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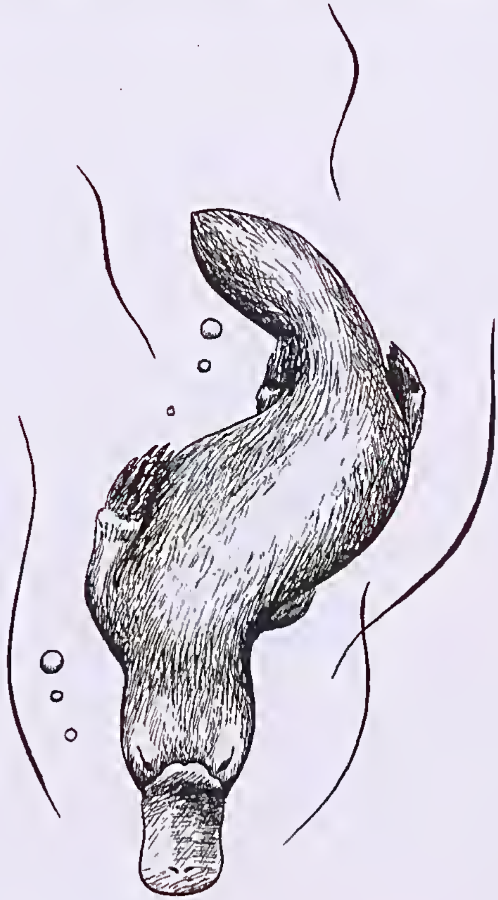

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The Tasmanian Naturalist

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T.F.N.C

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EDITORIAL NOTE

Mark Wapstra
Editor, *The Tasmanian Naturalist*

This is the third volume of *The Tasmanian Naturalist* I've had the pleasure of editing. It's becoming a habit, but once again I must say how pleased I am to have received such a diverse range of submissions from a wide authorship.

This volume is as diverse as previous ones but what is particularly pleasing is the increase in naturalist's notes and shorter contributions: I think *The Tasmanian Naturalist* provides a great forum for getting some important observations out to the wider world. Also pleasing is the number of non-biological articles: our fauna and flora belong to a physical world and it's great to see some contributions on items such as weather patterns. And there are articles on flora (both vascular and non-vascular) and fauna (invertebrates, mammals and birds), covering at least some of the biological diversity out there.

Volume 131 contains colour images with many articles. The club has received generous donations to support the higher cost of production from Forestry Tasmania and Environmental Consulting Options Tasmania.

Once again, I wish you happy reading of this year's edition of *The Tasmanian Naturalist*.

TASMANIA'S EARLY SNOWFALLS 1800–1900

Keith Roberts

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INTRODUCTION

The appearance of snow on the slopes of Mt Wellington generates a strange response from the citizens of Hobart. Cars can be seen streaming up the mountain road with the ensuing delays and frustrations, generating the annual calls for a cable car access.

However, a search for information on snowfalls since Hobart's settlement indicates that in early times, the snow came to Hobart rather than the citizens going to the snow. The warming trend of the last 100 years, coupled with a recent decline in rainfall, has brought about a lifting in the snowfall levels.

Setting the parameters for what constitutes a low-level snowfall is no easy task due to the changing detail available over the years. A brief reference in the early 1800s to snow in Hobart and the interior could well hide what today would be headlined as "Icy Blast Grips State".

Initial information comes from the diaries of the Rev. R. Knopwood (1804-07) recounting inclement weather in the colony's early years. Little if anything is recorded until well into the 1820s when some weather events are noted in the *Hobart Town Gazette*. The development of newspapers in the following years gave an improved coverage of snowfalls. In the period 1860-80 we are fortunate for the meteorological data recorded by Francis Abbott of Murray Street. Abbot, a jeweller by profession, had been transported to Tasmania for a misdemeanour but was soon released and established a business in Hobart. Another of his interests was to record snowfalls and snow duration on Mt Wellington. Abbott's departure from the scene was to some extent replaced by the establishment of the Weather Bureau at Anglesea Barracks in 1882. More snowfall data came from early notes at the Springs and the visit of Clement Wragge with his mountaintop weather station in 1895.

EARLY SNOWFALLS

The first note of snow on Mt Wellington pre-dated the settlement of Hobart in 1804. La Perouse, visiting the island for a second time in January 1793, noted that the summit of the mountain was still carrying snowdrifts. Brown and Humphries climbed the mountain on March 13, 1804 and arrived at the peak in snow showers.

It wasn't long before Knopwood noted that a south-easterly wind had brought snow to all the low hills about the town (July 19, 1804). A lengthier burst of cold weather saw snow in the town on three days over the period May 1-5 in 1806. The major snow event in his diary occurred July 20-22 of 1807: "Snow more than ever seen before fell; all the ground was covered; there was a great quantity of snow with all the low hills also covered". There was a repeat performance on August 13-14 when a great quantity of snow fell and the temperature fell to 31°F.

Information is sparse for the next 20 years, although references from the 1830s suggest that Knopwood's snowy weather may have been absent for some winters. *Bents News* (1836-38) refers to heavy snow in Hobart Town between August 15-18, 1814. The first mention of snow in the interior occurs in July 1819. The Jericho district withstood three continuous days of snow, and when it cleared, the cover was reported to be 3 feet deep. The interior in the early 1800s appeared to be anywhere beyond the Derwent from Granton. Hobart Town featured with several inches of snow on September 6, 1820, with similar events in 1826 and 1829. In the later snowfall, the interior once again was well covered with a 6 inches to one foot fall.

The Hobart fall of 1820 was replicated in 1830 when, following 3 days of snowy weather, several inches covered the town on July 14. The interior had an unparalleled cover again of up to 3 feet. The Hobart Rivulet in the following days was noted to be thick with snow melt and debris.

NEWSPAPER REPORTS

With the appearance of several newspapers in the 1830-50 periods, items of news about various weather events both in Hobart and the interior give us a wider view on snowfalls.

In July 1831 for 10 days the country from Clyde to Shannon and beyond lay under considerable snow, the ground being too frozen to plough. September of that year also saw more snowy weather; ice on the Shannon was thick enough to walk on. Meanwhile, severe frosts killed tracks of wattle and eucalypt trees in the same districts. A new term was now being used for windy days, as they were described as "boisterous".

August 22-23, 1832 produced boisterous weather, which included sleet and snow that eventually covered the Hobart streets as if it were Edinburgh in Scotland. An additional note said that winter snow on Mt Wellington usually lasted six to seven months of the year. Our next snowfall mentions unheard of depths for Hobart Town. June 8-9, 1836 tells of heavy overnight snow coupled with thunder and lightning. The residents awoke in the morning to find the town a mass of white with a fall of 6 inches with up to 1 foot in some other parts of the town.

The following year (1837) was to provide more extreme moments. Firstly, *Bents News* reported ice cover on the Hobart Rivulet (July), the cover being thick enough to walk on and of sufficient cover to let the children play "sliding games".

However, a letter from Hamilton told of a more dangerous experience for two men trapped in the interior. Incessant snowfalls and cover from June 19 to August 24 had trapped two men in huts at Three Mile Marsh and then Bashan Plains. The snow had lain 5 feet deep at the Marsh and 4 feet at the Plains. The weather was so cold that Lake Echo was frozen and they were able to walk out a distance of 200 yards onto the lake. Many kangaroo and cattle had been killed by the extreme cold conditions.

