting Church to 2006 – now privately-owned	8 Oct. 1999; A. North; NVA 227789 (HO 504249); "Amongst graves beneath Cupressus macrocarpa. *L. pseudotasmanicum* also present", "Small population of <10 plants". 1 Nov. 1999; A. North; NVA 344876 (presumed duplicate of NVA 227789).	7 Apr. 2017 **SPECIES NOW ABSENT**
2	**Jericho** St James Church, owned by the Trustees of the Diocese of Tasmania	1 Jan. 1991 (database artefact – precise to year only); G. Blake; NVA 944498 (HO 513739); "Under conifers". 20 Mar. 1991; L. Gilfedder; NVA 228106 (HO 443104); "Degraded native grassland under *P. radiata* with *Vittadinia gracilis, Einadia nutans*, *Bromus sterilis*".	21 March 2017 **SPECIES NOW ABSENT**
3	**Lake River** St Mark's Church, owned by the Trustees of the Diocese of Tasmania	26 Apr. 1991; P. Collier; NVA 227395 (HO 143052 with duplicates at CANB 476277.1 & MEL1615409A); "Under a large pine tree, well mulched ground", "common in habitat, absent elsewhere".	21 March 2017 **SPECIES NOW ABSENT**
4	**Bothwell** St Luke's Uniting Church owned by the Uniting Church in Australia Property Trust but sites within the area owned by the Central Highlands Council	1 Jan. 1991 (database artefact – precise to year only); NVA 300897); no information 1 Nov. 2006; G. Green; NVA 954321; "10"	7 Apr. 2017 **SPECIES STILL PRESENT**

was detected but several individuals of *Lepidium pseudotasmanicum* were present below the large pine tree (Plate 1). There appears to be no particular reason for the absence of *Lepidium hyssopifolium*, other than perhaps natural senescence of this perennial species (the longevity of individuals is not known). It will be interesting to monitor this site to see if *Lepidium hyssopifolium* reappears.

Plate 2. Previous habitat of *Lepidium hyssopifolium* at the Jericho cemetery – note the stump of a *Pinus radiata* near the front fence and the stand of *Pinus radiata* in the background.

Jericho cemetery

This site is widely recognised as a "hotspot" for threatened flora restricted to a localised remnant of lowland *Themeda triandra* (kangaroo grass) grassland. Indeed, the trustees of the church have erected an interpretation sign on this subject. The grassland within the church yard is also carefully managed to provide opportunities for the grassland species to flower and set seed. This appears to have been successful for a small patch of grassland thickly dominated by *Themeda triandra*. Several threatened flora species remain present at this site including *Vittadinia cuneata*, *V. gracilis*, *Velleia paradoxa*, *Dianella amoena* and *Leptorhynchus elongatus* (the site remains one of just three sites for this species in Tasmania). Unfortunately, *Lepidium hyssopifolium* appears to have disappeared from this site. A large *Pinus radiata* remains present on the western boundary of the church yard and this is seemingly ideal habitat for *Lepidium hyssopifolium* (Plate 2). This habitat extends into the private title to the west and along Jericho Road. No evidence of the species was found in the accessible parts of this potential habitat. A large radiata pine has been removed from the frontage of the church yard (Plate 2). It is presumed that this was the site supporting *Lepidium hyssopifolium* and that the removal of the coniferous cover has eliminated the habitat for the species.

Lake River cemetery

This site is an historic church yard with both historical and modern grave sites. The vegetation is mainly native grassland dominated by *Themeda triandra*, *Austrostipa* species and *Lachnagrostis* species, with a high component of weedy grasses and herbs. Some small ornamental conifers remain in the middle of the church yard but the large radiata pine that once dominated the frontage on Macquarie Road has been removed many years ago (Plate 3). Presumably, as with the site at Jericho, this removed the habitat of *Lepidium hyssopifolium*.

Plate 3. Previous habitat of *Lepidium hyssopifolium* at the Lake River cemetery – note the stump of a *Pinus radiata* in the foreground.

Plate 4. Habitat of *Lepidium hyssopifolium* at the Bothwell cemetery – the species occurs in the drip zone of the radiata pine (note that the pile of landscaping soil nearby).

Bothwell cemetery

Similar to the Jericho cemetery, the Bothwell cemetery has been long-recognised an important site for conservation of lowland *Themeda triandra* grassland and threatened flora. As with the Jericho site, the owners and local council manage the church yard for both its utilitarian values and conservation values, with interpretation signs present that explain the slashing regime. While the database information on *Lepidium hyssopifolium* from this site is somewhat obscure and limited, field botanists generally know of this cemetery as a "good" population of the species. Field assessment confirmed the species from two sites in the cemetery, both under exotic trees (northern site under an old *Pinus radiata*, western site under ornamental "macrocarpa"-type conifer around graves).

The security of this population is considered precarious. One patch is under a mature *Pinus radiata* but is being rapidly encroached by invasive perennial weeds including *Vinca major* (forming an ever-increasingly dense ground cover) and *Rosa rubiginosa* (Plate 4). Close to this site, council have created a materials store area for pinebark and the like (Plate 4). There is a locally dense and multi-aged patch of perhaps low 100s of individuals around historic graves with macrocarpa-type ornamentals (Plate 5).

Plate 5. Habitat of *Lepidium hyssopifolium* at the Bothwell cemetery – the species occurs mainly in the shade of the smaller ornamental conifer but also spreads out to the graves in the foreground.

This patch is subject to intensive rabbit grazing (possibly causing the multi-aged population structure) and appears secure while the shading is present and ground disturbance is minimised. However, there has already been removal of mature conifers close to this site (Plate 6).

Plate 6. Overview of the Bothwell cemetery showing stump of ornamental conifer – no *Lepidium hyssopifolium* was found in this area

Discussion

Benign neglect appears to be an appropriate management strategy for *Lepidium hyssopifolium* across most of its range in Tasmania. That is to say, populations of the species appear to have persisted (and probably spread) along several major road systems despite (or perhaps because) of routine management activities such as slashing. However, in some presumed safe and secure sites such as private cemeteries, *Lepidium hyssopifolium* has disappeared. At two sites, this is probably attributable to the removal of the shading *Pinus radiata*. Perversely and paradoxically, *Lepidium hyssopifolium*, either one of our most endangered species or a weed with a narrow habitat tolerance, occurs mainly in the drip zone of mature ornamental conifers. The species can occur in unshaded habitats. For example, there is a seemingly healthy population along Hollow Tree Road amongst frequently slashed and stock-trodden grass (mainly exotic species), although only a few kilometres down the same road, another population in virtually identical habitat is no longer present. This may indicate that these unshaded populations may become extinct. However, they may persist for many years, as seems to be the case at Nant Lane north of Bothwell, where there is a well-established population in a wide grassy road verge, frequently subject to stock movements and grazing. A population at the junction of Valleyfield and Barton roads is still present but the mature macrocarpa conifer has been recently chopped down (some re-sprouting is occurring) and this site may provide further evidence of the longevity of the species in the absence of the shading.

Under the Tasmanian *Threatened Species Protection Act 1995*, "a person must not knowingly, without a permit…take, keep, trade in or process any specimen of a listed taxon of flora or fauna…" (Section 51) where "take includes kill, injure, catch, damage, destroy and collect" but does not include the concept of "disturb". This probably means that a permit is not required for the removal of ornamental conifer trees that act as habitat for *Lepidium hyssopifolium*. It is doubtful if this type of action would be regarded as "significant" within the intent of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

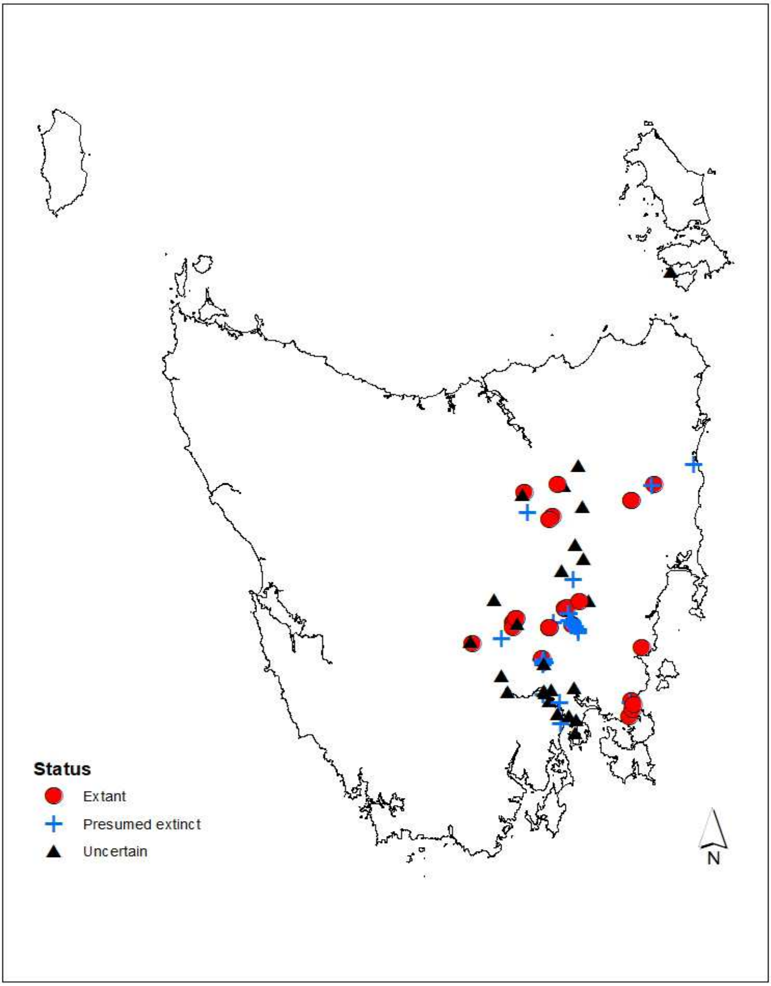

Figure 1. Statewide distribution of *Lepidium hyssopifolium* showing status (extant, presumed extinct, uncertain) based on M. Wapstra (unpubl. data)

In terms of the long-term security of *Lepidium hyssopifolium* (and probably several other species of threatened flora) in privately-owned cemeteries, it seems that we cannot rely on divine protection (benign neglect) – if these sites are to act as repositories of threatened flora, active intervention is almost certainly needed. While this paper has focused on *Lepidium hyssopifolium*, the findings have broader implications for other species, some of which are wholly restricted to a single privately-owned cemetery. Examples include species such as *Prasophyllum taphanyx* (graveside leek-orchid), one of the nation's most threatened species, represented by just a few individuals that flower erratically in a cemetery at Campbell Town. Of particular concern is the recent proposed sale of many country churches and attendant grounds. Authorities such as the Department of Primary Industries, Parks, Water & Environment, local councils and NRM groups, will need to work innovatively and cooperatively with cemetery owners if some of our most precious species are to survive.

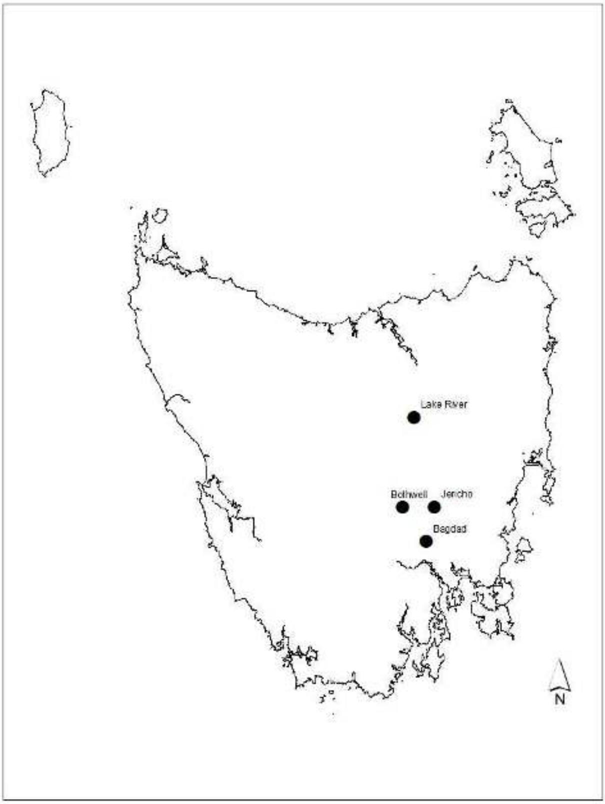

Figure 2. Location of cemeteries in Tasmania where *Lepidium hyssopifolium* has been recorded (cross-reference to Table 1).

Acknowledgements

This paper is derived from a project undertaken by the author for the Tasmanian Department of State Growth: Matt Davis, Jillian Jones and Tori Harvey are thanked for project coordination, provision of data, and comments on draft documents. Miguel de Salas, Matthew Baker and Kim Hill (Tasmanian Herbarium) are thanked for access to specimens and provision of database information. Phil Collier, Louise Gilfedder and Andy North provided information on populations. Lorilee Yeates provided comments on initial findings and on an earlier draft of this manuscript. I also thank Mick Brown and Stephen Harris for reviewing the manuscript.

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An established population of the mainland Australian false garden mantis *Pseudomantis albofimbriata* (Stal, 1860) (Mantodea: Mantidae) in northern Tasmania

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Australia is home to some 160 spp. of Mantodea comprising 37 genera in 3 families (Rentz, 1996). Tindale (1923) suggested that five species occur in Tasmania: *Paraoxypilus tasmaniensis*, *P. verreauxii* (Amorphoscelidae), *Orthodera ministralis*, *Tenodera australasiae* and *Pseudomantis albofimbriata* (Mantidae), and further Rentz (1996) states that *Mantis octospilota* (Mantidae) occurs in all Australian states. However, of these six species, only three are known to occur naturally in Tasmania with any degree of certainty. No specimens of *P. verreauxii* or *M. octospilota* are held in any public Tasmanian entomological collections nor are there any registered specimens in any mainland institutions and (until recently) no specimens of *P. albofimbriata* either (Atlas of Living Australia (ALA), 2018 a,b,c, S. Grove pers. comm., J. Davies pers. comm.) In addition, the author has not seen or collected any Mantodea corresponding to these three species in 40 years of field work in Tasmania. The original reference to Tasmanian specimens of *P. verreauxii* and *P. albofimbriata* (Tindale, 1923) refers to old specimens held in European institutions and the collection data may be in error. It is interesting and possibly significant that the distribution of both species appears to be essentially tropical so that the reference to Tasmanian specimens is somewhat incongruous (Tindale, 1923, ALAa, b). Of perhaps even more significance is that there are no specimens of any of the three doubtful species in the entomology collection of Museum Victoria (K. Walker pers. comm.). All Victorian records of *P. albofimbriata* on ALA (ALA, 2018b) are citizen science sighting records, are mostly centered on Melbourne and all later than 2010. Graham Milledge of the Australian Museum (pers. comm.) is currently working on a revision of *Paraoxypilus* and suggests that available evidence so far indicates that Tasmanian records of *P. verreauxii* are probably in error and that published records of Tasmanian *M. octospilota* fall into the same category. He further supported the possibility that *P. albofimbriata* may be moving south of its essentially tropical natural range and may only have recently colonised Melbourne, as indicated by a lack of any historical specimens.

It now appears that only three species of Mantodea occur naturally in Tasmania- black bark mantid *Paraoxypilus tasmaniensis* (Saussure, 1870), green mantid *Orthodera ministralis* (Fabricius, 1775) and purplewinged mantid *Tenodera australasiae* (Leach, 1814).

When the first specimens of *P. albofimbriata* were collected at the author's residence in 2013 they were considered unusual but were initially misidentified as *Mantis octospilota* (Fearn & Maynard, 2013) on the basis of a statement in Rentz (1996) that this species occurred in all states. It was not until the author had the opportunity to examine an adult female *M. octospilota* from Queensland (QVM:2018:12:0433) that it was realised a different species was involved.

The Queen Victoria Museum and Art Gallery (QVMAG) now has 7 male and 2 female specimens of *P. albofimbriata* recently collected in Launceston, northern Tasmania (QVMAG Reg. No. QVM.2018.12.0330-0338) (Plate 1). This species is large (males 40-45mm, females 45-50mm) with a distinctive black spot on the underside of the femur on the prey grasping fore leg (Plate 2).

Plate 1. Adult female (left) and male of *Pseudomantis albofimbriata* from Launceston, Tasmania. Note reduced wings of female exposing most of the abdomen. Photograph: David Maynard

Plate 2. Distinctive black spot on underside of grasping fore leg femur. This diagnostic character occurs on both male and female *P. albofimbriata*. Photograph: David Maynard

Males are smaller and more gracile than females and readily fly whereas the females have reduced wings and are not capable of flight (Plate 1). *Pseudomantis albofimbriata* occurs in two distinctive green and brown colour phases, both of which have been collected in Launceston (Plate 1). High resolution images of the Launceston specimens were supplied to two of Australia's foremost authorities on the Mantodea (D. Rentz & G. Milledge *pers. comm.*) who confirmed the author's determinations. All these adult specimens were collected at the author's residence in the suburb of Riverside between 2013 and 2018 in the months of March and April. Six of the males were taken at a 240 volt, 1.2m black light/blue fluorescent tube, one male and one female were observed concealed among the foliage of low shrubs in a garden bed during the day and the remaining female was found on the exterior wall of the house. To the best of the author's knowledge, these specimens represent the first record of this relatively large and distinctive species from Tasmania. In addition, the author suggests that these specimens indicate a recently established population.

This appears to be the second newly-established population of a relatively large mainland orthopteroid insect to have been detected by QVMAG staff in the last 12 months. The large and distinctive Western Australian cockroach *Drymaplaneta semivitta* (Blattidae: Polyzosterinae) is established in central Launceston and most likely entered the state through freight (Fearn & Rainbird, 2017). The ootheca of blattodeans, which are often attached to a range of substrates by adult females, are an easily anthropogenically transportable and resistant life cycle stage (Rentz, 2014). Similarly, the ootheca of the Mantodea are typically firmly attached by females onto vegetation, tree trunks and even anthropogenic structures (Rentz, 1996). This characteristic may enable this group to travel easily in movements of nursery stock and other garden materials. A warming climate in association with ever increasing volumes of freight and human movements will inevitably result in more mainland insects arriving in Tasmania and encountering suitable conditions for survival, reproduction and growth (Fearn & Rainbird, 2017). The Mantodea are relatively rare insects in most habitats (Rentz, 1996) and it could be argued that the establishment of a mainland species in Tasmania will have no measurable impact on local insect populations. However, if breeding populations of two relatively large mainland insects can be detected in 12 months with limited sampling by a very small number of entomologically aware individuals, there may be many smaller and more cryptic translocated terrestrial invertebrates that have yet to be formally recognised in Tasmania. Projected increases of freight and people movements around the world coupled with declining numbers of professional entomologists with taxonomic expertise will make the detection of such invasive organisms increasingly difficult (Rentz, 2014).

Acknowledgements

Many thanks to the various entomologists/curators who checked data base records and specimens for me: Simon Grove (Tasmanian Museum and Art Gallery), Jamie Davies and Lionel Hill (Biosecurity Tasmania) and Ken Walker (Museum Victoria). Special thanks to David Rentz for his ongoing assistance with specimen identifications and Graham Milledge (Australian Museum) for confirming the identity of the mantid and imparting important distribution information. Thanks also to David Maynard (QVMAG) for his timely and excellent photography and Alastair Richardson for editorial input.

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The St. Andrew's Cross spider (Araneidae *Argiopes keyserlingi*, Harsch 1878) breeding in northern Tasmania

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Introduction

The St. Andrew's Cross spider (Araneidae *Argiopes keyserlingi*, Harsch 1878) was first recorded in Tasmania by Douglas (2016). At that time six females were positively identified from five locations in northern Tasmania. No males were found. This paper reports the first Tasmanian record of male *A. keyserlingi*, evidence of successful breeding, and the species' current distribution.

Previous distribution and records

Prior to *A. keyserlingi* being recorded in Tasmania (Douglas 2016), the species was thought to be distributed through Queensland, New South Wales and Lord Howe Island, with some recent records from Melbourne, Victoria. At the time of writing (20 April 2018), the Atlas of Living Australia (ALA) contained 141 records of preserved specimens collected from Queensland (57), New South Wales (72), Northern Territory (1), Victoria (7) and Tasmania (2), Vanuatu (1) and the Solomon Islands (1). The ALA also contains a further 1,148 observations (a few with supporting images) of *A. keyserlingi*. If these identifications are correct then this species distribution extends to Perth, Western Australia (11), regional Victoria (84), New Guinea (1) and Anhui Province, China (1).

No new Tasmanian observations or preserved specimens of *A. keyserlingi* have appeared on the ALA since Douglas' 2016 report. However, images of what appear to be females, males and egg sacs located in northern Tasmania have been posted on social media sites through the summer of 2017/18.

Field observations

The first author observed and photographed an immature female *A. keyserlingi* in her web at his property at Deviot on 20 December 2017. The web of this spider was amongst the leaves of *Lomandra longifolia* (Plate 1). This specimen was collected as a voucher for the Queen Victoria Museum and Art Gallery

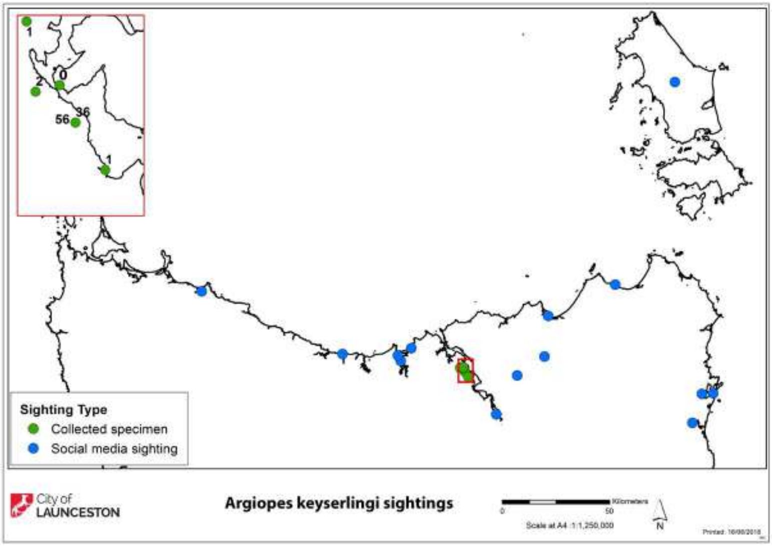

Figure 1. The distribution of *Argiopes keyserlingi* in northern Tasmania, based on the social media observations listed in Table 1 (blue dots), and the five sites from which voucher specimens were collected (green dots) and the number collected.

(QVMAG) (QVM.2018.13.0324). The site (-41.23415 S 146.92654 E) is about 25 km SSE of Bass Strait, on the River Tamar (Figure 1). It is pasture that has been reverting to bushland over the last decade, and is bordered by *Eucalyptus amygdalina* coastal woodland.

Plate 1. *Lomandra longifolia*. This plant was the site for *Argiopes keyserlingi* adults and breeding activity.

On 22 December a one-hour survey at this site (around 600 m^2) was conducted and about 100 clumps of *L. longifolia* were searched. Seventeen females (6-13 mm body length), 16 males (4-5 mm body length) and three juveniles were found. Voucher specimens of each sex, including male-female pairs from the same web, were collected (QVM.2018.13.0195-0198; n=12) (plate 2).

The spider population at this site was occasionally monitored until mid-April. On 10 January five adult and three juvenile females, and two males were observed, along with five egg sacs, one of which was collected as a voucher (QVM.2018.13.0322) (Plate 3). A number of females were observed but not males. A second egg sac, containing

Plate 2. A male (above), and female (below) *Argiopes keyserlingi* in a web amongst the leaves of *Lomandra longifolia* on 22 December 2017.

Plate 3. The egg sac of *Argiopes keyserlingi* collected from *Lomandra longifolia* at Deviot on 10 January 2018 (QVM.2018.13.0322).

Plate 4. Hatchlings of *Argioipes keyserlingi* massed in a web on 18 February 2018.

spiderlings ready to hatch, was collected on 8 February (QVM.2018.13. 0323), and on 18 February a cluster of over 100 hatchlings were observed on a web. Fifty six of these were collected as vouchers (QVM.2018.13.0321) (Plate 4). It should be noted that most of the population was left undisturbed.

The last *A. keyserlingi* observed at this site was an adult female on 23 March 2018. Subsequent searches were conducted until 13 April 2018 and none were observed. Species within the genus *Argiopes* live less than a year; the female dies after making an egg sac (Levi 1968). There is nothing documented about the overwintering habits of the species.

Secondary sites

On 23 December, two days after the first spiders were observed at the Deviot site, three nearby locations of similar habitat were surveyed, each for about 15 minutes. A juvenile female *A. keyserlingi* (QVM.2018.13.0199) was found amongst *L. longifolia* on the northern bank of the Supply River, Robigana (-41.25689 S 146.94545 E), about 3 km to the south west of the Deviot site. A juvenile male and juvenile female (QVM.2018.13.0200; n=2) were found amongst *L. longifolia* next to the Batman Highway, Sidmouth (-41.21934 S 146.90122 E), about 2.7 km to the north east of the Deviot site. No specimens were found below the Batman Bridge on the eastern shore of the Tamar River estuary (-41.21621 S 146.91649 E), about 2.1 km to the north-north east of the Deviot site (Figure 1).

Lastly, on 4 March a female *A. keyserlingi* was collected from a property at Rowella (-41.18020 S 146.89467 E; QVM.2018.13.0320) in an area of mixed pasture, blackberry, bracken and sparse eucalypt.

Behavioural observations

Smaller-sized females were always alone in their web, while the larger females were in their webs were either unaccompanied or, more often, with one or two males. Where two males were present, one sat at the margin of the web, while the other was within a few centimetres of the female. Unaccompanied males were observed in their own web, which lacked the characteristic cross-pattern of the female's web.

The St Andrews Cross spider appeared to be the most common species at this location and time, with only 15 other web-building spiders of various other species observed.

Sightings posted on social media

A number of photographs posted on the popular Facebook page *Tasmanian Insects and Spiders* show what appear to be *A. keyserlingi* females, males and eggs sacs (but note that *A. trifaciata* is also present in Tasmania and bears strong resemblance to *A. keyserlingi*). These unvouchered sightings imply that the species has been present in Tasmania since at least 2015, is present across central north Tasmania and the upper east coast, and that it is breeding at many locations (Table 1).

Table 1. Unvouchered records of St. Andrew's Cross spider *(Argiopes keyserlingi)* posted on the Facebook page Tasmanian Insects and Spiders (as at 14 April 2018).

Nearest Name Place	Date	Male	Female	Juvenile	Egg sac
Riverside	31 Jan. 2014		Y		
Bridport	21 Jan. 2015		Y		Y
Steiglitz	22 Feb. 2015		Y		
Narawantapu	22 Feb. 2015		Y		
St Helens	8 Dec. 2015		Y		
Squeaking Point	28 Dec. 2015		Y		
Upper Scamander	1 Feb. 2016		Y		
Port Sorell	26 Feb. 2016		Y		
Lilydale	16 Feb. 2017		Y	Y (hatchlings)	
Flinders Island	17 Feb. 2017	Y	Y		
Squeaking Point	21 Dec. 2017		Y		
Squeaking Point	27 Dec.2017		Y		
Nabowla	28 Dec. 2017		Y		
Squeaking Point	2 Jan. 2018	Y	Y		Y
Narawantapu	7 Jan. 2018	Y	Y	Y	Y
Squeaking Point	14 Jan. 2018	Y	Y		Y
Squeaking Point	16 Jan. 2018	Y	Y		
Tomahawk	17 Jan. 2018		Y		
Narawantapu	26 Jan.2018	Y	Y		
Squeaking Point	27 Jan. 2018			Y (hatchlings)	
Rocky Cape	29 Jan. 2018	Y	Y	Y	Y
Turners Beach	18 Feb.2018		Y		
Narawantapu	25 Feb. 2018			Y (hatchlings)	

Conclusion

This is the first time that male *A. keyserlingi* have been recorded in Tasmania, and the presence of breeding pairs, egg cases, juveniles and hatchlings at multiple sites in northern Tasmania implies that this species now persists in Tasmania. Observations posted on social media have assisted in recording the species' summer distribution. The species' successful breeding in Tasmania may reflect a permanent southerly range extension in response to the warming climate, or simply that the species, always ballooning in on northerly winds, had a good breeding year in response to Tasmania's warm summer of 2017/18 (Bureau of Meteorology 2018). The observational data suggest that females will be seen from late December until late March. If the hatchlings that are recorded in this paper survive the 2018 winter they are likely to be observed in early December 2019. The first author will be monitoring the primary site for what may be overwintered juveniles.

QVMAG will continue to record observations made through social media, and fieldwork, to track the St Andrews Cross spiders' range extension. Future research is needed to understand the ecological impact of this species in Tasmania.

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Inventory and Monitoring of the Vascular Plants of Tasmanian Saltmarsh Wetlands

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Summary

Tasmanian coastal saltmarsh wetlands are found in sheltered low-energy environments associated with large estuaries, creek mouths, lagoons and embayments. They are mapped as two major plant communities: Succulent Saline Herbland (TASVEG Code: ASS) and Saline Sedgeland/Rushland (TASVEG Code: ARS). In Aug 2013, coastal saltmarsh was the second vegetation community in the State to be listed as a 'threatened ecological community' (category: vulnerable) under the Australian Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Given this status, it is important to monitor saltmarsh extent and condition. Since plants play the central role in structuring the saltmarsh ecosystem, they require monitoring as a priority. In the present paper we provide the justifications for, and details of, the species and attributes we use in State-wide monitoring of saltmarsh plants. We also outline monitoring methods and a citizen science approach. A *Tasmanian Saltmarsh Wetland Plants Checklist*, *Saltmarsh App* and a *User Guide to Entering Plant Data into the Saltmarsh App* have been designed to assist in this endeavour.

Plants of saltmarsh wetlands

Saltmarsh wetlands occur in both coastal and inland areas of Tasmania. Coastal saltmarshes are characterised by their tidal connectivity to the sea. The connectivity can be regular (with the daily semidiurnal tidal flows) or intermittent (with episodal spring tides and storm surges), and can also include groundwater connectivity. Coastal saltmarshes occur extensively along sheltered, low energy, shallow intertidal environments in large estuaries, creek mouths, lagoons and embayments, particularly in the south-east, east, north and north-west parts of the State, as well as Flinders Island (see Figure 1). Saltmarsh flora is also common on the outer islands of the Furneaux Group and has been mapped at a detailed level by Harris *et al.* (2001). Inland saltmarshes lack any tidal connectivity but have high evaporation rates resulting in salinity levels suitable for saltmarsh plants. They occur both on the coastal zone (e.g. Sellars Lagoon, Flinders Island) and in the dry Tasmanian Midlands region (e.g. Township Lagoon, Tunbridge). Inland saltmarshes are therefore functionally different due to lack of tidal exchange and yet floristically similar to their coastal counterparts. The EPBC Act listing only applies to the tidally connected coastal saltmarshes (Threatened Species Scientific Committee 2013).

Tasmanian saltmarshes, both coastal and inland, are mapped by their plant communities as outlined by the Tasmanian Vegetation Monitoring and Mapping Program (TVMMP), to be part of the Digital Vegetation Map of Tasmania (TASVEG, digital map available through www.thelist.tas.gov.au). The two major TASVEG saltmarsh plant communities are (after Kitchener and Harris 2013: *Saltmarsh and wetland* section):

Succulent Saline Herbland (ASS)

Vegetation dominated by herbaceous species growing on the margins of highly saline, protected, flat estuarine shorelines inundated with sea water during high tides, dominated by halophytic plants, predominantly *Sarcocornia quinqueflora* and/or *Sclerostegia arbuscula* [now *Tecticornia arbuscula*].

Saline Sedgeland/Rushland (ARS)

Vegetation dominated by sedges, rushes and occasionally tussock grasses growing in highly saline environments, often inundated by tidal water, dominated by halophytic plants commonly *Gahnia filum* and *Juncus kraussii*.

These two TASVEG community types simplify the 15 structural/dominance communities of Kirkpatrick and Glasby (1981). One of these 15 community types is *Spartina anglica* grassland, made up of the exotic and highly invasive *S. anglica* (rice grass), and is mapped separately by TASVEG as *Spartina* marshland (FSM).

Tasmanian saltmarshes are characterised by vascular plants which have developed a range of physiological adaptations to waterlogging, salinity and exposure to sun, waves and wind (Adam 1990; Kirkpatrick and Glasby 1981; Kirkpatrick and Harris 1999). These plants include obligate species that are largely confined to Tasmanian saltmarshes and facultative species that are less confined. The Vegetation Benchmarks defined by TVMMP include a list of 'dominant species' and 'other typical species' for both ASS and ARS communities (Department of Primary Industries, Parks, Water and Environment 2016). These species lists are not fully inclusive or reflective of the dominant life forms found across Tasmanian saltmarshes. There is a need for a more systematic and complete process of developing an updated list of vascular plants of Tasmanian saltmarshes.

Saltmarshes in Tasmania have been under a range of local anthropogenic threats (Prahalad 2014b) as well as being subject to impacts from climate change and relative sea level rise (Prahalad *et al.* 2012, Prahalad *et al.* 2015a). A study of land clearing in north-west Tasmania found that 16% of saltmarsh extent has been lost since the 1950s, while 65% of the remaining marshes have been subject to impacts, such as draining and grazing (Prahalad 2014b). Another study in south-east Tasmania examining decadal scale vegetation change in saltmarshes reported over 40% change in community composition largely due to climate change and relative sea level rise (Prahalad *et al.* 2012). A national response to these impacts has been the inclusion of *Subtropical and Temperate Coastal Saltmarsh* as a 'threatened ecological community' (category: vulnerable) under the EPBC Act. The conservation advice associated with the listing identifies a need to monitor changes in species composition and distribution (Threatened Species Scientific Committee 2013).

Plants play the central role in structuring the saltmarsh ecosystem and the vegetation structure and composition strongly reflect environmental variation (Adam 1990). Plants are therefore well regarded as excellent indicators for saltmarsh management and are widely used in monitoring programmes (e.g. Neckles *et al.* 2002, Konisky *et al.* 2006). There are a few existing programmes in Tasmania that provide baseline data that can be used to monitor changes in saltmarsh vegetation. However, these programmes are not directed at saltmarshes in particular and have been used sporadically in the past with variable data accuracy and coverage (e.g. Figure 1). Efforts at improving data collection can be enhanced through collaboration between scientists, managers and interested members of the public, facilitated through dedicated 'citizen science' tools and initiatives (Cohn 2008, Prahalad *et al.* 2015b).

The present paper aims to address the following questions:

(1) What is a saltmarsh plant, or, what plants are likely to occur in Tasmanian saltmarshes (i.e. a saltmarsh plants list/ inventory)?

(2) What is the relative likelihood of finding a plant species in Tasmanian saltmarshes, or, what plants are more or less important for a monitoring programme (i.e. a monitoring shortlist)?

(3) What information can be recorded while documenting plants of Tasmanian saltmarshes (i.e. monitoring attributes)?

In answering these questions, we provide the justifications for, and details of, the species and attributes we use in State-wide monitoring of saltmarsh plants. A selected list of these species and attributes are used in the *Tasmanian Saltmarsh Wetland Plants Checklist* and *Saltmarsh App* as part of a citizen science project focussed on saltmarsh monitoring (NRM North 2017, NRM South 2016).

Methods

Generating a list of vascular plants

The first step towards developing a Tasmanian saltmarsh wetland plants inventory involved examining five sources (plant records, lists) to produce an updated and thorough list of relevant vascular plants (Appendix 1). Kirkpatrick and Glasby (1981) documented the distribution of saltmarsh and saltmarsh plant species in Tasmania, including Flinders Island. Bridgewater *et al.* (1981) provided an identification guide for *The Saltmarsh Plants of Southern Australia*. Saintilan (2009a) provided species lists for all States in Australia as part of the book, *Australian Saltmarsh Ecology* (Saintilan 2009b). The TASVEG Version 1.0 *Benchmark for Vegetation Condition Assessment* (Department of Primary Industries, Parks, Water and Environment 2016) includes a plant list derived from expert inputs (Karyl Michaels pers. comm. 2015). The online resource *Key to Tasmanian Vascular Plants* (Jordan *et al.* 2011) lists plants according to their families and genera rather than their habitat associations, i.e. saltmarsh in the present case. However, species habitats are noted for several of the plants. These sources were used to develop an initial list of Tasmanian saltmarsh plants.

The list thus produced was further curated by the authors with inputs from Greg Jordan (pers. comm. 2014) and Richard Schahinger (pers. comm. 2014), to produce the final list presented in Appendix 2. Photographic records from various field visits by the senior author (VP) were also reviewed in this process. Where there were isolated incidences of species (< 3 occurrences), they were omitted from the list.

Habitat occupancy coding

The plants listed were assigned a habitat occupancy code to rank the relative likelihood of finding a plant species in Tasmanian saltmarshes. The codes were based on a rating scheme adapted from the U.S. *National Wetland Plant List* (Table 1, based on Lichvar *et al.* 2012, Reed 1988). The modified rating scheme uses five classes based on the probability of occurrence in Tasmanian saltmarsh wetlands. We applied this scheme to the list of Tasmanian saltmarsh plants using expert knowledge based on extensive field observations, written and photographic records (VP, drawing from Prahalad 2009, Mount *et al.* 2010, Prahalad and Mount 2011, Prahalad 2012, Prahalad and Pearson 2013, Prahalad 2014c; JK, drawing from Kirkpatrick and Glasby 1981, Kirkpatrick and Harwood 1983). Expert knowledge was used here in lieu of the distribution data available from Tasmanian Natural Values Atlas (NVA) and intersecting it with saltmarsh mapping on ArcGIS platform (as shown in Figure 1). The spatial distribution data were found to be unreliable for this task, with several records occurring over water bodies and vegetation community types known to be unsuitable habitat. Another limitation with using the NVA records here was the lack of data coverage for many parts of the State (Figure 1).

Selecting attributes for monitoring

Current field identification and recording of plant species occurrence is facilitated through three main interfaces: Atlas of Living Australia (ALA, www.ala.org.au), Natural Values Atlas (NVA, www.naturalvaluesatlas.tas.gov.au) and Vegetation Condition Assessment (VCA, Michaels 2006). Data entry for ALA and NVA are done online, while

Table 1. The modified rating scheme used here in relation to the parent scheme used by the U.S. National Wetland Plant List based on Lichvar et al. (2012) and Reed (1988). * The code also includes a suffix letter to identify the provenance of the species: .n for natives; .e for endemics; and .i for introduced species

Rating	**Code**	**Description**	**Modified rating**	**Code***
Obligate Wetland	OBL	Occur almost always (estimated probability > 99%) under natural conditions in saltmarsh wetlands	Obligate Saltmarsh	Obl.
Facultative Wetland	FACW	Usually occur in saltmarsh wetlands (estimated probability 67%-99%), but occasionally found in other habitats	Common in Saltmarsh	Com.
Facultative	FAC	Equally likely to occur in saltmarsh wetlands and other habitats (estimated probability 34%-66%)	Occasional in Saltmarsh	Occ.
Facultative Upland	FACU	Only occasionally found in saltmarsh wetlands (estimated probability 1%-33%), usually occur in other habitats	Uncommon in Saltmarsh	Unc.
Upland	UPL	Occur almost always (estimated probability > 99%) under natural conditions in other upland habitats	Upland to Saltmarsh	Ter.

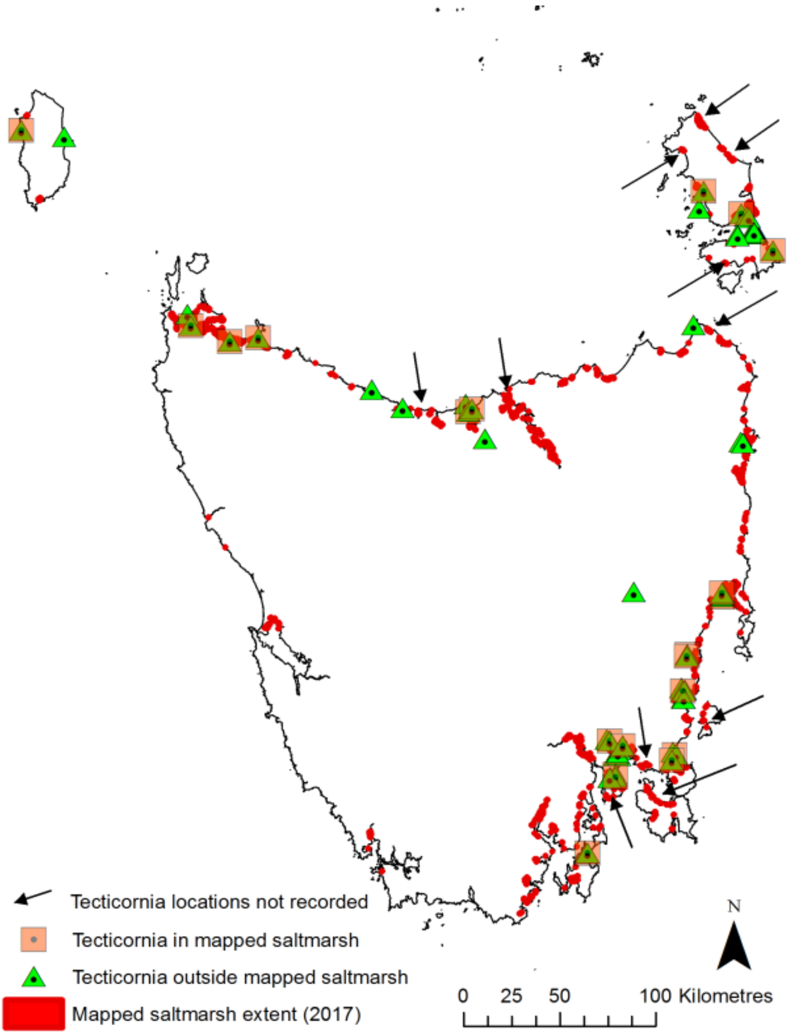

Figure 1. *Tecticornia arbuscula* distribution records obtained from the Tasmanian Natural Values Atlas (NVA) showing either, the inaccuracy of some of the data points (e.g. the one in central eastern Tasmania, over 50 kms away from the nearest coastline), and the lack of coverage for areas pointed to with arrows (e.g. east coast of Flinders Island).

VCA is completed in paper form and then used to create a VCA Report. ALA is a national database supported by the Australian Government, while NVA and VCA are specific to Tasmania. The attributes collected for each of these three monitoring systems are listed in Table 2. From these attributes, a list of default, essential and optional attributes have been identified for monitoring of the plants of Tasmanian saltmarsh wetlands. The essential attributes are designed specifically to allow for the survey to develop a saltmarsh site specific plant species list that can be compared to lists from other saltmarshes around the State.

Results and Discussion

List of vascular plants

The list consists of 132 species (not counting subspecies in some cases) from 34 families (presented in Appendix 2). Of the 132 species, 76 (58%) are dicots and 56 (42%) monocots. The saltmarsh dicots are made up of 26 families compared to 8 families of saltmarsh monocots. The largest family of dicots is the Chenopodiaceae with 15 species, including the dominant and widespread *Sarcocornia* spp. and *Tecticornia arbuscula*. The largest monocot family is the Poaceae with 25 species. There are 14 species (11%) that are listed as rare under the Tasmanian *Threatened Species Protection Act 1995* (accessed 2014). Of these, 10 species were dicots and 4 monocots. Only two taxa were endemic to Tasmania, namely *Limonium australe* var. *baudinii* and *Puccinellia harcusiana*. The list also includes 32 introduced (non-native) species (24%), of which 19 are dicots and 13 monocots.

Habitat occupancy coding

There were 21 obligate species (16%) and 18 common species (14%), with the majority of the rest being either occasional (23%) or uncommon (45%) in saltmarsh (Figure 2). Two species were assigned to the terrestrial class and are almost always found upland to saltmarsh.

The obligate species (Code: Obl.) include taxa that are invariably restricted to saltmarshes, such as *Wilsonia* spp. and *Limonium australe*, and taxa that also occur rarely in the coastal spray zone, such as *Sarcocornia* spp., *Suaeda australis*, *Selliera radicans*, *Lawrencia spicata* (e.g. Plate 1), *Juncus kraussii* and *Puccinellia stricta*. Common species (Code: Com.) include *Disphyma crassifolium* and *Austrostipa stipoides*, for example, found frequently in the coastal spray zone. The rare *Frankenia pauciflora* is identified as common due its occurrence on two saltmarsh islands in north-west Tasmania (Threatened Species Unit n.d.). The species is otherwise more common on the coastal spray zone (Harris *et al.* 2001). *Mimulus repens*, *Leptinella longipes, Lilaeopsis polyantha*, *Isolepis cernua*, *Triglochin striata* and *Apodasmia brownii* are examples of taxa common to saltmarsh but also occur frequently in coastal heaths, dunes or other wetland environments.

The occasional species (Code: Occ.) include *Tetragonia implexicoma*, *Rhagodia candolleana*, *Ficinia nodosa* and *Poa poiformis*, which are frequent in saltmarshes but are highly facultative and occur commonly

Table 2. Attributes collected as part of Atlas of Living Australia, Natural Values Atlas and Vegetation Condition Assessment protocols for recording of plant species occurrence.

Atlas of Living Australia	Natural Values Atlas	Vegetation Condition Assessment	Monitoring of the Plants of Tasmanian Saltmarsh Wetlands
Default attributes (no need to record them as part of the survey)			
Project Name/ Code	Project Name/ Code	-	Default: 'Saltmarsh Monitoring'
Basis of Record	Observation Type	-	Default: 'Field based observation'
Essential attributes (need to be recorded to complete the survey)			
Recorded By	Observer Names	Assessor	Name of the observer(s)
-	-	TASVEG Code	Either ARS or ASS (based on % abundance data for key species)
Scientific Name	Species Name	Species Name	Record scientific name (essential)
Common Name	-	Common Name	Record common name (if known)
Accuracy Rating	Data Accuracy	-	Indicate observation as 'doubtful' if unsure of species identification
Date	Observation Date	Date	Date and time of day of the survey/observation
Locality	Location Description	Location	Location details of the site (including any landmarks)
-	-	Site Name	Name of the site
Eastings and Northings	Eastings and Northings	Eastings and Northings	Eastings and Northings of the survey location

Table 2 continued

Atlas of Living Australia	**Natural Values Atlas**	**Vegetation Condition Assessment**	**Monitoring of the Plants of Tasmanian Saltmarsh Wetlands**
Optional attributes (can be recorded, though not essential to complete the survey)			
Error Margin (metres) in E, N	Position Accuracy	-	Could be noted in additional comments section
Individual Count	Individuals Count	-	Count of individual plants (only for listed species or important weeds)
-	Coverage Area	-	Coverage area in m^2 (only for listed species or important weeds)
-	Reproduction Status	-	Flowering status (if known)
Associated Media	-	-	Mention in additional comments section if photos were taken
-	Land Use	Current Land Use	Could be noted in additional comments section*
Additional Notes/ Comments	Observation Notes	Comments	Could be noted in additional comments section

*A separate survey process and checklist is available for recording human impacts on saltmarshes. In the present case of vegetation monitoring, a section has been included for recording weed species that need priority management.

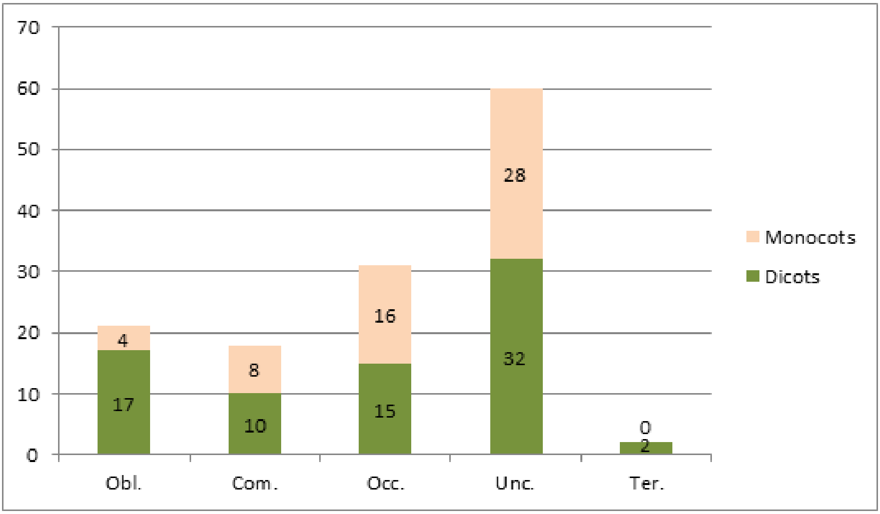

Figure 2. Distribution of the 132 plant species across the five classes (see Table 1 for class descriptions). Dicots and monocots were relatively equally represented for uncommon, occasional and common species. Monocots were poorly represented in obligate species.

in other coastal environments. *Melaleuca ericifolia* and *Phragmites australis* are also classed here as occasional species as they regularly occur in the ecotonal boundary between saltmarsh and nearby freshwater wetlands dominated by either of the these two species.

Uncommon species (Code: Unc.) made up the largest proportion (45%) of the five classes. Prominent examples are *Senecio pinnatifolius*, *Melaleuca gibbosa*, *Epilobium billardiereanum*, *Rumex brownii*, *Eleocharis acuta*, *Juncus pallidus*, *Leptocarpus tenax* and *Typha* spp. Uncommon species also notably include 18 of the 32 introduced taxa (56%), such as *Carpobrotus edulis*, *Euphorbia paralias*, *Hordeum marinum* and *Thinopyrum junceiforme*. Photographic material collected during various field visits showed isolated incidences of some native dicots such as *Acaena novae-zelandiae*, *Plantago* spp., *Sebaea ovata*, *Senecio* spp. and *Urtica incisa*. Similarly, introduced dicots such *Centaurium erythraea*, *Lotus corniculatus* and *Trifolium* spp. were also present in the photographic records. Several uncommon monocot species are also likely to have been overlooked largely due to the difficulty in identification.

Only two terrestrial species (Code: Ter.) have been included in this list, namely *Allocasuarina verticillata* and *Myoporum insulare*. These species almost always occur in other nearby upland habitats and on rare occasions, are either on the upland margins of saltmarsh as part of successional change or on small mounds in the marsh. There are also a number of predominantly terrestrial weeds that do sometimes occur within saltmarsh, such as, *Chrysanthemoides monilifera*, *Cortaderia* spp., *Erica lusitanica*, *Lycium ferocissimum*, *Pinus radiata*, *Rosa rubiginosa*, *Rubus fruticosus* and *Ulex europaeus* (VP pers. obs.). These species are omitted from the list, but included in an optional section of the saltmarsh plants monitoring survey for priority weed management.

Monitoring attributes

The attributes selected for monitoring include both essential and optional details (see Table 2). The essential attributes include the location of the saltmarsh (site name, landmarks etc.), Eastings and Northings of the survey location, name of the recorder(s) and/or group involved (e.g. Conservation Volunteers Australia), date and time of day of field observations, scientific and common name of the plants recorded and the accuracy of plant species identification (i.e. a confirmed record or doubtful?). For plants that are listed as 'rare' under State legislation, further (optional) details can be noted, including: number of plants/individuals and/or area occupied (in m^2). Additional (optional) notes, including flowering status, can be entered for all records, as necessary. Apart from generating species lists, the survey can also include data on species composition by recording % abundance of the structurally dominant plant species and use these data to assign a vegetation community type (either ARS or ASS) to the survey area. The key marker species for ARS community type

Plate 1. *Lawrencia spicata* seen well established (>1.5 m high) on a coastal spray zone microhabitat in the north-east corner of Flinders Island (north of Holloway Point).

include *Juncus kraussii*, *Gahnia filum* and *Austrostipa stipoides*. The marker species for the ASS community type include *Sarcocornia* spp. and *Tecticornia arbuscula*. Either ARS or ASS community type is assigned to a saltmarsh area based on the vegetation type that occupies greater than 50% of the area.

Another optional attribute included in the survey relates to invasive species of plants. A separate optional section is allocated to record the presence and % abundance of *Spartina anglica*, considered to be the most deleterious weed in the context of Tasmanian saltmarshes (Mount *et al.* 2010). Other prominent weed species can also be recorded (species listed in previous section) and would help direct management. For example, the local community group Wildcare Deslacs has identified *Erica lusitanica* as their high priority weed for managing the natural values of the Pipe Clay Lagoon saltmarshes, in south-east Tasmania (Prahalad 2016).

Future work and plants monitoring

The list of vascular plants of Tasmanian saltmarsh wetlands presented in Appendix 2 and their preliminary expert-evidence based ranking are a starting point for refinement with the collection of further data of plant distribution in the State. Existing databases such as NVA and ALA have served a limited purpose in systematically collecting plant distribution data specific to saltmarshes. The scheme proposed here for the State-wide monitoring of saltmarsh plants aims to fill in an important gap in enriching data via site-specific species lists and extending the spatial coverage across Tasmania. The monitoring process aims to involve a broader cross-section of the community, such as Field Naturalists club members, Threatened Plants Tasmania members and volunteers, University of Tasmania staff and students, and other trained volunteers, through citizen science (Cohn 2008), to provide increased capacity for field data collection for improved management outcomes.

Generic site-specific species lists can be used as an important starting point for monitoring the plants of particular saltmarsh sites by recording the plant species present. This could be done through a dedicated survey conducted in specific saltmarsh sites during the flowering season (for easy species level identification), or be linked with citizen science activities such as the BioBlitzes (e.g. Extinction Matters Bioblitz 2016). Species data collected will help improve our understanding of the State-wide distribution of saltmarsh plants, their ecology and biogeography (relating distribution data to local and regional environmental factors), and management needs (Saintilan 2009c). When these data are collected over decadal scales, it can also indicate any species-range shifts that occur as a consequence of climate change. Collected data could also be curated and transferred into ALA and NVA portals, allowing for multiple uses for the same data.

Data collection could follow one of three following methods (cf. Prahalad *et* *al*. 2015b). A *Tasmanian Saltmarsh Wetland Plants Checklist*, *Saltmarsh App* and a *User Guide to Entering Plant Data into the Saltmarsh App* have been designed to assist in data collection and are available through NRM North (2017), NRM South (2016) and the authors. The data collected through the *Saltmarsh App* can be visualised, analysed and downloaded as a datasheet through QGIS (http://www.qgis.org), a desktop geographic information system. Access is currently open to the senior author (VP) and is also the point of contact for any data requests from contributors, managers and researchers. It is envisaged that the data collected will be periodically curated and published in publically available reports and articles (e.g. Tamar Saltmarsh Monitoring Program 2016-18: Dykman and Prahalad 2018).

Area search

For saltmarsh sites under 2 ha, the entire site can be surveyed. Use the Checklist (and/or the App) to record observations of all vascular plant species present at the site. These data can be used as a measure of species richness for each saltmarsh site that is comparable across sites and also provides a basis for saltmarsh rehabilitation (Konisky *et al*. 2006, Saintilan 2009c). A TASVEG community type (either ASS or ARS) can then be assigned based on the % abundance of the key marker species (as noted in previous section).

For larger saltmarshes and those with low accessibility (e.g. with deep creeks and muddy sections), a 2 ha area can be selected for the survey (e.g. a rectangle of 100 x 200 m or a circle of 80 m radius). For large marshes (of > 5 ha), multiple 2 ha areas can be surveyed, allowing for a separation between two survey locations by a minimum of 300 m. Selection of total number and distribution of the 2 ha survey locations can done such that they are proportional to the extent of the marsh area (e.g. two 2 ha locations for sites between 5-10 ha) and the diversity in the vegetation types (e.g. a 2 ha survey location each in of the two TASVEG community types, if both are present in the site). The basis of recommending 2 ha survey areas is to link plant species richness/ abundance data with bird species richness/ abundance and behaviour data collected at the same location following the preferred '2-ha Search' method used by BirdLife Australia (BirdLife Australia n.d., Prahalad *et al*. 2015b).

Fixed-route monitoring

The fixed-route monitoring method is suitable for larger marshes where transect(s) in the form of fixed-route(s) marked by pickets/stakes or other landmarks (such as formed walking tracks, boardwalks) can be established (e.g. Plate 2). All plants encountered along the fixed-route are to be recorded. Any prominent weed species listed in the Checklist can also be noted. A TASVEG community type may or may not be assigned depending on the size of the marsh and the difficulty in determining % abundance scores for the key marker species.

The fixed-route survey could also be linked to a 1 x 1 m quadrat survey undertaken at regular 20-30 m intervals. In addition to presence/absence data, a

Plate 2. Henderson Lagoon saltmarsh (near Scamander on the east coast of Tasmania) has a clearly marked walking track with boardwalks suitable for recording all plant species encountered along the fixed-route.

quadrat survey can provide data on the percentage cover of each species (as a measure of relative abundance: Morgan and Short 2002), and indications of saltmarsh health using vegetation height and presence of any bare areas as proxies (Prahalad 2012). The quadrat survey can also be coupled with photo-point monitoring (Michel *et al.* 2010), by taking photographs of the quadrats and developing a temporal photo series for each quadrat/saltmarsh. A quadrat survey coupled with photo-point monitoring provides high resolution baseline data on saltmarsh plants and can be used especially to accompany saltmarsh restoration activities (Neckles *et al.* 2002). Although the transect-based quadrat survey is a commonly used survey method in saltmarsh vegetation monitoring, the method is labour, expertise and material intensive and may not be the preferred option for citizen science projects.

Incidental search

An incidental search method is suitable for one-off sightings of plants that do not follow one of the two methods discussed above. This method may be particularly suitable for rare species and other species of concern, whose distribution and abundance data (number of individual plants and/or area covered in m^2) is essential for species conservation and recovery efforts (e.g. Konisky *et al.* 2006).

Conclusion

Tasmanian saltmarsh wetlands are under increasing threat from both direct human impacts and global change factors. This threat is coupled with a decreasing capacity of managers to collect baseline data and monitor for changes. In the present paper we identify monitoring methods and a citizen science approach that could help mitigate these threats and lack of capacity by involving a broader cross-section of the community to develop a State-wide database to help inform saltmarsh conservation and rehabilitation. We also envisage that the engagement of these stakeholders/participants in monitoring will confer the benefits of science communication and place attachment usually attributed to such citizen science projects. An enhanced interest in and knowledge of saltmarsh plants and their habitat can therefore potentially help advance science and support nature conservation.

Acknowledgements

Thanks to Greg Jordan and Richard Schahinger for providing comments that helped in developing this paper. Thanks also to the two reviewers Mick Brown and Stephen Harris. The research was supported by funding assistance from Natural Resource Management North and Australian Government Research Training Program Scholarship. Natural Resource Management South helped fund the development of the *Saltmarsh App* by Esk Mapping & GIS.

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Appendix 1. Collation of existing lists of the vascular plants of Tasmanian saltmarsh wetlands

Kirkpatrick and Glasby 1981	Bridgewater, Rosser and de Corona 1981	Saintilan 2009a	TASVEG Version 1.0 by DPIPWE 2016	Dicot Key by Jordan *et al.* 2011
Dicots				
Aizoaceae				
Carpobrotus edulis	-	-	-	-
Carpobrotus rossii	*Carpobrotus rossii*	*Carpobrotus rossii*	*Carpobrotus rossii*	-
Disphyma blackii	*Disphyma clavellatum*	*Disphyma crassifolium*	*Disphyma crassifolium*	*Disphyma crassifolium*
Tetragonia implexicoma	-	-	-	-
Amaranthaceae				
Hemichroa pentandra	*Hemichroa pentandra*	*Hemichroa pentandra*	*Hemichroa pentandra*	*Hemichroa pentandra*
Apiaceae				
-	-	-	-	*Apium annuum*
Apium prostratum	*Apium prostratum*	*Apium prostratum*	*Apium prostratum*	-
-	-	-	*Centella cordifolia*	-
Eryngium vesiculosum	-	-	-	*Eryngium vesiculosum*
-	*Hydrocotyle capillaris*	-	-	-
Lilaeopsis brownii	-	*Lilaeopsis brownii*	-	*Lilaeopsis polyantha*
Asteraceae				
Angianthus preissianus (syn. *A. eriocephalus*)	*Angianthus preissianus*	*Angianthus preissianus*	-	*Angianthus preissianus*
Brachycome graminea	-	-	-	*Brachyscome graminea*
Centipeda minima	-	-	-	-
Cotula coronopifolia	*Cotula coronopifolia*	*Cotula coronopifolia*	-	*Cotula coronopifolia*

-	-	-	-	*Gnaphalium indutum*
Cotula longipes	-	-	-	-
Cotula reptans		*Cotula reptans*	-	-
-	-	*Cotula spicatum*	-	-
-	*Senecio lautus*	*Senecio lautus*	-	-
-	-	*Aster australasica*	-	-
-	-	*Aster subulatus*	-	-
Gnaphalium candidissimum	-	-	-	-
Campanulaceae				
Lobelia alata	-	*Lobelia alata*	-	*Lobelia anceps*
Pratia platycalyx	-	-	-	*Lobelia irrigua*
Caryophyllaceae				
Spergularia media	*Spergularia media*	*Spergularia media*	-	*Spergularia tasmanica*
Chenopodiaceae				
-	-	-	-	*Atriplex australasica*
Atriplex cinerea	*Atriplex cinerea*	*Atriplex cinerea*	*Atriplex cinerea*	*Atriplex cinerea*
Atriplex paludosa	*Atriplex paludosa*	*Atriplex padulosa*	-	*Atriplex paludosa*
Atriplex hastata	*Atriplex hastata*	-	-	*Atriplex prostrata*
-	-	*Atriplex semibaccata*	-	-
Chenopodium glaucum ssp. *ambiguum*	-	*Chenopodium glaucum*	-	*Chenopodium glaucum*
-	*Maireana oppositifolia*	-	-	-
Rhagodia baccata	*Rhagodia baccata*	*Rhagodia baccata*	*Rhagodia candolleana*	*Rhagodia candolleana*
-	*Salsola kali*	-	-	-
Salicornia blackiana	*Salicornia blackiana*	*Sarcocornia blackiana*	*Sarcocornia blackiana*	*Sarcocornia blackiana*

Salicornia quinqueflora	*Salicornia quinqueflora*	*Sarcocornia quinqueflora*	*Sarcocornia quinqueflora*	*Sarcocornia quinqueflora*
Suaeda australis	*Suaeda australis*	*Suaeda australis*	*Suaeda australis*	*Suaeda australis*
-	-	-	-	-
Arthrocnemum arbuscula	*Arthrocnemum arbusculum*	*Tecticornia arbuscula*	*Sclerostegia arbuscula*	*Tecticornia arbuscula*
-	*Arthrocnemum bidens*	-	-	-
-	*Arthrocnemum halocnemoides*	*Tecticornia halocnemoides*	-	-
Convolvulaceae				
Wilsonia backhousei	*Wilsonia backhousei*	*Wilsonia backhousei*	*Wilsonia backhousei*	*Wilsonia backhousei*
Wilsonia humilis	*Wilsonia humilis*	*Wilsonia humilis*	*Wilsonia humilis*	*Wilsonia humilis*
Wilsonia rotundifolia	*Wilsonia rotundifolia*	*Wilsonia rotundifolia*	*Wilsonia rotundifolia*	*Wilsonia rotundifolia*
Cuscutaceae				
Cuscuta tasmanica	-	-	-	*Cuscuta tasmanica*
Fabaceae				
-	-	*Lotus australis*	-	-
Frankeniaceae				
-	*Frankenia pauciflora*	*Frankenia pauciflora*	-	*Frankenia pauciflora*
Gentianaceae				
-	*Centaurium pulchellum*	-	-	-
-	*Centaurium spicatum*	-	-	-
Sebaea albidiflora	*Sebaea albidiflora*	-	-	*Sebaea albidiflora*
Goodeniaceae				
Selliera radicans	*Selliera radicans*	*Selliera radicans*	*Selliera radicans*	*Selliera radicans*
Malvaceae				
Lawrencia spicata	*Lawrencia spicata*	*Lawrencia spicata*	-	*Lawrencia spicata*

-	-	-	-	*Lawrencia squamata*
Myoporaceae				
-	-	*Myoporum insulare*	-	-
Plantaginaceae				
Plantago coronopus	*Plantago coronopus*	*Plantago coronopus*	-	-
Plumbaginaceae				
Limonium australe	*Limonium australe*	*Limonium australe*	*Limonium australe*	*Limonium australe*
-	-	-	-	*Limonium baudinii*
Polygonacea				
Rumex brownii	-	-	-	-
Portulacaceae				
-	-	*Portulaca oleracea*	-	-
Primulaceae				
-	*Samolus junceus*	-	-	-
Samolus repens	*Samolus repens*	*Samolus repens*	*Samolus repens*	*Samolus repens*
Rubiaceae				
Nertera depressa	-	-	-	-
Scrophulariaceae				
Mimulus repens	-	*Mimulus repens*	*Mimulus repens*	*Mimulus repens*
Monocots				
Centrolepidaceae				
-	*Centrolepis polygyna*	*Centrolepis polygyna*	*Centrolepis* spp.	-
Cyperaceae				
-	-	*Baumea acuta*	-	-
-	-	-	*Baumea arthrophylla*	-
Baumea juncea	*Baumea juncea*	*Baumea juncea*	*Baumea juncea*	-
-	*Scirpus maritimus*	-	-	
-	-	-	*Carex appressa*	-
Eleocharis acuta	-	-	-	-
Scirpus nodosus	*Scirpus nodosus*	*Isolepis nodosa* (syn. *S. nodosus*)	*Isolepis nodosa*	-

-	*Scirpus marginatus*	-	-	
Gahnia filum	*Gahnia filum*	*Gahnia filum*	*Gahnia filum*	-
Gahnia trifida	-	-	*Gahnia trifida*	-
Scirpus cernuus	-	*Isolepis cernua*	*Isolepis cernua*	-
Scirpus inundatus	-	-	-	-
-	-	-	*Isolepis platycarpa*	-
Scirpus pungens	-	-	-	-
Schoenus nitens	*Schoenus nitens*	*Schoenus nitens*	*Schoenus nitens*	-
Juncaceae				
-	-	*Juncus bufonius*	-	-
Juncus kraussii	*Juncus kraussii*	*Juncus kraussii*	*Juncus kraussii*	-
Juncus pallidus	-	-	-	-
Juncus planifolius	-	-	-	-
Juncus revolutus	*Juncus revolutus*	-	-	-
Juncaginaceae				
Triglochin minutissima	-	*Triglochin minutissima*	-	*Triglochin minutissima*
-	*Triglochin mucronata*	-	-	*Triglochin mucronata*
Triglochin centrocarpa	*Triglochin centrocarpa*	-	-	-
Triglochin striata	-	*Triglochin striata*	*Triglochin striatum*	-
Poaceae				
Agrostis stolonifera	-	-	-	-
Stipa stipoides	*Stipa stipoides*	*Austrostipa stipoides*	*Austrostipa stipoides*	-
-	-	*Cynodon dactylon*	-	-
-	-	-	-	*Deschampsia cespitosa*
Distichlis distichophylla	*Distichlis distichophylla*	*Distichlis distichophylla*	*Distichlis distichophylla*	-
Festuca arundinacea	-	-	-	-
-	*Monerma cylindrica*	*Hainardia cylindrical*	-	-
-	*Hordeum geniculatum*	-	-	-
Agrostis aemula	-	-	-	-

Agrostis billardieri	*Agrostis billardieri*	*Lachnagrostis billardieri*	-	-
Agrostis avenacea	-	-	-	-
Parapholis incurva	*Parapholis incurva*		-	*Parapholis* spp.
-	-	*Phragmites australis*	*Phragmites australis*	-
Poa annua	-	-	-	-
Poa labillardieri	-	-	-	-
Poa poiformis	-	-	*Poa poiformis*	-
Polypogon monspeliensis	*Polypogon monspeliensis*	*Polypogon monspeliensis*	-	-
-	-	-	-	*Puccinellia* spp.
Puccinellia stricta	*Puccinellia stricta*	*Puccinelliia stricta*	*Puccinellia stricta*	*Puccinellia* spp.
Spartina townsendii	*Spartina townsendii*	*Spartina anglica*	-	*Spartina anglica*
-	*Sporobolus virginicus*	*Sporobolus virginicus*	-	-
Vulpia megalura	-	-	-	-
-	-	*Zoysia macrantha*	*Zoysia macrantha*	-
Zoysia matrella	-	*Zoysia matrella*	-	-
Restionaceae				
Leptocarpus brownii	*Leptocarpus brownii*	*Leptocarpus brownii*	*Apodasmia brownii*	-
-	-	-	*Leptocarpus tenax*	-
Ruppiaceae				
-	*Ruppia maritima*	-	-	-

Appendix 2. An updated list of the vascular plants of Tasmanian saltmarsh wetlands

Scientific names as per de Salas and Baker, 2014 (i - introduced; r - rare; e - endemic)	Common names as per Wapstra et al., 2010	Book Page No. cf. Prahalad, 2014a	Plant Code (see Table 1 for details of codes used)
Dicots			
Aizoaceae	**Pigface Family**		
Carpobrotus edulis [i]	yellow pigface	-	Unc.i
Carpobrotus rossii	native pigface	p. 16	Occ.n
Disphyma crassifolium subsp. *clavellatum*	roundleaf pigface	p. 17	Com.n
Tetragonia implexicoma	bower spinach	p. 18	Occ.n
Tetragonia tetragonioides	new zealand spinach	-	Unc.n
Amaranthaceae	**Amaranth Family**		
Hemichroa pentandra	trailing saltstar	p. 19	Obl.n
Apiaceae	**Celery Family**		
Apium annuum	annual sea-celery	-	Unc.n
Apium prostratum subsp. *prostratum* var. *prostratum*	creeping sea-celery	p. 20	Com.n
Centella cordifolia	swampwort	-	Unc.n
Eryngium vesiculosum	prickfoot	p. 21	Occ.n
Hydrocotyle capillaris	thread pennywort	-	Unc.n
Hydrocotyle muscosa	mossy pennywort	-	Unc.n
Lilaeopsis polyantha	jointed swampstalks	p. 21	Com.n
Asteraceae	**Daisy Family**		
Angianthus preissianus	salt cupflower	p. 22	Com.n
Brachyscome graminea	grass daisy	p. 22	Occ.n
Centipeda elatinoides	spreading sneezeweed	-	Unc.n
Cotula coronopifolia [i]	water buttons	p. 23	Com.i
Cotula vulgaris var. *australasica* [r]	slender buttons	-	Unc.n
Gnaphalium indutum subsp. *indutum*	tiny cottonleaf	-	Unc.n

Leontodon saxatilis	hairy hawkbit	-	Unc.i
Leptinella longipes	coast buttons	p. 24	Com.n
Leptinella reptans	creeping buttons	-	Unc.n
Nablonium calyceroides	spiny everlasting	-	Unc.n
Senecio elegans	purple groundsel	-	Unc.i
Senecio pinnatifolius var. *pinnatifolius*	common coast groundsel	p. 25	Unc.n
Symphyotrichum subulatum	asterweed	-	Unc.i
Vellereophyton dealbatum	white cudweed	p. 25	Occ.i
Campanulaceae	Bellflower Family		
Lobelia anceps	angled lobelia	p. 26	Com.n
Lobelia irrigua	salt pratia	p. 26	Occ.n
Caryophyllaceae	Starwort Family		
Spergularia bocconei	lesser sandspurrey	-	Occ.i
Spergularia marina	lesser seaspurrey	-	Occ.i
Spergularia rubra [i]	greater sandspurrey	-	Occ.i
Spergularia tasmanica	greater seaspurrey	p. 27	Obl.n
Casuarinaceae	**Sheoak Family**		
Allocasuarina verticillata	drooping sheoak	-	Ter.n
Chenopodiaceae	**Goosefoot Family**		
Atriplex australasica	southern saltbush	-	Unc.i?
Atriplex cinerea	grey saltbush	p. 28	Occ.n
Atriplex paludosa subsp. *paludosa*	marsh saltbush	p. 29	Obl.n
Atriplex prostrata	creeping orache	p. 30	Com.i
Atriplex semibaccata	berry saltbush	-	Unc.i
Atriplex suberecta[r]	sprawling saltbush	-	Unc.n
Chenopodium glaucum	pale goosefoot	p. 31	Occ.i?
Rhagodia candolleana subsp. *candolleana*	coastal saltbush	p. 31	Occ.n
Salsola australis	prickly saltwort	-	Unc.n
Sarcocornia blackiana	thickhead glasswort	p. 32	Obl.n
Sarcocornia quinqueflora subsp. *quinqueflora*	beaded glasswort	p. 33	Obl.n
Suaeda australis	southern seablite	p. 34	Obl.n

Suaeda maritima subsp. *maritima* [i]	annual seablite	-	Unc.i
Tecticornia arbuscula	shrubby glasswort	p. 35	Obl.n
Threlkeldia diffusa	coast bonefruit	-	Unc.n
Convolvulaceae	**Bindweed Family**		
Wilsonia backhousei	narrowleaf wilsonia	p. 36	Obl.n
Wilsonia humilis [r]	silky wilsonia	p. 37	Obl.n
Wilsonia rotundifolia [r]	roundleaf wilsonia	p. 38	Obl.n
Cuscutaceae	**Dodder Family**		
Cuscuta tasmanica [r]	golden dodder	p. 39	Obl.n
Euphorbiaceae	**Spurge Family**		
Euphorbia paralias [i]	sea spurge	p. 40	Unc.i
Fabaceae	**Pea Family**		
Lotus australis [r]	australian trefoil	-	Unc.n
Frankeniaceae	**Seaheath Family**		
Frankenia pauciflora var. *gunnii* [r]	southern seaheath	p. 41	Com.n
Gentianaceae	**Gentian Family**		
Centaurium tenuiflorum [i]	slender centaury	-	Unc.i
Schenkia australis [r]	spike centaury	-	Unc.n
Sebaea albidiflora	white sebaea	p. 41	Occ.n
Goodeniaceae	**Native-primrose Family**		
Scaevola hookeri	creeping fanflower	p. 42	Unc.n
Selliera radicans	shiny swampmat	p. 43	Obl.n
Malvaceae	**Mallow Family**		
Lawrencia spicata	*candle saltmallow*	p. 44	Obl.n
Lawrencia squamata [i?]	*thorny saltmallow*	-	Obl.i?
Myoporaceae	**Boobialla Family**		
Myoporum insulare	*common boobialla*	-	Ter.n
Myrtaceae	**Myrtle Family**		
Melaleuca ericifolia	coast paperbark	p. 45	Unc.n
Melaleuca gibbosa	slender honeymyrtle	-	Unc.n