Bents News was proving to be a good source for cold weather events. This time it was the stage coach from Launceston to Hobart (July 20, 1838). Heavy snow across the Midlands was so thick the coachman could hardly see where the coach was heading as a 6 inch fall covered the road.

Following the demise of *Bents News*, the editors of other newspapers did not seem as interested in snowfall stories so that some years appear to be devoid of any cold weather.

There were snowfalls of varying intensity in Hobart in 1839, 1841, 1842, 1843, 1844 and 1849. Then a 'melancholy' incident in June 1847 suggested that the winters of the 19th century were somewhat colder than today. Two sawyers were working on Bagdad Tiers (between Constitution Hill and Colebrook), when it was decided one should go away to collect provisions. Returning a few days later, the sawyer could find no sign of his companion. Subsequently two bushrangers were apprehended and found to have the missing man's gear. The murdered sawyer's body was located on a hilltop in the Tiers. It was perfectly preserved after spending five weeks under several inches of snow.

Despite at times the lack of news, the first 50 years of settlement had provide some interesting tales. On May 11 1851, a "Mystery" hurricane occurred near Mt Ponsonby on the Oatlands to Jericho road. Thunder preceded a shower of ice that covered the ground, and then a hurricane wind tore up trees in a direct patch. About 40 to 50 trees were felled or split over a period of 5 minutes before all was calm again.

Gold was the lure now for expeditions into unexplored areas of the state, but this time in September 1851 the chase for the elusive gold was to prove fatal. The "Gold Party" was in the "New Country" around the Marlborough district. Heavy snow overnight caught the party in their camp, and it was with a deal of difficulty they prevented the snow from collapsing the tents. Two men set out to obtain fresh provisions from the nearby Shepherd's Hut. Their failure to return prompted the remaining four men to abandon the expedition. The men had experienced great difficulty as they struggled through the snow to reach safety. The two missing men were never found.

The second half of the century made a good start with snow in Hobart in both 1852 and 1853, but it was rain not snow that made the news in 1854. February 6 brought over 4 inches of rain to Hobart with the rivulet in flood causing damage to houses and sinking boats in the harbour. More was to follow between March 19-22. This time 6 inches-plus fell, sweeping away Sandy Bay Rivulet bridge, O'Briens Bridge, and inflicting more damage on houses alongside the creek. Three men were drowned when they were caught in the rivulet near the town's centre and swept away. The Coal River at Richmond was only 4 feet below the arch so immense was the flow of water, whilst Capt. Chalmers reported the Bagdad Creek had risen by 12 feet.

Henry Butler Stoney in his book "*A Residence in Tasmania*" (1856) remarks that there are snowdrifts which do not entirely melt all summer, out of which little rivulets run from miniature glaciers. "I have seen such drifts on the side of Mt King William and Mt Field etc: snow covers areas like Great Lake, St. Patricks and King William Plains for weeks at a time".

THE 1860S, A GREAT TIME FOR SNOW

For the next 20 or so years, we no longer have to rely on the vagaries of the newspapers as the notes of Francis Abbott and E. Swarbreck Hall provide extra detail on Mt Wellington snowfalls. In 1861, a very late fall of snow occurred in Hobart on November 26. However, the following year, 1862, saw snow over the town on four occasions.

The more impressive fall was on June 26 when snow covered the low hills, then settled overnight in the town. The Cascades reported snow up to 6 inches deep. Mr J.M. Wilson (MLC) had his men load a 4 foot diameter snowball on to a dray and brought to Murray Street. The huge snowball was displayed for all to see in front of the Duchess of Kent Hotel.

The 1860s was one of the best decades for snowfalls. As settlement expanded across the state, so did reports of winter snows. July 7, 1863 saw mention of snow from more widespread locations than in previous events. The stage coach heading south travelled through a snow covered Midlands, and by the time they reached Hobart, the roof was covered by 6 inches of snow. At Evandale, the depth was between 6 to 8 inches, whilst snow was even reported falling in Launceston, with some the nearby hills covered. In the far north-west snow fell at Circular Head and the snow settled across the low hills. The Huon Valley is mentioned also for the first time as snow covered the district, whilst rivers such as the Derwent, Forth and South Esk were in flood. Abbott's records for the first time hint at the life of winter snow banks on Mt Wellington. The snow from June, with continued falls in following months, lasted until washed away by heavy rain on December 13.

Another four snow events were noted in Hobart during 1864, with the snow arriving on Mt. Wellington in May and lasting (Abbott) until the start of December. Only a few snowfalls reached the town in 1865, but the winter snow lasted until the start of January 1866. The snow started to accumulate in May and despite varying fluctuations persisted until the close of the year, complete with a top up on Christmas day.

Winter, according to the old residents, made a slow start in 1867, so that an item on an ascent of Mt Wellington on November 17 makes fascinating reading. Mr Woods at The Springs could not dissuade three walkers from heading for the Pinnacle. The trip to the summit was a feat not normally accomplished so early in the season or attempted this early in the spring. When the climbers reached the summit plateau, they found it covered by a 3 foot layer of snow. There was no sign of the track and it was slow going as the fissures and rocks were under snow. The flagstaff at the summit was covered in ice and had a flag of ice projecting from it. With snow falling and a fog moving in, the intrepid climbers still managed to make a safe return to the town. In comparison with today's weather, 3cms on the mountain in November would be noteworthy.

The trend of low-level falls continued during 1868. This time snow covered Hobart and the whole island on two consecutive days (July 17-18). Drifts in the Midlands were 2 feet deep with snow along the main road for almost the whole distance. Melton Mowbray received 4 inches, Oatlands 6 inches, Ross, Campbell Town and Longford ½ inch falls. Snow fell in Launceston but did not settle, whilst heavy snow covered Fingal.

1870-1880

The next few years appeared to bring a respite from the annual visitation of snow to Hobart (dare we say signs of a change?). However, Abbott's notes still show the mountain cover appearing about May/June and lasting well into November. The Mt Arthur landslide was a feature of 1872, with heavy rains bringing floods to southern areas and a mass of rocks and trees rushing down the creek through Glenorchy and sweeping away O'Briens Bridge. Severe weather at the start of August saw snow in the capital city again, settling around Launceston with a very heavy fall of 18 inches at Oatlands. A party of timber workers on the Tiers near Glenora fled for their lives as heavy snow brought down tree limbs on their camp and deposited knee-deep snow over the countryside. Another Mt Wellington story supports Abbott's snow notes; this time it involved a lost boy. The boy became separated from a walking party on a visit to the mountain on November 11. He went missing whilst crossing the plateau which was under knee-deep snow. The hapless youth found shelter for the night and then spent another day and a half struggling down the mountain before searchers found him on the Finger Post Track.

Snow and wind made the news in 1874. First it was spring snow in September. Hobart saw snow, as did northern areas. Westbury received 8 inches, the West Tamar hills were all white, and a first mention of snow at such places as Don and Ulverstone occurred. October and November produced boisterous winds as houses were damaged, horse cabs blown over, vessels blown across the harbour, timber stacks swept off the docks into the water, persons rescued from the river, and telegraph lines blown down.