Onagraceae	**Willowherb Family**		
Epilobium billardiereanum subsp. *billardiereanum*	robust willowherb	p. 46	Unc.n
Plantaginaceae	**Plantain Family**		
Plantago coronopus subsp. *coronopus*	slender buckshorn plantain	p. 47	Occ.i
Plumbaginaceae	**Leadwort Family**		
Limonium australe var. *australer*	yellow sea-lavender	p. 48	Obl.n
Limonium australe var. *baudinii*	tasmanian sea-lavender	-	Obl.e
Polygonacea	**Dock Family**		
Rumex brownii	slender dock	-	Unc.n
Rumex crispus	curled dock	-	Unc.i
Portulacaceae	**Purslane Family**		
Portulaca oleracea	common purslane	-	Unc.n
Primulaceae	**Primrose Family**		
Samolus repens var. *repens*	creeping brookweed	p. 49	Obl.n
Rubiaceae	**Madder Family**		
Nertera granadensis	orange cushionbeads	-	Unc.n
Scrophulariaceae	**Snapdragon Family**		
Mimulus repens	creeping monkeyflower	p. 50	Com.n
Monocots			
Centrolepidaceae	**Bristlewort Family**		
Centrolepis polygyna	wiry bristlewort	p. 54	Occ.n
Cyperaceae	**Sedge Family**		
Baumea acuta	pale twigsedge	-	Unc.n
Baumea arthrophylla	fine twigsedge	-	Unc.n
Baumea juncea	bare twigsedge	p. 54	Occ.n
Bolboschoenus caldwellii	sea clubsedge	-	Unc.n
Carex appressa	tall sedge	-	Unc.n
Eleocharis acuta	common spikesedge	p. 55	Unc.n
Ficinia nodosa	knobby clubsedge	p. 55	Occ.n
Gahnia filum	chaffy sawsedge	p. 56	Com.n

Gahnia trifida	coast sawsedge	-	Occ.n
Isolepis cernua	nodding clubsedge	p. 57	Com.n
Isolepis inundata	swamp clubsedge	-	Unc.n
Isolepis platycarpa	flatfruit clubsedge	-	Unc.n
Schoenoplectus pungens	sharp clubsedge	p. 57	Occ.n
Schoenus nitens	shiny bogsedge	p. 58	Com.n
Juncaceae	**Rush Family**		
Juncus acutus [i]	sharp rush	p. 58	Occ.i
Juncus bufonius	toad rush	-	Unc.n
Juncus kraussii subsp. *australiensis*	sea rush	p. 59	Obl.n
Juncus pallidus	pale rush	-	Unc.n
Juncus planifolius	broadleaf rush	-	Unc.n
Juncus revolutus	creeping rush	-	Unc.n
Juncaginaceae	**Water-ribbon Family**		
Triglochin minutissimar	tiny arrowgrass	-	Unc.n
Triglochin mucronatar	prickly arrowgrass	-	Unc.n
Triglochin nana	dwarf arrowgrass	-	Unc.n
Triglochin striata	streaked arrowgrass	p. 60	Com.n
Poaceae	**Grass Family**		
Agrostis stolonifera [i]	creeping bent	-	Unc.i
Austrostipa stipoides	coast speargrass	p. 61	Com.n
Cynodon dactylon var. *dactylon* [i]	couchgrass	-	Occ.i
Deschampsia cespitosa	tufted hairgrass	p. 62	Occ.n
Distichlis distichophylla	australian saltgrass	p. 63	Com.n
Festuca arundinacea [i]	tall fescue	p. 64	Occ.i
Hainardia cylindrica [i]	thintail barbgrass	-	Unc.i
Hordeum marinum [i]	sea barleygrass	-	Unc.i
Lachnagrostis aemula	tumbling blowngrass	-	Unc.n
Lachnagrostis billardierei subsp. *billardierei*	coast blowngrass	p. 65	Occ.n
Lachnagrostis filiformis	common blowngrass	-	Unc.n
Parapholis incurva	coast barbgrass	p. 65	Occ.i
Phragmites australis	southern reed	p. 66	Occ.n

Poa annua	winter grass	-	Unc.i
Poa labillardieri var. *labillardieri*	silver tussockgrass	p. 67	Occ.n
Poa poiformis var. *poiformis*	coastal tussockgrass	-	Occ.n
Polypogon monspeliensis	annual beardgrass	p. 67	Occ.i
Puccinellia harcusianae	island saltmarshgrass	-	Obl.e
Puccinellia stricta	australian saltmarshgrass	p. 68	Obl.n
Spartina anglica	common cordgrass	p. 69	Obl.i
Sporobolus virginicus [r]	salt couch	p. 70	Com.n
Thinopyrum junceiforme	sea wheatgrass	-	Unc.i
Vulpia fasciculata	dune fescue	-	Unc.i
Vulpia myuros	foxtail or ratstail fescue (depending on respective forma)	-	Unc.i
Zoysia macrantha subsp. *walshii*	prickly couch	p. 71	Occ.n
Restionaceae	**Cord-rush Family**		
Apodasmia brownii	coarse twinerush	p. 72	Com.n
Leptocarpus tenax	slender twinerush	-	Unc.n
Ruppiaceae	**Sea-tassel Family**		
Ruppia polycarpa	manyfruit seatassel	-	Unc.n
Typhaceae	**Cumbungi Family**		
Typha domingensis	slender cumbungi	p. 73	Unc.n
Typha latifolia	great reedmace	-	Unc.i
Typha orientalis	broadleaf cumbungi	-	Unc.n

A new eucalypt host plant and ecological notes for adult green and gold stag beetle *Lamprima aurata* (Scarabaeoidea: Lucanidae) in North West Tasmania

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Introduction

The *Lamprima* stag beetles have a very complex taxonomic history with > 30 synonyms in use across the genus at various times. This history is explained by poor taxonomy which typically focussed on variation in trivial features such as colour, size, body proportions and surface sculpture (Reid, *et al*. 2018). A recent taxonomic revision of *Lamprima* recognises five species: one in New Guinea (*L. adolphinae* Gestro, 1875), two on isolated western Pacific islands (*L. aenea* Fabricius, 1792: Norfolk Island; *L. insularis* W.J.Macleay, 1885: Lord Howe Island), one in north eastern New South Wales (*L. imberbis* Carter, 1926) and a common widespread species in eastern and southern Australia (*L. aurata* Latreille, 1817) (Reid, *et* a*l* 2018). *Lamprima aurata* is widespread in coastal and near coastal mainland Australia from Cooktown in northern Queensland to the southern coast of Victoria and west from the Lakes Entrance, Victoria to Geraldton in Western Australia (Reid, *et* a*l* 2018).*Lamprima aurata* is common and widespread in eastern and coastal Tasmania including the larger Bass Strait islands (Fearn 1996; Reid, *et* a*l* 2018).

Life histories and ecology appear to be analogous for those species for which field data have been collected (*L. aurata*, *L. insularis*, *L. adolphinae*) with larvae infesting decomposing timber, typically subterranean root systems and stumps in the cooler and drier parts of the range in the south and tablelands, and logs and dead standing trees in the more humid portions of the range in the tropics (Reid, *et* a*l* 2018; Hangay & de Keyzer 2017; Fearn 1996; Suzuki 1995).

Species in the genus are strongly dimorphic with males typically having longer limbs, larger bodies and well-developed mandibles in comparison to females (Plate 1). These dimorphic traits are common in lucanids around the world (Goyens *et al*. 2015). Larger male size and mandibular length appears to be driven by competition for food resources and females (Emlen & Nijhout 2000; Fearn 1996, 2016; Goyens *et al*. 2015). Males will fight over a prime shoot-tip, and typically the largest male will win and defend it. The adults feed on the sugary liquids that a plant produces when a shoot-tip is cut off. Males use their enlarged mandibles to make this cut, and then the flow of sap is maintained by the feeding male. It appears to be the scent of the sap that attracts females to the location of the males which facilitates mating (Fearn 1996, 2015, 2016, 2017; Suzuki 1995).

Tasmanian *L. aurata* are the only members of the genus for which adult food plants are well documented. Congregations of both sexes and mating pairs have been collected on the native grass *Lomandra longifolia* (Fearn 1996), native vine *Clematis decipiens* (Fearn 2017), coast everlasting *Ozothamnus turbinatus* (Fearn 2016), drooping she-oak *Allocasuarina verticillata* (Fearn 2017), gum trees *Eucalyptus globulus*, *E. viminalis* and *E. ovata* (Fearn 1996), ornamental apricot *Prunus armeniaca* (Fearn 2015) and red leaf photinia *Photinia* sp. (Fearn 1996).

All eucalypt species previously recorded as adult host plants in Tasmania are closely related smooth barked taxa. In this work we document the first record of a feeding aggregation on a 'stringy-barked' eucalypt, the giant ash, *Eucalyptus regnans*.

Field observations

During entomological fieldwork in north western Tasmania on the 21 January 2018 a large aggregation of adult *L. aurata* was discovered in a logging coup off Tayatea Road, Trowutta (GDA 94: 0344663mE 5453209mN). The site was clear-felled and burnt about two years previously, and had extensive natural regrowth of a wide variety of native

Plate 1. Mating pair of *Lamprima aurata* on *Eucalyptus regnans* at Trowutta, north west Tasmania. Note severed shoot tip with sap exuding from tip, larger male body, limb and mandible size and purple colouration of this population. Photograph: David Maynard.

trees and shrubs. Of particular note were the large numbers of *Eucalyptus regnans* saplings ranging from 0.6-4 m high. Adult *L. aurata* appeared to be attracted to specific saplings within a stand, with as many as 12 beetles on a single sapling. The beetles were present as single males or mating pairs (Plate 2), and they were observed feeding by lapping up sap from the cut shoot tips (Plate1). Twenty nine males and seven females were collected as vouchers from an area roughly 200 m^2 of the approximately 14.5 ha site. These specimens were lodged in the entomology collection of the Queen Victoria Museum and Art Gallery (QVMAG) (QVM.2018.120100-0135).

Plate 2. Typical sapling *Eucalyptus regnans* at the Trowutta site containing mating aggregation of adult *Lamprima aurata*. Photograph: David Maynard.

Discussion

The appearance of *L. aurata* in a male-biased, localised aggregation is typical for Tasmanian populations, however the host plant, *Eucalyptus regnans,* has not been previously recorded.

There were four males for each female at this site; this skewed sex ratio probably drives competition between males for food, mating sites and females (Fearn 1996, 2016).

Our observations at the Trowutta site also further support the previously documented ability of *L. aurata* to rapidly exploit areas of anthropogenic disturbance (Fearn 1996). As previously stated, *Lamprima* larvae are saproxylic. Larval Tasmanian *L. aurata* live within the dead and decaying root systems and trunks of a wide variety of native and introduced trees and larger shrubs (Fearn 1996). In addition, timber in service that is in close contact with substrates wholly or partly buried (such as untreated fence posts) is often colonised. Larval infestations are typically associated with well drained sites exposed to solar radiation. Any land-clearing operations that do not include removal or destruction of stumps and logs can provide ideal conditions for *L. aurata*. It has been previously documented that forestry coups in particular can provide relatively enormous food resources for larvae and adults, especially in the early years of plantation establishment or succession before substrates are shaded out (Fearn, 1996).

In Tasmania, *L. aurata* has not been documented from undisturbed closed forest habitats (S. Fearn, unpublished data). Similar ecologies have been documented on Lord Howe Island for *L. insularis* which can form high larval densities in anthropogenically cut tree logs and palms in urban areas (Fearn, 2004; Reid, 2004). In north Queensland dense aggregations of adult *L. aurata* occur on *Alphotonia* sp. saplings growing among windrows after rainforest clearing (Moore, 1997) and in the highlands of New Guinea the apparently ecologically analogous *L. adolphinae* forms high population densities in rainforest clearings created by traditional slash and burn agriculture. Unburnt logs and stumps in these clearings are rapidly colonised by larvae and adults that congregate on a small shrub with composite flower heads that grow in profusion on recently burnt and cleared sites. Male *L. adolphinae* sever the flower heads promoting sap flow in the same way as Tasmanian *L. aurata* (Suzuki 1995).

Eucalyptus regnans (giant ash) is widespread and locally common in the higher rainfall districts of eastern and north west coastal Tasmania (Wiltshire & Potts 2007). However, it may not be a common food plant for *L. aurata* as it typically grows in closed, wet sclerophyll habitats that are apparently unsuitable for *L. aurata* larval development. Anthropogenic disturbance, severe storm damage or bushfire are probably the only way such forests could be utilised by *L. aurata* for a relatively brief period early in the successional cycle. Suggestions by Reid *et al.* (2018) that *L. aurata* is absent from western Tasmania probably reflect lack of collecting effort rather than true absence. In addition to the sample described in this work, specimens have also been collected from the Nut at Stanley, from Wiltshire and from Three Hummock Island, in western Bass Strait (S. Fearn & D. Maynard, unpublished data) In addition, much suitable coastal habitat occurs along the west Tasmanian coast as well as extensive anthropogenically disturbed habitats that could be colonised by *L. aurata.*

Finally, the Trowutta population is the only one found by the authors to date that does not appear to display a typical green/gold phenotype. All specimens collected or observed on the site were dark purple to blueish in colouration (Plate 1). In all other predominately purple-coloured populations documented by the senior author (see Fearn 2016), a proportion are nonetheless of the typical green-gold colouration. Tasmanian *L. aurata* display wide regional variations in colour but the reasons are as yet unclear (Fearn 2016).

Acknowledgements

Thanks to Alastair Richardson for reviewing the manuscript and Akari Koyama for translating a paper from the Japanese (Suzuki 1995).

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Recent finds of several species of heteropteran bugs (Hemiptera) not previously recorded from Tasmania

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As part of my recent insect-collecting efforts aimed at building the collections at the Tasmanian Museum & Art Gallery (TMAG), I have encountered quite a range of noteworthy species across a wide range of insect Orders. Some of these apparently represent undescribed species, while others are not listed in the catalogue of Semmens *et al.* (1992) and appear, on the basis of my enquiries, to be new records for Tasmania of species otherwise only recorded elsewhere in Australia. I have had particular success with finding species of 'true' bugs (Hemiptera: Heteroptera) that have one or other of these noteworthy traits; since heteropteran bugs as a group are relatively poorly known in Tasmania, I thought that I would document these finds here. I have also taken the opportunity to present photos of some of the specimens collected, putting to good use the specialised photographic and image-processing hardware and software that we have recently acquired at TMAG. I was helped in my identifications by Australia's leading taxonomic experts on these bugs, Professor Gerry Cassis (University of New South Wales) and Dr Lionel Hill (Tasmanian DPIPWE). I also checked with Simon Fearn (Queen Victoria Museum & Art Gallery) as to whether there were any specimens of these species in that museum's collections.

In the notes that follow, the 'TMAG' numbers (prefixed with an 'F') are registration numbers of specimens now held in the TMAG collections.

Pateena sp. nr. *polymitarior* Hill, 1980 (Dipsocoroidea: Schizopteridae) (Plate 1)

Schizopterid bugs in the subfamily that includes *Pateena* (Hypselomatinae) have forewings that are developed into elytra that completely cover the hind wings and abdomen, much as they would in a beetle. These tiny jumping bugs, only about a millimetre in length, are inhabitants of leaf-litter and tussock-grasses. The Australian members of the subfamily were the subject of taxonomic research and revision by Lionel Hill in the 1980s (Hill 1980, 1984, 1985). The four known Tasmanian species are primarily associated with the cooler, wetter and higher-altitude western parts of the state. It therefore came as a surprise to find four examples that had hopped into some yellow-pan traps that I had set on the ground among sparse *Poa* tussocks in dry, lowland *Callitris* – *Bursaria* scrubby woodland at Wind Song near Little Swanport in October 2017. I sent the specimens to Lionel Hill, who recognised them as members of the genus *Pateena*. Though they looked similar to *P. polymitarior* – a species found both in Tasmania and on the Australian mainland – he felt that the differences in the male genitalia, along with the dry, lowland collecting locality, together suggested that they represent a new, undescribed species.

Record details: Little Swanport: Wind Song: *Callitris* gulley, 42.3495 S x 147.9169 E, yellow-pan trap, 27 Oct 2017; TMAG: F47315, F47316, F47317, F47318.

Plate 1. *Pateena* sp nr *polymitarior*

Lestonia haustorifera China, 1955 (Pentatomoidea: Lestoniidae) (Plate 2)

Lestoniid bugs are only found in Australia. Originally considered as part of the largely Asian family Plataspidae (China 1955), they are now considered as a family in their own right, and sister group to the much more widespread Acanthosomatidae (Wu *et al.* 2016). They are strange-looking bugs which (at least in the case of *L. haustorifera*) attach themselves to the growing tips of *Callitris* shoots, on which they apparently feed (McDonald 1970). There are only two described species, both in the genus *Lestonia*; neither has previously been reported from Tasmania. All the more surprising, then, that I found a single nymph among insect specimens that I had swept from dry sclerophyll vegetation on private property on the hill behind Taroona in December 2016. The specimen was identified from its photo as *L. haustorifera* by Gerry Cassis, and is a good match for the description of this species provided in McDonald (1970). Then in September 2018 I beat an earlier-instar nymph from *Allocasuarina* foliage at the Peter Murrell Reserve, Blackmans Bay. To the best of my knowledge, notwithstanding a 1933 Rodway-collected specimen of *Callitris oblonga* from 'Blackmans Bay' now held by the National Herbarium of New South Wales (record visible on the Atlas of Living Australia), there is no extant *Callitris* within many kilometres of these localities, so the bug's presence here is a mystery. Gerry Cassis related to me that on the Australian mainland he sometimes finds *Lestonia* individuals on other plant species, particularly on shrubs such as *Allocasuarina* that have functionally similar foliage to *Callitris;*

Plate 2. *Lestonia haustorifera*

however he regards such observations as 'sitting records' rather than an indication of an additional host-plant.

Record details: Taroona: Vaughans Hillside, 42.9495 S x 147.3344 E, swept from dry sclerophyll vegetation, 31 Dec 2016; TMAG: F57772. Blackmans Bay: Peter Murrell Reserve, 42.9998 S x 147.2999 E, beaten from *Allocasuarina* foliage, 13 Sep 2018; TMAG: F94515.

Riptortus sp. (Coreoidea: Alydidae) (Plate 3)

Bugs in this genus are known as pod-sucking bugs. The genus is largely tropical Asian and Australian, and includes species that are pests of soya and other beans (e.g. Rahman & Lim 2017). One further member of the same family (*Mutusca brevicornis*) is known from Tasmania, where it is common in dry grassland. However, I am not aware of any previous Tasmanian records of *Riptortus*. My two specimens were both swept off wet heathland vegetation at the Peter Murrell Reserve, Blackmans Bay in October 2017. Gerry Cassis confirmed the generic identity from a series of photos, but was not able to assign them to any of the four described Australian species, commenting that there are multiple new species that await description in Australia, and furthermore that there is uncertainty about the identity of the described species. According to Simon Fearn, there are further putative specimens of Tasmanian *Riptortus* at QVMAG.

Record details: Peter Murrell Reserve, 43.0047 S x 147.3048 E, swept off wet heathland vegetation, 17 Oct 2017; TMAG: F46814, F46815.

Plate 3. *Riptortus* sp.

Plate 4. *Gonystus nasutus*

Plate 5. *Gonystus sp.*

Gonystus nasutus Stål, 1874 & *Gonystus* sp. (Lygaeoidea: Cryptorhamphidae) (Plates 4 & 5)

The small family Cryptorhamphidae comprises two genera of elongated bugs that are grass- and sedge-feeders. *Cryptorhamphus orbus* is not uncommon in dry grassland in Tasmania. There are only two described species of *Gonystus* (Hamid 1971), but to the best of my knowledge, neither is previously recorded from Tasmania. Using Hamid (1971), I identified as *G. nasutus* a series of specimens that I swept from *Gahnia grandis* along the Fern Tree walking-track at Ridgeway in February 2017. A further series that I swept from rank vegetation (including *Gahnia* sp.) at Five Mile Beach, near Hobart Airport, in January 2017, I could not identify to species since some of the characters on my specimens were not good matches for those of the two described species. While they could be local variants of *G. nasutus*, I am reluctant to assume that this is the case, since on discussing my finds with Gerry Cassis he related that he too has noted a lot of variation, suggesting that the genus warrants closer investigation to check for the existence of further, undescribed species.

Record details: (G. *nasutus*) Ridgeway: Fern Tree walking-track, 42.9229 S x 147.2803 E, swept from *Gahnia grandis,* 19 Feb 2017; TMAG: F57942 & F57943. (*Gonystus sp.)* Five Mile Beach hinterland, 42.8301 S x 147.5249 E, swept from *Gahnia sp.*, 5 Jan 2017; TMAG: F57938, F57939, F57940, F579410.

Plate 6. *Delacampius lateralis*

Delacampius lateralis (Walker, 1872) (Pyrrhocoridea: Largidae) (Plate 6)

The largids are plant-feeding bugs that in Australia comprise just four species in two genera. These bugs are strikingly marked with red and black, and so ought to be readily noticed; yet I am not aware of any previous Tasmanian records of any of these. I have now found *Delacampius lateralis* in two places in the southern part of the state: on a road through forest near Lucaston in December 2016; and at Taroona, where I have seen it at a couple of spots along the cliff path between Hinsby Beach and the Shot Tower – I collected a specimen from above Hinsby Beach in December 2016. I was not able to identify these bugs, but on posting a photo on iNaturalist I received a tentative identification from WongGun Kim; Gerry Cassis later corroborated the identification from this photo. According to Simon Fearn, there are further putative specimens of *D. lateralis* at QVMAG, collected from within rotting *Banksia marginata* logs at Bridport, and from under logs in open woodland at Supply River Reserve, West Tamar.

Record details: Lucaston: end of Bakers Creek Road, 42.9639 S x 147.0040 E, hand-collected off road, 26 Dec 2016; TMAG: F57933, F57934, F57935, F57936. Taroona: Hinsby steps, 42.9548 S x 147.3444 E, hand-collected off hand-rail, 4 Dec 2016; TMAG: F57937.

Acknowledgements

I thank Gerry Cassis and Lionel Hill for help with identifying these bugs and for explaining the taxonomic issues arising; and Simon Fearn for letting me know about the presence of further specimens of some of these species in the collections at QVMAG.

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New adult host plant and distributional data for the Slender Red Weevil *Rhinotia haemoptera* (Coleoptera: Belidae) in North West Tasmania

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Introduction

The Slender Red Weevil *Rhinotia haemoptera* (Kirby, 1819) (Plate 1) occurs in coastal and near coastal mesic woodland habitats in south eastern Australia from southern Queensland, NSW, Victoria to south east South Australia (Hawkeswood *et al.* 1994). Only two registered voucher specimens are known from Tasmania, both collected at Taroona, Hobart in 2016 and housed in the Tasmanian Museum and Art Gallery (TMAG) (Atlas of Living Australia (ALA, 2018a)). According to Hawkeswood *et. al.* (1994), *R. haemoptera* is considered rare to uncommon throughout its range. The status of the species in Tasmania is unknown with no literature records since it was first listed as occurring in the state by Lea (1906). Having collected coleoptera extensively in northern Tasmania for many years, the senior author suggests that encounter rates of *R. haemoptera* are low and discrete. Specimens may not be seen for years until localised, relatively dense concentrations of adults are opportunistically encountered during field work.

Rhinotia haemoptera is one of a suite of mimics of the highly chemically protected lycid beetle *Porrostoma rhipidium* (W. S. Macleay, 1826) (= *Metriorrhynchus rhipidius* in earlier literature) (Plate 2) which is also widespread in eastern Australia and Tasmania (ALA, 2018b). The slender red weevil has no chemical defences whatsoever (Moore & Brown 1989) and represents an example of Batesian mimicry in which palatable species are protected by resemblance to distasteful models.

Adult *R. haemoptera* are phyllophagous and live exclusively on Acacia (wattles). Oviposition, larval development and pupation occur in the stems of host plants (Hawkeswood *et al.* 1994).

In this work we document new locality records for *R. haemoptera*, previously unpublished host plant associations, and field observations that may aid in the detection of this somewhat cryptic species.

Plate 1. A pair of adult *Rhinotia haemoptera* feeding on the shoots of *Acacia mucronata* var. *mucronata* at Trowutta, north west Tasmania. Photograph: David Maynard

Field observations

During entomological fieldwork in north western Tasmania between 20/01 and 26 /01/ 2018, ten specimens of *R. haemoptera* were collected at four locations in western Tasmania (Plate 2) and these voucher specimens were lodged in the entomology collection of the Queen Victoria Museum and Art Gallery (QVMAG) (QVM.2018.12.0181-0190). These specimens were collected while they were actively feeding on shoot tips of *Acacia mucronata* Willd. ex H. L. Wendl var. *mucronata* (six specimens), *A. melanoxylon* R. Br. (three specimens) and *A. dealbata* Link (one specimen). All host plants were saplings, standing 1-2.4 m in height, and all were located at heavily anthropogenically disturbed sites of wet *Eucalyptus regnans* forest regrowth. Two of the sites were logging coups, one was a periodically slashed vegetation remnant at the junction of several roads and another was a native garden bed in the Corinna Township (Plate 3).

Plate 2. *Porrostoma rhipidium* (Lycidae) the chemically protected model for the Batesian mimic *Rhinotia haemoptera*. Photograph: David Maynard

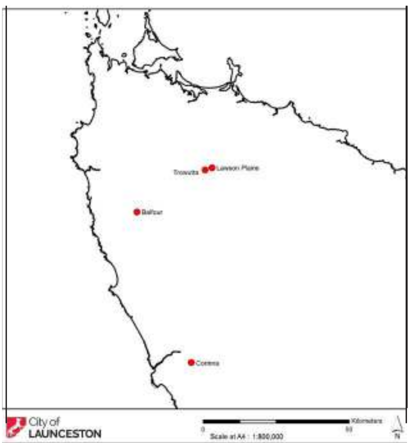

Plate 3. Collection localities of *Rhinotia haemoptera* in western Tasmania. Image: Kathryn Pugh

Discussion

None of the three host plants documented here have appeared in the literature. Previously six *Acacia* host plants were recorded in the literature and by direct observation in NSW (*A. decurrans*, *A. elongata*, *A. obtusifolia*, *A. pubescens*, *A. suaveolens*, and *A. terminalis*) (Hawkeswood *et al.* 1994). Tasmanian *R. haemoptera* have been previously collected on *A. melanoxylon* at Taroona, Hobart (S. Grove pers. comm.), on juvenile *A. dealbata* at Warra in southern Tasmania (C. Spencer pers. comm.) and on *A. melanoxylon* in the Liffey Valley, northern Tasmania where large numbers of *R. haemoptera* were attracted to a row of saplings planted as a wind break (S. Fearn unpublished data). *Rhinotia haemoptera* would appear to be relatively unselective in terms of host plant associations within the *Acacia* genus and future field work may well record them on additional host species.

During field work in the north west of Tasmania the authors were not specifically targeting *R. haemoptera* but given the frequency with which we encountered specimens at locations many kilometres apart, we suggest that at least at that period in time, the species was relatively common in the region. All four locations where specimens were collected were heavily anthropogenically disturbed and were characterised by extensive sapling regeneration of a wide range of native trees and shrubs. All ten specimens documented in this paper were located on the terminal shoots of host plants. Four of the collected specimens were pairs and while copulation was not observed, both pairs were feeding on the same shoot tip in very close proximity to each other (Plate 1). The beetles appeared to have a distinctive feeding pattern, eating into one side of shoot stems eventually causing the terminal 40-80 mm portion of the shoot to tip over at right angles to the remaining portion of the stem. This feature became a useful indicator of the presence of *R. haemoptera* on individual saplings. The Corrina specimen was discovered when shoot tips were observed hanging at right angles on several small specimens of *A. mucronata*. The trees were searched until the beetle was discovered.

Rhinotia haemoptera can probably be best described as a sparse species as defined by Rabinowvitz (1981) because it appears to occupy a large range in several habitats but in low populations. We suggest that the perceived rarity of *R. rhinotia* in Tasmania is probably related to a lack of suitable collection effort in core habitat. Anyone attempting to locate this species in field surveys should focus on disturbed habitats with extensive *Acacia* sapling regrowth, including periodically slashed road verge habitats. In addition, *R. haemoptera* appears to be attracted to discrete patches of juvenile *Acacia* planted in garden beds or as wind breaks.

Acknowledgements

Sincere thanks to Mark Wapstra for his ongoing assistance with botanical identifications. Thanks also to Simon Grove of TMAG and Chris Spencer for host plant association data, Kathryn Pugh Environmental Scientist, City of Launceston for preparing Plate 3 and Alastair Richardson for constructive comments on the manuscript.

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Aspects of the biology and habits of the broad-toothed stag beetle, *Lissotes latidens* (Westwood 1871) (Coleoptera: Lucanidae) an endemic Tasmanian species

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The Broad-toothed Stag Beetle, *Lissotes latidens* (Westwood, 1871) belongs to a large genus of flightless lucanid beetles confined to south-eastern Australia, containing 29 described species, 25 of which are endemic to Tasmania (Hangay & De Keyzer 2017). Many of the Tasmanian *Lissotes* spp. are range-restricted. One of these, *L. latidens,* occupies an area of about 437 km^2, bordered by Orford, Copping and Nugent in south-eastern Tasmania and also occurs within a 6 km^2 area on northern Maria Island. The species is listed as endangered on the *Threatened Species Protection Act 1995* due to its restricted distribution, low population density and habitat loss (Invertebrate Advisory Committee 1994).

In the original description of *L. latidens* by Westwood (1871), the male holotype specimen was reportedly one of five collected by Dr. Howitt, all of which were obtained from either "Maria Island" or "East coast Tasmania"; however, the exact locality for the holotype was unspecified. In contrast, the labels accompanying the image of the holotype male, which is housed in the Oxford Museum and depicted in Bartolozzi *et al.*. (2017), read "West coast of Tasmania", the second bears a less legible location but suggests "West coast". It appears there can be no doubt that Westwood (1871) and Bartolozzi *et al.* (2017) are referring to the same specimen, but while several *Lissotes* spp. are known from Tasmania's West Coast, none resemble *L. latidens.* This raises a question regarding the authenticity of the holotype labels.

This ground-dwelling species inhabits the understorey litter of wet forest, rainforest and dry forest types (Plate 1) within its distribution; although in the dry forests it is more often encountered in the riparian and damper regions (Meggs & Munks 2003). Previous studies have determined that *L. latidens* occurs in low densities across its range (Meggs & Munks 2003; Grove *et al.*. 2006; Richards *et al.*. 2006). New information on aspects of the life history of laboratory-reared *L. latidens*, along with field observations of naturally occurring specimens, is presented here.

The behaviour of captive-reared and

free ranging adult *L. latidens* indicates that the species prefers nocturnal/crepuscular activity, adults sheltering from daylight beneath dead wood, where, when disturbed, they were often observed to burrow into the substrate.

Plate 1. Wet forest *Lissotes latidens* habitat

Such digging behaviour was also noted by Meggs & Munks (2003) following release of specimens. Adult *L. latidens* are very efficient excavators spending a significant proportion of their time below ground. The extent of their tunnelling ability is evident from the recovery of female exoskeletal material at soil depths approaching 25 cm in otherwise undisturbed ground. Activity of adult *L. latidens* ceases over the cooler months, when both male and female beetles become immobile, either beneath coarse woody debris (CWD), or below the ground surface, where they enter a period of torpor. A general lack of active adults of other *Lissotes* spp. observed during the colder months indicates this behaviour may be common across the genus.

Mating of *L. latidens* was observed on two occasions, both in late December. In the first instance, a captive pair began copulating at 1700 hours and remained in copula for 45 minutes. Immediately post-copulation, a second male attempted to mate with the female; however, his advances were rejected. The second mating event was recorded at Mt Morrison; in this instance the pair was found in copula beneath CWD; consequently, the period of the coupling could not be verified.

The period of time between copulation and egg deposition in *L. latidens* remains uncertain; but the following observations were made of a captive female maintained at ambient air temperature. Three days post-copulation, an egg was observed on the base of the aquarium, at a soil depth of 5 cm. The female remained underground for much of the time, but the male was predominantly on the surface beneath wood. After a further 10 days the adults were removed and the substrate excavated, but no additional eggs were recovered, therefore, an accurate assessment of the species' fecundity remains in question. Yaxley (2013) reported seasonal variation in the reproductive development of two other *Lissotes* spp., *L. menalcas* (Westwood, 1855) and *L. cancroides* (Fabricius, 1787). Both species were found to be capable of producing multiple eggs throughout the year, peaking in summer. *Lissotes menalcas* produced up to 24 eggs during summer, so it is probable that *L. latidens* is also capable of producing multiple eggs.

The single *L. latidens* egg was spherical, 1.5 mm in diameter and pearly white with a moist sheen (Plate 2). At day 19 the chorion became translucent allowing the white larval shape with darker head

Plate 2. Excavated *Lissotes latidens* egg *in situ*

capsule to be visible; eclosion occurred on day 27. For a period of two days post-eclosion the larva remained visible through the aquarium base, where it was observed to be actively moving through the soil medium. On day 20, the larva was again detected, this time at the soil-wood interface, soil clearly evident in its gut confirming the edaphic habits of *L. latidens* larvae as suggested by Meggs & Munks (2003). At this stage the larva was 1 mm in diameter and 5 mm in length, active and appeared healthy.

The growth rate of *L. latidens* larvae is slow. Data collected from the rearing of several individuals of differing instars, as well as pre-pupae, confirm a larval term of up to two years, during which the larvae pass through three instars, as is the case for other lucanids (Harvey *et al.*. 2011; Hangay & De Keyzer 2017). *Lissotes latidens* larvae tend to be proportionally longer and thinner in comparison with those of the co-occurring *L. curvicornis* (Boisduval, 1835) and *L. obtusatus* (Westwood, 1838). Like the adults, *L. latidens* larvae are energetic tunnelers and captive specimens were periodically found to occupy the soil/wood interface, where, when exposed, they actively retreated into the substrate or beneath shelter to escape light. In the field, the association with CWD is borne out by the results of larval pit excavations conducted in the footprint of decaying logs, which yielded larvae, whereas similar surveys in open ground did not; pre-pupae also shared a similar affinity for the soil/wood interface.

The pre-pupal period varies; in captivity it commences in spring and lasts a minimum of 3 months. In the field, pre-pupae have been located between August and November. This developmental stage is recognisable by the change of body colour from translucent white to cheesy yellow. Pupation lasts approximately 4 weeks, in an underground cell moulded from soil and excrement. The cell wall is compacted by the incessant wriggling of the pre-pupa. This activity continues throughout pupation, which in captive animals began in late November and early December. *Lissotes latidens* pupae can be sexed by mandible size and shape, as well as the presence of external male genitalia (Plate 3), characters common to other *Lissotes* spp. (Spencer & Richards unpub. data).

Laboratory-reared *L. latidens* of both sexes eclosed in early January. Teneral adults were soft, of a light chestnut colour and remained underground for a period of 7-10 days, following which they emerged from the soil, fully hardened and black in appearance. As for other members of the *Lissotes* genus, adult males are identifiable using external features, specifically the mandibles, which in the case of *L. latidens*, have a distinctive "bull's horn" appearance (Plate 4). Most females of the genus are less easily differentiated as their external features are similar.

Adults of some lucanid genera, such as the European species *Lucanus cervus* (Linnaeus, 1758) and the Australian species *Lamprima aurata* (Latreille, 1817) and *Cacostomus squamosus* (Newman, 1840) are known to eat (Harvey *et al.*. 2011, Fearn 2017, Hangay & De Keyzer 2017). While a captive adult *Lissotes darlingtoni* (Benesh, 1943) has been recorded eating ripe nectarines (Hangay & De Keyzer 2017), no published

Plate 3: Male pupa, showing external aedeagus (inset).

Plate 4. Male *Lissotes latidens*

records of Tasmanian adult *Lissotes* ingesting food are available. While we have not observed this behaviour in *L. latidens,* in our Collinsvale garden we have on two occasions recorded male *L. obtusatus* eating: one burrowing into a carrot and another gorging on an overripe strawberry (Plate 5).

As most of our captive-reared specimens were released following maturation, the longevity of adult *L. latidens* is uncertain, but one retained male survived for 11 months. In the field *L. latidens* adults are often located beneath CWD in freshly excavated depressions of loose soil. One marked male was found to occupy such a site under a log offcut in a Eucalyptus plantation for over 400 days, indicating that at least some male specimens survive for more than one year.

Discussion

It was previously considered likely that the adults and larvae of *L. latidens* are soil dwellers, a conclusion drawn from the captive rearing of a single larval specimen by Dr P. McQuillan, as well as from observations of the behaviour of adults upon release (Meggs 1999). Our data on the feeding habits of multiple *L. latidens* larvae of all three instars, the exhumation of exoskeletal remains from considerable soil depths, as well as egg deposition beneath the soil surface, support the suggestion that this is a soil-dependent species.

Lissotes latidens seems to occur in low population densities, the data from several studies recording only low adult numbers at any location (Michaels & Bornemissza 1999; Meggs and Munks 2003; Grove *et al*.. 2006; Richards *et al*..

2006). In one study involving 64 sites, we reported the beetles to be sparsely distributed, locating only 14 live beetles and remains of 2 dead specimens from 9 of the survey sites (Richards *et al.*. 2006). In a more detailed study (Meggs & Munks 2003) encompassing 93 locations in which multiple survey methods were applied, *L. latidens* were recovered in a greater percentage of sites, but again only in low numbers. The species was present at 28 of the 93 sites surveyed; 53 beetles were located, of which 32 were live. In all these studies, the species was seldom recorded in dry forest types; however, Michaels & Bornemisszа (1999) deployed pitfall traps in dry eucalypt forests and recorded *L. latidens* in very low numbers, recovering 5 beetles from 72 traps which were monitored six-weekly for a period of one year; whereas Grove (2006), using pitfall traps around large logs in wet and dry forest types, failed to capture *L. latidens*. Our unpublished data confirm that the species is present in very low numbers in relatively harsh, dry, rocky, exposed situations, whereas greater beetle densities occur in the wetter forest types and moist gullies, as identified in Meggs & Munks (2003) and Richards *et al.*. (2006). While we recognise that in comparison to the co-occurring *Lissotes* spp., the population density of *L. latidens* is low, the edaphic habits and nocturnal activity of adult *L. latidens* may help to explain the paucity of observable animals, and perhaps also the highly skewed sex ratio, even in optimal habitat.