After a respite of one year, wild weather was back to test Hobart's residents. A severe thunderstorm in late January 1876 saw lightning strike the Mt Nelson Signal Station. Oatlands and Richmond experienced a hurricane wind that blew in doors and windows, brought down trees, and stripped the vegetation from others with marble-sized hailstones. Just for a contrast, the upper slopes of Mt Wellington were swept by a bushfire about a month later. Mid May saw an unusually heavy snowfall for time of year with the first mention of the Lake Country receiving a one foot cover. The Mt Wellington snow drifts were to persist right through until November. Just to keep the variety going, mid June was all wind. More houses were damaged, the Fern Tree Inn suffered damage from falling timber, and trees were brought down on the Domain. The local ferry steamer was unable to cross the Derwent, whilst a sailor drowned when two ships capsized. Down the Huon things were no better, with timber mills and tramways in the Southport district were damaged, and an estimated 300 trees were blown down at the Narrows. By mid July, it was all about frosty weather as ice was up to 2 inches thick on pools and lasted all day in the shade. Bothwell experienced intense cold as the Clyde River iced over and the ground was frozen to a depth of 3 inches. The mountain snow had not gone away either, as one man found out on August 24. The walker had apparently disappeared on South Wellington and there was concern for his safety due to the depth of snow. The summit of the mountain was under 3 to 4 feet of snow, with even deeper snow on the Hobart side up to 6 feet. Despite spending the night out in the open, our determined walker managed, despite snow-covered gullies and boulders, to find his way down the east face of the mountain to safety. The closing years of the 1870s saw more benign conditions, although heavy snow on November 7, 1877 lay well down on the mountain ranges, and covered from St Georges Bay to Oatlands. The last of the Mt Wellington drifts melted away in early December. The following year Abbott again noted the last of the mountain's snow lingering until early December.

In 1879 the major snow event was at the beginning of August with snow settling thickly in the city. Many parts of the colony were under snow, mention being made of some new locations. There was a heavy fall in the Midlands and snow fell at

Sorell, Swansea, Beaconsfield district, Carrick, and Hadspen. Snow was also reported in Launceston but only settled on hills about the town.

THE BIG FALLS OF THE 1880s

The 1880s were away to a good start in early 1880 when late April saw "winter snow now started". There were Statewide floods, gales, many trees brought down and ships grounded or wrecked and it was soon followed in May by more of the same. Snow fell in the Midlands and Huon, whilst Hobart experienced a great quantity of rain and hail. The more benign conditions for the rest of the year and through 1881 were to be more than made up for in the big snowstorm of 1882.

Heavy snow fell for a while in Hobart on the evening of June 15 before clearing. However, more was to fall in the early hours of June 16 and by morning, the citizens of Hobart awoke to a countryside carpeted in white down to the river's edge. Snow was thicker in Sandy Bay than in the city which recorded a 3 inch snowfall. The eastern shore hills and paddocks were also under snow to sea level. Overnight snow had also left a thin cover in Launceston with snow almost to the coast at Beaconsfield. Snow covered a wide area of the Midlands and Huon. Just when the snow started to melt, another snowstorm swept over Hobart late in the afternoon to settle again over gardens and rooftops. Out in the west, snow was 2 feet deep on the Waratah tramway, whilst snow was reported from Burnie to Deloraine.

There was another snowfall on the morning of July 13 that once more clad the city and hills in snow, also delaying the arrival of the overnight coach from Launceston. The snowfalls kept coming with another day of snow on September 13. There was a fierce south-west wind in the city and after each snowstorm the hills on each side of the river were white right to the water's edge. Snow was reported all along the rail line to Launceston. The cold weather just did not want to relent as more rain and snow fell in Hobart on September 26. Then on October 20th snow 6 to 7 inches thick settled over the Midlands.

A respite of two years followed until an early fall to lower levels hampered transport on May 15, 1884. Heavy snow in the Huon saw the stagecoach arrive at the Bristol Hotel (Hobart) with 2 feet of snow on the roof. The trains on the mainline fared no better as snow on the rails delayed movements. It snowed all day at Glenora in the Derwent Valley with the cover building up to 18 inches. The Derwent Valley and Midlands received further good falls of snow on July 16.

The next year (1885) there was again an early fall of snow in the suburbs and city on April 27, then frequent snowfalls were noted in the city on July 28. Tasmania's unpredictable weather is no better illustrated by the spring snow on the late date of November 10/11. Sleet was seen in Hobart with snowfalls in the north, Midlands, west, and Derwent Valley, 2 inches covering Macquarie Plains.

The next two years provided fairly average winters, with some snow in the city and across the State. An interesting note from June of 1886 mentions the snow and Hobart's water supply: "Early snowfalls on the mountain remain as the sun does not have the strength to melt it. This in turn supplies water to the town later in the year with the gradual snowmelt".

The biggest fall as the century slowly moved to a close occurred between July 21-24, 1888. It had already been snowing on Mt Wellington for three days when colder weather spread a wider snow mantle. Wide areas of the Huon, Midlands, and north were under snow. Locations not normally known for snowfalls included George Town, Beaconsfield, Low Head, Scottsdale, Latrobe, Penguin, and Circular Head. The East Tamar hills sported a cover of white, whilst Waratah, as expected, recorded 6 inches of snow.

The following day (22^{nd}) was even colder as Hobart awoke to a city of white as the snow kept falling at intervals throughout the day. Snow depths were also growing in country towns; Geeveston with 8 inches, and Franklin hills with two feet. Down the Channel, the snow had settled to sea level, with 5 inches at Woodbridge. Falls across the Tasman Peninsula were claimed to be the heaviest ever seen. All the Derwent Valley was white by nightfall, with Fentonbury groaning under 3 feet of snow. Snow continued virtually everywhere, having spread to locations such as Ringarooma, St Marys, and Launceston. Snow was all over the north and northwest, Deloraine with 3 inches, Dunorlan 6 inches, and Waratah now 14 inches. All the coastal towns noted snowfalls.

As if this was not enough, the State was still under snow on the 23^{rd}, as snow just kept coming. Huon areas now had 5 inches of snow, New Norfolk four, Bushy Park eight, Bothwell three, and good old Waratah was under a cover of eighteen inches of snow. The train line from Waratah to Burnie was snow-covered the whole way.

Finally on the 24^{th}, despite snow and rain in Hobart until night, it finally cleared by the next morning. Light falls had continued in the north at such places as Longford and Evandale. In the far north-east the Blue Tier was covered by 6 inches of snow. In the west, the huge fall of snow collapsed the roof of the mine dressing shed at Waratah. The snow was still on the low hills in the Huon at the start of August. One can only wonder at the immense cover on the higher mountains of the interior; probably enough to last until the next winter?

Cold outbreaks occurred in 1891, 1892, 1894, and 1895. However, whilst snow fell to low levels, none of these events were of the intensity of the great snow of 1888. The period had seen the establishment of telegraph lines to Queenstown and weather notes taken at the Springs (Mt Wellington). July 18-19, 1894 saw a fall of 14 inches at the Springs, whilst lines to Queenstown came down under the weight of snow. Linesmen out to repair the break laboured through snowdrifts on Mt Arrowsmith 15 to16 feet deep. It was no surprise that the rail from Waratah to Burnie was closed by the deep snow.

The last notable outbreak of the century was in September 1895. A traveller caught in the snow in the Derwent Valley perished only a few hundred yards from the Rosegarland Hotel. The same storm produced seas that broke over the buildings at the Iron Pot light house.

Was it the first hint of climate change? The last few years of the 1890s tended to produce less dramatic snowfalls almost as if the big events of the '80s had emptied the snow basket.

FRANCIS ABBOTT RECORDS

During the period 1862 to 1879 Abbott made some interesting notes on Mt Wellington snowfalls, keeping track of the continuous snow cover on the mountain until the disappearance of the last drift (Table 1). Abbott's observations indicate a predictable start to the snow cover about May to June, with cover lasting more often than not into November (and beyond, a few times).

A record of the last 14 winters (Table 2) appears to have no pattern, other than an unpredictable start to snowfalls, and a rapid decline in the period of cover. However, this appears to support the noted decline in rainfall (and snow) coupled with milder temperatures.

The mountain once held gleaming snowdrifts for a good six months; now it varies from a couple of months to no more than four. Climate change occurring right before our eyes!

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Table 1. Abbott records 1862-1879.

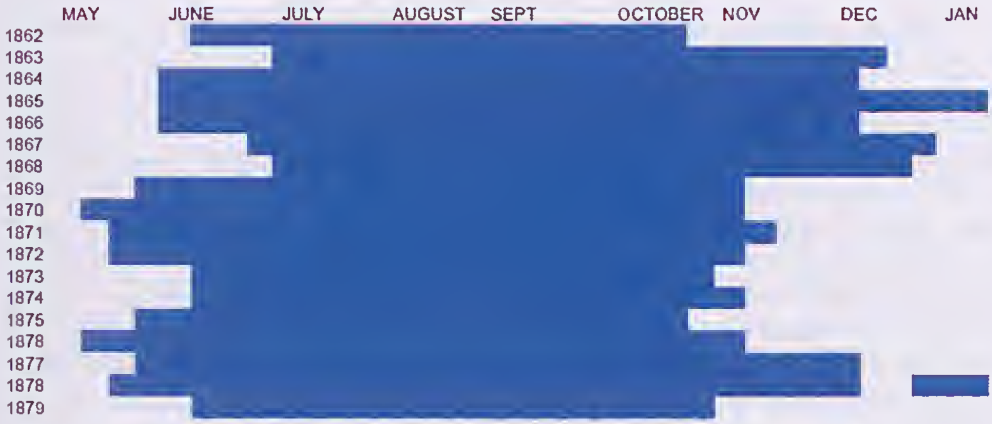
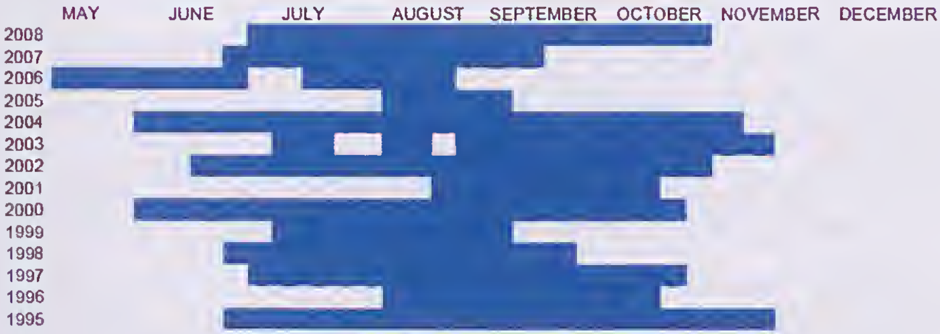


Table 2. Roberts records last 14 years.



RESURRECTING *HIBBERTIA RUFA* (BROWN GUINEAFLOWER)

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The afternoon of 1st December 2008 found me botanising (i.e. having a pleasant stroll while looking at flowers) in an area of wet heathland a few kilometres west of The Gardens on the east coast of Tasmania. The heathland, part of the Doctors Peak Forest Reserve, is one I have visited several times a year since I first saw it about ten years ago. At that time it had been burned quite recently, allowing a mass flowering of species which would not be able to compete with the sedges and shrubs that normally blanket the area. Even from the road, my wife Louise and I could see that this was worth a closer look. The fire meant that access was easy and we had soon discovered dozens of species in flower.

The heathland is rather like an archipelago with the "sea" being the low-lying swampy areas and the "islands" being very low rises covered in dry sclerophyll woodland (Plate 1). It is dissected by small creeks that eventually drain into either the Ansons River or the George River.

Ten years after the fire, the tussock grasses, sedges and shrubs again dominate the area and the thick growth of *Leptospermum lanigerum* along the creeks makes access much more difficult. Small clearings persist, probably maintained by wombats and other grazing animals, and in these grow prostrate herbs such as *Scaevola hookeri*. Despite the competition, a variety of lilies, orchids and other smaller flowering plants manage to put on an impressive display of colour.

As I wandered through this area on 1st December a small *Hibbertia* plant caught my eye. I had just seen *H. acicularis* with its needle-pointed leaves on the nearby better-drained heathy rise but this plant was different. It had smaller flowers and the leaves, rather than being pungent, were blunt and many of them had tiny tufts of hairs at their tips. It was new to me, so I took a sample and a GPS reading and then hurried back to the car as a storm rapidly approached.

Back in Launceston I consulted a key to *Hibbertia* and found the only match for my specimen was *H. rufa*, described as "Tas., known from one collection by W. Fitzgerald (1892) at St Helens" (Curtis 1956). Further checking told me that this species was now regarded as extinct in Tasmania (although it grows in Victoria and NSW). As I always do when in a situation like this, I sent my specimen to the Tasmanian Herbarium and within a short time Alex Buchanan had emailed me that he agreed with my identification. However, the Herbarium's only record, that of the above-mentioned W. Fitzgerald, was on loan to the State Herbarium of South

Australia where Dr Hellmut Toelken was using it as part of a revision of Australian species of *Hibbertia*. Alex sent the specimen to Adelaide and within a couple of days Hellmut had confirmed Alex's opinion. *Hibbertia rufa* was very much alive after hiding for nearly 120 years!

Over the holiday period several people came with me to look at the *H. rufa* and together we found quite a number of plants spread over an area of about 1 km by a couple of hundred metres. It appeared that we had found several hundred plants but Hellmut cautioned that this species has a habit of spreading by suckering so that what looks like a number plants over an area of several square metres may be just one.

It has been a huge pleasure for me to find a species that had not been seen in Tasmania for over a century and was thought to be extinct in this State. It was also nice to be the first to photograph it in Tasmania (Plate 2).

I wonder exactly where Fitzgerald found his specimen, which he annotated as being "George Bay" (Plate 3). This was in the days before GPS and botanists at that time did not seem to worry too much about providing details for the locations of their discoveries, and the term Georges Bay was probably used to refer to much of the hinterland in and around the modern town of St Helens, and possibly as far afield as Ansons Bay.

The area around the Bay of Fires and Georges Bay contains a number of threatened plant species. The most notable of these is *Phebalium daviesii* (davies waxflower) that grows only in Tasmania. With only thirty or so plants in the wild and all of these on the banks of the George River, it must be one of the rarest plants in the world (although it is easy to propagate and grows well in the garden). I am pleased to have added to the number of these precious species known to exist in this wonderful part of Tasmania.

The rediscovery of the brown guineaflower reminds us of the need to protect our natural heritage. We do not have a complete knowledge of what is out there and it would be a great shame if we lost something before we even knew it existed. *H. rufa* is added to the growing list of vascular species previously considered extinct in Tasmania (e.g. Wapstra *et al*. 2006; Bonham 2008), giving hope to many of us that other species may yet be rediscovered.