Field surveys for *L. latidens* applying log rolling techniques have recorded an uneven sex ratio, with male beetles significantly outnumbering females. In one study we reported as much as a 90% imbalance favouring males (Richards *et al.*. 2006). This finding is further

Plate 5. Male *Lissotes obtusatus* feeding on a ripe strawberry

supported by the authors' unpublished reports from surveys conducted for *L. latidens* on private land. However, such results were not replicated in Michaels & Bornemissza's (1999) study using pitfall traps; in this instance three of the five specimens captured were female. Unfortunately, sex data was not reported in the Meggs & Munks (2003) study, so no direct comparisons with this work are possible. Assuming the skewed sex ratio is a true representation of the population structure, explanations might include behavioural differences, such as males inhabiting suitable habitat beneath decaying wood known to attract wandering females; or different burrowing habits of males and females. We might also speculate that the imbalance implies that males live longer than females. The discovery of only female exoskeletal material below ground suggests that females spend more time beneath the surface and may even die underground after oviposition, or that some individuals eclose and fail to reach the surface, making them less available for capture, either by hand or in pitfall traps. Differences in the active period or peak activity of male and female *L. latidens* may also be responsible. Data for *L. rudis* (Lea, 1910) taken from both our road transect studies and unpublished pitfall surveys show that adults of this species are active between October and May (Spencer & Richards 2013). As with *Hoplogonus simsoni* (Parry, 1876), the sexes of *L. rudis* are evenly represented across the active season; however, the peak active period differs between the sexes, female activity peaking in March and male activity reaching maximum abundance in April.

Most *Lissotes* spp. are thought to be nocturnal (Hangay & De Keyzer 2017), but at least one species, *L. latidens,* has been reported wandering on leaf litter or on roads during the day (Meggs & Munks 2003). The authors' observations of captive reared and free-ranging *L. latidens* revealed the beetles to be active at night, and very sensitive to torch light, indicating a strong preference for low light conditions. The species appears extremely light sensitive, more so than other *Lissotes* spp. including *L. menalcas,* an obligate CWD-dwelling species, suggesting that surface daylight activity by *L. latidens* is likely to be uncommon. However, we have recorded diurnal activity in other lucanids, including some *Lissotes* spp.: *L. rudis* and *H. simsoni* (Spencer & Richards 2013), and *L. obtusatus*, which was observed crossing the Ada Lagoon track during the day (Richards & Spencer 2017). In addition, we have unpublished records of *L. cancroides, L. curvicornis, L. menalcas, L. obtusatus, H. bornemisszai* (Bartolozzi, 1996) and *H. vanderschoori (*Bartolozzi, 1996) all frequently active during daylight hours.

Both wood and rocks are known to provide moist refuges for invertebrates (Madden *et al.*. 1976; Moldenke & Lattin 1990). However, despite occurring in stony locations, *L. latidens,* unlike *L. obtusatus*, has not been recorded beneath rocks, implying they are able to differentiate between these types of cover. The ability to detect decaying wood or the fungi responsible is perhaps a likely explanation, but the true nature of the relationship between this beetle, soil and logs remains unclear. Michaels (1996) reported finding a dead male within a rotting log. While such an occurrence is likely to be anomalous, Spencer (unpublished data) also observed a live male between layers of rotting wood near the base of a log, suggesting that travelling beetles will utilise a range of available microhabitats for shelter.

The optimum habitat conditions for *L. latidens* are moist soils beneath CWD and leaf litter in wet forest communities (Meggs 1999; Richards *et al*.. 2006,). The size of CWD for sheltering is considered to be important for the beetle, with small to medium-sized logs identified as optimal (Meggs & Munks 2003; Richards *et al*.. 2006); however, the value of larger logs was not included in these studies and remained speculative for a period. Grove (2006) investigated the importance of large logs for the retention of soil moisture and provision of habitat for adult *L. latidens,* demonstrating the limited value of such CWD as habitat, due to soil compaction and lack of soil-wood contact. Grove *et al*.. (2006) concluded that large logs (in Wielangta) do not appear to be particularly good *L. latidens* habitat.

Clearly, *L. latidens* presents some unusual characteristics amongst *Lissotes* spp. Future research may provide confirmation of larval period, adult longevity and fecundity, as well as improving the understanding of CWD-dependence and survival of the species in dry forest habitat.

Acknowledgement

The authors sincerely thank Roger De Keyzer for constructive comments on an early draft of this work.

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Studies on triploid clones of silver wattle (*Acacia dealbata*) in southeast Tasmania

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Introduction

Silver wattle (*Acacia dealbata*) is common in forests and woodlands in Tasmania at elevations up to 900 m, and is often the dominant tree species in transitional forests establishing on disturbed sites (Kitchener and Harris 2013). The species varies in size from a low shrub on dry, shallow soils to a tall straight tree over 25 m in height on deep soils on wetter sites (Boland *et al.* 2006). Since being introduced to many countries outside Australia, it has been widely planted for ornamental purposes and perfumery (Griffin *et al.* 2011).

Silver wattle is a pioneer species with great potential for weediness, as it exhibits a rapid growth rate, produces prolific long-lived seeds, and has a high capacity for re-sprouting through coppice and root-suckers, especially after heavy disturbance such as fire or clear cutting (Le Maitre *et al.* 2011). Due to this propensity for rapid colonization, the species has become an invasive exotic in many temperate regions around the world (Richardson and Rejmanek 2011).

Most plant and animal species are diploid; they possess two copies of their genome, organized in paired chromosomes. Typically one of each pair is inherited from the female and one from the male parent. However, polyploidy, the condition under which an organism has more than two copies of its genome and hence of its chromosomes, is widespread and plays a key role in evolution and the founding of new plant species (Ramsey and Schemske 2002).

The great majority of Australian *Acacia* species are considered to be diploid (2*x*) (Griffin *et al.* 2011), but cytotypes of higher ploidy are reported for some species. Triploid, tetraploid and pentaploid populations were found in the geographically wide-ranging species *A. aneura* (Andrew *et al.* 2003; Pedley 1973) and both diploid and triploid cytotypes in *A. loderi* , a species of semi-arid lands in Western New South Wales (Roberts *et al.* 2016). *A. heterophylla* from Reunion Island in the Pacific, a close relative of the Australian species *A. melanoxylon* (blackwood) is tetraploid (Coulaud *et al.* 1995). Polyploidy is also common in African acacias (now *Senegalia*) and Diallo *et al.* (2016) claim an adaptive advantage for polyploid taxa of *S. senegal* in sub-Saharan environments.

Silver wattle is diploid, with 13 chromosome pairs (Bukhari 1997), but both triploid and tetraploid seedlings were observed in plants raised from seedlots collected from natural populations in Victoria and NSW, though not from Tasmania (Blakesley *et al.* 2002).

Ten populations of silver wattle growing on a range of site types in Southeast Tasmania were sampled to determine the occurrence of polyploidy (Nghiem *et al.* 2018). At each site, 50-100 well-spaced trees were examined. Trees at seven of the ten sites were exclusively diploid, but we found triploid individuals at Mt Knocklofty, West Hobart and on the University of Tasmania Sandy Bay Campus (UTas), and tetraploid suckers on one individual near Conningham. Here we focus on the identification and characteristics of the two triploid populations, addressing issues that may be of particular interest to field naturalists:

- Detection, mapping and genetic identity of the triploid populations of silver wattle at Knocklofty and UTas;
- The development of the triploid population at Knocklofty in relation to the history of site disturbance and vegetation change at this site;
- The sexual reproductive potential of diploid and triploid genotypes; and
- Whether triploidy in silver wattle can be detected by field naturalists.

Materials and methods

Study sites and ploidy sampling

As part of the wider study reported by Nghiem *et al.* (2018), we took leaf samples from trees of silver wattle at Knocklofty and UTas to determine their ploidy status (Table 1). In an initial phase of sampling, trees were chosen at wide spacing (at least 20 m apart) so as to avoid sampling stems that obviously derived from the same clone. Three triploid stems were detected among 40 stems initially sampled at Knocklofty and one at UTas. It was evident from inspection of root systems that the triploids occurred in clumps consisting of varying numbers of stems that had developed from clonal suckers. In a second phase of sampling at Knocklofty, samples were taken progressing radially in all directions from the originally identified triploid stems until the boundaries between triploid and adjacent diploid clumps or individual trees were established. The areal extent of contiguous triploid clumps was then plotted on a Google Earth image and total number of triploid ramets counted.

One of the largest triploid stems was cross-cut for annual ring counts for age determination. At UTas there was a clear discontinuity between the clump around the originally determined triploid tree and any other silver wattle trees so all trees in the clump were sampled, as well as four nearby trees separate from the clump.

Ploidy Determination

Ploidy levels were determined using flow cytometry. Full details of the procedures are provided by Nghiem *et al.* (2018).The steps in this process include chopping up fresh leaf samples, suspending the chopped sample in a buffer solution, staining and then running the suspension through a ploidy analyser which determines an average quantity of DNA in individual cell nuclei. Samples prepared from a variety of pea (*Pisum sativum*) are run as a standard for comparison. Flow cytometry enables reliable discrimination between diploid, triploid and tetraploid cytotypes of silver wattle.

Genetic analysis

Once we had determined the distribution of triploid trees at Knocklofty, we used a set of ten DNA markers to determine the genetic relationships among a subsample of 27 individual triploid stems. We also sampled 17 stems in the surrounding diploid population. At UTas, all 11 stems surrounding the triploid identified on Stage 1 sampling were also triploid and, by inspection of the root systems, we were confident that these were all suckers from a single founder. Therefore only the apparent founder of the UTas clone (the ortet) was genotyped. Details of DNA sample

Table 1. Locations of study sites and numbers of silver wattle stems stems assayed for ploidy and genotyped

Site	Knocklofty	University of Tasmania (Sandy Bay Campus)
Latitude (S)	42°53′	42°54
Longitude (E)	′147°18′	147°19′
Number of stems assayed for ploidy	155	17
Number of diploid stems	77	4
Number of triploid stems	78	13
No of diploid stems genotyped	17	-
Number of triploid stems genotyped	27	1

preparation and genotyping are provided by Nghiem *et al.* (2018a).

Reproductive characteristics

At Knocklofty we examined flowering, pollen viability, pod set and seed production from triploid and nearby diploid individuals. Most trees on the site with diameters at breast height exceeding 5 cm exhibited the mass flowering characteristic of the species. For each of four diploid and four triploid trees, two branches were selected with good crops of flowers and an architecture that more or less filled a 75 x 75 cm frame held perpendicular to the branch axis. (Plate 1). The proximal point of the branch system included in each frame was tagged with a label. Pods developing on all branchlets distal to that point were included in counts without a need to use the frame.

Plate 1. Frame used as a method of selecting flowering branch systems for monitoring of pod set

Fresh pollen was collected from four diploid and six triploid trees and sieved directly on 6 cm petri dishes containing 1 % agar, 10 % sucrose and 0.01 % boric acid. Petri dishes were sealed and left at ambient temperature for 48 h. Germinated pollen was observed under light microscopy (Zeiss Axiolab).

Developing green pods on each sample branch were counted after 12 weeks at which stage the number of developing locules per pod could easily be observed. Samples were collected from elsewhere in the crown of each tree and returned to the laboratory. A sub-sample of 20 pods per tree was measured for length and the number of locules that contained partially developed seeds was counted.

When the pods had turned brown and were beginning to dehisce, final counts were made of each framed branch set and all pods harvested to determine seed production. Harvesting took place in mid-January 2017, approximately 5 months after peak flowering. Since the seed crop on marked branches was limited, additional pods were collected from the marked trees and from several additional known diploid and triploid trees, to expand sample sizes for estimation of the number of seeds per pod.

Results

Mapping of triploid clumps

Sampling of ploidy status using flow cytometry at Knocklofty enabled determination of the boundaries of triploid clumps and plotting of their areal extent. The main area of the triploid population, with stems shown in orange in Plate 2, included about 200 stems and covered approximately 930 m^2, with 56 m between the most distant ramets. The age of the large stem that was felled for ring counting was estimated to be 28 years. Unexpectedly, a further three triploid stems were identified about 80 m away on the other side of the water reservoir constructed in the 1950s.

At UTas all thirteen of the stems in the clump were triploid, and from inspection of tree distribution and root systems we concluded that these stems were all part of a single clone. The diameter of the largest stem was 20 cm and it is likely to have been of relatively recent origin. The clone was approximately 50 m^2 in extent with 20 m between the most distant ramets (Plate 3). Four nearby trees clearly not belonging to the same clonal clump were diploid.

Genotype determinations

All the triploid stems sampled from Knocklofty had identical DNA profiles across the ten markers (Nghiem *et al.* 2018a) with three different alleles present at each of two of the markers. The probability of finding more than one different genet with the same genotype was estimated to be 3.6 $\times 10^{-6}$, thereby providing strong evidence that all triploid stems belonged to a single clone.

Plate 2. Map of triploid clumps of *A. dealbata* at Knocklofty. Dots show positions of individual trees with stem diameter at breast height greater than or less than 10 cm with ploidy determined. Points A, B and C on the map relate to development of the triploid clumps. D1, D2 and D3 denote stems belonging to three diploid clones identified through genotyping (full extent not determined).

The triploid genotype at UTas carried three alleles at one locus, and differed from the triploid at Knocklofty in its allelic profiles at four of the ten markers.

All diploid genotypes sampled at Knocklofty showed allelic differences from the adjacent triploid. There were three groups of adjacent diploid stems (D1, D2 and D3 in Plate 2) each with identical genotypes, providing strong evidence that they were members of three different diploid clones.

Reproductive attributes of diploid and triploid trees

No pollen from the Knocklofty triploid showed viability, although pollen from the triploid genotype at UTas did germinate at a low frequency (2.7 %) compared with the 19 % germination rate of the diploid controls harvested at the same time.

Inflorescence counts (Nghiem *et al.* 2018a) suggested that production of over 1 million flowers per season would be common on the larger trees, although very few flowers yielded mature seed bearing pods (Table 2).

Pod development and seed yield per pod on diploid trees at Knocklofty were low compared with that commonly observed on more well-watered sites (Harbard unpubl. data). Nevertheless they were substantially greater than on the triploid clone. One of four triploid ramets carried a large number of developing pods at 3 months but 74% of these had abscissed by 5 months and none of those which did persist yielded any full seeds. Two other triploid ramets carried a small number of pods to 3 months but all had dropped by 5

Plate 3. Triploid clump on landscaped ground at the University of Tasmania campus, Sandy Bay. Observers standing at either end of the triploid population. Large stem in right-centre foreground is believed to be the ortet (founder of the clone). Smaller stems have developed from root suckers.

Table 2. Pod size at three months and pod harvest and seed count at Knocklofty, five months after flowering. Tags 1 & 2 per tree combined.

Ploidy	Tree ID	Pod length at 3 months (mm)	Mean no. of locules with developing seeds at 3 months	Estimated no. of pods developing at 3 months	No. of pods harvested	Mean no. of seeds per pod at 5 months
2x	061/1	-	-	51	70	0
2x	055/5	30.7	3.9	80	73	0.04
2x	052	38.5	3.9	66	21	0
2x	049	39.2	4.6	234	108	0.17
3x	051/8	-	-	4	0	0
3x	051/10	-	-	0	0	0
3x	054/7	13	0	577	150	0
3x	540	-	-	4	0	0

months. Plate 4 shows pods on studied diploid and triploid trees at 5 months, just prior to harvest, and Plate 5 shows harvested pods. All four tagged diploid trees carried developing pods through to maturity. It is evident that pod maturation is no guarantee of full seed production since only two of the trees produced any seeds.

Pod length and number of locules bearing developing seeds at 3 months clearly differed between cytotypes (Plate 5). The pods on the three diploid trees assessed were nearly three times as long as from the triploid and had on average 4.1 locules with partially developed seeds. None of the many pods retained on triploid trees showed any sign of seed development within locules, and most pods only contained one empty locule.

Discussion

Putative origins and histories of the triploid clones

In predominantly diploid populations, triploid genotypes are most commonly produced by fusion of a normal haploid gamete with an unreduced gamete (Husband 2004) and we assume that such seedlings were the original founders of the two triploid clones that we found. Both triploid genotypes had three different alleles at one or more of the DNA marker locations, providing strong inferential evidence that the founding individual was derived from outcrossing between two parents, one having produced an unreduced gamete, rather than by selfing or apomixis (asexual production of seeds without fertilization), which would yield a maximum of two alleles per locus.

Silver wattle was undoubtedly a natural

Plate 4a. Diploid pods

Plate 4b. Triploid pods

Plate 5. Harvested pods of triploid (left) and diploid (right) trees

component of the pre-European vegetation of Knocklofty, since it occurs across the current reserve area as a prominent component of the understorey and secondary tree layers. However, Knocklofty has a long history of site disturbance extending back to the early European settlement of Hobart (Evans and Evans 2015). Firewood, building stone and topsoil were all sourced in the 19th and the first half of the 20th centuries from the Frog Ponds area at the eastern side of the current reserve where the triploid population is located. High-resolution aerial photography taken in 1946 (Plate 6) showed that the area around the current triploid clump was then treeless with low grassy ground cover and signs of extensive past soil disturbance. This is also evident in a photograph of the Pigeon House building, now demolished, from the late 19th Century (Plate 7). Commencing in 1986, much of the Frog Ponds area was sprayed and bulldozed under the Regional Employment Development Scheme to remove a heavy gorse infestation that had developed over previous decades (Plate 8). Control of gorse, broom and other weeds continued through the 1990s, implemented by the Friends of Knocklofty Bushcare Group supported by the City of Hobart and grants from the Natural Heritage Trust (Evans and Evans 2015). Planting of trees and

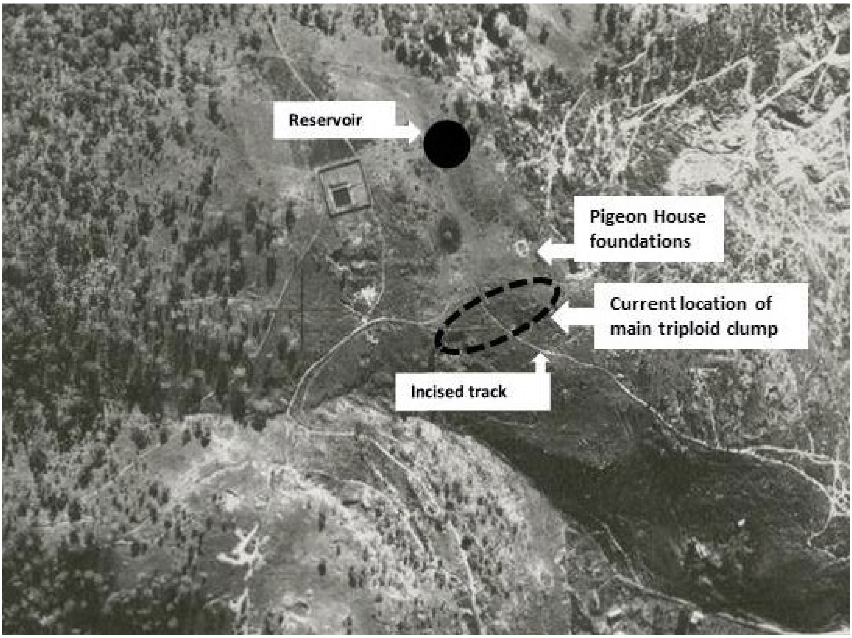

Plate 6. Aerial photograph of Frog Ponds area of Knocklofty taken in 1946, with location of water reservoir constructed in 1958 added. Black dotted oval shows approximate extent of main triploid clump in 2016

shrubs, including some silver wattle seedlings, was undertaken by the Friends of Knocklofty in the 1990s.

It appears that the triploid clump has spread into the area that it now occupies by suckering. This would have commenced no later than the 1980s, based on the 2016 age estimate of 28 years for the large stem in the centre of the current clump. However, the original triploid seedling ortet could have established at a much earlier date. In the 1946 aerial photograph, a few small shrubs, possibly silver wattle, are visible on both sides of the incised, eroded cart track (near points A and B, Plate 2) that was already well-established in the 19th Century. It seems unlikely that roots of the clone could have extended below this track once it had eroded down to bedrock along most of its length. The clone is now growing on both sides of

Plate 7. The Pigeon House, view taken from the north west looking across one of the frog ponds, taken at some time between 1860 and 1892 (State Archives photo PH30-1-5235). Eastern boundary of current triploid silver wattle clump indicated by arrow

Plate 8. A composite of photos in 1986 looking southeast past the water reservoir, showing herbicide-killed gorse in the foreground and bulldozed ground, previously gorse-infested, in the centre. Photos taken by Mr Anthony Ault. Current location of the main triploid silver wattle clump is indicated by the arrow.

the incised track and has a very extensive network of large surface roots, often of larger diameter than the current stems deriving from it (Plate 9). This suggests repeated cycles of death of individual stems and resprouting of new stems over several decades.

The currently discontinuous outlier of the triploid clone at point C, 80 m from the main clump (Plate 2) is located on a raised heap of soil and rock that was apparently created by bulldozing during the gorse clearance in the late 1980s. It most probably established from triploid root or stem material from the main clump moved by bulldozer along with soil during weed control. The spatial discontinuity of the Knocklofty triploid clone is an interesting demonstration that the biology of the species is sufficiently resilient that rapid invasive dispersal can be by vegetative as well as sexual reproduction.

Our estimate of the current extent of the main clonal clump, 930 m^2, is within the size range observed for clones of *A. loderi* (Roberts *et al.* 2016) of 19 - 4000 m^2, although triploid clonal clumps of much larger extent have been observed in other genera, for example the Tasmanian endemic *Lomatia tasmanica* (Lynch *et al.* 1998). The greatest distance between ramets of the nearby diploid clones at Knocklofty was 35 m (Plate 2), but this is a minimum estimate since we did not do a complete survey of diploid clonality.

Silver wattle is not a common component of the remnant native vegetation on the Sandy Bay Campus, University of Tasmania. As the triploid clone we identified is in an area that has been landscaped in the past, we suggest that a triploid seed brought in from elsewhere, via soil or mulch, may have founded the clone, which then spread by

Plate 9. Strongly developed surface root system interconnecting stems of the triploid clone at point A, Plate 2.

root suckering in a landscaped area.

The extent of clonal development is likely a function of density of the original regeneration event at a site. On higher quality sites carrying many reproductively mature trees seed production will be heavier and more reliable, and when fire or disturbance favours regeneration, seedling genets will establish at high density. Once dense regenerating stands are established, there is no space for clones to extend by root suckering. The converse will be true where only a few seedling genets are present, as we infer from the history of the historically disturbed Knocklofty site.

Reproductive potential of triploids compared with diploids

Since inflorescences are somatic structures (i.e. relating to the body of the tree, not its germ line) the expectation is that triploid trees will flower normally. However the gametes produced will be largely, but not entirely, inviable due to unmatched pairing during meiosis (Ramsey and Schemske 1998). This pattern was evident in the high flowering intensity at Knocklofty and in the pollen viability, pod development and seed yields of triploid in comparison to diploid trees.

The reproductive output of a population in any one season is determined by many factors and can vary from year to year (Broadhurst and Young 2006). The Knocklofty population showed the synchronous mass flowering typical of silver wattle and pollen availability *per se* should not have been limiting. However, effective pollen transfer (*i.e.* resulting in the production of viable seeds) is largely determined by the genetic structure of the stand in relation to the breeding system and the suite of pollen vectors active on the site.

Diploid silver wattle has been shown to be partially self-fertile (Rogers and Johnson 2013; Correia *et al.* 2014) but with inbreeding depression exhibiting as reduced seed yield per pod and reduced early growth of progeny. Broadhurst *et al.* (2008) found that a high proportion of viable open pollinated seed collected from multiple sites in NSW were outcrosses. How is this explainable given the high probability that in *Acacia* geitonogamous pollination (pollination between different flowers of the same individual) is likely to occur with high frequency (Nghiem *et al.* 2016)? Clonal development presumably increases the frequency of geitonogamy as pollen is transferred between ramets of individual clones as well as within crowns of individual trees. Given the very low ratios of pod maturation to flower number in acacias even in supplementary pollination experiments (Rogers and Johnson 2013), it seems reasonable to assume that fruit development is strongly resource-limited where selfed embryos are less able to compete for the resources necessary for successful development, resulting in a preferential outcrossing system. More detailed experimental work is required before we can be sure of the mechanism underlying the low number of seeds per pod which we observed (Table 2).

The vectors responsible for pollination of silver wattle within its native range are yet to be determined though in exotic environments both honeybees and a range of dipteran taxa have been observed on the flowers (Montesinos *et al.* 2016; Rogers and Johnson 2013). *Acacia* species are generally assumed to be pollinated by native bees (Bernhardt 1989; Stone *et al.* 2003), yet in Southeast Tasmania silver wattle flowers in late winter/early spring where conditions are cold, windy, often wet and generally unfavourable for insect activity. Since flower heads have longevity of ~15 days perhaps within that period there are times when the insect pollinators might be effective. The results of Broadhurst *et al.* (2008) indicate that somehow there is indeed effective pollen transfer between genets and we cannot discount the possibility that birds may play a part. A number of honeyeater species and also green rosellas have been observed to be active within the crowns of flowering trees in Southeast Tasmania (M.J. Brown pers. comm. 2017). In mixed cytotype populations such as Knocklofty where the effectively sterile triploid is making a substantial contribution to the pollen cloud and where clonality in the diploid genets is presumably increasing the chances of geitonogamous self-pollination, it might be predicted that seed production in the diploids will be below that expected in genetically diverse non-clonal stands.

No viable seeds were produced from the triploid clone in spite of profuse flowering and the initial development of pods, some of which were retained to maturity (Table 2). All diploid trees had significantly larger pods which unlike the triploid showed signs of seed development at 3 months with an average of 4.1 filled locules per pod (compared with the expected 13 per ovary determined by (Correia *et al.* 2014). However, by maturation, two of the four studied diploids did not produce any seed and there were many empty pods in those which did produce a few seeds. This abortion of partially developed seeds is most likely one of the many expressions of inbreeding depression following self-pollination. At UTas the triploid clone also flowered normally and did produce a low percentage of viable pollen, but no pods developed to maturity.

Failure of seed production in spite of profuse flowering is not unusual for acacias. Several of the silver wattle populations studied by Broadhurst and Young (2006) produced no seed over one or two years. However, the seeds of these perennial taxa are typically very long-lasting in the seedbank so regular annual production may not be an important determinant of population viability. Sterility of triploid *Acacia* has potential practical application in countries where the genus is an important tree crop and weediness is a concern. In Vietnam, effective sterility has been demonstrated for clones of *A. auriculiformis* and its interspecific hybrid with *A. mangium* (Nghiem *et al.* 2018b).

Can field naturalists identify triploid silver wattles?

In this study we have used technology-based procedures such as flow analysis, to determine the ploidy levels of trees and DNA SSR marker profiling, to determine whether different stems are genetically identical. This has enabled us to identify and map the extent of triploid clumps of silver wattle and confirm that they are clones. However, field naturalists could potentially identify triploid silver wattle trees by repeated observations over the August-December period of flowering and pod development. If a tree displays normal flowering but then its pods fail to grow beyond 20-30 mm in length, carry only a single locule and yield no seeds, it may well be a triploid. Observers should be able to distinguish this pattern of development from that of neighboring diploid trees in which pods extend to at least 40-50 mm in length and display four or more locules by November and then some pods yield one or more fully developed seeds at maturity in December-January. The Knocklofty site provides a reference population that clearly demonstrates these differences between triploid and adjacent diploid trees. We would be pleased to hear from field naturalists of any other putative triploid trees so we can check their ploidy status.

History of Knocklofty, and the future of the triploid clump

Finally, the study at Knocklofty introduced us to a site with a remarkable history, soon to be detailed in a forthcoming book authored by Ms Suzanne Smythe titled "Knocklofty: Hobart's Back Door". The Frog Ponds area was largely treeless in the second half of the 19th Century and for most of the 20th Century. An eroded, gorse-infested wasteland had developed by the middle decades of the 20th Century. The efforts of the City of Hobart and the Friends of Knocklofty have created the current landscape with a woodland tree cover dominated by eucalypts, silver wattle and several other secondary tree and shrub species over a grassy understorey that is now intensively cropped by Bennetts Wallaby and other marsupial browsers. There is no current recruitment of silver wattle, either by suckering or seed germination, in the immediate vicinity of the triploid clump, although controlled burning should enable its recruitment elsewhere in the Knocklofty reserve. Some larger stems in the main triploid clump are dead or dying as a consequence of borer attack and storm damage, although many younger and smaller stems remain healthy. We are hoping to build on our knowledge of the Knocklofty population through observations of the flower visitors which might effect pollination and also survey the extent of diploid clones through additional genotyping. Plans are now under way to develop interpretative signage describing the triploid clump, which constitutes a valuable resource for scientific education, and to secure its ongoing viability.

Glossary

Allele: One or two or more variant forms of a gene or other short DNA sequence located at a particular point (locus) on a chromosome

Clone: In the context of this paper a clone is a clump of silver wattle that has spread by root suckering, such that all of the stems (= ramets) are genetically identical and derive from a single founding individual, the ortet

Cytotype: Cytotype refers to the chromosome complement of an individual. In this article we distinguish between diploid, triploid and tetraploid cytotypes.

Diploid: The most common state in which an organism has two complete copies of its genome (genetic code) held in paired chromosomes

Geitonogamy: Pollination between flowers within the same plant – a form of selfing

Genet: One individual plant or a set of individuals (e.g. stems belonging to a single clone) with a unique genotype

Genotype: The genetic constitution of a specific individual

Locule: The small cavity within a seed pod in which each developing seed expands

Ortet: The original founder of a clone

Outcrossing: Mating in which the pollen the fertilizes an ovum comes from an unrelated tree

Polyploid: An organism having more than two copies of each chromosome

Ramet: Ramets in this context are stems originating by suckering from the same founder tree and hence with identical genotypes; they are members of a single clone, although root connections between them may no longer exist.

Selfing: Mating in which the pollen that fertilizes the ovum comes from the same genotype; in the case of a clone it may come from a different tree of the same clone

Triploid: Organism with three complete sets of its genome held in three copies of each chromosome

Tetraploid: Organism with four complete sets of the genome held in four copies of each chromosome

Acknowledgments

We thank the City of Hobart for permission to conduct research at Knocklofty, and the Friends of Knocklofty Landcare group, in particular Mr Anthony Ault, and Ms Suzanne Smythe for valuable insights into the history of Knocklofty.

Dr Nghiem Quynh Chi received an Asia–Pacific Economic Cooperation (APEC) – Australia Women in Science Fellowship that supported her contribution to the study.

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Endemic and enigmatic: distribution, habitat and conservation status of *Cassytha pedicellosa* J. Z. Weber (Lauraceae) in Tasmania

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Abstract

Cassytha pedicellosa J.Z.Weber (Lauraceae) is a little-known member of the genus, restricted to Tasmania. It was first described in 1981 from material collected in 1892. The species then went seemingly unnoticed until 1983, before again slipping into shadow until re-discovered in 2005. From then, the species appears to have become better known, and is now recognised from about 20 widespread and disjunct, mainly near-coastal, locations. The preferred habitat is dry heathland and heathy woodland, usually on sandy soils. The species is very well-reserved, with nearly all locations inside formal reserves, but population extent and abundance varies greatly. A cautious approach to the management of this species is recommended. In the absence of a category on the Tasmanian *Threatened Species Protection Act* 1995 such as "data deficient" that may afford some level of legislated management, a cautious listing of this endemic and enigmatic species may be defensible.

Introduction

Cassytha L. is an interesting genus of the Lauraceae family. The family, comprising many thousands of mainly woody shrubs and trees, has a global distribution. *Cassytha* comprises about two dozen species, mainly within Australia but a few extending to Africa, southern Asia, various islands, and regions in the Americas (Weber 2007).

As a genus within Lauraceae, *Cassytha* is unusual in that they are climbing herbs and obligate parasites. The species are stem parasites, adhering to their hosts by haustoria (specialised structures that grow into or around another structure to absorb water or nutrients). The wiry or thread-like stems twine around the host and turn yellowish once they have established themselves on a host because then then reduce or stop their production of chlorophyll.

Tasmania has four species of *Cassytha* (de Salas & Baker 2017). All four species are widespread, with three (*C. melantha, C. pubescens* and *C. glabella*) being very common and often locally abundant. All are extensively scandent and often prolific smotherers of their hosts. The last species is the non-scandent and ground-hugging *Cassytha pedicellosa*. This paper describes the distribution, habitat, reservation and conservation status of this endemic and enigmatic species.

Methods

Three sources of records of native plants were interrogated and reviewed to produce a complete list of all known locations of the species in Tasmania, as follows: collections at the Tasmanian Herbarium (Tasmanian Museum & Art Gallery); DPIPWE's *Natural Values Atlas* database (NVA); and *Atlas of Living Australia* (ALA).

Results and discussion

Distribution and collecting history

Cassytha pedicellosa has a widespread distribution in lowland, mainly coastal and near-coastal, parts of Tasmania. It occurs principally on the southeast, east, northeast and north coasts, extending inland in the northwest to Seventeen Mile Plain and to the northern part of King Island (Figure 1, Table 1).

The species apparently evaded formal recognition until a major review of the genus *Cassytha* in Australia (Weber 1981). At that time, the species was described based on a "single collection made by Rodway from the Derwent" in 1892. It is impossible to know precisely where Rodway's location of "Derwent, Tasmania" was because he collected plants from a wide area in the catchment of the River Derwent. Creation of a point location that precisely represents Rodway's type location is impractical and would simply be an artificial construct. DPIPWE's *Natural Values Atlas* database currently places Rodway's location west of New Norfolk. However, now that the species has been recorded from several sites in the greater Hobart area (such as the Peter Murrell Reserve and South Arm Peninsula), it seems more likely that Rodway's site was closer to Hobart (especially since his residence was in Blackmans Bay).

While Weber (1981) separated the new species on morphological features (namely that it is glabrous, cilia and fimbriae are absent from the bracts and sepals, and the flowers and fruits are pedicellate), the most distinctive field

Plate 1. Ground-hugging habit of *Cassytha pedicellosa*. Photograph: M. Wapstra

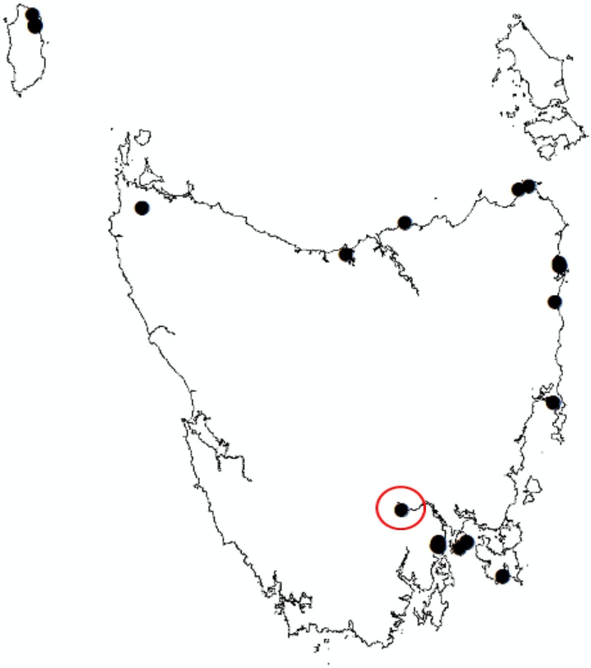

Figure 1. Statewide distribution of *Cassytha pedicellosa*: the circled record is the type location (as arbitrarily indicated on DPIPWE's *Natural Values Atlas* database), which is probably erroneously placed this far up the River Derwent, with the more likely location closer to the cluster of records around Hobart.