H. rufa (commonly known as the 'brown guineaflower' from its red-brown branchlets) is one of fourteen species of *Hibbertia* present in Tasmania (Buchanan 2008). Species of *Hibbertia* are easy to identify as a group because all but one of the Tasmanian species have five showy yellow petals (hence the name 'guineaflower') that are slightly indented at the rounded tips. Some species have large flowers and make very good garden plants. They are not so suitable for the vase as they lose their petals quite readily, which is also of great annoyance to field botanists collecting specimens for identification because often all one has left are loose yellow petals stuck to the inside of the collecting bag. *H. rufa* seems to be unique amongst our *Hibbertia* species in that the petals remain present after collection and during curation. Most of the Tasmanian *Hibbertia* species are very common but some are listed as threatened including *H. virgata* (also present in the St Helens area), *H. calycina* (restricted to dry ridgelines behind Scamander), *H. basaltica* (restricted to the basalt areas around Pontville in the southern Midlands) and *H. obtusifolia* (collected from Clarke Island in Bass Strait in 1892 and from heathlands near Conical Rocks on the west coast in 1983).

ACKNOWLEDGEMENTS

Alex Buchanan (Tasmanian Herbarium) and Hellmut Toelken (State Herbarium of South Australia) confirmed the identification of the specimens first collected by the author. Hellmut Toelken kindy provided scanned images of the early collections of *H. rufa*.

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EDITORIAL POSTSCRIPT

Roy's rediscovery of *Hibbertia rufa* led to successful extension surveys being conducted in the St Helens to Ansons Bay area by Mark Wapstra, with funding by NRM North, and field assistance by Roy Skabo and Brian French. Several additional sites were located, and the findings will be formally presented at a later date but in the mean time for those interested, a report is available: ECO*tas* (Mark Wapstra) (2009). *Extension Surveys for* Hibbertia rufa *(brown guineaflower) in North-eastern Tasmania*. A Report to the Northern Tasmanian Natural Resource Management Association Inc. by Environmental Consulting Options Tasmania 1 June 2009.

Plate 1. Habitat of *Hibbertia rufa*. Note the archipelago-like arrangement of the "sea" of low-lying swampy areas and the "islands" of low rises covered in dry sclerophyll woodland. *H. rufa* grows in the transition zone between the heathy woodland and the denser wetter heathland, extending out on the broad flat terrain (about where the people are standing). Image: Jennifer Skabo.

Plate 2. Close-up of *Hibbertia rufa*. Note the trailing habit, small flowers, low number (less than four) stamens in a group on one side of the ovary, and leaf shape (including the small tuft of white hairs at the apex). Image: Roy Skabo.

Plate 3. First collection of *Hibbertia rufa* from Tasmania from "George Bay" by W. Fitzgerald in 1892.

THE WEATHER'S DIFFERENT THESE DAYS — BUT WHAT DOES 'DIFFERENT' MEAN?

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Talking about the weather, my older neighbours in northwest Tasmania often say something like this:

> *When we were growing up years ago on the farm, we'd get rain for weeks on end. Now there's rain for a day or two, then long sunny spells.*

If they're right, then rainfall patterns have changed dramatically in recent years. But in what way? When it gets wet, are rainy spells really shorter than they used to be? Are the sunny spells longer? How about the rainfall totals? If today's rainy spells are shorter, do they 'compensate' by delivering as much rain as the longer rainy spells of past years?

In this article I explore these questions using long-term daily rainfall records from a single northwest locality, Burnie. Before I begin, I offer two disclaimers.

The first is that I don't hope to convince either believers or skeptics with numbers. There are always possible rejoinders like It *was different where I grew up* and *Don't go by Bureau of Met figures, a lot of the time they're way off.* And the old reliable *You can prove anything with statistics.*

The second has to do with the nature of memory. It isn't a clock-like record of what we experience. Memory is more like a set of beads that can be threaded together in different ways, some of them non-chronological. For example, I remember my first decade in Tasmania, the 1970s, as being very wet. As it happens, decade-by-decade rainfall summaries for the State are consistent with those memories. But the figures don't *validate* my memories, which are just undated mental pictures of a small number of wet days (small relative to the 3652-day total for the decade).

Conversely, facts cannot *invalidate* memories. People remember what they remember. Learning that a memory is incorrect doesn't automatically erase the memory or make it any less convincing.

OBVIOUS TRENDS

My working dataset is daily rainfall at Burnie over the 64 years from 1945-2008 (see Appendix for data treatment, and why I picked Burnie), and to smooth the variation I've used five-year moving averages. The most obvious overall trend is that Burnie has been getting less rain since the beginning of the 1980s (Figure 1). The average annual rainfall for the last 32 years of the period was only 85% of the average for the first 32 years.

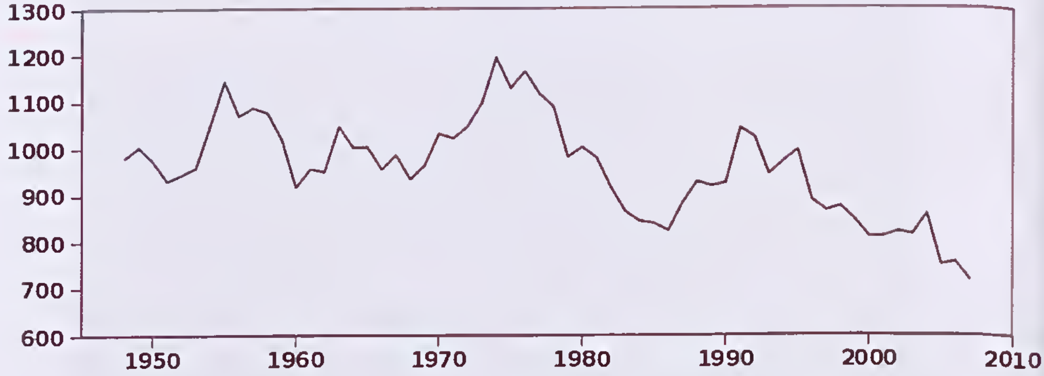

Figure 1. Five year moving average of annual rainfall (mm) at Burnie, 1945-2008.

This recent decline in rainfall is associated with a drop in the number of raindays (Figure 2), i.e. days when rain is recorded (see Appendix).

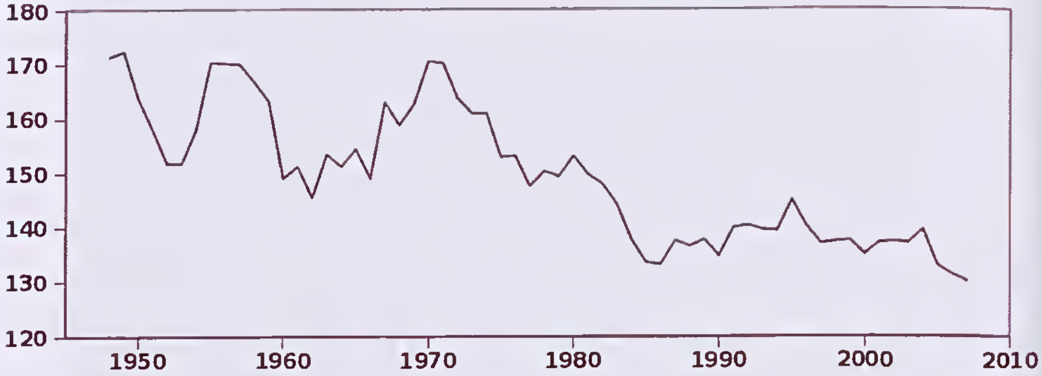

Figure 2. Five year moving average of number of raindays per year at Burnie, 1945-2008.

The decline in raindays largely explains the drop in annual rainfall. As shown in Figure 3, there hasn't been a parallel decline in the average fall per rainday, which is a rough measure of rainfall intensity.

Note, however, the downward trend over the last 10 years or so (Figure 3). That's largely explained by a drop in the falls on the days of highest rainfall. Figure 4 shows this trend for the 10 heaviest one-day falls each year. These 10 days account, on average, for one-third of Burnie's annual rainfall, and in 1965, 1982 and 1997 they contributed just over 40% of the year's total.

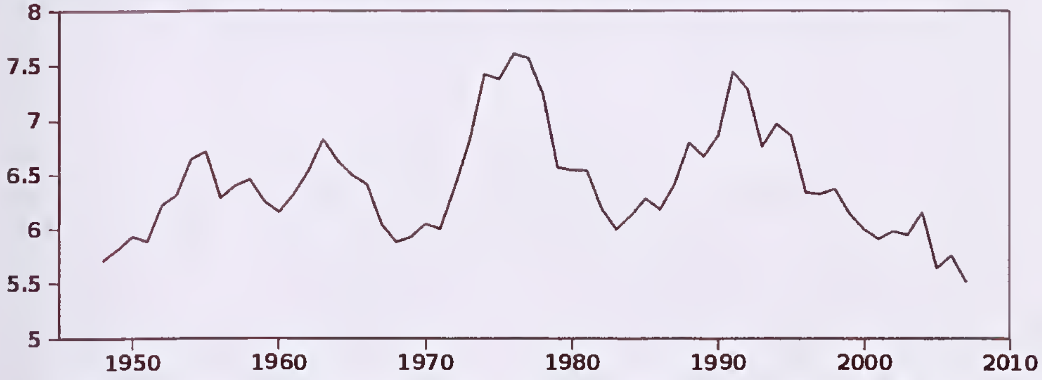

Figure 3. Five year moving average of mean fall per rainday (mm/day) at Burnie, 1945-2008.

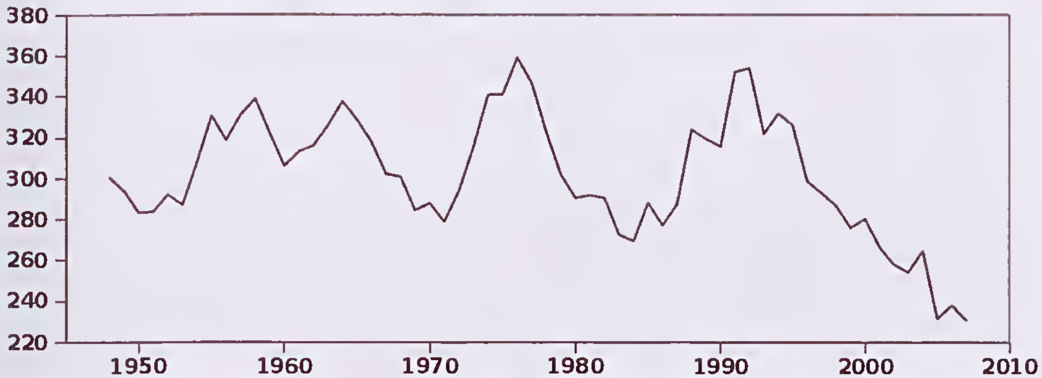

Figure 4. Five year moving average of 10 heaviest one-day falls (mm) each year at Burnie, 1945-2008.

NOT-SO-OBVIOUS TRENDS

So far I've shown that Burnie's rainfall pattern has indeed changed in recent years. It rains on fewer days per year, and it doesn't bucket down the way it used to on heavy-rainfall days.

However, we haven't yet looked at the *sequence pattern* of rainfalls, i.e. the lengths and distributions of rainy spells. To make the analysis a little easier, I'll arbitrarily define a 'rainy spell' as seven or more raindays in a row.

There were 197 such rainy spells at Burnie in the 64 years, the longest being a 19-day wet in 1946. Has the *length* of individual rainy spells changed over the years?

Yes, a bit, as shown in Figure 5. The average rainy spell in the first half of the 64-year period lasted 9.1 days, compared to 8.6 days in the second half. The decline in *number* of rainy spells per year has been much more dramatic (Figure 6), dropping from an average of 3.8 per year in the first 32 years to 2.2 per year in the second 32 years.

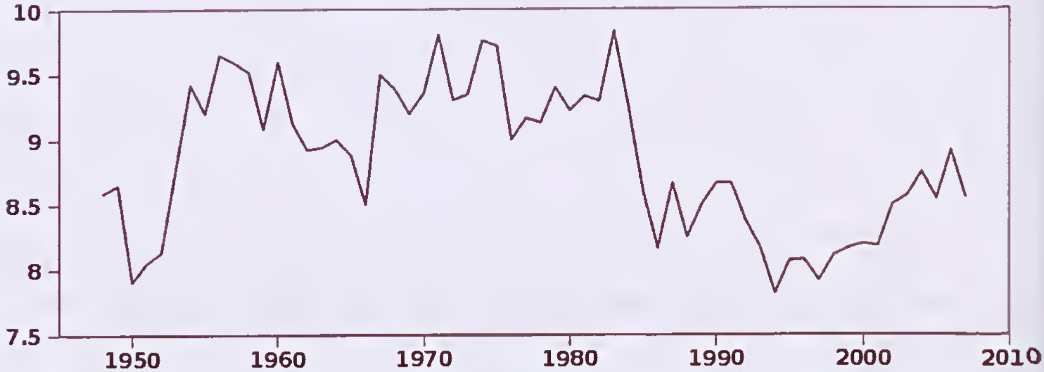

Figure 5. Five year moving average of mean length of 'rainy spells' (in days) at Burnie, 1945-2008.

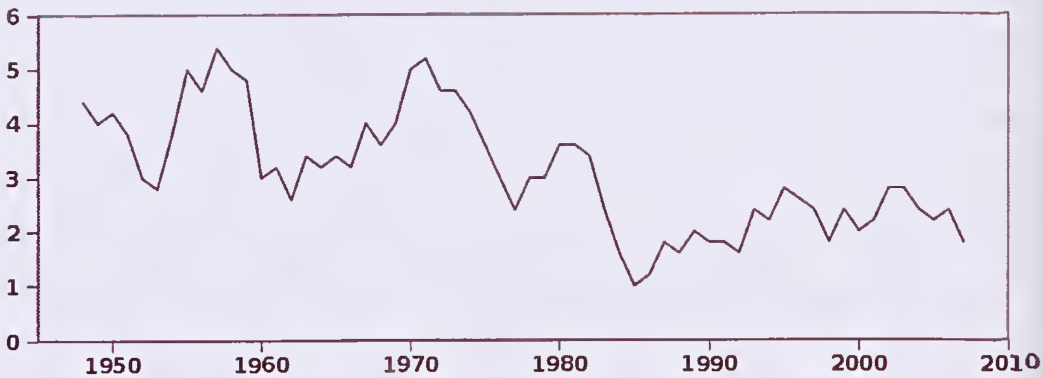

Figure 6. Five year moving average of number of 'rainy spells' per year at Burnie, 1945-2008.

We now have another change in rainfall pattern. In recent years there have been fewer long, continuous stretches of raindays, and the stretches have been a little shorter. But these figures don't tell us how rainy periods have been distributed through the year. A month of on-off rain is a wet month, even if it doesn't contain any 7-day-plus rainy spells. To look more closely at rainday distribution, I moved a 30-day window through the year, one day at a time, and totalled up the raindays within that window. I arbitrarily define a 'wet window' as a 30-day period in which there were at least 21 raindays, in any order.