Plate 2. Pedicellate fruit of *Cassytha pedicellosa* showing striped pattern.
Photograph: M. Wapstra

Plate 3. Fruit of *Cassytha pedicellosa* showing habit of becoming partly buried in loose sandy soil.
Photograph: H. & A. Wapstra

Table 1. Locations for *Cassytha pedicellosa*

No.	Location[1]	Tenure	Comments
1	"Derwent, Tasmania"	Unknown	1892, L. Rodway [Type]
2	"Little Musselroe Bay"	Assumed to be Musselroe Bay Conservation Area	1983 [First mainland Tasmanian record after formal description]
3	"Martha Lavinia Road (S. side)", King Island	Road reserve	2005, Eades
4a	"Nook Swamps (edge of track), King Island"	Lavinia State Reserve	2009, M. Wapstra et al.
4b	"Nook Plains, King Island"	Lavinia State Reserve	2011, Schahinger et al.
5	"Seventeen Mile Plain"	Informal reserve on public land	2010, Buchanan et al.
6	Petal Point	Boobyalla Conservation Area	2011, M. Wapstra
7	"Rubicon Sanctuary, Port Sorell"	Private (Rubicon Private Sanctuary)	2009, Collier
8	"Stony Head" [Stony Head Artillery Range]	Commonwealth of Australia	2011, Ziegeler
9	"Swimcart Beach"	Bay of Fires Conservation Area	2011, M. Wapstra
10a	"Grants Lagoon on crown reserve and extending into private property"	Bay of Fires Conservation Area & private property	2012, Skabo
10b	"Near Grants Lagoon"	Bay of Fires Conservation Area	2012, Skabo
11	"Next to track behind Binalong Bay Beach"	Bay of Fires Conservation Area	2013, Skabo
12	"Scamander, Winifred Curtis Reserve"	Private (conservation covenant)	2011, Wood
13	[Coles Bay Conservation Area] – 2 sites close to one another	Coles Bay Conservation Area	2016, Visoiu
14	"Track to Mt Brown" and "Mt Brown walking track, Tasman Peninsula" – 2 sites close to one another	Tasman National Park	2010, M. Wapstra 2010, Wood

No.	Location[1]	Tenure	Comments
15	"Cape Deslacs Nature Reserve, South Arm Peninsula" & "Cape Deslacs walking track" – 2 sites close to one another	Cape Deslacs Nature Reserve	2009, H. & A. Wapstra 2009, M. Wapstra
16	"South Arm Road, on roadside"	Road reserve?	2011, de Salas
17	"Denison Street, Kingston"	Kingborough Council (bushland reserve)	2009, H. & A. Wapstra
18	"Hawthorn Drive, Maranoa Heights, Kingston" & "Bushland off Hawthorn Drive, Kingston" &	Kingborough Council (bushland reserve)	2009, H. & A. Wapstra 2011, North
19	"Algona Road, Maranoa Heights" [Algona Road Reserve]	Kingborough Council (bushland reserve) & private land (new subdivision)	2011, Ziegeler
20	"Boronia Hill (far S boundary along fence)"	Kingborough Council (bushland reserve)	2009, M. Wapstra
21	"Peter Murrell Conservation Area" "Peter Murrell Reserve, Link Fire Trail" "Peter Murrell Conservation Area, S end" "Peter Murrell Reserve" [no location]	Peter Murrell State Reserve	2009, Visoiu 2011, H. & A. Wapstra 2009, Visoiu & Wood 2009, M. Wapstra 2009, Visoiu

[1] Locations in " " are taken direct from database and/or Tasmanian Herbarium collections

character is the ground-hugging growth habit (Plate 1). The species forms spreading patches of threadlike golden-reddish to brown stems that rarely extend more than a few centimetres up into the shrubs on which it is parasitic. The stalked flowers and fruits are also distinctive, especially the mature fruit, which are striped and almost bury themselves into the sandy soil (Plates 2 & 3). Weber (1981) notes that the species "differs from *C. glabella* in the conspicuous pedicel, floral bracts in two planes and dark brown fruit". In practice, *C. glabella* is a much more robust species and is usually a distinctive climber over low shrubs. Where the two species co-occur (e.g. Cape Deslacs, Peter Murrell Reserve), *C. glabella* can sometimes be ground-hugging in younger plants but always becomes scandent, and the two species can be easily separated on flower and fruit characters.

Following the description of the species in 1981, it then remained incognito until 1983, when Tony Moscal made a collection from Little Musselroe Bay. The sheet at the Tasmanian Herbarium (HO70138) includes material of both *C. glabella* and *C. pedicellosa*, the latter only determined in 1993 by D.I. Morris. This collection is acknowledged in the *Flora of Australia* treatment in which Weber (2007) states "endemic to Tas, known from the type collection and from Little Musselroe Bay", the treatment still pre-dating the oncoming burst of new sightings.

The species fell into apparent obscurity until 2005 when it was collected from northern King Island. Since then, the species has been collected and recorded several times, with several new locations, including a second location on King Island, a further site relatively close to Moscal's 1983 collection (i.e. Petal Point), additional sites on the north coast, and several sites on the northeast, east and southeast coasts. The most recent (2016) recording is from the Coles Bay Conservation Area, which represents a relatively significant range infilling between Scamander (2009) and Cape Deslacs (2009) and the track to Mt Brown (2010). The contemporary distribution, which is made up largely of sites that post-date 2005, are strongly suggestive that further range extensions and infillings will be made.

Habitat

Cassytha pedicellosa occurs in dry (to wet) heathland/shrubland and heathy woodlands (Plates 4 & 5), the latter usually dominated by *Eucalyptus amygdalina* (black peppermint). The substrate is variable but is usually sandy soils derived from Triassic sandstone or other siliceous substrates. The vegetation in which the species occurs is fire-prone and subject to relatively frequent wildfires and/or fuel reduction burning. The species appears to be tolerant of (or perhaps dependent on) this fire regime, often appearing to take advantage of gaps created in the post-fire understorey. The species occurs on the immediate verge of old vehicle tracks (e.g. King Island, Petal Point), on the edge of walking tracks (e.g. track between Remarkable Cave and Mt Brown, tracks in Peter Murrell Reserve, Boronia Hill, Hawthorn Drive, etc.) and on some road verges (e.g. South Arm Road, Martha Lavinia Road).

Extent and abundance

Cassytha pedicellosa tends to occur in localised patches, with descriptions of its extent and abundance often including terms such as scattered, occasional and localised. However, several collections include terms such as extensive, locally frequent and locally common. Notes with some collections indicate that the species was likely to be more widespread but that no formal surveys were undertaken.

Reservation status

Cassytha pedicellosa occurs in numerous public reserves including Lavinia State Reserve, Musselroe Bay Conservation Area (assumed), Boobyalla Conservation Area, Bay of Fires Conservation Area, Coles Bay Conservation Area, Tasman National Park, Cape Deslacs Nature Reserve, and Peter Murrell Reserve. It also occurs in two reserves on private land subject to conservation covenants under the Tasmanian Nature Conservation Act 2002 (Winifred Curtis Reserve, Rubicon Sanctuary). In addition, the species occurs in four "bushland reserves", managed by Kingborough Council for their conservation values (mainly *Eucalyptus amygdalina* forest and woodland on sandstone – a threatened vegetation type, and locations of threatened flora and fauna).

Conservation status

Cassytha pedicellosa is not currently listed on the Tasmanian *Threatened Species Protection Act* 1995. The opportunity is taken here to review the available information to ascertain if the species may qualify for listing.

The Scientific Advisory Committee, established under the provisions of the Tasmanian *Threatened Species Protection Act* 1995, published *Guidelines for Eligibility for Listing* under the *Threatened Species Protection Act* 1995, which were updated in 2008 (DPIW 2008).

Following are the criteria for Schedule 5 (rare), copied verbatim, with my comments on their specific application to *Cassytha pedicellosa* in square brackets below each.

A taxon of native flora or fauna may be listed as rare if it has a small population in Tasmania that is not endangered or vulnerable but is at risk. (Section 15(4) of the Act).

[In my opinion, *Cassytha pedicellosa* certainly does not qualify under the criteria for a higher status i.e. vulnerable or endangered, but it does not automatically follow that it therefore qualifies as rare].

The following criteria may provide evidence of the level of threat. In order to be considered as rare at least ONE of the criteria A-B should apply.

(A) A taxon of limited distribution or numbers, threatened by existing on-going processes occurring over sufficient of their range to suggest that they would satisfy the indicative criteria for vulnerable unless the threatening process was abated based on (and specifying) any one of the following:

1. the extent of occurrence is less than 80 x 80 km or 2,000 km^2;

[A minimum convex polygon around all sites yields an extent of occurrence of c. 63,000 km^2 (this is reduced to c. 44,000 km2) if the King Island disjunction is excluded). The east-west and north-south linear extents of the species far exceed the 80 x 80 km threshold].

2. the area of occupancy is not more than 0.5 km^2 (50 hectares);

[Estimating the area of occupancy of *Cassytha* pedicellosa is difficult because many sites are one-off serendipitous discoveries, the results of surveys that ceased as soon as the species was detected, and the limited notes included with collections and database records. Personal observations at sites such as King Island, Cape Deslacs, Peter Murrell Reserve, Swimcart Beach and the Tasman Peninsula are suggestive of the species occupying several hectares at each site (albeit in a scattered occurrence). However, I estimate the area of occupancy to be less than the 50 ha threshold but apply a low to medium reliability to this only. In my opinion, the application of this subcriterion is problematic for a species such as *Cassytha pedicellosa* and should be used with caution].

3. taxa that are not A1 or A2 above, but that have very small and localised subpopulations wherever they occur (generally no subpopulation with an area of occupancy greater than 0.01 km^2 (1 hectare) and no more than 1,000 mature individuals).

[Technically, this criterion may or may not apply, depending on how A2 is interpreted. We now know *Cassytha pedicellosa* from c. 20 subpopulations, but whether these are all very small and localised is open to interpretation. Estimating the total abundance of the species (or indeed the abundance and extent of any particular subpopulation) is difficult with collection notes being highly variable (e.g. "10-100", "two patches found in brief search", "four small plants in 1 square metre open area among taller shrubs, more plants found scattered in slashed open area…", "patch 3 x 3 m in area, probably widespread in general area as numerous 'seedlings' (first straggly twiners) observed on ground…", "locally common", ">5", "scattered across reserve", "3 plants over 9 sq m", "occasional", "locally frequent", "seems to be localised but survey not widespread", "about 10 plants", "extensive patch on edge of track"). Estimating the number of individuals at any site for a creeping and spreading plant such as *Cassytha pedicellosa* is also not practical, rendering this subcriterion somewhat difficult to apply].

(B) Total population small or restricted and at risk in the form of EITHER of the following:

1. the total population consists of fewer than 10,000 mature individuals, and no more than 2,500 mature individuals occur on land that is in an area free from sudden processes capable of causing largely irreversible loss of individuals or habitat; OR

[The term "and at risk" is critical to a species meeting criterion B. In terms of predictable threats such as fire, *Cassytha pedicellosa* appears to be a resilient and robust species. One part of one subpopulation may have been lost to residential subdivision but most of the remaining sites are all effectively within reserves. It is noted that reservation status *per se* does not form part of these criteria. However, for some species such as *Cassytha pedicellosa*, which occurs in vegetation not requiring specific management intervention to ensure persistence, occurrence in reserves contributes significantly to the concept of "security from risk". This leaves stochastic events as the main threatening process, which by definition are unpredictable. For some species that occur as a single population, stochasticity can come into play. An example is *Azorella macquariensis* (Macquarie cushion), which occurs on subantarctic Macquarie Island, where it was assumed to be quite secure, before being devastated by a disease, an event that caught everyone by surprise i.e. genuinely stochastic. In the case of *Cassytha pedicellosa*, the potential impact of a stochastic event is unlikely to manifest as a Statewide whole-of-population crash because of the widespread and geographically separated subpopulations.

It is probably reasonable to argue that the total population of *Cassytha pedicellosa* is "small or restricted" but it is probably not "at risk". Whether the "total population consists of fewer than 10,000 mature individuals" is not known, and determine if "no more than 2,500 mature individuals occur on land that is an area free from sudden processes capable of causing largely irreversible loss of individuals or habitat" is probably nor practical, rendering this subcriterion somewhat difficult to apply].

2. 90% of mature individuals occur in 15 or fewer subpopulations or locations and no more than 5 of these occur in an area that is free from sudden processes capable of causing largely irreversible loss of individuals or habitat.

[This criterion is based on the same risk of stochastic events causing an irreversible loss of individuals or habitat – see discussion under criterion B1. *Cassytha pedicellosa* is represented by c. 20 subpopulations, many of which occur in secure sites, but it is impractical to estimate if "90% of mature individuals occur in 15 or fewer subpopulations or locations and no more than 5 of these occur in an area that is free from sudden processes capable of causing largely irreversible loss of individuals or habitat"].

There is probably insufficient conclusive evidence to nominate *Cassytha pedicellosa* as a threatened species under the Tasmanian *Threatened Species Protection Act* 1995. Evidence to support a listing is not unequivocal. On the one hand, the available information seems to point to a species that is widespread, represented by several subpopulations that are well-reserved, and resilient to various forms of natural and anthropogenic disturbance. On the other hand, the species is represented by a relatively small number of subpopulations, many of which may be limited in their extent and abundance. Irrespective of the formal conservation status of the species, a precautionary approach to the management of the species is warranted. In the absence of

Plate 4. Habitat of *Cassytha pedicellosa: Eucalyptus amygdalina* (black peppermint) open forest on sandy soils (derived from Triassic sandstone) at Denison Street, Kingston. Photograph: M. Wapstra

Plate 5. Habitat of *Cassytha pedicellosa*: coastal heathland with sandy soils on walking track between Remarkable Cave and Mt Brown, Tasman Peninsula Photograph: M. Wapstra

a category on the Tasmanian *Threatened Species Protection Act* 1995 such as "data deficient" that may afford some level of legislated management, a cautious listing of this endemic and enigmatic species may be defensible.

Acknowledgements

Miguel de Salas and Kim Hill (Tasmanian Herbarium) are thanked for provision of database information. Lorilee Yeates provided comments on an earlier draft of this manuscript. Comments from Miguel de Salas improved the readability and factual accuracy of the manuscript.

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Severe decline of the Giant Freshwater Crayfish, *Astacopsis gouldi*, in Caroline Creek, northern Tasmania

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Abstract

A reserve for the giant freshwater crayfish, *Astacopsis gouldi*, was established in 1973 in Caroline Creek, a small tributary of the Mersey River south of Railton, on the basis of an abundant population of giant crayfish in the creek. Subsequent surveys in 1987, 2009 and 2014 recorded adult animals in the lower reaches, below the steady input of water pumped from the Cement Australia limestone mine. However, a survey in 2017 failed to record any giant crayfish in the lower reaches, despite the use of baited drop nets for 25 trap hours, and 12 person-hours of visual searching, under good conditions. A single small male was observed in the upper reaches, which are now isolated from the lower reaches by a large recent sinkhole. Possible reasons for this severe decline, or possible extinction, of *A. gouldi* in the lower reaches of Caroline Creek are discussed, particularly the effects of the catastrophic floods in June 2016.

Introduction

The giant freshwater crayfish, *Astacopsis gouldi* Clark 1936, is endemic to streams and rivers flowing into Bass Strait, with the exception of the Tamar catchment and the addition of the Arthur River and its tributaries (Horwitz 1994). As the world's largest freshwater crayfish, and indeed the largest freshwater invertebrate, it is an iconic member of Tasmania's fauna. It is currently listed as vulnerable under both the Tasmanian *Threatened Species Protection Act 1995* and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. It is also listed as endangered in the IUCN Red List of Threatened

Species. Threats to the species include habitat loss or disturbance in the form of sedimentation, loss of riparian tree cover and loss of in-stream woody debris; modifications to water flow; illegal fishing; and climate change (CofA 2017).

Prior to 1993, the holder of an inland fisheries permit could take up to twelve *A. gouldi* per day provided they exceeded the minimum carapace length of 130 mm and were not females in berry. From the 1993-4 season, the bag limit was restricted to three sized males per day, and the taking of any females was prohibited. Recreational fishing was banned in an amendment of the Tasmanian *Inland Fisheries Act 1995* on 1 January 1998, but poaching still occurs. The species was included on the Tasmanian *Threatened Species Protection Act 1995* at the promulgation of the Act, meaning that between 1995 and 1998 the species could be fished legally despite its legislated threatened status.

Some concern for *A. gouldi* was noted as early as the 1960s (Lynch 1967, 1969) and in response the Inland Fisheries Commission declared Caroline Creek to be a reserve for the species in 1973 (Horwitz & Hamr 1988).

Rationale

The rationale for the present paper is a study commissioned by Forico Pty Limited on the part of the catchment of Caroline Creek under their management to better understand the distribution of *A. gouldi*. The objectives of the original study were to document the population structure within Caroline Creek (e.g. sex ratios, adult and juvenile abundance, size profiles, etc.) and to establish a long-term monitoring program. The latter program was intended to document the rates of recruitment and mortality through use of capture-mark-recapture using passive integrated transponder (PIT) tags (e.g. Bubb *et al.* 2002; Shepherd *et al.* 2011), with a view to further informing a broader statewide long-term monitoring program (Richardson & Walsh in prep.). However, the surveys did not capture sufficient crayfish to utilise the PIT tags, raising the question of the current status of *A. gouldi* in Caroline Creek. This present paper describes the methods and results used in the Forico survey, and collates the results of previous surveys for giant freshwater crayfish in Caroline Creek. It also discusses the possible reasons for the apparent decline of the species in the catchment. This is considered of benefit to the broader research into the geomorphological and hydrological studies in the catchment, which in turn may also shed light on the occurrence of *A. gouldi*.

Caroline Creek

Caroline Creek is a short stream, rising in the Badgers Range and discharging into the Mersey River just south of Latrobe. It has a complex catchment with multiple land uses and several different land owners and managers (Figures 1-3). The upper reaches are mainly now classified as Future Potential Production Forest (Crown) with some areas of Permanent Timber Production Zone Land (Sustainable Timber Tasmania).

Figure 1. General location of Caroline Creek (shown as a red line) [source: TheList]

A small part of the catchment (upstream of the confluence with Marine Creek) is classified as the Caroline Creek Regional Reserve (Parks & Wildlife Service). Additional parts of the catchment are classified as the Bonneys Tier Regional Reserve (Parks & Wildlife Service). A small part of the upper catchment (west of New Bed Road) is subject to a conservation covenant established under the Tasmanian *Nature Conservation Act 2002*. A much larger part of the lower part of the catchment is subject to a conservation covenant, equating to approximately 2 km of the length of Caroline Creek upstream of the crossing by the Western Line.

In the middle part of the catchment, Cement Australia (Goliath) Pty Limited owns and manages the long-term limestone quarry (pit mine), and also several surrounding titles. Water is discharged from this facility mostly into a drain referred to as Browns Drain, which in turn flows into Caroline Creek. The discharge pumped from the mine has provided the majority of the river's flow during droughts (Doran & Richardson 2010). There is also a waste disposal facility located opposite Haines Siding, which is operated by the Dulverton Regional Waste Management Authority (Latrobe Council). The balance of the catchment is private land, developed to varying degrees from relatively intact native vegetation through to primary production (cropping and grazing), and plantations. Forico Pty Limited own and manage several hundred hectares of hardwood and softwood plantation within the catchment of Caroline Creek, mainly downstream of Cement Australia's quarry facility: some plantations are on Forico's freehold, while others are on land owned by Cement Australia (Figure 2). The latter area in particular (mainly between the quarry facility and north to Youngmans Road) is geomorphologically active and includes many large sinkholes. This area is subject to a current research project undertaken by the University of Queensland and the Forest Practices Authority. A large, recent sinkhole separates the upper reaches of the creek above Browns Drain from the lower reaches, where most of the sightings of *A. gouldi* have been recorded.

Records of *A. gouldi* in Caroline Creek

Figure 3 shows the existing records of *A. gouldi* in Caroline Creek [source: *Natural Values Atlas*, accessed 14 Dec. 2017]. There are no historical or recent records in Caroline Creek upstream of Haines Siding i.e. a few hundred metres upstream of the crossing of the creek on Dawsons Siding Road.

The gazettal of part of Caroline Creek as a crayfish reserve in 1973 was based on anecdotal evidence of the abundance of crayfish in the river. The first formal assessment was by Horwitz & Hamr (1988) who used a combination of baitlines, tangle nets, drop nets and hand collecting over three days in November/December 1987. They confined their sampling to the crayfish reserve (effectively between Railton Road and Dawsons Siding Road). They collected 24 animals and saw a further four, ranging in size from 38.6-126.6 mm (carapace length, CPL).

In 2009, Cement Australia commissioned an assessment of threatened fauna in Caroline Creek below their mine. As part of this study, Doran & Richardson (2010) surveyed the river over four days between December 2009 and January 2010 by walking the creek, turning rocks and collecting crayfish by hand. They caught and measured eight animals ranging from 26-136 mm CPL and observed several more between the junction with the Mersey River and approximately 2.5 km downstream of the Cement Australia property.

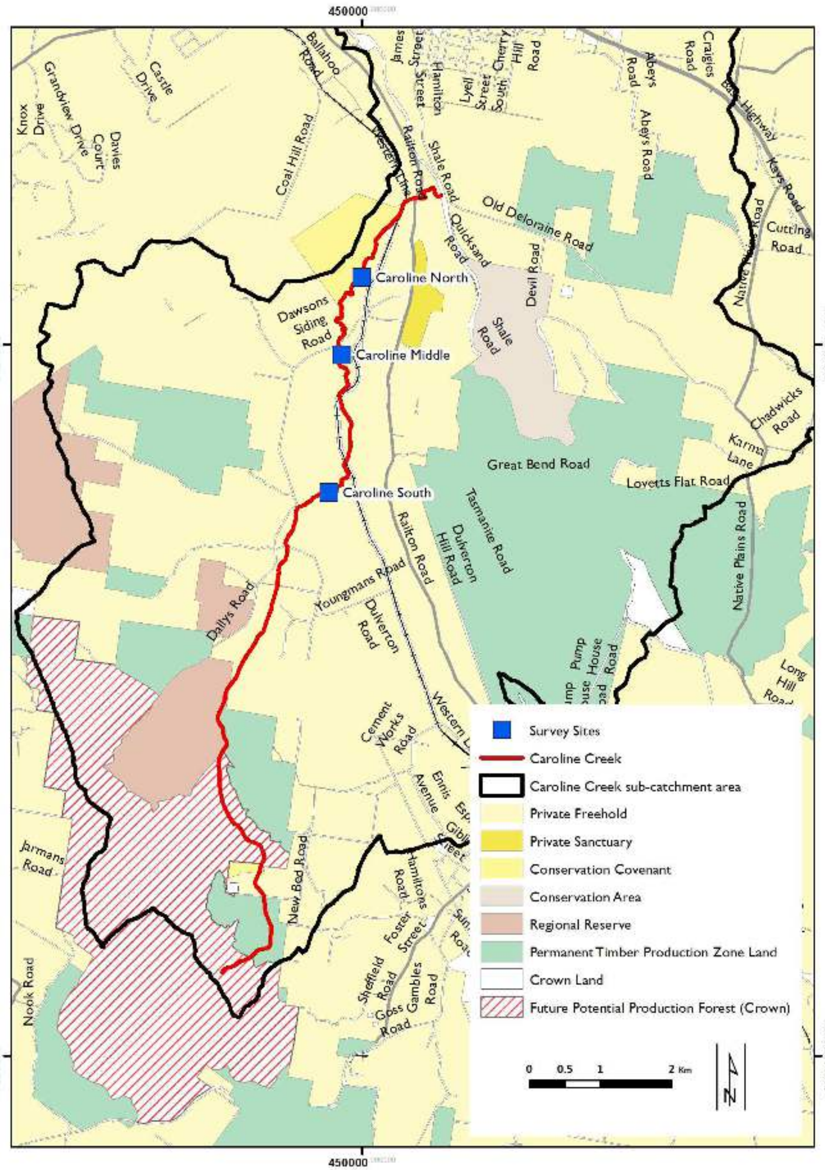

Figure 2. Catchment of Caroline Creek showing land tenure and sample sites [source: TheList]

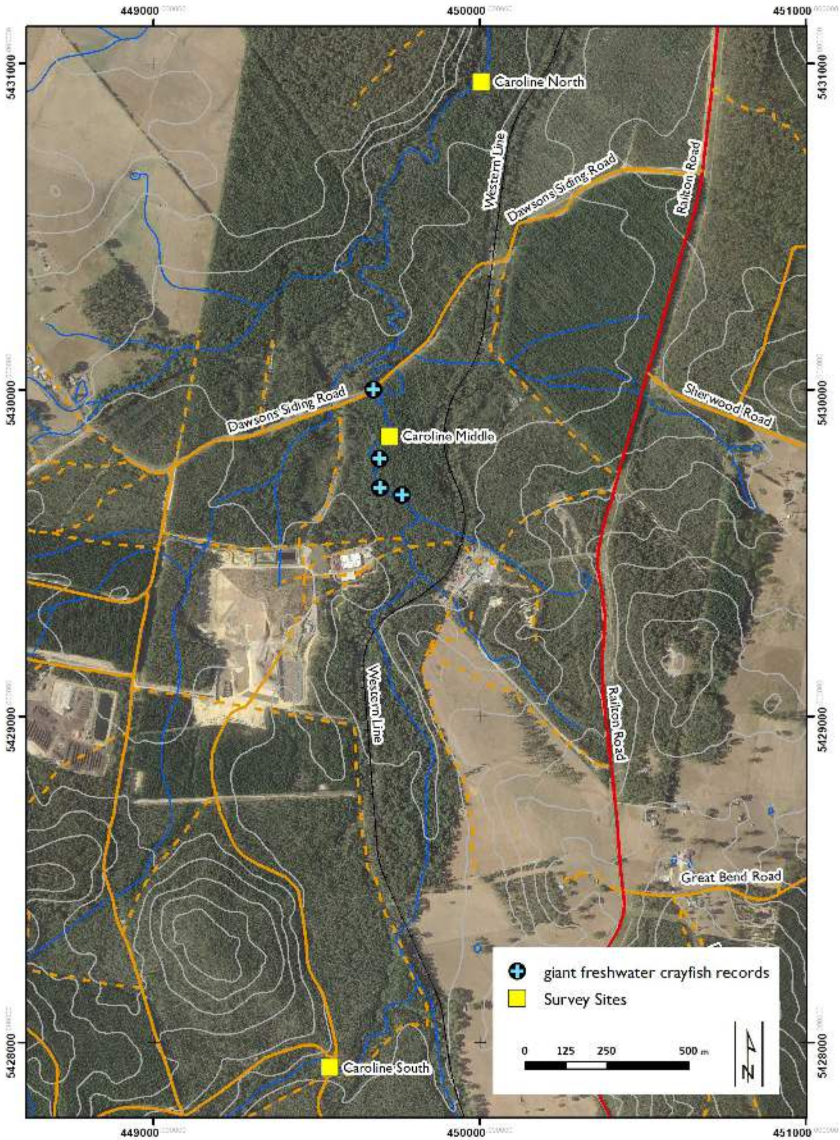

Figure 3. Section of Caroline Creek catchment showing plantation areas, sample sites (2017 survey) and records of *A. gouldi* (note that the juvenile was captured at "Caroline South") [source: *Natural Values Atlas*; Doran & Richardson (2010); other observations]

Plate 1. Adult male *Astacopsis gouldi* (CPL 130 mm) caught in Caroline Creek on 5 Nov. 2014

Photograph: M. Wapstra

Plate 2. Juvenile male *Astacopsis gouldi* (CPL 54.3 mm) caught in Caroline Creek on 12 Dec. 2017
Photograph: B. French

In November 2014, during the field component of an NRM freshwater crayfish training day, an adult male (Plate 1), 130 mm CPL, was captured immediately upstream of Dawsons Siding Road (A. Richardson, unpubl. data).

In May 2016, Mark Wapstra and Alastair Richardson walked the river from Railton Road to Dawsons Siding Road to identify suitable sampling sites for the study commissioned by Forico Pty Limited. No crayfish were sighted during this survey, but water temperature was dropping, and the animals may have been inactive (T. Walsh pers. comm.)

Recent survey

Most recently the site was surveyed on 11 & 12 December 2017 by Alastair Richardson and Brian French as the first stage in the long-term study commissioned by Forico. Three potential monitoring sites, one (south) in the upper reaches, and two (middle and north) in the lower reaches (Figure 3) were sampled using ring nets baited with pilchards. The traps were checked regularly during the day and were left in place over night at the middle site. Sections of the creek adjacent to each trapping site were waded several times (c 300 m at the northern and middle sites, 30 m at the southern site), turning rocks with a pond net held downstream, and visually searching for crayfish. The water was clear, and visibility was good. Downstream of the southern site the creek went underground in a recently-developed sinkhole.

No crayfish were caught or sighted at the northern and middle sites; baits left overnight at the middle site were only slightly damaged, but one fish was missing from a bait bag. No animals were seen on the damaged baits, but brown trout were plentiful and several stoneflies (*Eusthenia* sp.) and freshwater shrimps (*Paratya australiensis*) were observed at these sites and may have been responsible. At the southern site, upstream of the new sinkhole (Figure 3), a single male crayfish (CPL 54.3 mm) was captured by hand (Plate 2).

Both the middle and northern sites showed some signs of sedimentation, with fine marl (lime-rich mud) covering rocks and logs in slower flowing reaches. In some sections, grey filamentous algae covered the bottom, while adjacent sections had beds of *Cycnogeton* (syn. *Triglochin*) (water-ribbons) and *Potamogeton* (pondweed). The northern and middle sites had plenty of apparently suitable habitat for adult *A. gouldi*, while the southern site appeared to have suitable habitat for smaller *A. gouldi*.

Discussion

Status of population of *Astacopsis gouldi* in Caroline Creek

The apparent absence of *Astacopsis gouldi* from the lower reaches of Caroline Creek is surprising and disturbing. As well as the intensive baiting at the middle and northern sites most of the section downstream from Haines Siding was walked several times without any crayfish being sighted. But as recently as 2014 a large adult was caught close to the middle sampling area of the present study (2016-2017), and the past three investigations into the presence of the species in the creek have readily located animals, not only by trapping, but simply through sightings while walking the creek.

Although the intensity of sampling in this study was lower than that of Horwitz & Hamr (1988) it still involved over 25 trap hours and about 12 person-hours of visual observation in ideal conditions, and it substantially exceeded the sampling intensity of the Doran & Richardson (2010) survey. The absence of significant damage to the baits left out overnight is particularly telling. The superficial damage observed can be attributed to small fish or freshwater shrimps, and the loss of a whole fish from one bag was most likely to due to an eel. There was no evidence of the extensive damage caused by crayfish.

It is hard to escape the conclusion that *A. gouldi* is effectively extinct in the lower reaches of Caroline Creek, which leads to speculation as to the cause of its disappearance and what might be done about it.

If a few animals the size of the male captured at the south site have survived, it will be over ten years until breeding is likely to occur, since females do not mature until 14 years of age (120 mm CPL), and males at 9 years (75 mm CPL) (Hamr 1996). Further, the unreliable stream flow in the upper reaches makes the survival of large animals doubtful.

Possible causes of population reduction

The loss of the animals may have been due to changes in river conditions or poaching. The only evidence of poaching was a single old baitline, but we can consider what changes might have occurred in the river and its catchment since 2014. Three land-uses stand out in the catchment: the Cement Australia mine, forestry plantations, and the refuse disposal area.

Since the survey of Doran & Richardson (2010), and measures put in place by Cement Australia, discharge of fine sediment from the mine into the river has declined, but sediment deposits were visible at both the northern and middle sites, coating rocks and logs. In 2016, a local landowner reported occasional pulses of sediment-laden water. However, crayfish were present in the river before the present controls were in place, suggesting that they can tolerate moderate levels of sedimentation.

No substantial harvesting has occurred in the plantations in the Caroline Creek catchment since 2014. No information is available about the use of pesticides or herbicides in the catchment, but it seems unlikely their use could have eliminated the crayfish without affecting the other freshwater invertebrates in the creek. The presence of stoneflies and freshwater shrimps suggests good average water quality under the AUSRIVAS protocol for assessing stream quality (DPIPWE 2016)

Although no water chemistry is available, it seems unlikely that some unknown seepage from the refuse disposal site could have eliminated the crayfish. Once again the lack of any apparent impact on the other freshwater invertebrates in the creek argues against any chemical pollution.

Since these environmental factors seem to be eliminated we can consider natural events. On 5-6 June 2016, northern Tasmania experienced a severe rainfall event and subsequent flooding (BOM 2017). Record flooding was recorded in the adjacent Mersey River catchment and rainfall in the Caroline Creek catchment was very high. A landowner on the River Leven at Gunns Plains reported finding the carcasses of 50-100 crayfish in paddocks after the flood (The Advocate 2016; ABC News 2016). It is possible that this extreme flood event was sufficient to remove these large animals from a small drainage system like Caroline Creek, which has few refuges in the banks, especially if the water rose very quickly before the animals could respond in whatever behavioural ways they might have to protect themselves from floods.

The floods also affected the drainage patterns in this geomorphologically active area. The headwaters now disappear underground just downstream of the southern sample site, but it is unclear where they re-surface and whether they contribute to flows in the lower reaches. If they do not, then the lower reaches are almost entirely dependent on the water pumped from the mine, and so are at the mercy of occasional stoppages in the flow. However, short-term (i.e. a day or so) stoppages would be unlikely to affect crayfish, which would simply retreat to the deeper pools.

It is of course very difficult to prove the complete absence of *A. gouldi* from the lower reaches of Caroline Creek, but the capture of one small male in the headwaters suggests that a very few animals may have survived in the lower reaches. However, if survival is more likely in the headwaters, where the flood would have been less violent, those animals are now cut off from the lower reaches by the sinkholes that appeared during the flood. Re-colonisation from the Mersey River is a remote possibility, but only in the very long-term, since crayfish there are likely to have suffered the same effects as reported in the River Leven.

Further records of mass kills of *A. gouldi*, or its disappearance from previously well-stocked sites, would be of great interest. If intense rainfall events like the one that occurred in June 2016 become more frequent as climate changes, catastrophic flooding may become a serious pressure on populations of *A. gouldi*, especially in cleared, or partially cleared, catchments without a forest cover to buffer runoff.

Future actions

Translocation of breeding animals to re-populate Caroline Creek might be considered, but animals would have to be carefully chosen from genetically similar stock (most likely in nearby rivers). No official translocations of *A. gouldi* have been made to date, though introduced populations are known outside the natural range in one or two locations, viz. River Clyde near Hamilton and St Patricks River near Nunamara (CofA 2017). At present, we do not advocate this course of action for Caroline Creek. If it emerges from other observations that *A. gouldi* is vulnerable to catastrophic flooding in some catchments there will be little point in trying to re-establish them in such places when such events are predicted to become more common.

Further surveys of Caroline Creek between the Cement Australia facility and the Mersey River may be warranted, although the scheduling of these should take into account the apparent absence of the species at present and the very slow growth rate of any small individuals that may be present. That is, a survey in the next few years is unlikely to reveal significant information. It may be prudent to undertake additional surveys in c. 5-10 years. The form of the survey should probably be similar to the one presented herein i.e. a walk-through combined with strategic baited nets.

Land management in the part of the catchment upstream of the Haines Siding area becomes somewhat more complicated with multiple landowners and managers, making a coordinated approach to surveys important. It is important to gain an understanding of the relative roles of different land uses within the catchment, how these interact with one another and with natural processes (including the geomorphology, hydrology and functioning of Caroline Creek and other parts of the catchment), and the influence of this on the population of *A. gouldi*. We have presented this paper as part of the broader picture to inform a coordinated approach to catchment management (recognising that it is probably a complex combination of historical and contemporary factors that influence the population of *A. gouldi* in Caroline Creek).

Acknowledgments

Todd Walsh provided advice on sampling design and findings. Karen Richards (DPIPWE) assisted with the research permit application processing. All sampling and animal handling was undertaken under the DPIPWE-issued permits to take threatened fauna for scientific research TFA 16101 & TFA 17074. Simon Cook (Forico Pty Limited) and other landowners facilitated site access. We thank Simon Grove for helpful comments on the manuscript.

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First Tasmanian record In 80 years: *Achthosus Westwoodi* Pascoe, 1863 (Coleoptera: Tenebrionidae: Ulomini) from Three Hummock Island, Western Bass Strait with ecological notes

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Introduction

Achthosus westwoodi (Plate 1) is a saproxylic tenebrionid beetle 15-25 mm in length that occurs in eastern Australia from the high tropics of Queensland to southern Victoria in a wide variety of climate and habitat types (Atlas of Living Australia 2018). The species has also been recorded from King Island, western Bass Strait, on several occasions (Lea 1908; this study). The biology and habits of *A. westwoodi* are poorly documented. A summary of several decades of field notes by Hawkeswood (2009) provides an insight into this species. Adults and larvae are always associated with rotting branches, logs and stumps of a wide variety of both native and introduced trees lying on the substrate in sheltered or moist situations. Only well-decomposed and moist wood is utilised, usually after being partially broken down by other saproxylic coleopterans such as Cerambycidae (long horns) and Passalidae (passalid beetles). Typically, *A. westwoodi* is only present in small colonies of a few adults and larvae in chambers made in the rotting wood by the tunnelling adults. The ecological notes of Hawkeswood (2009) are in broad agreement with both authors' personal observations of this species in the field.

Plate 1. Dorsal and lateral views of adult male *Achthosus westwoodi* (QVM.2017.12.2204) from Three Hummock Island, north west Tasmania. Note the distinctive form of the thorax. Photograph: D. Maynard.

Achthosus westwoodi has never been recorded from mainland Tasmania. To date, the southern extent of the species was King Island; the eight specimens held in Australian museums were collected on King Island between 1906 and 1938.

In this paper we firstly report on the first specimens of *A. westwoodi* collected from the Bass Strait islands for 80 years, secondly a ~25 km southerly extension in distribution to Three Hummock Island off northwest Tasmania, and thirdly we ponder the absence of this species from mainland Tasmania.

Field observations

On the 18th of January 2017 the first author was conducting entomological field work for the Queen Victoria Museum and Art Gallery (QVMAG) in *Eucalyptus nitida* dry forest and woodland a few hundred metres inland of Rape Bay, Three Hummock Island (GDA 94 322880 E 5525899 N). Four adult specimens of *A. westwoodi* were found in a decomposing eucalypt limb lying on the ground. All four specimens were retained and are now in the entomological collection of QVMAG (QVM.2017.12.2203-2206).

The limb was lying amongst moist eucalypt leaf litter on a low gradient slope with a generally easterly aspect. The understorey was sheltered from the prevailing winds and afternoon sun. The limb was approximately 180 mm diameter and about 1500 mm long. It was well rotted and easily broken up. The centre was moist and friable, and galleries had been formed by the beetles along its length.