As shown in Figure 7, 'wet windows' have been much less frequent at Burnie since the early 1980s.

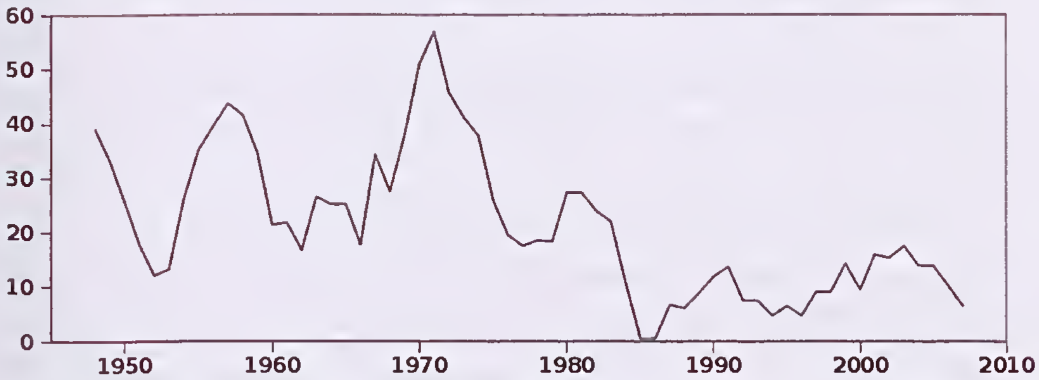

Figure 7. Five year moving average of number of 'wet windows'per year at Burnie, 1945-2008.

Broadly speaking, we could say that it rains less these days and less often. The 'often' in that sentence can be gauged in still another way. Consider a string of days on which rain was either recorded ('rain') or not ('fine'). There are four possible transitions from one day to the next: fine-fine, fine-rain, rain-rain and rain-fine. Now imagine a year in which there was only one long, continuous rainy period of 180-odd days, i.e. half the year. In that year there would be a single fine-rain transition (as the rainy spell began) and a single rain-fine transition (as the spell ended). All the other 360-odd transitions would be fine-fine or rain-rain.

At the other extreme, imagine a year in which rain and fine days alternated monotonously: rain-fine-rain-fine-rain-fine-etc. In such a year there would be 180-odd fine-rain transitions, the same number of rain-fine transitions, and no rain-rain or fine-fine transitions at all.

Does it rain more 'often' in the first imagined year or the second? In both years it rains on 180-odd days, but I'd suggest that in the second case we'd *perceive* the rain as falling more often. We could cope with six months of continuous rain by planning around it, but rain every second day would be a serious nuisance. We might wait patiently for the end of a six-month rainy spell which we knew lasted just six months. I don't think we'd wait as patiently in the second imagined case. We'd soon be saying *I wish it wouldn't rain so often.*

The number of fine-rain transitions per year might be seen as a 'psychological' index of raininess. Interestingly, this measure hasn't noticeably trended over the past 64 years (Figure 8).

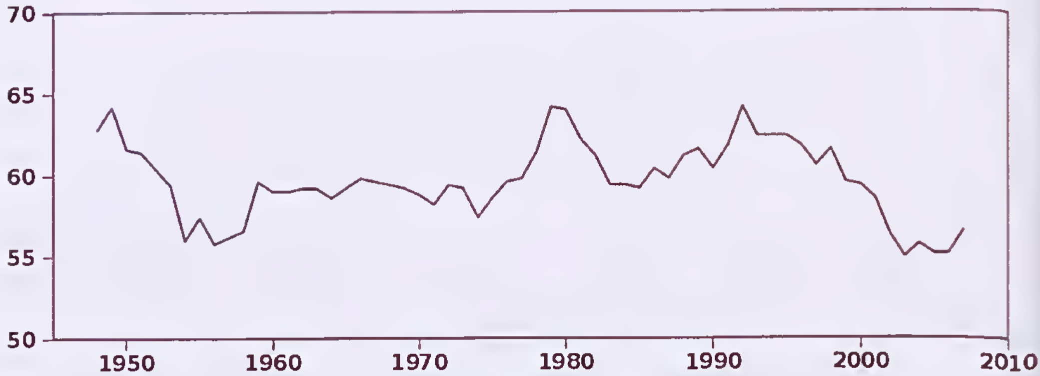

Figure 8. Five year moving average of number of fine-rain transitions per year at Burnie, 1945-2008.

SUMMING UP

There is a *lot* of variation in rainfall data. It's hard to detect rainfall trends unless variations are smoothed, as I've done here using a five year moving average. Even when trends are detected, it may not be obvious when they begin or end, or how strong they are. Nevertheless, I think I've shown in the analysis above that the old-timers are right. Not only is less rain falling these days at Burnie, but the intensity and sequence of rainfalls have also changed in detectable ways. There are also likely to be trends in the seasonality of rainfall, but I'll leave that study to other meteorological hobbyists!

APPENDIX: DATA TREATMENT

Daily rainfall records in digital form were obtained from the Tasmanian office of the Commonwealth Bureau of Meteorology. I chose Burnie (Round Hill) because it has a long run of records up to the present, and relatively few gaps: only 266 days out of 23376 in 1945-2008 (99% complete).

The gaps are of two kinds. 'Accumulation' gaps are periods when the rainfall observer recorded the total amount of rain that had accumulated in the gauge over the preceding few days. 'No record' gaps are periods when the rainfall station wasn't attended (e.g. over the Christmas holidays) and rainfall wasn't accumulated.

Conveniently for analysis, all of the 122 accumulation and 144 no-record gap days at Burnie can be filled using data from Elliott Research Station, 14 km to the southwest. Elliott is wetter than Burnie, however (1190 mm annually vs. 955 mm), which means the gap-filling has to be done a little judiciously. I first cleared the Burnie and Elliott histories of all accumulation and no-record days. This left 19736 days in 1945-2008 for which both stations had records. On 16635 of those days (84%), Burnie and Elliott agreed that it was a rainday or that it was not a rainday. Of the days when rain was recorded at Elliott but not at Burnie, 72% were falls of 0.5 mm or less. I therefore filled the Burnie gaps this way: (1) no rain at Elliott or 0.5 mm or less, no rainday at Burnie; (2) >0.5 mm at Elliott, rainday at Burnie.

For calculating yearly rainfall totals I used uncorrected Elliott data in the Burnie gaps. The possible inflation over the true (unknown) Burnie totals would have to be very small, as the gaps are only 1% of all days and occur mainly in the low-rainfall months of December and January.

The Bureau of Meteorology defines a day of rain as one on which at least 0.2 mm, not solely attributable to frost, fog or dew, has accumulated in the rain gauge by 9 am. To ensure consistency through the 64-year dataset, I defined a 'rainday' as a day on which at least 0.3 mm had accumulated.

Year-by-year analysis would have been complicated if rainy spells regularly occurred over New Year. Fortunately, they didn't. The only 'bridging' rainy spell was in 1971-72, and I ignored this bridge when calculating numbers and lengths of spells per year.

The 30-day window analysis, of course, doesn't respect year-ends. I assigned windows overlapping the year-end to either the old or new year by majority rule of days. In the 15-15 day case, the window was assigned to the old year.