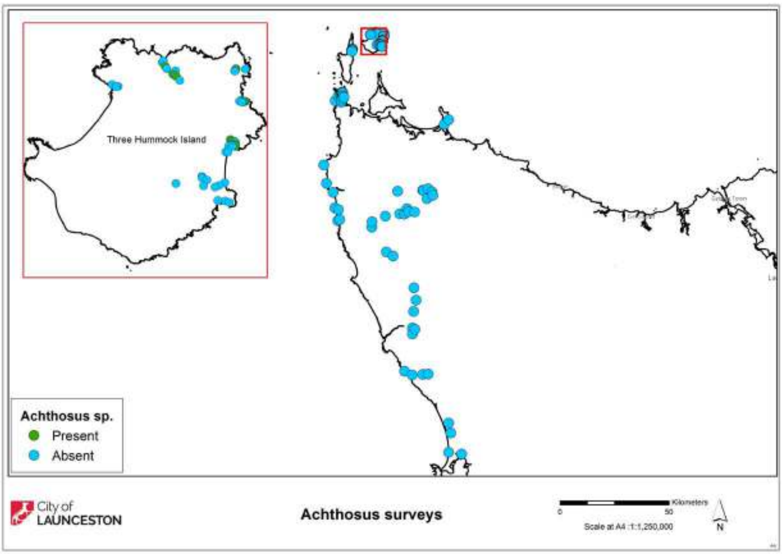

Figure 1. Sampling sites visited by the authors and searched for saproxylic beetles in December 2017 and January 2018.

During a second collecting expedition by the first author to Three Hummock Island from 27 December 2017 - 04 January 2018, *A. westwoodi* was found to be locally common. A further 94 specimens being collected from 20 sites (QVM.2018.12.0006-0099) (Figure 1). All but two of these specimens were collected from galleries in decomposing limbs and logs (referred to as logs from now on) of *Eucalyptus viminalis*, *Banksia marginata*, *Melaleuca ericifolia*, *Bursaria spinosa*, *Acacia stricta* and *Leptospermum scoparium*. The remaining two beetles were collected beneath two different fallen logs.

Plate 2. The typical habitat, and rotting eucalypt log in which *Achthosus westwoodi* was found on Three Hummock Island. Rainbow Bay, 28 December 2017. Photograph D. Maynard.

Typically, the beetles inhabited logs that were 100 - 150 mm diameter with the largest being 180 mm. All of these logs were lying in direct contact with the substrate in dense, sheltered and well shaded tree and shrub thickets (Plate 2). Most of the logs examined appeared to have resulted from storm damage or, more commonly, were victims of succession. Often it appeared that *Melaleuca ericifolia* had over grown and shaded out *Banksia marginata* causing them to die and eventually fall to the ground.

Discussion

Collection history

The authors worked with Australian museums and other publicly owned collections to document all of the specimens collected in the Tasmanian region. In all, just eight specimens were found in the collections, and all of them were from King Island. The Australian National Insect Collection (ANIC) holds three of these specimens. These were collected by A. M. Lea (collection date unknown). The South Australian Museum (SAM) holds one specimen (collection date unknown) and it is presumed to have been collected by Lea as it has a listing number on the label (10307) referring to his original index of specimen names at the museum. All four of the above specimens are most likely part of the sample of ten collected by Lea in 1906 and reported in Lea (1908). The Australian Museum (AM) holds another two *A. westwoodi* from King Island. These were collected from under logs by A.P. Bassett-Hull in December 1932. The remaining two specimens are held by Museum Victoria (MV); one was collected by J. A. Kershaw (collection date unknown), and the other was collected in January 1938 with no collector name recorded.

The specimens from ANIC, SAM and MV were all initially labelled as *Achthosus westwoodi* var. *insularis* from Lea (1908) in which he stated:

> *"… there are ten specimens before me, which, after considerable hesitation, I have regarded as a variety of westwoodi, rather than representing a distinct species".*

Lea goes on to describe what are by today's standards rather minor variations in size and colour. All these specimens have a later label reinstating them as *A. westwoodi* Pascoe after examination by renowned Hungarian coleopterist Zoltan Kaszab (1915-1986) in 1981.

Tasmanian distribution

Achthosus westwoodi is widespread and common in eastern Australia, and until now, only been recorded on King Island and Three Hummock Island off Tasmania's northwest coast. It was not found during 2018 fieldwork at Shepherds Bay, Hunter Island (~11 km ESE of Three Hummock Island), or Woolnorth Point on mainland Tasmania (~27 km SE of Three Hummock Island). *A. westwoodi* is fully-flighted, however there is no information on its relative dispersal ability. If it is unable to fly between the islands of the Hunter Group and mainland Tasmania then it has presumably been isolated on Three Hummock Island for about 10 000 years since final separation by eustatic sea level rise.

We don't yet understand what determines this species' southerly distribution. It may be related to habitat, winter temperatures, competition or predation (or a combination of these factors).

Habitat

The vegetation of Three Hummock Island has changed since European arrival. At various times there have been attempts to inhabit the island, the longest period being from 1951 to 1976 when the dune land was farmed and livestock were grazed. From 1976 the Island has been managed as a Nature Reserve by the Parks and Wildlife Service. In 1982 and 1984 wildfires destroyed much of the island's vegetation. Since that time much of the island's vegetation has reverted to scrub and short forest (Bryant *et al.* 2008).

The areas in which *A. westwoodi* were collected are now predominantly *Eucalyptus nitida* dry forest and woodland. The number of available host logs on the ground was considerable and may be the result of succession. If so, host log availability may decline with time. Perhaps *Achthosus* is enjoying a habitat 'boom' on Three Hummock Island. Similar habitat was absent from the area searched on Hunter Island; more extensive searching is needed to confirm the species presence or absence. Woolnorth Point had some suitable habitat but again, *A. westwoodi* was not found (discussed further below).

Temperature

King Island's climate is unique, having one of the most equable thermal regimes in the Australian region, with less than 6°C difference between mean summer and winter temperatures (Porch *et al.* 2009). Further, the combination of moderate summers and relatively warm winters, indicative of the strong maritime influence on the climate, results in a mean annual temperature of 12.9°C.

If the southern distribution of *A. westwoodi* was solely limited by temperature, and specifically Tasmania's cold winters, then there are areas with similar winter temperatures to King Island that could support them. Such an area extends from Cape in Victoria to Marrawah on Tasmania's west coast. Analysis of the average monthly minimum temperatures (AMMT) from 2009 to 2017 (Bureau of Meteorology 2018) for Cape Otway (8.3°C), King Island Airport (7.6°C), Cape Grim (8.2°C), Marrawah (7.2°C), Smithton Aerodrome (4.7°C) and Wynyard Airport (3.5°C) suggests that there may be two winter temperature zones in northwest Tasmania. The AMMT for the western locations (King Island Airport, Cape Grim and Marrawah), is at least 2.5°C higher than the north coast locations (Smithton aerodrome and Wynyard Airport) (Figure 2).

The AMMT for Three Hummock Island, the other island with *A. westwoodi*, was calculated for the same period, and it reflected the same trend, but was warmer than all other locations (9.0°C; Figure 2). It should be noted that the Three Hummock Island data is not BOM data. Instead it was collected by the island's caretakers using personal equipment and the calibration history of the unit is unknown. Three Hummock Island's AMMT appears to closely align with the western locations, rather than the northern locations.

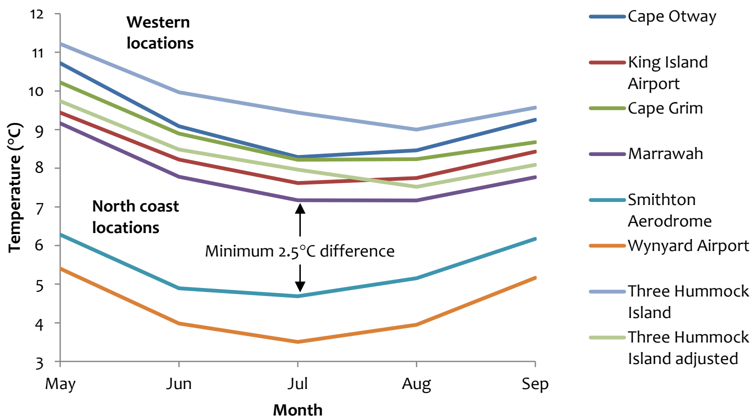

Figure 2. The average monthly minimum temperatures (May-September 2009-17) for six locations; five in northwest Tasmania, and one, Cape Otway, in Victoria.

So, there would appear to be parts of northwest Tasmania with similar winter conditions to Cape Otway, King Island and Three Hummock Island where *A. westwoodi* could exist. Woolnorth Point is once such place. It is just ~27 km south of Three Hummock Island, a relatively short distance for a flighted species. Between 01/12/2017 and 06/12/2017 and again on 27/01/2018 both authors sampled 25 sites across Woolnorth Point (Figure 1). Thousands of insects were collected (by hand, net and light trapping) including a rich assemblage of saproxylic species associated with similar habitat to that on Three Hummock Island; decomposing logs of a variety of tree species were abundant at most sites. Yet, *A. westwoodi* was not found. Given our search effort, we suggest that at least during the sampling period, *A. westwoodi* was not present at Woolnorth Point even though the temperature regime is unlikely to be a limiting factor. It is worth noting that all the other coleopteran species, particularly tenebrionids, associated with rotting logs collected from Three Hummock Island were also common at Woolnorth Point.

Competition

Another factor that may limit the distribution of *A. westwoodi* is competition with other Tenebrionidae. Although *A. westwoodi* is widespread on the mainland with a wide host range, Hawkeswood (2009) suggests that it is not able to maintain large population sizes like other Tenebrionidae such as *Adelium* spp. Recent collecting on Three Hummock Island by QVMAG staff has recorded *Adelium tenebroides*, several as yet undetermined *Adelium* spp. as well as the ubiquitous *Mineristes australis*. All these species are commonly associated with a wide variety of decomposing host timber and specimens, but they were rarely collected from the same log as *A. westwoodi*. *Mineristes australis* in particular is widespread and locally abundant in Tasmania where it can form high population densities of both adults and larvae in individual logs and stumps of a wide variety of native and ornamental trees and large shrubs (S. Fearn, unpublished data). These competing species may prevent *A. westwoodi* from establishing in a new area.

Predation

Achthosus westwoodi was found to be common and abundant on Three Hummock Island and this may, in part, reflect a low level of predation. There appear to be very few insectivores that live on or visit Three Hummock Island. The echidna (*Tachyglossus aculeatus*) was not recorded in a 2006 faunal survey (Bryant *et al.* 2008), and the resident caretakers of the private accommodation have never seen it (Bev and John O'Brian, pers. comm.). Also, neither of these sources recorded the presence of the southern brown bandicoot (*Isoodon obesulus*) or eastern barred bandicoot (*Perameles gunnii*). However, the first author did see evidence of animals breaking apart fallen logs. This is likely to be the work of the forest raven (*Corvus tasmanicus*), black currawong (*Strepera fuliginosa*) and/or yellow-tailed black-cockatoo (*Calyptorhynchus (Zanda) funereus*), all of which are recorded from the island (Bryant *et al.* 2008; D. Maynard personal obs.) The low rates of predation may be a factor in the locally high abundance of *A. westwoodi* on Three Hummock Island.

Conclusion

The insect fauna of King Island and northwest Tasmania is too poorly documented at this time to draw any firm conclusions. For example, the beetle fauna of King Island is mainly documented from lists that are a century old and amount to fewer than 350 species which has been estimated to be a significant underestimate of the true diversity (Lea 1908; McQuillan 2003; Porch *et al*. 2009). According to the ALA, the insect faunas of Three Hummock Island (46 records) and Hunter Island (8 records) are even less well known.

The distribution patterns of a range of other invertebrates in the western Bass Strait region, such as the millipede *Pogonosternum nigrovirgatum* (Decker 2016; R. Mesibov pers. comm.), terrestrial amphipods (Friend 1987) and native land snails (Bonham 1997, 2003), reflect that of *Achthosus westwoodi*. At least seven snail species known from King Island are either (a) found in Victoria but nowhere further south than King Island in Tasmania, or (b) are King Island endemics with Victorian rather than Tasmanian affinities at the genus level (K. Bonham pers. comm.). Two species (*Tasmaphena lamproides* and *Allocharopa tarravillensis*) are widespread in Victoria and have 'toe-holds' in the Hunter Group of islands and far northwest Tasmania. The Tasmanian distribution of both species is likely to be climate limited, particularly *T. lamproides* which has been well surveyed and disappears with altitude on higher ridges south of the northwest coastal forests (Bonham pers. comm.).

There is clearly scope for further research on the distributions and southerly range extensions for mainland Australian insects, particularly for species that pose a biosecurity risk. Factors to be investigated include effects of land area, climatic variability, competition, and biogeographical boundaries (Addo-Bediako *et al*. 2000; Gaston *et al*. 1998).

A thorough understanding of the insect fauna of north west Tasmania, King Island and other western Bass Strait island groups is decades away and will require dogged, systematic collecting of voucher specimens. QVMAG is planning field trips to attempt to locate *A. westwoodi* in discrete patches of apparently suitable coastal habitat in North West Tasmania as well as offshore islands in coming seasons.

Acknowledgements

Sincere thanks to all the curators who kindly gave up their time to check collections for specimens of *Achthosus*: Simon Grove (TMAG), Simon Hinkley (MV), Chris Reid (AM), Christine Lambkin (QM), Peter Hudson (SAM), Nikolai Tatarnic (WAM) and Cate Lemann (ANIC). Thanks to Bob Mesibov for his advice, and to Nick Porch for providing a copy of his paper. Special thanks to the crew of *Sooty Petrel*, Lesley and Peter Wells, and Dianne Maynard for supporting field work on Three Hummock Island and Hunter

Island. Thanks to Evan Rolley and Peter Van Zyl from Moon Lake Investments for access to Woolnorth Point. Thanks also to Mark Wapstra for botanical identifications and advice, Kevin Bonham for biogeographical advice, John and Bev O'Brian, caretakers of Three hummock Island accommodation for their help with wildlife observations, and Kathryn Pugh and Mark Brown for their GIS skills. Thanks to Alastair Richardson for reviewing the manuscript.

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Recent records of two uncommon Lycaenid butterfly species (the Saltbush blue and the Dull heath blue) in Tasmania

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The saltbush blue (*Theclinesthes serpentata,* Lycaenidae) in eastern and south eastern Tasmania

Introduction

The saltbush blue butterfly, *Theclinesthes serpentata* (Herrich-Schäffer) (Family Lycaenidae, Subfamily Polyommatinae) is one of the three Tasmanian butterfly species listed under the *Threatened Species Protection Act 1992*, in which its endemic south-eastern subspecies, *T. s. lavara,* is classified as Rare. This species, which also occurs widely in southern, eastern and inland Australia, is of fairly limited occurrence in the Tasmanian region, being known from coastal habitats in north eastern and south eastern Tasmania, and on Flinders Island. There are two races in Tasmania; subspecies *lavara* (Plate 1) is known only from the south east, while the north eastern and Flinders Island populations are recorded as the subspecies *serpentata,* which is also the form on mainland Australia.

On the mainland its habitat has been described as variable by Braby (2004), ranging from inland salt bush shrublands, woodlands to coastal salt marshes and sand dunes, but these habitats would appear to be linked by the presence of saltbush plant species (Braby 2004). In Tasmania its habitat is more restricted, being described as saltmarshes and mudflat margins by Collier (1994), habitats where its larval food plant, the salt bush species *Rhagodia candolleana* (Amaranthaceae), occurs.

Plate 1. An adult male saltbush blue (*Theclinesthes serpentata lavara*) at Calvert's Beach, 31 March 2017 on *Rhagodia candolleana*

The subspecies *T. s. lavara,* which was described by Couchman (1954), is characterised by its wings having more distinct underside markings and having more extensive areas of blue on the upper sides without the purplish sheen. It is threatened by processes such as infilling and grazing of salt marshes in the south, which, along with its localised occurrence, justified its listing as Rare. The other subspecies, *T. s. serpentata,* is not yet considered as threatened in Tasmania or the Australian mainland.

Previous known occurrences in Tasmania

The south eastern subspecies, T. s. lavara, was originally collected and described from Cambridge (Barilla Bay) by Len Couchman in the 1950s, who also noted that the nominate race, *T. s. serpentata*, was recorded from Whitemark, Flinders Island (Couchman 1956). Since then the saltbush blue has been recorded from localities elsewhere in the Tasmanian region including on Flinders Island (Bush Blitz Species Discovery Program 2014), on Clarke Island (Natural and Cultural Heritage Division 2014), north-eastern Tasmania (Braby 2000), Low Head (Bowerbird, Sightings 2015), Marion Bay (Grove 2016), Dodges Ferry (About Tasmania 2017), Pittwater (Natural Values Atlas), Lauderdale (Natural Values Atlas), and Taroona Point (Grove 2016). Some of the south-eastern records are ascribed to subspecies *lavara*, but in other cases the subspecies is not specified.

New records of this species

We have recorded the saltbush blue from a number of localities in eastern and south eastern Tasmania in recent years (most of these have been entered in the Natural Values Atlas). These new records include Five Mile Beach, Pittwater, April 2011; Cressy Beach, south of Swansea, 15 April 2013; Hazards Beach (southern end), Freycinet National Park, 30 March 2014; Pipe Clay Lagoon (northern side) 17 April 2016; and Calvert's Lagoon, 31 March 2017. In all localities but one these records were of adult insects flying over and landing on shrubs of the saltbush species *Rhagodia candolleana* (Amaranthaceae) (Plate 2). Numbers observed ranged from two to eight individuals. The exception was at Pittwater where the butterfly was seen at bushes of *Atriplex paludosa*. A further potential record was from Long Point, Sandy Bay on the Derwent River in early

Plate 2. An adult saltbush blue (*Theclinesthes serpentata)* at Cressy Beach, 15 April 2013 on *Rhagodia candolleana*

April 2017 where a lycaenid butterfly species was glimpsed flying over a *Rhagodia* bush but was then carried off by a strong gust of wind before it could be positively identified.

Conclusion

These recent records have considerably filled in the Tasmanian range of the saltbush blue. We were not able to ascertain whether the Cressy Beach and Hazards Beach specimens were of the subspecies *lavara* or the nominate subspecies *serpentata* or of some possibly intermediate form between the two, so the boundary between the two subspecies remains uncertain. The south-eastern records have markedly added to the knowledge of conservation status of the subspecies *lavara*. However for the species as a whole it would also be interesting to find out whether it extends westwards of the Tamar Estuary along the Bass Strait coast to the north west coast. One point arising from these records is that the butterfly appears to be strongly associated with the shrub *Rhagodia candolleana*, its presumed larval food plant in Tasmania, whereas on mainland Australia it has a much wider range of larval food plants. Another point is that although *R. candolleana* is a common coastal shrub of almost weedy occurrence (it grows in seaside shack gardens and on roadside verges, e.g. at Lauderdale Canal, South Arm and Opossum Bay) the butterfly is not necessarily present. This is possibly because of its need for relatively undisturbed coastal habitat and the presence of particular species of larval attendant ants.

A new locality for the dull heath blue (*Neolucia mathewi*) in Tasmania

The small lycaenid butterfly, the dull heath blue (*Neolucia mathewi* Miskin), is one of Tasmania's least known butterfly species. Early records of the species in Tasmania come from the Launceston region and Flinders Island. However, the dull heath blue was never recorded in Tasmania by the state's notable 20th century butterfly specialist Len Couchman, despite his and his wife's extensive searching. In their article "The Butterflies of Tasmania" in the Tasmanian Year Book (Couchman & Couchman 1977) they state that despite their searching both in the Underwood district in central northern Tasmania, the locality where "it was recorded many years ago", and "in the triangle of Bridport-South Mount Cameron-Musselroe Bay", their searches were unsuccessful. Couchman and Couchman concluded that (based on knowledge of its New South Wales habitat occurrences) "Flinders Island is more likely a locality than the inland east Tamar region".

Collier *et al.* (1994) state that the dull heath blue (under the alternate name of Mathew's blue) occurs on King Island (as well as Flinders Island) and close to sea level in the north (of Tasmania), but is not recorded from montane areas in Tasmania. It is associated by inference with its larval food plant, the coastal shrub *Monotoca elliptica*. Despite their suggestion of a broader range they map it only from Flinders Island and two localities in the Launceston region, one probably being the old Underwood recording. Braby (2004) maps the species from Flinders and King Islands within the Tasmanian region as well as portraying the site of the old Underwood record as a former locality. The website *"Insects of Tasmania – an online field guide"* includes three photos that are identified as the "dull heath blue?" taken in mid-January 2012. These photos only show the upper wing surfaces and therefore the key feature of less prominent markings on the underside of the wings is not visible, hence the uncertain identification. Finally, the CSIRO web site "Atlas of Living Australia" has three records from Tasmania based on collections in the Museums Victoria Entomological Collection. Two collections are from the Underwood vicinity and are apparently the basis for the early literature records. The other is from the Mount La Perouse area of southern Tasmania to the west of Lune River; this record is highly doubtful and may be misidentification of a worn specimen of the montane heath blue (*Neolucia hobartensis*) which is widespread in alpine moorland in Tasmania. Couchman and Couchman (1977) were of the opinion that the Underwood locality "may have been the place of dispatch rather than origin" of the specimens.

Dora Point – a new locality for the dull heath blue in Tasmania

On a recent visit to Dora Point in the Humbug Point State Nature Recreation Area near St Helens, the authors recorded a single *Neolucia* butterfly flying around the outer branches of the shrub *Monotoca elliptica* at the camp site on the 25 November 2017. Because of the heavily overcast conditions the butterfly soon rested in the bush and closed its wings enabling good views of the undersides which were photographed (Plate 3). The following morning (26 November 2017) in the same vicinity up to five individuals were flying over the *Monotoca* bushes in bright sunshine. All of these insects were rather worn, accentuating any 'dull heath blue' appearance, however the lack of prominent markings underneath, apparent smaller size compared to the common heath blue (*Neolucia agricola*), which occurs in dry forests and heathlands, as well as their attraction the known larval food plant strongly suggest that these butterflies were the dull heath blue.

Plate 3: Male dull heath blue (*Neolucia mathewi*) resting on a dead branchlet of *Monotoca elliptica* at Dora Point camping ground, Humbug Point Nature Recreation Reserve taken on 25 November 2017. The relatively obscure markings of the wing undersides are characteristic of this species in contrast with the stronger and darker markings of the other *Neolucia* species in Tasmania.

Conclusion

According to Braby (2004) the dull heath blue also occurs on mainland south eastern Australia in coastal southern New South Wales and eastern Victoria, along with occurrences in the montane and subalpine hinterlands of the Great Dividing Range where it is of "very common but very local" status. In Tasmania its food plant, the coastal shrub *Monotoca elliptica,* is common and widespread on dune habitats along the northern and eastern coasts, which potentially suggests a considerably greater range than its known current range in Tasmania. We agree with Couchman and Couchman (1977) that the Underwood location is doubtful, as is the Mount La Perouse record. The potential range of this species is habitat similar to the Dora Point site, which occurs around Tasmania's warmer north east and north west coasts and Bass Strait islands. These habitats, if searched in the late spring flying season of the species, may reveal that it is of more widespread occurrence than earlier records suggest.

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A biological investigation of the Great Lake Giant Freshwater Limpet, *Ancylastrum cumingianus* (Bourguignat 1853) and its larger cousin *A. irvinae* (Petterd 1888)

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The Great Lake Giant Freshwater Limpet *Ancylastrum cumingianus* (Bourguignat 1853) was so named as it is significantly larger than other freshwater species and its shell superficially resembles those of marine limpets. Despite the shell similarity, the common name is erroneous on two counts. The first is that it is not a limpet (which is a common term given to several groups of marine molluscs); rather it belongs to the freshwater Pulmonata: Planorbidae, a large family with species showing a diversity of shell shapes, from flat to high-spired, and all sharing the features of sinistral coiling of the shell (opening to the left) and the absence of an operculum. Secondly, the genus *Ancylastrum* has in fact two recognised species: *A. cumingianus* (Bourguignat 1853) and *A. irvinae* (Petterd 1888) (Plate 1), and ironically, *A. cumingianu*s (up to 12 mm) is the smaller of the two, *A. irvinae* measuring up to 20 mm (Ponder *et al.* 2016). It is unclear when this common name was established, but the first published usage of a similar name appears in Gooderham & Tsyrlin (2002)

Plate 1. *Ancylastrum cumingianus* (left), *A. irvinae* (right).

where *Ancylastrum* is referred to as "the giant limpet", and again in a brief article on *A. cumingianu*s on the Companion to Tasmanian History website in which the species was considered likely to be extinct (Smith 2006). Indeed, the only other references to a 'common' name for *A. cumingianus* are in May (1920), where he notes "our large fresh-water limpet", and on the International Union for Conservation of Nature and Natural Resources (IUCN) red list, where it is referred to as "Tasmanian Freshwater 'Limpet'" (Mollusc Specialist Group 1996, Wells *et al.* 1983).

As the common names suggest, *Ancylastrum* species are patelliform (limpet-shaped), although the shell retains a remnant of a spiral on its apex. The original description of *A. irvinae* is incomplete, limited to external shell morphology (Petterd 1888); however, recent works provide more detailed anatomical descriptions for both species (Hubendick 1964, Walker 1988) and are the basis for the contemporary *Ancylastrum* taxonomy recognised in the interactive freshwater mollusc key (Ponder *et al.* 2016). While external differences in shell length, shape of the vestigial spire and presence and development of radiating ribs on the shells are key features separating the two species, internally there are also morphological differences, including dentition of the radula and in the reproductive system, specifically the number of lobes of the penis (unilobed in *A. cumingianus*, bilobed in *A. irvinae*) (Walker 1988).

As previously reported in Richards *et al.* (2015), historical records and localities for the species reveal some questionable locations; for *A. irvinae*, the site at Pipers River in NE Tasmania is clearly incorrect, while for *A. cumingianus* the sites at Plenty, the Ouse River near Hamilton and Lake Meadowbank are suspect, but cannot be fully discounted. Tenison-Woods (1876) specifies "in streams between New Norfolk and Hamilton, the large ones referred to from a small stream running into the Derwent near Dunrobin – R. Maddock" [near Ouse]. Despite the records in various museums suggesting that these species occur at several locations across Tasmania, many lack accuracy and should be discounted as erroneous. Further, some Tasmanian museum-held specimens are incorrectly labelled as *A. cumingianus*, since as recently as 2002 publications including Smith & Kershaw (1981) and Gooderham & Tsyrlin (2002) failed to recognise the existence of two species of *Ancylastrum*, despite the review by Walker (1988). Adding to the confusion, the figure in Smith & Kershaw (1981), though ascribed to *A. cumingianus*, is actually *A. irvinae*, while the text describes features of both species. Further, the description in Gooderham & Tsyrlin (2002) clearly pertains to *A. irvinae*, while a more historical account investigating the food of trout in *yingina*/Great Lake superbly illustrates *A. irvinae,* labelling it *A. cumingianus* var. *irvinae* (Evans 1942). The vagaries of collection data, misidentifications based on inaccurate descriptions of species, failure of texts to recognise both species, as well as the application of misleading common names have resulted in confusion surrounding this molluscan genus. Regardless of the historical distribution records, it is likely that both species of *Ancylastrum* are now restricted to a single Central Highlands lake, *yingina*/ Great Lake, perhaps owing to a decline in water quality of inflowing streams of the upper Derwent, but more likely due to the introduction of predatory trout (Evans 1942, Smith & Kershaw 1981, Ponder 1994, Gooderham & Tsyrlin 2002). Both *Ancylastrum* species are predated by trout (Richards *et al.* 2015) and *Ancylastrum* are a valuable source of food (Evans 1942), therefore, it is intriguing that *A. irvinae* persists in large numbers in *yingina*/Great Lake alongside predatory trout.

In 2015, owing to a combination of drought and drawdown for water allocation and hydroelectric generation demands resulting from the extensive Basslink cable outage, the water level of *yingina*/Great Lake was significantly lowered, exposing a substantial proportion of the lake bed. This unfortunate situation provided an unprecedented opportunity to access areas previously inundated by metres of water, and only occasionally exposed since dam construction (Gilmour 1973). Our (KR & CPS) principal interests involved investigating the impacts of the dewatering on aquatic invertebrate fauna, in particular *Ancylastrum*, following the recent discovery of *A. cumingianus* in trout gut contents (Richards *et al.* 2015), and the tantalising images of *A. irvinae* forwarded by KM whilst undertaking surveys for Hydro Tasmania. These images provided the first records of *Ancylastrum* egg masses, showing them encased in a thick gelatinous capsule, the "*pallium gelatinosum*" (Taylor 2003). The egg masses are formed in a clockwise spiral, the *pallium gelatinosum* overlaying an internal protective capsular wall which appears to be strengthened by a series of thickened, opaque bands (Plate 2). Following this report KR & CPS visited the *yingina*/Great Lake foreshore several times over the summer of 2015-16 to both collect *Ancylastrum* specimens and survey for evidence of *A. cumingianus*.

Plate 2. Egg mass showing internal structure, diameter 18 mm.

A significant population of *A. irvinae* had been reported (by KM) northwest of Tods Corner, at depths of 0 – 3.3 m. This location was particularly useful for shore-based surveying, since it was shallow, allowing wading for some distance from shore. Multiple *Ancylastrum* adults and egg masses containing one to three eggs were present, adhering to all surfaces of submerged basalt and dolerite substrate; snails were visible both in the water and on exposed (dewatered) rocks, where they desiccated (Plate 3).

In the shallows where water

temperatures exceeded 30°C, many of the molluscs were unresponsive, and substantial mortality occurred, either as a result of the high temperatures or the lack of oxygenated water.

Plate 3. Stranded, desiccating *A. irvinae*.

Dead and dying *A. irvinae* in the shallow water were eaten by masses of flatworms (Turbellaria) (Plate 4). The dewatering also affected the egg masses in the shallows where, when exposed to high temperatures, the protective gelatinous capsules readily sloughed off, leaving the snail embryos unprotected. Dewatering to such a low level is rare in *yingina*/Great Lake, but the mass kill of *Ancylastrum* at this site suggests that they are incapable of migrating fast or far enough to escape the receding water level.

Although somewhat distressing to observe, the mass death event provided an opportunity to collect a series of *A. irvinae* shells to obtain data on size and variation within the species. Despite extensive searching, no evidence of *A. cumingianus,* or the presumed extinct *Bedommeia tumida,* was recorded at this site.

The conditions made it impractical to accurately document the breeding biology of these molluscs *in situ* due to the vagaries of water levels and weather; therefore, a captive study of *A. irvinae* was initiated. Adult and juvenile *A. irvinae* along with accompanying manageable-sized submerged rocks with

Plate 4. Flatworms feeding on deceased *A. irvinae*.

accompanying egg masses were collected in December 2015, from a depth of 80 cm, adjacent to the shoreline, northwest of Tods Corner. Additional periphyton-covered rocks were also obtained, along with extra lake water. The molluscs and stones were transported to Hobart in lidded buckets containing lake water, then housed in an aerated 20L Perspex aquarium at ambient air temperature, which was exposed to 4 hours of direct sunlight in summer, but received little direct sunlight in winter. Temperature was recorded with an in-tank thermometer. The tank water level was maintained using *yingina*/Great Lake water and was cleaned monthly to minimise algal growth. Mollusc activity was monitored closely for several weeks, then at fortnightly intervals. During that summer the molluscs experienced maximum ambient air temperatures of 25°C and water temperature remained around 19°C; winter water temperatures at times lowered to 1°C.

Over the initial five days following collection, four molluscs were found dead and most of the *pallium gelatinosum* had become opaque and sloughed off the rocks, causing failure of all but one egg mass. In February 2016, 75 days after collection, a juvenile snail approximately 4 x 3 mm was observed on the aquarium wall and on the following day it had moved to a nearby rock. As the exact date of emergence was not observed, a developmental period of 75 days is likely to be an overestimate. The remaining nine molluscs grazed periphyton on the rocks, floor and sides of aquaria; no further deaths were recorded.

Shortly after the appearance of the captive juvenile *A. irvinae,* in early March KM, while undertaking aquatic transect surveys, reported egg masses still present on the rocks in *yingina*/Great Lake. However, he noted that on average these were significantly smaller than those previously recorded. At this time the water temperature in the shallows was 23°C at < 50 cm depth, reducing to 18°C between 0.50 - 1 m depth.

Captive *A. irvinae* appear to show no preference for either diurnal or nocturnal activity, feeding or wandering by day and night. By late autumn all were still actively feeding and using much of the stone and aquarium surfaces. One of the largest individuals was observed grazing on the tank wall, its body partially out of the water; behaviour not previously noted, but which in some aquatic invertebrates, such as crayfish, is recognised as a symptom of poorly oxygenated water (A. Richardson pers. com.). As it approached three months of age no apparent size increase was detectable in the juvenile.

The behaviour of the *Ancylastrum* specimens remained similar during winter; while they were no longer active on the aquarium walls the four larger individuals were visible on rocks. However, no juveniles were evident, apparently preferring to remain on the underside of the rocks. In early July, three large animals, two intermediate-sized ones and four juveniles, including the captive-hatched specimen, were observed, the 5 larger individuals feeding on the aquarium walls, while the juveniles remained on or beneath rocks and on the aquarium base. At this time the water temperature had lowered to 5.5°C and numerous copepods were visible in the upper 4-5 cm of water.

Pulmonate snails are functional hermaphrodites and capable of self-fertilisation; although most eggs are cross-fertilised. Though copulation was not observed, in late October 2016, a single *pallium gelatinosum* containing three pink eggs (average size 7.5 x 5 mm) was observed in a corner of the aquarium. Images of the underside were taken daily through the aquarium wall to record development, although little or no change was observed until early December, when embryonic development was obvious. At this point the tiny snail embryos in two eggs had increased in size and began moving across the egg surfaces. Two juvenile *A. irvinae* emerged from the *pallium gelatinosum* at the end of December; the developmental period was 64 days (Plate 5). The failed egg had retained normal colouration until day 44 before beginning to fade, becoming opaque,

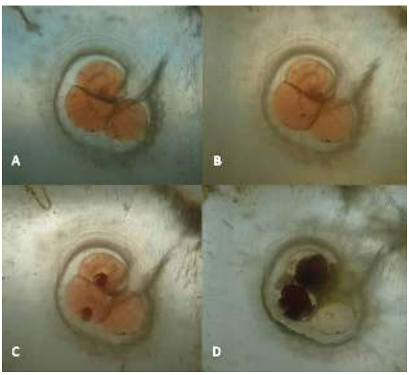

Plate 5. Embryonic development of *A. irvinae*

and then being consumed by the juveniles around day 60. The emergent juveniles measured 4 x 2.4 mm and were approximately 1 mm high.

An unexpected windfall of two adult *A. cumingianus* came in late September when KM snagged a drowned tree branch in *yingina*/Great Lake on a boat anchor. The individuals measured 10.5 x 7.5 mm and 9.5 x 7.0 mm respectively (Plate 1). They were housed in an identical manner to the *A. irvinae* specimens and provided with rocks and submerged wood habitat. A further *A. cumingianus* specimen, co-occupying an anchor-snagged rock with a single *A. irvinae* was collected by KM in late October; unfortunately the animal died in transit.

The *A. cumingianus* specimens were collected from depths of 9.5 and 10.0 m at two locations north and east of Reynolds Island (Figure 1). When these collection points were superimposed over the 1847 map of *yingina*/Great Lake, and compared to the depth soundings provided by Kingsmill and Legge in 1903, both locations are well within the original *yingina*/Great Lake footprint off Reynolds Neck and correspond to 1903 depths of 8 and 9.6 feet respectively. The latter sounding was on rock, but sadly there is no record of the substrate at the former; however KM noted that the substrate at this collection point consisted of basalt pebbles, cobbles and patches of brittle tuff.

In early December one of the two *A. cumingianus* was found dead, but the remaining individual appeared healthy and two very fresh egg masses were located on separate sections of

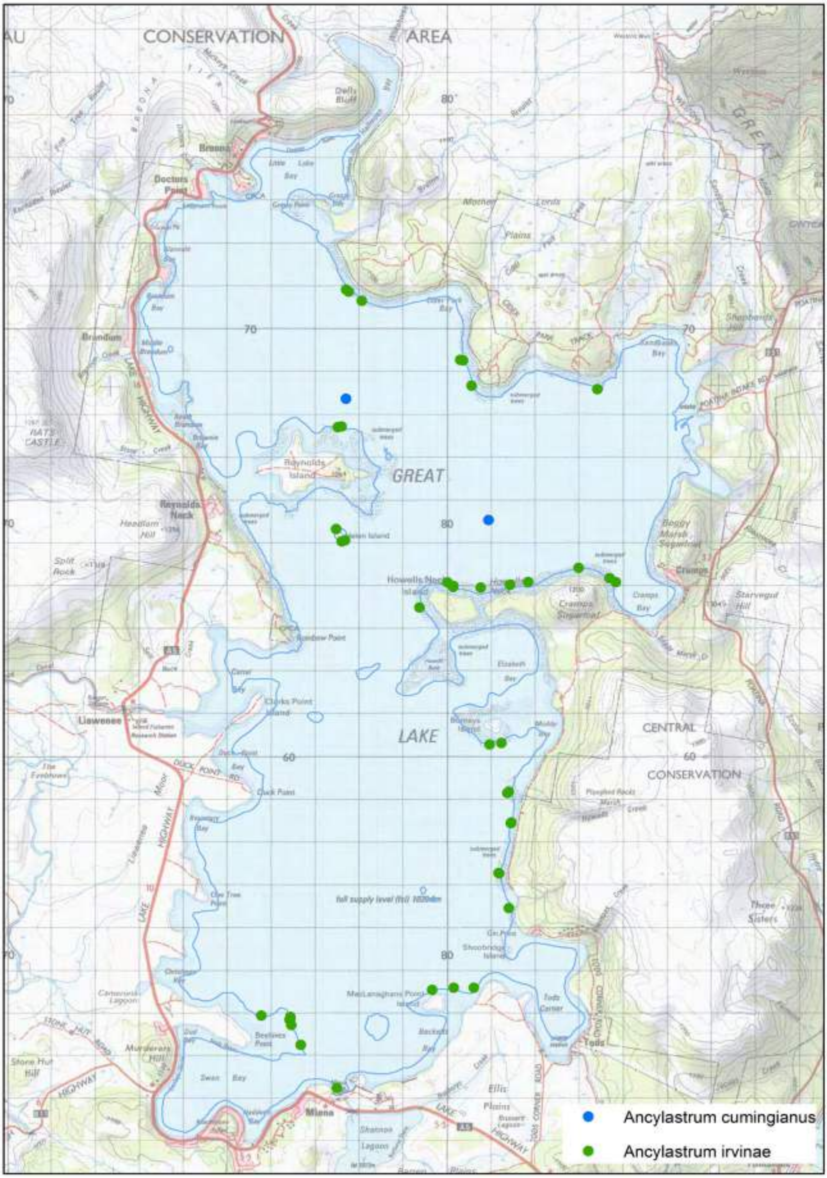

Figure 1. Distribution of *Ancylastrum* species in Great Lake located during 2015-18 surveys. The blue line represents the average low water mark.

wood. A further five egg masses were produced over the ensuing month, some on stone but all deposited in low light situations. By late December we suspected that the third egg capsule was addled. However, it was clear that one of the original capsules contained three growing embryos; all others were too undeveloped to be certain of their status. Despite the healthy appearance of several of the egg masses, over time each became opaque, the embryos inside ceased growing and all eventually failed.

Egg failures were observed in both species, but the exact causes remain conjectural. There is some evidence of miniature oligochaetes breaching the *pallium gelatinosum* of a few egg masses. Whether this activity indirectly affected the developing embryos is unknown. However, the successful hatching of two *A. irvinae* from a worm-infested *pallium gelatinosum* suggests this natural occurrence may not be deleterious.

Notwithstanding the setbacks, we did manage to captive breed *A. irvinae*, obtaining a wealth of information on the way. We can confirm that for both species the number of eggs deposited per egg mass is from 1–3. This fecundity is low compared with the population of planorbid *Glyptophysa* sp. in Sandfly Creek, Lake Pedder, which produce multiple egg masses containing between 1 – 7 eggs per mass, averaging 5 (KR & CPS unpub data). Similarly, the European ancylid species *Ancylus fluviatilis* (Müller 1774) produce between 10 – 20 capsules containing up to 12 eggs, with the number of eggs per capsule decreasing as the season progresses; an average of 50 eggs laid per individual (Geldiay 1956, Maňas 2016).

The size of the egg masses deposited by the two *Ancylastrum* species reflected the size of adults, those of *A. irvinae* achieving maximum dimensions of 17 x 15 x 9 mm, while those of *A. cumingianus* are smaller, the maximum dimensions 11 x 11 x 3 mm. However, it is worth noting that egg mass volume appeared to reduce as the season progressed. In captivity the latter three *A. cumingianus* egg masses were noticeably smaller than those produced earlier in the month. We had initially considered this to be a factor of being produced by a single snail, but KM's field observations of *A. irvinae* egg masses also indicated a reduction in size towards the end of summer. Geldiay (1956) and Hunter (1961) reported a similar decrease in egg capsule size towards the end of the breeding season for *Ancylus fluviatilis* and *Physa fontinalis* (Linneaus 1758) respectively.

Many Ancylidae, Physidae and Planorbidae are reported to breed annually in summer (Geldiay 1956, Hunter 1961, Gooderham & Tsyrlin 2002). Similarly, *Ancylastrum* egg deposition appears limited to the warmer months, beginning in October and continuing through to February or March. The duration of embryonic development for one of the species (*A. irvinae*) was found to be a minimum of 64 days. Based on the similarity in developmental stages of the embryos of *A. irvinae* and *A. cumingianus* prior to the latter's egg failures, it is fair to suppose that a similar maturation period would be expected for *A. cumingianus*. Such an extended incubation is at odds with the shorter egg developmental period of *P. fontinalis*; however, this species lives for only one year (Hunter 1961).

In captivity the two *Ancylastrum* species produced very different numbers of egg masses; the five large *A. irvinae* produced a mere three egg masses, whilst a single *A. cumingianus* generated at least seven. Given this apparent discrepancy in fertility we might speculate that *A. irvinae* ought to be the less numerous species, however other factors are likely to influence egg production and abundance.

Shell shape and dimensions of *A. irvinae* show morphological plasticity; some specimens are raised, narrow and are robustly ribbed, while others are squat and possess less obvious ridges (Plate 6). Of the 265 individuals measured, the maximum shell dimensions were: 19 x 15 x 9 mm (l x w x h). Given the paucity of available specimens, limited data exist for *A. cumingianus*, but from internet images and retained specimens, some level of shell variation is also evident, the maximum shell dimensions were 10.5 x 7.5 x 8 mm.

The two species showed behavioural differences in captivity, *A. cumingianus* displaying a preference for low light conditions, sheltering beneath wood or rocks during the daytime, whereas *A. irvinae* adults were unaffected by daylight, grazing on the aquarium walls and every other inundated surface in both full light and at night. Despite their relatively slow speed (< 1.5 cm per

Plate 6. Variation in *A. irvinae* shell structure

minute), *A. irvinae* were quite mobile on submerged surfaces and on aquarium walls. Conversely, *A. cumingianus* were never observed on the walls, remaining in the shady or darker areas of the aquarium. Additionally, *A. cumingianus* indicated a preference for grazing and depositing egg masses on submerged wood, in dim light conditions, or less often on the shadier side of rocks.

Rapid growth rates are a feature of short-lived species such as *P. fontinalis* and *A. fluviatilis*, which achieve adult size within a year, prior to the single breeding season (Geldiay 1956, Hunter 1961). However, *Ancylastrum* growth rates are extremely slow, suggesting they are long-lived species. Newly emerged juvenile *A. irvinae* are 4 x 2.5 mm and possess radiating ribs on the shell. Despite grazing continually, no significant increase in shell size was visible 3 months after hatching, and immature snails housed to date (2.5 years) remain in the intermediate size range for the species. They do not yet appear to be mature as they have not reproduced, but given the limited number of egg masses deposited previously, the aquarium environment may not be ideal for reproduction. Thus, determination of the species' maturation time and longevity in captivity remains ongoing and will need to be calibrated with field data and shell growth marks.

Snorkelling surveys around the margins of *yingina*/Great Lake (KM) identified a correlation between exposed shores with little sediment or dense algal detritus covering the rocks and the presence of *A. irvinae*. Though considerable external variation was noted in *A. irvinae* specimens, no *A. cumingianus* were recorded. In captivity *A. irvinae* displayed a distinct preference for cleaner basalt rocks (less algal growth) collected from the site northwest of Tods Corner. The geological substrate of the areas where *Ancylastrum* were recorded consists predominantly of dolerite and basalt rocks and cobbles, although KM also observed snails grazing on the drowned consolidated terrestrial earth surfaces and mineral-rich leached brittle accretion in areas where lake levels had receded below the rock substrate. Despite the intensive search effort, snorkelling (KM) and shore-based wading (KR & CPS) surveys failed to locate *A. irvinae* adults or egg masses on submerged wood in areas where the species occurred on rock substrate.

Clear evidence of a strong and robust population of *A. irvinae* within *yingina*/Great Lake was shown in the surveys conducted by KM for Hydro Tasmania, while the presence of *A. cumingianus* was only detected on two occasions, and not recorded outside of the original *yingina*/Great Lake footprint. Given the observed high population density of *A. irvinae* and the historical reported abundance of *A. cumingianus* in *yingina*/Great Lake, it is surprising that *A. irvinae* was not described until 35 years after the original description of *A. cumingianus*.

Because of earlier misidentifications of specimens it is difficult to draw any sound conclusions regarding the population density or area of occupancy of *A. cumingianus*. Historically the species was reported to be abundant (Smith 2006) and the collection of numerous specimens for museums in the late 1900s – early 2000s implies its accessibility in shallow water. The results of the current surveys now suggest that the species may be confined to deeper water and may only occur in very low numbers at few localities. The captive specimens taken from these deep water localities displayed a preference for reduced light conditions. Increased illumination may have played a part in the failure of eggs and adults in captivity.

The (smaller) Giant Freshwater Limpet, *A. cumingianus*, was recognised as threatened (Critically Endangered A1 e ver. 2.3) by the IUCN 1996 (Wells *et al.* 1983), based on criterion A1 – Population reduction in the past where the causes of the reduction have ceased, and (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites. Although *A. irvinae* shares a similar distribution, the species was not considered for similar listing. The reason for this decision is unclear, but the species may simply have been overlooked; on the basis of distribution alone, perhaps *A. irvinae* might also qualify. However, data collected during the 2016 investigations indicates that the population of *A. irvinae* in *yingina*/Great Lake is robust; it is difficult to see how any of the 5 IUCN threatened category criteria could apply to this species.

Thus, some questions relating to the distribution of the two *Ancylastrum* species require clarification. It is crucial to determine whether the species are restricted to *yingina*/Great Lake or whether the historic collection localities, such as Woods Lake and Lake St Clair for *A. cumiginanus*, are correct, and the species are more widely distributed. Confirmation of correct identification of *Ancylastrum* specimens in Australian and overseas museum collections is essential to clarify distribution records databases. Phylogenetic investigations are required to ascertain the true relationship between the *Ancylastrum* species, providing confirmation of their taxonomic status. Likewise, it would be useful to determine whether the morphological variation observed in *A. irvinae* is supported by sufficient genetic differentiation to consider further taxonomic separation.

Recent survey work instigated by Hydro Tasmania has assisted in improving our knowledge of these two species by mapping their occurrence in *yingina*/Great Lake. However, further effort is necessary to fully understand the spatial distribution and specific habitat requirements of these unique Tasmanian freshwater molluscs.

Acknowledgements

The authors wish to thank Dr Leon Barmuta, Dr Stephanie Clark, "the team" from Hydro Tasmania and the editor for constructive comments on early drafts of this paper. Thanks also to Felicity Faulkner for map production and Toni Venettacci for assistance locating obscure reference material.

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Highlights of pelagic birding from Eaglehawk Neck 2017/2018

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This is the seventh in a continuous series of articles summarising the highlights of pelagic sea birding off Tasmania's coast (Wakefield 2012; Wakefield & Brooks 2013; Wakefield 2014; Brooks 2015; Wakefield 2016; Wakefield 2017).

From July 2017 to June 2018 there were 31 pelagics trips from Eaglehawk Neck on the MV Pauletta skippered by John Males.

On the 2nd July trip organised by Paul Brooks we had a distant views of various interesting birds including a white morph Southern Giant Petrel (*Macronectes giganteus*), that disappeared as soon as we changed course to get a closer look. However, the Southern Fulmar (*Fulmaris glacialoides*), made a closer approach and a Slender-billed Prion (*Pachyptila belcheri*) made a couple of passes. Two Providence Petrels (*Pterodroma solandri*) made fairly brief fly-bys.

Rohan Clark organised two pelagic seabird trips for the 15th and 16th July. The highlight for the first day was an immature Northern Royal Albatross (*Diomedea sanfordi*) and the 16th July featured possibly the same bird that was seen the day before.

The following trips were again held over two consecutive days, the 19th and 20th August and were led by Hal Epstein with Roger McGovern as report compiler. Highlights were two Sooty Albatross (*Phoebetria fusca*) two Light-mantled Albatross (*Phoebetria palpebrata*) and three Grey Petrel (*Procellaria cinerea*) which as Roger commented made this an outstanding trip, even for Eaglehawk Neck and especially for the Sydney-based birders for whom these were life-birds. A Light-mantled Albatross and two Grey Petrel appeared again the following day.

A week later Paul Brooks led a trip on Sunday the 27th August and we were all hoping to see some of the birds seen the weekend before. We were not disappointed as a Light-mantled Albatross was spotted within a minute of pulling up to berley, soon followed by a Grey Petrel. Other highlights were two Slender-billed Prion, (*Pachyptila belcheri*), a White-headed Petrel (*Pterodroma lessonii*) and a Soft-plumaged Petrel (*Pterodroma mollis*). The seas were quite rough and the wind picked up more than expected blowing up to 35 knots. There were flurries of snow over the peninsula as we left the Hippolytes in the morning.

News of 45 knot winds at Maatsuyker Island left us with no choice but to head back to port earlier than usual and as we returned past the Hippolytes, we were assailed by a couple of hail showers.

James Mustafa led the next trips on 2nd September and 3rd September. On Saturday an Arctic Tern (*Sterna paradisea*) and an Antarctic Prion (*Pachyptila desolata*) were the highlights of the weekend.

On the 15th October Paul Brooks led the trip in lovely spring conditions and the highlights were an adult Northern Royal Albatross and spectacular numbers of Short-tailed Shearwaters (*Ardenna tenuirostris*) especially the massive flock of at least 15,000 birds around the Hippolytes and Cheverton Rock in the morning. This flock was still there when we came back in the afternoon.

Paul Brooks was a guide on a trip organised for Inala Tours on the 3rd November. This featured another Northern Royal Albatross as the highlight. Paul reported that he had photographed an Australasian Gannet (*Morus serrator*) carrying nesting material to the area on the Hippolytes where other gannets were roosting in the same places where nesting had occurred the previous season.

This was followed by a trip on the 11th November that Paul Brooks guided for Australian Ornithological Services. They found themselves amongst an immense southerly migration of *Pterodroma* petrels, the majority of which were Mottled Petrel (*Pterodroma inexpectata*) with 132 counted, perhaps the most seen in one day in Australian continental waters. Other highlights include a single Black-winged Petrel (*Pterodroma nigripennis*), a first record for Eaglehawk Neck for which an Unusual Record Report Form is with BirdLife Tasmania, 19 Gould's Petrel (*Pterodroma leucoptera)* and two Cook's Petrel (*Pterodroma cookii*) flying south with the *Pterodroma* migration and a single light morph Long-tailed Jaeger (*Stercorarius longicaudus*).

Friday 17th November was a led by Karen Dick who wrote the report using notes taken by Mona Loofs-Samorzewski and myself. This was the first of three trips for the weekend and we started off in drizzle and thick fog restricting visibility to 300m. We were hoping to see some of the large numbers of Mottled Petrel reported the previous week. The fog worsened and it was interesting to watch the birds appear and disappear into the fog only 100m from the boat. Somehow the small birds looked larger and the larger birds appeared much smaller making identification difficult. A Southern Royal Albatross, a single Salvin's Albatross, three Cook's Petrels and an Arctic Tern were the highlights for the day as well as the numbers of *Pterodroma* or petrel species, which was exceptional. These included the Cook's Petrel, Grey-faced Petrel (*Pterodroma gouldi*), White-headed Petrel (*Pterodroma lessonii*), 13 Mottled Petrel, Gould's Petrel and White-chinned Petrel (*Procellaria aequinoctialis)*.

The following day, the 18th November, Paul Brooks guided another trip for Inala Nature Tours and the *Pterodroma* petrel bonanza continued with sightings of seven species. This time 18 Mottled

Petrel, 29 Gould's Petrel and eight Cook's Petrel, possibly the highest number of this species seen on one day in Australian waters, regularly lingered in the slick and made repeat passes with the Cook's Petrels giving all-time great views. A Black-bellied Storm Petrel (*Fregetta tropica*) fed in the slick for extended periods giving great views and there were three White-headed Petrel, two Providence Petrel, one Soft-plumaged Petrel and a single Buller's Shearwater (*Ardenna bulleri*) inshore in the morning.

On the 19th November I led a trip where we again hoped to see one of the reported Mottled Petrel in the area. The wind had changed to northerly and the swell was low and confused so the skipper decided to head directly north east to the south east of Maria Island. We were rewarded with good numbers and a variety of very exciting birds, the highlights being a Flesh-footed Shearwater (*Ardenna carneipes*), two Providence Petrel and a Kermadec Petrel (*Pterodroma neglecta*) which was a 'lifer' for some of the party and only the eighth record for Tasmania. But for Neil the highlight was seeing four Mottled Petrel, closely followed by seven Gould's Petrel that appeared just before we headed back to shore.

On the 10th December Paul Brooks led a trip to see if any of the Mottled Petrels and *Cookilarias* that been seen in such high numbers the previous month were still about. We only saw one Gould's Petrel and one Cook's Petrel. There were also two Providence Petrel as well as two long-staying Northern Royal Albatross as highlights of the trip. We paid special attention to the gannet colony on the Hippolytes where they were nesting in two separate locations last year and again this season.

Plate 1. Juan Fernandez Petrel

The trip on January 14th led by Paul Brooks was probably the most exciting this year for all on board. It was preceded by an out of season cold snap with thunderstorms, snow and hail over parts of Tasmania. We were hoping that something special would blow in but nobody expected the Juan Fernandez Petrel (*Pterodroma externa*), named after the island where it breeds west of Chile (Plates 1, 2). This was only the second confirmed record for the species in Australia and definitely a first for Tasmania and for all of us on board. The first impression of the bird was of a White-necked Petrel (*Pterodroma cervicalis*) but it lacked the white neck of this species and had much reduced carpal marks on the underwing. Reference material was consulted and the bird was quickly identified as Juan Fernandez Petrel; some on board did a Latin American dance of excitement. We also had four Black-bellied Storm Petrel, a Flesh-footed Shearwater, an uncommon bird in Tasmania and a fly past of a Little-type Shearwater which couldn't be identified with 100% confidence (*Puffinus elegans*). There were two White-headed Petrel, two Providence Petrel and large numbers of storm petrels including 180 White-faced Storm Petrel in the slick and dozens of albatross of many varieties. The two gannet colonies on the Hippolytes were checked again but no chicks were seen that day.

On Rohan Clarke's trip on the 20th January the highlights were a Black-bellied Storm-Petrel that Rohan described as an interesting bird with an extensively black belly and active tail moult. Other highlights included nine Buller's Shearwater, 12 Gould's Petrel and three Cook's Petrel. They also saw a Sunfish in offshore waters.

On Saturday 3rd February Paul Brooks guided a tour on which highlights included a Salvin's Albatross (*Thalassarche salvini*), Providence Petrel, four White-headed Petrel, 57 Mottled Petrel, seven Cook's Petrel, seven Gould's Petrel, four Buller's Shearwater and two Long-tailed Jaeger.

The following weekend's trip on Feb 10th was part of a Tasmanian tour with Patricia and Philip Maher who were joined by four birders from Tasmania, including Peter Vaughan and I helping Philip by taking notes. Highlights included an Albatross that had a red colour band on the right leg and a silver band on the left as well as a blue dye mark on its head. This was identified by the Australian Bird and Bat Banding Scheme (ABBBS) through their contacts in New Zealand as a male bird, possibly a Gibson's Wandering Albatross (*Diomedea antipodensis gibsoni*) that was banded as a nestling on Adams Island, part of the Auckland Island archipelago. The blue mark was to show from a distance that it had already been banded. There were also a Gould's Petrel and Cook's Petrel which was a 'lifer' for Peter. Other highlights included five Soft-plumaged Petrel, one Buller's Shearwater, five Wedge-tailed Shearwater (*Ardenna pacificus*) and no less than 72 White-faced Storm-Petrel (*Pelagodroma marina*) but strangely only one Wilson's Storm-Petrel (*Oceanites oceanicus*).

Paul Brooks led a trip on 4th March. At the start of the trip Rob Hamilton photographed a flying fish that rose to the surface at the stern for a short flight before disappearing again but as he was seated right beside the fish, he managed an excellent shot with the sun shining through the fins from behind. At the Hippolytes we closely examined the gannet nests and counted three chicks on the lower colony and three on the top colony. At the shelf there was a Black-bellied Storm-Petrel that seemed to be missing its left foot. We had good views of Little Shearwater, an uncommon bird on Eaglehawk trips and a lifer for most on board and a couple of Soft-plumaged Petrel, and some had fleeting views of Buller's Shearwater. This trip also featured all four of the Storm-Petrels; (Wilson's, White-faced, Grey-backed (*Garrodia nereis*) and Black-bellied), quite a rare occurrence.

Rohan Clarke described the weather as superb for this trip on the 28th April. It was calm, almost windless and with no cloud to speak of although he said he and the birds like some wind. The sea was mostly glassy smooth though with some small-scale ripple at times and at the shelf there was a long interval 1m swell from the south. The first highlight was of a single Great Shearwater (*Ardenna gravis*) as they reached the shelf and were over a depth of 150 fathoms. As they stopped the boat, the bird flew straight up to land a few metres off the stern. Towards the end of the day, as they headed back to shore, they stopped over 85 fathoms when a single Westland Petrel (*Procellaria westlandica*) appeared in their wake. This bird was unusual in that the bill tip was not entirely black but otherwise the structure of the bird confirmed the identification. It was exciting to hear that the Australasian Gannets seemed to have had a successful breeding season as Rohan reported 2 juveniles inshore and two juveniles offshore. There were glassy conditions that day, but all were disappointed to miss the reported Blue Whale that had surfaced near the Hippolytes.

The following day, the 29th April trip was another nice day at sea but with a little more wind. The first highlight was a Cook's Petrel that passed down the starboard side in lovely light, giving good views for everyone on board. The second highlight was up to four Westland Petrel. The first two had different bill colours as they flew past and out wide they had two together with all dark bill tips. After almost an hour they again had two birds together at the last berley stop back on the shelf. Rohan made a conservative estimate that there were at least four Westland Petrel. Another highlight were an adult and a juvenile/immature Northern Royal Albatross. This was followed by a close flyby of a Great Shearwater that flew up to the wake and passed on the port side in nice light and then made a second visit to circle the boat once at the third berley stop a while later. These two observations were probably of the same Great Shearwater seen on Saturday's trip, all being near to the shelf edge and just 5km north of the previous day's sighting.

Paul Brooks led two trips on the weekend of the 26th and 27th May. The highlights were a Westland Petrel on the Saturday, a bird that many participants had come specifically to see, and excellent views of a showy white morph Southern Giant Petrel. Other highlights included good sightings of three Soft-plumaged and two White-headed Petrels. Of interest was a Crescent Honeyeater (*Phylidonyris pyrrhopterus*), which perched on one of the Pauletta's aerials as we headed out to the shelf and a scuffle between a Peregrine Falcon (*Falco peregrinus*)and a White-bellied Sea Eagle (*Haliaeetus leucogaster*) near the Hippolytes. On our return, a juvenile/first winter immature Australasian Gannet was sighted, probably the result of a successful breeding attempt on the Hippolytes last breeding season.

On the Sunday, the strong northerlies blew in a steady stream of Great-winged, Grey-faced and Soft-Plumaged Petrel passing the boat. A Westland Petrel and an Antarctic Prion flew in, followed by a Grey Petrel that shot past the stern. A Sooty Albatross put in a distant appearance and another, or possibly the same bird approached the boat ten minutes later for reasonable views. An Arctic Tern passed the boat without stopping, four Antarctic Prions fed in the slick and a Light-mantled Albatross flew by a long way off. A Black-bellied Storm Petrel approached briefly in pelagic waters not long before we headed back to port. One or two Humpback Whales sounded a couple of times near the boat inshore to add to the excitement of the day.

Karen Dick led two trips on the 9th and 10th June. As I arrived very early on the Saturday, at Pirates Bay jetty, there was a very noisy group of Little Penguins heading out to sea before dawn. There were also lots of fishermen launching boats for the fishing competition. It was a lovely sunrise as we headed out to sea. A highlight was a Providence Petrel which was identified later from photographs and a Brown Skua (*Stercorarius antarcticus*) appeared twice, following the boat to shore. The breeding colony of a Wandering Albatross that was banded on both legs is still being identified by the Australian Bird and Bat Banding Scheme.

On the Sunday the 10th June, the weather was much calmer with fewer birds but despite our disappointment, there were two Northern Royal Albatross, a fairly rare occurrence, and a beautiful Grey Petrel did some close fly bys and even landed briefly behind the boat before we headed back to shore.

Richard Webber led two trips on 16th and 17th June. On the Saturday the main highlight for the day was a Westland Petrel. Other highlights included a Northern Royal Albatross and Providence Petrel with single birds passing through the day while at the shelf, and three birds hanging around at the back of the slick at the second berley stop. Over 200 Fairy Prions (*Pachyptila turtur*) flew around the boat, keeping us busy looking for unusual prions and one Antarctic Prion was identified.

The Sunday 17th June trip was cancelled due to bad weather.

Rob Morris organised two trips on the weekend of the 23rd/24th. The trip on the 23rd had avian highlights of two Blue Petrel (*Halobaena caerulea*), one Providence Petrel and good numbers of Grey-backed Storm Petrel and Cape Petrel (*Daption capense*) with approximately 20 and 15 recorded respectively. The one that got away was a species of *Sterna* tern which wasn't seen or photographed well enough to determine whether it was an Arctic or Antarctic Tern (*Sterna vittata*). Mammalian highlights were two Humpback Whales and a single Orca (*Orcinus orca*). The trip on the 24th was an abbreviated affair, with bad weather stopping the trip well before it reached deep water.

Acknowledgements

I would like to thank Paul Brooks for his assistance with this report. Thanks also to Paul Brooks, Rohan Clarke, Hal Epstein, Roger McGovern, James Mustafa, Karen Dick, Philip Maher and Richard Webber for their trip reports and thanks to our excellent skipper, John Males.

Plate 2. Juan Fernandez Petrel, partly obscured by albatross.

Appendix

Bird species list pelagic highlights 2017/2018 IOC taxonomy

Diomedeidae, Albatross

1. Gibson's Wandering Albatross (*Diomedea antipodensis gibsoni*)
2. Northern Royal Albatross (*Diomedea sanfordi*)
3. Sooty Albatross (*Phoebetria fusca*)
4. Light-mantled Albatross (*Phoebetria palpebrata*)
5. Salvin's Albatross (*Thalassarche salvini*)

Procellariidae, Petrels, Shearwaters

6. Southern Giant Petrel (*Macronectes giganteus*)
7. Southern Fulmar (*Fulmaris glacialoides*)
8. Blue Petrel (*Halobaena caerulea*)
9. Fairy Prion (*Pachyptila turtur*)
10. Antarctic Prion (*Pachyptila desolata*)
11. Slender-billed Prion (*Pachyptila belcheri*)
12. Grey-faced Petrel (*Pterodroma gouldi*)
13. White-headed Petrel (*Pterodroma lessonii*)
14. Providence Petrel (*Pterodroma* solandri)
15. Soft-plumaged Petrel (*Pterodroma mollis*)
16. Kermadec Petrel (*Pterodroma neglecta*)
17. Mottled Petrel (*Pterodroma inexpectata*)
18. Juan Fernandez Petrel (*Pterodroma externa*)
19. Black-winged Petrel (*Pterodroma nigripennis*)
20. Gould's Petrel (*Pterodroma leucoptera)*
21. Cook's Petrel (*Pterodroma* cookii)
22. Grey Petrel (*Procellaria cinerea*)
23. White-chinned Petrel (*Procellaria aequinoctialis*)

24. Westland Petrel (*Procellaria westlandica*)

25. Wedge-tailed Shearwater (*Ardenna pacificus*)

26. Buller's Shearwater (*Ardenna* bulleri)

27. Short-tailed Shearwaters (*Ardenna tenuirostris*)

28. Flesh-footed Shearwater (*Ardenna carneipes*)

29. Great Shearwater (*Ardenna gravis*)

30. Little Shearwater (*Puffinus elegans*)

Hydrobatidae, Storm Petrels

31. Wilson's Storm Petrel (O*ceanites oceanicus*)

32. Grey-backed Storm Petrel (*Garrodia nereis*)

33. White-faced Storm Petrel (*Pelagodroma marina*)

34. Black-bellied Storm Petrel (*Fregetta tropica*)

Sulidae, Gannets, Boobies

35. Australasian Gannet (*Morus serrator*)

Laridae, Terns

36. Arctic Tern (*Sterna paradisea*)

Stercorariidae, Skuas

37. Brown Skua (*Stercorarius antarcticus*)

38. Long-tailed Jaeger (*Stercorarius longicaudus*)

Accipitridae, Eagles

39. White-bellied Sea Eagle (*Haliaeetus leucogaster*)

Pandionidae, Hawks

40. Peregrine Falcon (*Falco peregrinus*)

Meliphagidae, Honeyeaters

41. Crescent Honeyeater (*Phylidonyris pyrrhopterus*)

'It takes just one teacher to inspire a child' Alan Mark Dean Hewer 1917-1999

Annabel L. Carle
Librarian, Tasmanian Field Naturalists Club (TFNC).

Alan Mark Dean Hewer (1917-1999) is a past president of the Tasmanian Field Naturalists Club (TFNC). He is remembered as an active member of the club for over forty years and for his collection of lantern slide photographs which he took on excursions and Easter camps from the late 1930s to the early 1950s. These have been scanned and a selection is available on TFNC's website at https://www.tasfieldnats.org.au/archives/alan-hewer-slides/ The original slides have now been deposited by A.M. Hewer's eldest son Roderick (Rod) Hewer with TFNC's other records in the Archives of Tasmania.

Alan was an all-round field naturalist, although reptiles, amphibians, butterflies and crustaceans (e.g. *Anaspides tasmaniae*) were his specialities.

Alan M. Hewer with blotched bluetongue lizard, *Tiliqua nigrolutea*.

Alan was on and off the TFNC committee between 1948-1975 holding positions of President, Secretary and Treasurer. Alan was a regular speaker at meetings between 1956 and 1989 often showing wildlife films and videos. He also spoke well on the subjects he knew and loved, especially on frogs and lizards, which he illustrated with slides from his large collection. From 1956 until 1989 he was a popular leader on club outings as he had such a wealth of knowledge to share with members. An early favourite destination was to Rocky Whelan's Cave on kunyani/Mt Wellington. In 1983 he was made a TFNC Life Member.

Alan M. Hewer with his much loved Exakta camera, probably on one of TFNC's dredging trips. Four such trips were organised by Dr E. Guiler between 1956 and 1965.

But who was the man?

Alan Mark Dean Hewer was born in 1917 at home in Duke Street, Sandy Bay, Hobart, the family moved later to Joynton Street, Newtown. He had one younger brother Harry Dean Hewer (1924-1982). Their mother was Irene Mary Hewer nee Elliott (1890-1946). Their father Alan Raymond Hewer (1894-1954) owned and ran the A.R. Hewer & Co. Accounting firm in Murray Street, Hobart. A.R. Hewer also lectured in accountancy at the University of Tasmania and was the Auditor for many Hobart businesses such as Charles Davis and Kemp and Denning.

The Hewer boys were sent to The Hutchins School where in Alan's case it took 'just one good teacher to inspire and guide a child'. TFNC has much to thank Mr Norman Walker, teacher at The Hutchins School who in 1926 joined a large number of boys as junior members of TFNC in order to get them interested in natural history. Amongst this cohort was Marcus Hurburgh and Alan M.D. Hewer who both were to become long-term members and Presidents of the Club.

In 1927 along with six other Hutchins boys, including Marcus, Alan at just age ten was to give his first of many talks, albeit in this case, a short 'lecturette' to the club titled 'On a trip to Dodges Ferry'.

After his schooling ended Alan began work in the family accounting business, but by then he was fascinated by reptiles and amphibians and seemed to spend more time with his bluetongue lizard and frogs than he did on his job and he never qualified as an accountant.

Alan was not able to enlist in WWII as his eyesight had been damaged in an accident whilst at The Hutchins School, instead he participated as part of the Home Voluntary Force. His younger brother Harry enlisted in the Royal Australian Navy and served on HMS Bowen. Harry returned from serving in WWII and to the family business where he qualified as an accountant and in due course took over the family business.

Meanwhile their father decided that it was time for Alan to find work elsewhere and he went on to work in the accounts department of Electrolytic Zinc Works followed by the State Library of Tasmania and eventually moving as an Inspector to the Scenery Preservation Board/Land Survey/National Parks and Wildlife Service. With them he was able to travel the state consulting with Rangers and at the same time indulging in his dual passions as a field naturalist and of photography. Alan stayed with them until he retired at age 65 in 1982.

The engagement of Alan to Dorothy June Rodway (1917-2011) was announced in 'The Mercury' on 16 March 1940. June was grand-daughter of Leonard Rodway (1853-1936) Dentist and Tasmanian Government Honorary Botanist and the daughter of Ernest Rodway (c.1886-1971) Dentist and collector of Aboriginal artefacts.

After Alan and June married they lived at Central Avenue, Prince of Wales Bay (Moonah) and in about 1948 they moved to King Street on the Bellerive Bluff. They went on to have four sons and one daughter. Money was always short and to supplement their income June grew and sold flowers and vegetables grown in her much loved garden. Alan was away from home frequently for work or when field naturalising, so his children helped at home with the many of the usual household jobs. The children's pets were of course Alan's frogs and lizards. There was a lace monitor that took some feeding as well as a frill neck lizard and of course bluetongue lizards.

Their eldest son Rod remembers attending many excursions and Easter Camps as a child where Eric Guiler and Leo Luckman were good mentors. Rod was the only one of their five children to become a field naturalist. At age 20 he was an inaugural member of the Lapidary Club of Tasmania which was to become his lifelong hobby. Rod's interest came not from his father but from his grandfather Ernest Rodway who collected Tasmanian Aboriginal artefacts, some of which were made of semi-precious gemstones. Rod has one of the largest collections of Tasmanian rocks (petrifactions and semi-precious gemstones: refer to White, Mary – Time in Our Hands, Reed Books, 1991). Rod was a member of TFNC and on the committee 1962-1966 and in 1962 was Assistant Secretary. He led TFNC Excursions in August 1962 to Arve Valley; September 1962 & March 1965 to Marion Bay and in February 1965 to Coningham. In October 1981 he was a speaker at the meeting on Lapidary (Petrifactions) and subsequently led an excursion to Lune River.

In his life time Alan was not only involved with TFNC, but became involved in a very wide range of other hobbies and activities.

He was a self-taught photographer and had a dark room at home and together with Jim Poynter (1918-2018) he processed photos for Olegas Truchanas (1923-1972), Joe Picone (1928-1966) and many others. He was a member of Southern Tasmanian Photographic Society and Alan regularly exhibited with success his photos both with them and at the Royal Hobart Show.

'Shimmering Silver' photograph by A. M. Hewer awarded certificate of merit by the Southern Tasmanian Photographic Society 1949.

(Photo held by State Library of Tasmania: TAHO TL.PE 799.991646 HEW)

He organised a nation-wide photographic competition to help celebrate TFNC's 50th (1954) Jubilee year. (Fenton 2004).

In 1954 Alan was elected one of the Vice Presidents of the newly formed Federation of Tasmanian Field Naturalists Clubs. (Fenton 2004). He was a member of the Hobart Walking Club and in 1946 was a founding member with Leo Luckman (1912-1976) and Roy Skinner (Ranger at Hastings Caves) of the Tasmanian Caverneering Club (the first such club in Australia). He enjoyed trout fishing with Max Shorter and listening mainly to classical music. Alan was fondly remembered on the Easter camps for his sense of humour (Fenton 2004) and for his prowess on a harmonica! Alan also spent several years assisting Len Couchman (1901-1992), school teacher and amateur entomologist/lepidopterist and his wife Ruth who were working on the Tasmanian hair-streak butterfly (Fenton 2004) and rediscovering the localities of skipper butterflies. In 1948 he was organising a booklet and a schools broadcast for ABC Radio in Hobart titled 'My Pet Lizard.' Between 1946 and 1952 there is surviving correspondence between Alan and Crosbie Morrison, Editor of 'Wildlife Australian Nature Magazine' to whom he had sent specimens of barnacles, a snail and a fungus for identification.

Over the Christmas/New Year period Dec 23 1950 to Jan 23 1951, Alan was away from home and walked with six friends including Bill Mollison (who kept a diary of the trip and in 1978 went on to found the Permaculture Institute) up the west coast from Zeehan to Smithton recording Aboriginal middens and field naturalising as they went.

In the July 1960 Bulletin newsletter thanks was given 'to Alan Hewer for a substantial donation to club funds through his good work for Woolworths in the recent floods. Along with some club lamps, Alan lent his own lamps whilst there was no electricity in town, meanwhile lending a hand to sort things out.'

Alan did not quite forget his early training in accountancy and was Honorary Auditor for the Royal Society of Tasmania 1957-1965 and in 1950 he was Treasurer of the Aero Club of Southern Tasmania. Whilst Alan never learnt to fly light planes he was often passenger with his friend Lloyd Jones and this way he had the opportunity field naturalise in places such as Melaleuca, Cox Bight, Maria Island and other more remote locations. On the 1st September 1950 The Adelaide Advertiser published the following article.

Treasurer of Vision

When Mr. A. M. Hewer, retiring treasurer of the Aero Club of Southern Tasmania, presented his financial statement to the annual meeting this week, he did so in a most unusual manner. By means of slides and a projector, the statement, was produced on a screen in front of members. Mr. Hewer said that if a lot of figures were read to members they would mean nothing, but if they could see them and were told what each item presented they would absorb the information much more readily. Such a novel idea seems to possess endless possibilities.

In 1962 with his friend Bill Mollison, Alan spent some time writing a book 'A field guide to the reptiles and amphibians of Tasmania: illustrated with line drawings.' The plan was for this to be the first of several small field guides that were to be published by Queen Victoria Museum and Art Gallery Launceston, but no record can be found that it was ever published. The third draft of the manuscript is held in the State Library of Tasmania. The front cover includes the heavily underlined annotation probably from Mollison 'Please return with photographs…' and although a list of Alan's reptile and amphibian slides had been appended to the draft, the photos themselves it seems were not. By becoming involved in so many projects, Alan did not manage to finish them all.

TFNC will be always be grateful to Alan for his contribution to the Club. His life as an amateur field naturalist was best was summarised in the 1965 August edition of The Tasmanian Naturalist as 'one of Tasmania's keenest naturalists, a stalwart of our club, a good camper and field observer.'

Alan M. Hewer and snake possibly at New River Lagoon.

Summary of Alan M. Hewer's TFNC Publications

(listed in chronological order)

- (1948) Tasmanian Lizards. *The Tasmanian Naturalist* 1: 3-8. In this paper Alan describes from the layman's point of view, the sixteen lizards found in Tasmania at that time. He points out the deciding factor is the shape and distribution of scales on the head and in the number of scales around the body and that contrary to popular opinion in Tasmania fourteen of these lizards gave birth to live young and do not lay eggs.

- (1951) Snails and Reptiles on Betsey Island. *The Tasmanian Naturalist* 2: 7 Members of the Tasmanian Field Naturalists' Club were fortunate to be able to visit Betsey Island on Mr. B. Cuthbertson's fishing vessel 'Weerutta H.' in March, 1951. Time did not permit an exhaustive survey, but a brief general report was given by various authors. Alan Hewer reported on two snails, *Bothriembryon gunnii* and *Caryodes dufresni* and on the reptiles *Leiolopisma ocellatum* and *Egernia whitii* which were common. A third species was tentatively identified as *Leiolopisma entrecasteauxii*, but this could not be confirmed as no specimen was taken.

- (1951) A New Discovery in the Tasmanian Amphibians. *The Tasmanian Naturalist* 2: 33-34. Initial report of an as yet unidentified frog he found from the Woolnorth Estate in NW Tasmania. It was yellowish with black stripes. (Note: Subsequently identified as *Hyla burrowsii*).

- (1951) An Interesting Crab. *The Tasmanian Naturalist* 2: 34. Male and female crabs were collected by Alan Hewer a few miles north of the Pieman River and found burrowing about 50 yards from the water's edge. They were later identified by Mr E.R. Guiler as the Shore Borrowing Crab *Brachynotus spinosus*. It was the first sighting of this crab from the west coast.

- (1965) Distribution of the species *Hyla burrowsii* in Tasmania. *The Tasmanian Naturalist* 2: 1-2. Alan Hewer discusses the number of frogs found in Tasmania, thought to be ten. He also discusses the increased distribution of frog *Hyla burrowsii* (now known as now *Litoria burrowsae*) that honks like a flock of ducks. Some of these new sightings were thanks to his friend Bill Mollison.

- (1967) *Anaspides tasmaniae* - Notes on its Discovery and Distribution. *The Tasmanian Naturalist*. 8: 1-2. Alan Hewer reviews the discovery of 'The Mountain Shrimp or *Anaspides*' as a living fossil in 1893 and of the 1907 one-man (Geoffrey Watkins Smith) expedition sponsored by the British Association who went on to describe the breeding habits of *Anaspides*. Watkins Smith was to die in action in France in 1915 during WWI

- (1968) *Anaspides tasmaniae*. *The Tasmanian Naturalist.* 12: 1-2. lan Hewer follows up on his previous article on *Anaspides tasmaniae* and bases his article on a paper by Emeritus Professor V.V. Hickman, published in 1936 which described the breeding habits of the species.

- (1980) Tasmanian Frogs and How to Identify them. *The Tasmanian Naturalist.* 63: 1-3. Alan Hewer states frogs are easily identified by their mating calls and that as some are very restricted in their distribution knowing this is of considerable help. Hewer provides Littlejohn and Martin's (1974) description of the distribution and mating calls of Tasmania's ten species of frog. He also supplies the key to identify frogs from the excellent publication *A Field Guide to Australian Frogs* by John Barker and Gordon Grigg.

Other A.M. Hewer Publications

Mollison, B.C. & Hewer, A.M. (1962). *A field guide to the reptiles and amphibians of Tasmania: illustrated with line drawings: third draft*. Unpublished MS. held by State Library of Tasmania: TAHO TL.PQ.597.909946 MOL

Hewer, A.M. (circa 1989?). *Tape recording of Frog Calls*. Held by the Sound Preservation Association of Tasmania Inc. (SPAT) Bellerive.

Hewer, A.M. (1989). Tape-recording of his TFNC Lecture 3/8/1989 including a tape-recording call of Tasmanian Frogs. (Held by Janet Fenton).

References

Fenton, Janet (2004). *A Century Afield. A History of the Tasmanian Field Naturalists Club.* Tasmanian Field Naturalists Club. The Franklin Press. Hobart.

Mollison B.C. (1950-1951). *Diary of Xmas Trip from 23rd December, 1950 to 23rd January, 1951*. Party: Bill Mollison (Leader); Joan Cleaver; Terry Woodward, Reima Hodgkinson, Alan Hewer, Tony Jackson and Derek Thorpe. (Held by Janet Fenton).

Acknowledgements

Thanks go to Roderick and Sharron Hewer and to Janet Fenton for assistance with this article.

Bonham's millipedes: a 2018 stocktake

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Members of the Tasmanian Field Naturalists Club might be interested to learn that Kevin Bonham, who has been Club president or vice-president on and off since 1990, is more than just a noted naturalist, malacologist, orchidologist, psephologist, chess player and chess administrator. Dr Bonham is also a remarkably skilled millipede collector. Here are some of his statistics to mid-2018:

- collected millipedes at more than 330 Tasmanian sites since 1988
- collected 86 named and 15 undescribed millipede species
- has three millipede species named in his honour: *Atrophotergum bonhami, Dasystigma bonhami* and *Atelomastix bonhami*
- collected the holotypes of *Asphalidesmus golovatchi, Gasterogramma wynyardense, Lissodesmus nivalis, Paredrodesmus purpureus, Tasmaniosoma australe* and *T. bruniense*
- collected the first known specimens of *Lissodesmus nivalis, Tasmaniosoma bruniense* and eight undescribed millipede species
- collected the first known Tasmanian specimen of the introduced millipede species *Akamptogonus novarae* (native to NSW)

His most recent accomplishment is worth noting in detail. Bonham found a male specimen of a *Lissodesmus* species during the Club's Easter Camp on the Ben Lomond plateau in April 2017. *Lissodesmus* is a common genus of dalodesmid millipedes in Tasmania and Victoria, but the Ben Lomond male looked to me like a new species. I searched for more specimens on Ben Lomond for several hours on 20 November 2017 but found only one presumed juvenile in the alpine shrubbery.

On 2 April this year Bonham and I returned to Ben Lomond. The weather was uncomfortable: 4°C and winds gusting over 40 km/hr. We originally planned to walk ca 1.7 km to the April 2017 site, but the cold and wind persuaded us to look in the shrubbery close to our starting point, and about 350 m from the ski village. Within a few minutes Bonham had found two adult males of the new species and a female under a single rock-hugging shrub. We continued searching that site and others for more than an hour without success, although the sites also yielded the common Northeast dalodesmids *Lissodesmus adrianae* and *Tasmaniosoma clarksonorum*.

In May I named the new species *Lissodesmus nivalis* (Mesibov 2018); "nivalis" means "of snow". *L. nivalis* is the second Tasmanian millipede so far known only from an alpine habitat. Northeast Tasmania has been very well collected for millipedes (Mesibov 2018) and nothing resembling *L. nivalis* has been found at lower elevations there.

I would have liked to have named the Ben Lomond species for Bonham, both for his diligence and extraordinary good luck. There is a possibility, however, that the genus *Dasystigma* may someday be synonymised with *Lissodesmus*. To avoid having two *bonhami* in the same genus, I chose *nivalis*.

There will be more *bonhami* millipedes, though, when I name those undescribed species he collected, several of which are in new genera. I hope he keeps collecting millipedes!

Reference

Mesibov, R. (2018) A new, alpine species of *Lissodesmus* Chamberlin, 1920 from Tasmania, Australia (Diplopoda, Polydesmida, Dalodesmidae). *ZooKeys* 754:103-111. https://doi.org/10.3897/zookeys.754.25704 (open access)

Seabird trip to Pedra Branca, Eddystone Rock and the edge of the continental shelf

7th October 2018

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In July 2008, Simon Mustoe and a group of birders hired the fishing boat La Golondrina, skippered by Morrie Wolf, to visit Pedra Branca for three consecutive days, leaving from Southport. It took me ten years to find another suitable vessel and organise a group to visit Pedra. This vessel was a large fishing boat, the Velocity skippered by David Wyatt with his son Albert as crew. The trip was planned many months in advance with the two last weekends booked in September in the hope of suitable weather for one of them. In fact the weather did not ease until the first weekend of October when a nice high arrived. The group arrived on the Saturday night to stay at the nearby Jetty House which offered very comfortable shared accommodation. We were welcomed by Rosalind with cakes and hot drinks before joining the skipper and his sons for a meal at the Southport Hotel - a nice way of meeting each other before the trip.

The boat left the jetty at 6:15am in fairly light north-easterly winds. There were nine passengers: Mona Loofs-Samorzewski, Jo Colahan, Ruth Brozek, Amanda Thomson, Michael Dempsey, Ramit Singal, Richard McMillan, Meriloy McMillan and Els Wakefield.

Heading out towards the Friars south of Bruny Island we were treated to a beautiful sunrise breaking through the clouds with soft greys and pinks. There were good views of the Labillardiere Peninsula, the Bruny Island Lighthouse and Courts Island. Some of us explored the fly-over deck of the boat, a small open area to the bow with room for three people and offering 360 degree views. We were surprised to see two Black Swans heading back to shore with purpose.

On reaching the Friars at 7:48am the sun was breaking through the clouds, hitting the rocks that looked very colourful in the morning light. There were two seals around the base and one Gannet, two Pacific Gulls, 12 Kelp Gulls, 22 Silver Gulls, 45 Black-faced Cormorants, one Tree Martin and two Sooty Oystercatchers on the nest. The depth was 18 fathoms.

We left the Friars at 8am and the cloud cleared as the boat headed offshore at an increased speed of 10 knots. We were immediately surrounded by large flocks of Short-tailed Shearwater, Shy Albatross, Australasian Gannets and Kelp Gulls There was a one to two metre swell as we reached a depth of 67 fathoms and by 9am we could see Pedra Branca and Eddystone Rock in the distance (Plate 1). As we approached there were four Diving Petrels. Albert threw out some berley to attract the birds.

On top of Eddystone Rock and on a shelf below the top was a colony of about 45 Gannets, 11 Black-faced Cormorants, and 33 Silver Gulls. The skipper managed to steer the boat close to the large swells breaking on the nearby reef where the surfing enthusiasts catch enormous waves when the conditions are perfect. Dave told us the surfers need large swells but absolutely no wind, a rare event in that area. We left the rock with a big breaker on our tail, a great party trick from the skipper.

From there it was not far to Pedra Branca and on the way we saw our first of many Southern and Northern Giant Petrels, a Buller's Albatross, five Crested Tern and numerous Shy Albatross and Gannets flying around us. At 10:30 we arrived at Pedra and the swell increased to two to three metres and the depth increased to 71 fathoms. Some berley was thrown overboard while cruising up and down the sheltered side of Pedra. We all counted and compared figures of the Shy Albatross on the nest. Because they were partially hidden among the rocks, it was difficult to count them but judging from photos, we estimated there were about 40 nesting there between the hundreds of Gannets. Two Welcome Swallows were flying about in the saddle at the top and there were Kelp Gulls including one juvenile, Sooty Oystercatchers and Black-faced Cormorants perched on the rock. There were 40 seals on the lower rock shelves. As Jo later wrote, "The seals were amusing, edging towards the brink and all disappearing together into the wave as it rose to meet them; except for the first, launched inadvertently as he slipped on the kelp as the previous wave declined!"

The skipper carefully took us around the back of Pedra before leaving. He then took us to "Flying Scud", a shallower berley spot, hoping to find a larger variety of birds. Between Pedra and Flying Scud, a White-fronted Tern dipped and dived with five Crested Terns above our heads.

There were two seals around the boat and the swells had increased to 3m when Dave turned off the engine so that we could all enjoy the natural sounds around us. Inspired by the enthusiasm on board, at 12:40 Dave headed out of the cabin, announcing that he had decided to take us to the continental shelf. With universal approval, he took us the extra distance to arrive at the edge of the shelf at 2pm, at a depth of 105 fathoms, and in sunny conditions.

The variety of birds did increase as there were about 270 Fairy Prions in various flocks, 54 Diving Petrels, two Cape Petrel, two White-chinned Petrel, a White-faced, a Grey-backed and a Wilson's Storm Petrel. This was also where we saw the two

Wanderers, four Southern Royal Albatross and the five Northern and two Southern Giant Petrels. After a berley stop of half an hour, with increasing wind, at 2:38 pm we needed to head back in order to cover the 40 miles to Southport before dark. On the way we had a small pod of Common Dolphin swimming beside us and lifting out of the water. There was also an exciting moment when a White-headed Petrel approached from the starboard side and disappeared on the port side after giving us a good view. Flocks of Short-tailed Shearwaters circled around us as we motored back to the jetty. Two Forest Ravens flew past just before we docked at 6:30pm in fading light. A full list of species observed is given in the Appendix.

We all agreed that it had been a long but very exciting twelve hour day at sea (Figure 1) and an adventure that all on board were eager to repeat next year.

Acknowledgements

Thanks to David and Albert Wyatt for an excellent trip, to Mona, Jo and Ramit for their assistance with the report and to everyone for their patience and perseverance in finally making our dream of going to Pedra Branca come true.

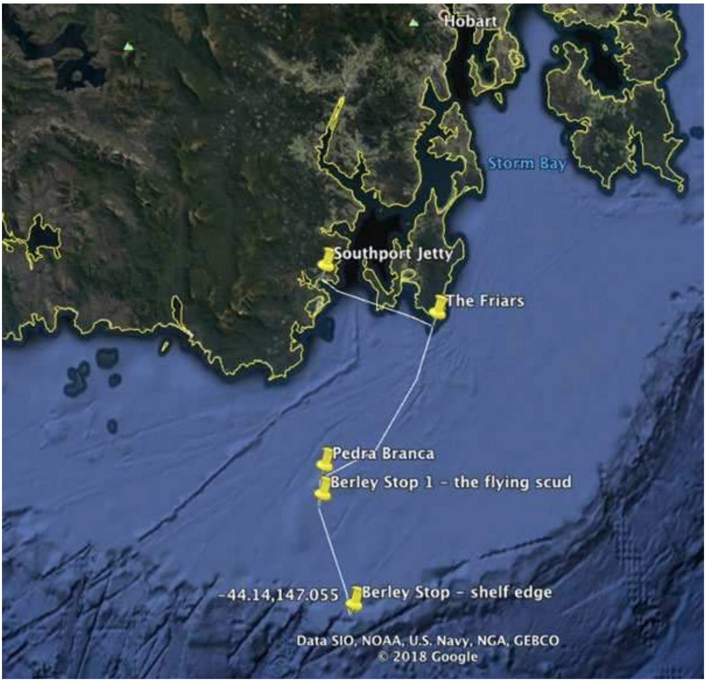

Figure 1. Route of FV Velocity from Southport to the Continental Shelf by way off Eddystone Rock and Pedra Branca October 2018. Map provided by Ramit Singal.

Appendix: Bird Species observed

Wilson's Storm Petrel 1
Grey-backed Storm Petrel 3
White-faced Storm Petrel 1
Wandering Albatross 2
Southern Royal Albatross 4
Black-browed/Campbell's Albatross 1
Shy Albatross 85
Buller's Albatross 3
Giant Petrel sp 3
Southern Giant Petrel 2
Northern Giant Petrel 5
Cape Petrel 2
Fairy Prion 271
Great-winged/Grey-faced Petrel 2
White-headed Petrel 1
White-chinned Petrel 2
Short-tailed Shearwater 5000 plus
Common Diving Petrel 58
Australasian Gannet 1,500
Black-faced Cormorant 73
Black Swan 2
Sooty Oystercatcher 4
Silver Gull 135
Pacific Gull 6
Kelp Gull 47
Greater Crested Tern 5
White-fronted Tern 1
Tree Martin 1
Welcome Swallow 2
Forest Raven 2

Plate 1. Eddystone Rock and Pedra Branca observed from FV Velocity in October 2018.

Tooms Lake Excursion Report

Sunday 4Th March 2018

Annabel Carle
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On a beautiful, early autumn day, 13 members gathered at Tooms Lake, East Coast Forest. It was the first visit to the area for everyone attending. (Plate 1).

Plate 1: The Field Naturalists group at Tooms Lake

Photograph: Amanda Thomson

Tooms Lake is 468m asl and only 24kms from Swansea (Figure 1), but access is usually via a one-hour drive, mainly on a gravel road from the Midland Highway. Tooms Lake was originally a wetland and an aboriginal meeting place. In 1828 ten Tasmanian aborigines were massacred there by nine soldiers from the 40th regiment.

A small 4m high dam was built in 1840 and Tooms Lake (Figure 2, Plate 2) provided water for one of the earliest irrigation schemes as it drains into the Tooms River, a tributary of the Macquarie River which provides the water supply for both the

Ross township as well as irrigation for properties in the area. By 1904 the shallow lake covering about 6.6 km^2 was stocked with Brown Tout and by about 1908 with Rainbow Trout. The lake has been regularly stocked since then and is still used for recreational fishing. There is a resident population of Jolly tails - *Galaxias maculatus* on which the fish feed. Tooms Lake provides water for one of the earliest irrigation schemes. It drains into the Tooms River, a tributary of the Macquarie River which provides the water supply for both the Ross township as well as irrigation for properties in the area.

Tooms Lake lies within the Tooms Lake Forest Reserve (Conservation Area) which is managed by Tasmania Parks & Wildlife Service and is included in the larger East Coast Forests.

Figure 1. Location of Tooms Lake Reserve

TFNC have had two previous visits to the Tooms Lake area, the first for a weekend trip in September 1949 (ref: *The Tasmanian Naturalist,* Vol. 2 No. 1 May 1950) and the second for the 1969 Easter camp (ref: *The Tasmanian Naturalist* No. 17 May 1969.) Digital copies of all of *The Tasmanian Naturalist* are available on the Club website.

The 1949 trip was to survey the native fauna, in particular the Forester Kangaroo which was feared to be heading for extinction. Only two were sighted the whole weekend, in addition three Bennett's wallabies and one pademelon were seen. It should be noted that because of the condition of the road much of it the trip was done on foot and in the time available they reached the Lake but barely entered the Reserve. In addition to the fauna, a list of birds, skinks and frogs observed was made. No plant list was made. They were surprised to hear a kookaburra which Len Wall (May 1950) reported had been 'introduced from the Mainland some 20-30 years ago and liberated in Epping Forest about 35 miles to the north-west….it seems that

Plate 2: Walking along the dam wall

Tasmanian conditions are not entirely suited to it, otherwise it would have spread much further in that time.'

The five-day 1969 Easter Camp made observations along the western and northern shores of the lake for distances up to three miles from the lake and compiled a plant list including grasses as well as a list of 34 birds and recorded two specimens of a pseudoscorpion. The only marsupials seen were 'a considerable number of Bennett's wallabies.'

By contrast the 2018 trip assembled at the camp ground on the west end of the dam wall. Members then walked east along the dam wall to the northern shore, along the exposed lake bed towards Swamp Bay and around on the eastern Iron Rocks Shore. At the lunch spot members had to contend with the European wasps

Figure 2. Map acknowledgement: Graeme Bartlett - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=4807925

(Vespula sp.) which buzzed around the food, and had also to avoid the nearby Jack jumpers (*Myrmecia pilosula)* nest.

After lunch some retraced their tracks, whilst others walked back along the track within the dominant *Eucalyptus viminalis* and *E. amagdylina* woodland surrounding the Lake and then explored the Tooms River below the dam wall in the hope of seeing a platypus. None was seen although part of the backbone of one was found.

The highlight of this year's trip was the discovery by Kevin Bonham of seven specimens of the snail "*Allocharopa*" sp. Freycinet – previously only known from one site on Schouten Island and one site on Mt Mayson, Freycinet.

Two dominant plants on the foreshore were the prostrate, spiny *Eryngium vesiculosum*, common name Prickfoot, which was in full flower. (Plate 3). It is well named, and on return to our vehicles our boot soles were found to be impaled with its seed heads.

Plate 3: *Eryngium vesiculosum*, Prickfoot
Photograph: Geoff Carle

On the water's edge were large beds of *Eleocharis sphacelata,* Tall Spike sedge (Plate 4) as well clumps of *Cycnogeton procerum* (Syn: *Triglochin procera*), Water ribbons.

The tiny *Ochtereus* sp. ,Velvet Shore bugs, were active along the rocks of shoreline and spotted by Geoff Carle and Amanda Thomson (Plate 5).

A number of birds were sighted and as previous excursions noted, they can be divided into those of the forest/woodland, the lake's water birds and those of the open plains on the road into Tooms Lake. It was too dry for fungi although a ring of Agaricus and an emerging Amanita were seen. It was thought it may be worth returning in fungi season after some reasonable rainfall.

An interesting and enjoyable trip, but all too short. Many attending, hope to be able to return to the Tooms Lake area in the future in order to explore it further.

Plate 4: *Eleocharis sphacelata*, Tall Spike sedge.

Plate 5: *Ochterus* sp Velvet Shore Bug

Photograph: Geoff Carle

Species lists

Birds (contributed by John Reid)

Open plains: Along the York Plains Road (C307) into Tooms Lake

Wedge-tailed Eagle (also noted in 1969)
Black-faced Cuckoo-shrike (also noted in 1949 as Blue Jay and in 1969)
Goshawk (Brown hawks noted in 1949 & 1969)
Sparrowhawk (also noted in 1949 & 1969 as Collared Sparrowhawk)
Black Currawong (also noted in 1949 as Clinking Currawong)

Woodland: at Tooms Lake

Yellow-throated Honeyeater (also noted in 1949 and 1969 trips)
Silvereye
Superb Fairy-wren
Scarlet(?) Robin (Flame Robin noted in 1949)
Grey Fantail

Tooms Lake birds

Chestnut Teal including juveniles (also noted in 1949 and 1969)
Black Cockatoo flying overhead (also noted in 1949)

Previous trips noted that Pacific Black Duck, Little Pied Cormorant, White-faced Heron, Black Swan and Spur-winged Plover were seen in/around the Lake, but as our trip this year was during the middle of the day it was not an ideal time for bird watching.

Other vertebrates

Tiger Snake (York Plains Road C307)
Bennett's Wallabies (also noted in 1949 & 1969)
Backbone of Platypus
Scats of Possum
Scats of Wombat.

Note: Colin Vincent (*pers. comm.*) reports a white wombat has been seen west of the lake in recent years.

Snails (contributed by Kevin Bonham & Abbey Throssell)

Victaphanta sp. "Green" (endemic to central east Tas.)
Helicarion cuvieri
Elsothera sp. "Grasstree."
"*Allocharopa*" sp. "Freycinet" (third record for this species, previously known from Schouten Island and Mt Mayson, Freycinet.)
Trocholaoma parvissima.
Punctidae sp. "Micro Cripps."
Paralaoma discors.

Paralaoma hobarti.
Gratilaoma sp. "Knocklofty."
Gratilaoma(?) sp. cf *halli* (form under review.)

Exotic slugs
Lehmannia nyctelia
Arion intermedius

Invertebrates (contributed by Geoff Carle & Amanda Thomson)

Araneae - Spiders
Salticidae - *Jotus* sp.
Salticidae - *Ocrisiona leucocomis* - Black & white jumping spider.
Lycosidae - *Arotriopsis expolita* – Wolf Spider.

Bees/Flies/Wasps
Apidae - Bombus sp. - Bumblebees.
Anisoptera - Dragonflies.
Zygoptera - Damselflies.
Diptera - Chironomid - green, unidentified.
Chrysisidae - Cuckoo Wasp.
Vespidae - *Vespula* sp. European Wasps (probably *Vespula germanicus,* German wasp.)

Coleopteran - Beetles
Ptomaphila lacrymosa - larvae of a Carrion & Burying Beetle (on roadside of York Plains Road C307.) (Plate 6).
Curculionidae - *Gonipterus* sp. - Weevil sp. (a plant feeder.)

Ephemeroptera - Mayflies
Both nymphs and adults, empty cases.
Caenidae - Adult Caenid (stout body, lacking hindwings.)

Formicidae - Ants
Myrmecia esuriens - Ant Tasmanian Inchman.
Myrmecia pilosula - Jack Jumper Ants.

Hemiptera - Bugs
Ochterus sp. - Velvet Shore bugs on rocks on the water's edge.
Gelastocoridae - Water bug ? Toad bug.

Lepidoptera - Butterflies and Moths
Heteronympha merope - Common Brown (male and females.)
Oenosandra boisduvallii - Boisduval's Autumn Moth (female.)

Orthoptera - Grasshoppers & Crickets
Acrididae - *Tasmaniacris tasmaniensis* - Tasmanian Grasshopper.
Trigonidiidae - Bush and Pygmy Cricket.

Plants (contributed by Annabel Carle)

The Tooms Lake plant species for the area surrounding the lake and the immediate surrounding forest can be found in the Natural Values Atlas (NVA). In addition, the following species not noted in the NVA were found during the excursion.

Apiaceae - *Centella cordifolia* - Swamp Pennywort.
Asteraceae - *Centipeda elantinoides* - Elatine Sneezewort.
Campanulaceae - *Isotoma fluviatalis* - Swamp Stars.
Fabaceae - **Ulex europaeus* - Gorse.
Phrymaceae - *Mazus pumilio* - Swamp Mazus.
Primulaceae - **Lysimachia arvenis* - Scarlet Pimpernel.
Proteaceae - *Hakea microcarpa* - Small-fruit Needlebush
*Introduced

Plate 6: *Ptomaphila lacrymosa l*arvae Carrion-burying beetle

Photograph: Geoff Carle

Book reviews

The Wasp and the Orchid the Remarkable Life of Australian Naturalist Edith Coleman

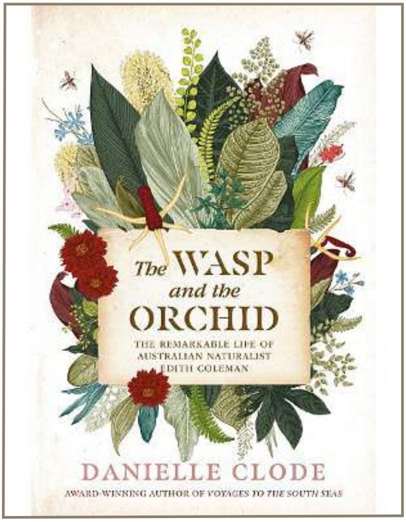
By Danielle Clode

Picador (an imprint of Pan Macmillan Australia) 2018

Hardback 420 pages.

Reviewed by Stephen Harris

dr.harris@live.com



The narrative of this book pivots around the discovery by Edith Coleman of pseudocopulation in Australian orchids and the prominence this brought her especially in orchid circles. There is also an underlying story in this book about how a woman of modest education was able to make notable contributions to science in the context of her times and how this might have differed in other times and circumstances.

The orchid family is the largest family amongst the flowering plants (more than 30,000 species) and the sheer variety of flower forms, colourful and bizarre displays and satisfaction of the pollinators with various rewards, perhaps prompted Charles Darwin in the nineteenth century to carry out (on British orchids) detailed observations and studies on the contrivances that have co-evolved in orchids in order to attract pollinators. Many display colorful, elaborate flowers and attractive scents. These deceive insects into approaching the flowers that look to promise a food reward in pollen or nectar. Darwin documents instances of sexual deceit where orchid flowers attract insects that they have evolved to visually mimic. He does not describe or observe instances of pseudocopulation. A Frenchman was the first to record the phenomenon early in the twentieth century, but his was an obscure paper that was overlooked for many years.

Pseudocopulation is the bizarre syndrome whereby orchids can emit a sex pheromone scent inducing the male insect pollinator to attempt copulation with the flower. The detection and verification of this in the case of each species requires patient observation.

Edith Coleman received training as a teacher monitor in Victoria but she always had a love of nature, a love that was directed, relatively later in life after she gave up teaching and got married, to studying the natural world that was easily accessible to her. She was an active participant in Field Naturalists Club of Victoria field trips, often with support from her husband who was a pioneering motorist and was happy providing transport into the field. She made patient observations in the field and in her own garden. There would have been other encouragement from her family as her two daughters were early graduates of the University of Melbourne.

Her careful observation of the actual act of pseudocopulation and her subsequent notes about it led her to publish a series of articles on this pollination syndrome. She published at least two papers on this in respected international science journals. She corresponded with the main orchid specialists of the day including Rodgers from Adelaide and Rupp from Sydney. She kept up a voluminous correspondence with a wider circle of people including experts in the various areas of her interests. Unfortunately most of her correspondence is now lost, a fact that would surely have made her biographer cry in frustration.

In this book the author inserts herself into the narrative, comparing and contrasting her own experience as a modern woman scientist and the experiences that Edith had as a woman naturalist in the first half of the twentieth century. While I initially found this approach disconcerting I accepted that the author was using Edith's experiences as a lens through which to understand the social history of Edith Coleman's Melbourne and our subject's life in it. Danielle Clode began her own career as a zoologist but now is a writer who admits her inspiration partly derives from learning about Edith Coleman. Edith was a loyal long serving member of the Field Naturalists Club of Victoria and wrote numerous articles that could be described as lyrical and emotional responses to the bush and its wildlife but contained her astute observation of what was occurring in nature.

Her contributions to the *Victorian Naturalist* continued right up to her death in 1951 and her passing drew generous obituaries that were a measure of her standing within the circles in which she moved. She was the first woman to receive the Australian Natural History Medallion. She inspired others too, including the botanical author Jean Galbraith.

The book evokes the excitement of motoring out to field excursions in the 1930s when motoring was still a novelty and prone to vicissitudes. It describes the domestic arrangements that a middle class woman might employ, the chances of education provided to her compared with her daughters (one attained a science degree and the other an arts degree), and her bucolic childhood in England.

The book is an interesting social history and portrays a woman who, with limited formal qualifications but with great enthusiasm and an intelligent mind could make original contributions to science from within the encouraging milieu of the field naturalist club.

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Tawny Frogmouth
by Gisela Kaplan

CSIRO publishing, Second Edition July 2018

Softback 168 pages

Reviewed by Amanda Thomson

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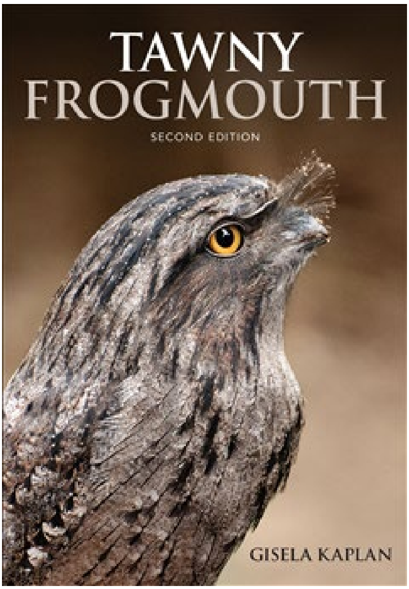

This book has completely endeared me to Tawny Frogmouths. As a child in Sydney, our remnant bush suburban

garden had a Tawny Frogmouth residing periodically in the same tree. I wish I had studied it more closely. It just seemed to sit!

Author Gisela Kaplan is Emeritus Professor in Animal Behaviour at the University of New England and Honorary Professor at the Queensland Brain Institute. This second edition, fully revised and updated, reflects Gisela Kaplan's continued research over 20 years into both wild and rehabilitated

Tawny Frogmouth birds. Kaplan is the author of 21 books and over 250 research articles on a range of topics related to complex cognition and communication in birds and other animals. Her knowledge and expertise in research into animal behaviour is evidenced in this, the most comprehensive study of Tawny Frogmouths.

Insights into this species include questions of taxonomy, characteristics of toe physiology, adaptive physiologies such as nose flaps for thermoregulation, complex defence mechanisms and joint parenting with apparent emotional attachments. I was particularly intrigued by the account of the Tawny Frogmouth's plumage development, with the nestling plumage resembling eucalypt blossoms, and the adults resembling a tree branch. Not only an effective camouflage, their feathers resist parasites, are water repellent and their characteristic bristles are thought to protect the bird from counter attack by prey such as centipedes!

Much interesting information is provided on bird calls. Black and white photographs illustrate the bird's idiosyncrasies of posture, anatomy and development.

Tawny Frogmouths do anything but just sit! Find out why they are known as "skunks of the air" and much more besides! Gisela Kaplan extends one's understanding of the complexities and diversity of birds - specifically with regard the Tawny Frogmouth. After reading this fascinating and scientific book you will look at all species with new eyes!

I thoroughly recommend this book to everyone.

Where the Slime Mould Creeps by Sarah Lloyd

Second edition, 2018,
Tympanocryptis Press, 112 pages

Reviewed by Genevieve Gates

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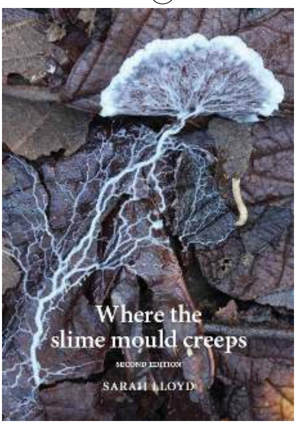

Slime moulds are a cryptic part of our terrestrial ecosystem. They grow on soil, litter (leaves, twigs, seeds, fruits), wood, and animal faeces and are only visible when in the plasmodial stage or when forming fruitbodies. The what stage? At this moment you are probably in need of a book and fortunately Sarah Lloyd's second edition of *Where the Slime mould creeps* has just been released.

The second edition is in the same format as the first with only an additional 12 pages, so it is still a compact size and easy to tote around the bush in your backpack. The binding is much improved, and the book can be opened flat without pages falling out. The number of illustrated species has increased from ca. 75 in the first edition to 121 in the second and the latter figure represents ca. 40% of all species recorded in Australia. Sarah is still confining her records to her property at Birralee in NW Tasmania which does make one rather curious as to how many more are yet to be discovered in Tasmania in different habitats. The cover is suitably creepier than the first and it would be practical to cover the book with contact to protect it from the amount of use it is sure to get.

To see slime moulds you pretty much have to act like one. So you crawl along on your hands and knees turning over bits of wood and litter, looking under logs in the hope of encountering the truly fascinating and beautiful structures they present in the visible stages of their life cycle. Armed with a magnifying device and this guide with its very high quality photographs interspersed with Sarah's easy to read technical facts and more poetic paragraphs, a whole new level of biodiversity will open up for you.

The guide can be obtained at a reasonable cost of $36 (which includes postage) direct from the author and will soon be available in bookshops. And, who knows, you could be the next person to have a slime mould named after you!

Faunaverse Wildlife in poetry Tasmania

by Alexander and Jane Dudley

Self published, 2018

Softback, 56 pages

Reviewed by Deirdre Brown

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This slim publication contains twenty verses, each accompanied by a photograph. The subjects cover 19 birds and animals and one tree. The authors have aimed to inform as well as to entertain their young audience. Each verse imparts facts about the subjects' habits and habitat, and conveys a strong conservation message, while entertaining in rhyme and rhythm. Subjects are not confined to the popular furred animals. For example there are verses for the jack jumper and the March fly, which explain the important place of these invertebrates in Tasmania's natural ecosystems.

The verses are aimed at children and are suitable for reading aloud, or for older children to read themselves.

This book is the second Faunaverse publication from the Dudley team, following on from *Faunaverse Australian Wildlife Poetry* in 2016.

Sponsorship

The Tasmanian Naturalist is published annually, with printing and distribution costs sourced directly from membership fees. With ever increasing costs to production and the Club's recent shift to a higher quality presentation of the journal, which includes perfect binding, better quality paper and full colour, the Club now looks for support to offset the higher costs of production each year.

As well as the printed version of The Tasmanian Naturalist, electronic copies of every edition since inception are available on our website at:

https://tasfieldnats.org.au/naturalist/

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Advice to contributors

The Tasmanian Naturalist publishes articles on all aspects of natural history and the conservation, management and sustainable use of natural resources, with a focus on Tasmania and Tasmanian naturalists. These can be either in a formal or informal style. Articles need not be written in a traditional scientific format unless appropriate for the content. A wide range of types of articles is accepted. For instance, the journal will publish articles that:

- summarise or review relevant scientific studies, in language that can be appreciated by field naturalists;
- stimulate interest in, or facilitate in identifying, studying or recording particular taxa or habitats;
- record interesting observations of behaviour, phenology, natural variation or biogeography;
- stimulate thinking and discussion on points of interest or contention to naturalists;
- put the study of natural history today into context through comparisons with past writings, archives, etc.;
- review recent publications that are relevant to the study of Tasmanian natural history.

Book reviews, web site reviews, poetry and prose and other informal natural-history related content are also accepted. If you are thinking of submitting such material, please check with the Editor first, to avoid duplication of items such as book reviews and for appropriateness of content.

Submission of manuscripts

Manuscripts should be emailed to the editor at mickjbrown1@outlook.com or to the Club's address. Contact the Editors (see the Club's website for current contact details) prior to submission if you have any issues to discuss. Formal articles should follow the style of similar articles in recent issues and include an abstract. Informal articles need not fit any particular format and need not have an abstract. Unless otherwise stated, all images are by the author(s). Formal articles will be refereed. Responsibility for accuracy and currency of taxonomic nomenclature rests with the author(s). Please refer to the Guidelines for Authors, available on the Club's website.

Submissions should be provided electronically in standard wordprocessing files. Images, tables and diagrams should be submitted in separate files. It is important that they be of high resolution and suitable to be published at A5 size.

Articles must be submitted by 31 August to meet publication schedules.