The analyses reported here were done and graphed on a spreadsheet (Gnumeric under Linux). For ease in exploring time series data such as the pattern of rain/no-rain days, I converted the numbers to strings of characters and analysed the resulting text. For example, if we call a no-rain day '0' and a rainday '1', the sequence for the 366 days in 1948 is:

1110010010010000000000100000000001111001100100111110000110111111000
111110000000100000000100000000011111010000010000000010101011011100
011111110001111111110100000111110000011100100111111100110111110000
000111110110110111111011000001110111111101001110011111101100011000
011111110010110110001111011111111000111101000111101100000110000000
001100010111101011001111000000111010

This string can easily be searched in a text editor for isolated sets of seven raindays, which would appear as 011111110 (there were four such sets in 1948). There are also scripts (e.g. in perl) for tallying selected substrings within a string.

Finally, I am very grateful to meteorologist Ian Barnes-Keoghan for helpful comments on an early draft of this article. All analytical and other errors are, of course, my own.

A DECADE OF DEADWOODOLOGY AT WARRA

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Decadent. Rotten. Waste. Residue. Unproductive. The superposition of the words 'dead' and 'wood' gives rise to so many negative connotations, why would anyone feel the need to coin another word to describe the study of this stuff? Consider this. Dead wood (or coarse woody debris, CWD) represents a fair chunk of the embedded energy from perhaps several hundred years of photosynthesis by some of the most successful and enduring organisms on the planet (that's trees). And it's just sitting there on the forest floor, waiting to be recycled back into multitudinous new life-forms. Systems scientists have accepted that the term 'embedded energy' needed shortening to 'emergy' – check Google if you don't believe me – so my view is, why not have one word that captures an entire field of research surrounding dead wood? In this article, I elaborate on what it means to have spent much of the past decade working on matters deadwoodological (there's another new word!) in and around southern Tasmania's Warra Long Term Ecological Research (LTER) site (Figure 1).

But first, how did Warra get to be the focal point for so much ecological research in general, and deadwoodological research in particular? After all, Warra is just a typical 16,000 ha patch of the southern forests – a mix of lowland wet *Eucalyptus obliqua* forest, rainforest, buttongrass and montane scrub and rock, some of it allocated to reserves, some of it allocated to wood production. But that's the point – typicality is exactly what the people that set up Warra were looking for back in the mid-nineties. Mick Brown – then at Forestry Tasmania (FT) – and others were looking for somewhere to explore the ecology of Tasmanian terrestrial ecosystems in general, and Tasmanian wet eucalypt forest in particular, because it's these forests that form the backbone of Tasmania's native forestry industry. If we want to understand how to manage these forests well, we'd better be sure we understand how they work. Establishing Warra as an LTER site not only formalised its role as a premier site for terrestrial ecological research in Tasmania, it also linked it into a national and international network of LTER sites and researchers. To this day, Warra continues to host fundamental ecological and hydrological research projects, both long-term and short-term, as well as acting as a testing-ground for different forms of forest management. The number of individual research projects has climbed to nearly 170, and the number of published journal articles and book chapters arising has reached 119.

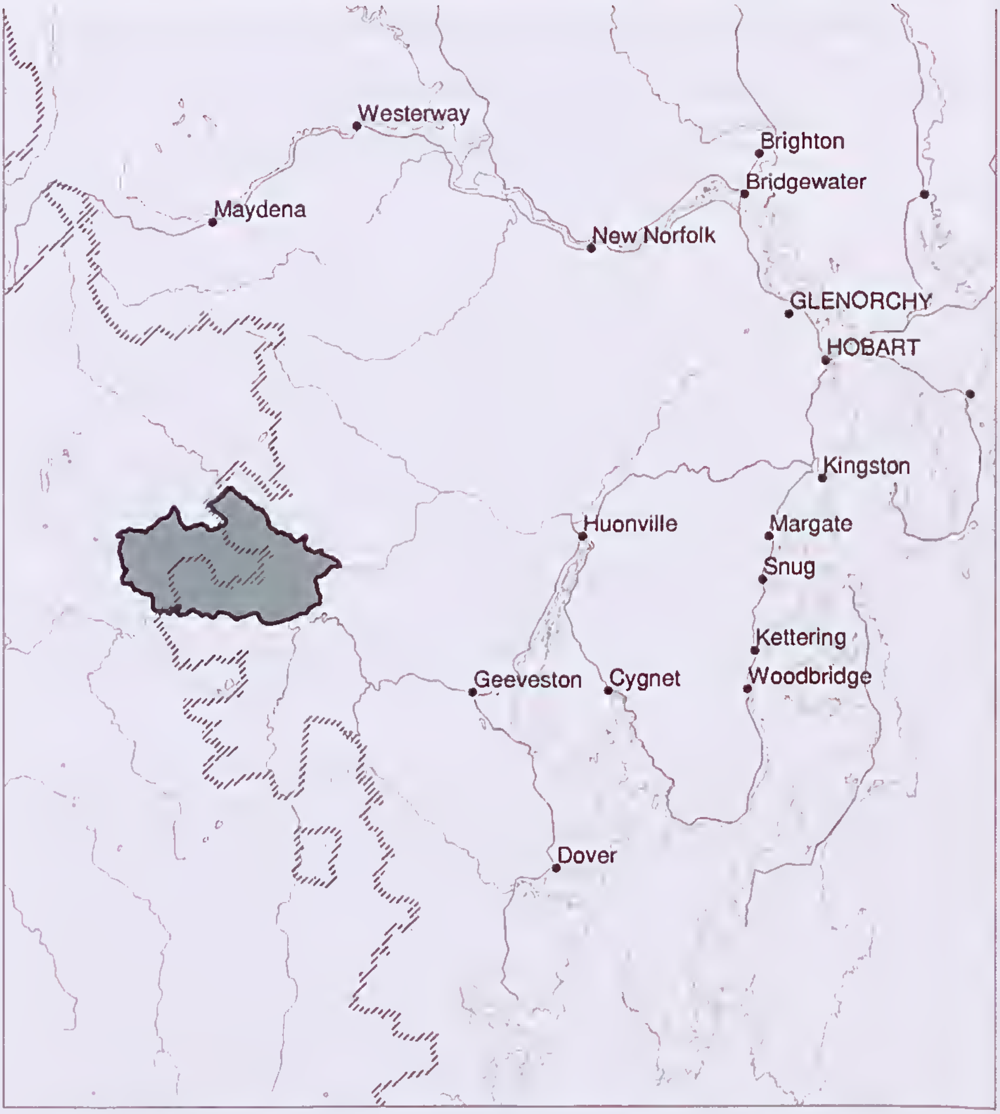

Figure 1. Southern Tasmania, showing location of the Warra Long Term Ecological Research site (shaded dark grey). The eastern boundary of the Western Wilderness World Heritage Area is shown as a hatched line.

Deadwoodology came early to Warra. By 1999, Rob Taylor (my predecessor as Conservation Biologist at FT) had established the log-decay project, with Caroline Mohammed and colleagues from the University of Tasmania (UTas) and with Tim Wardlaw, also from FT. The main aim was to monitor elements of the rich biodiversity inhabiting logs – chiefly saproxylic (dead-wood-associated) beetles –

as the logs gradually decomposed. Twelve *E. obliqua* trees were deliberately felled for the purpose, so that the process could be followed right from its start. The initial funding was for only three years. But the project lives on, and we have recently completed the second five-year cycle of emergence-trapping (Plate 1), bringing the total number of beetles collected from these twelve logs to 17,488, and the number of beetle species to 455. Through other research at Warra we now know that these logs are still likely to be in a sampleable condition two centuries hence. Only at Warra could such a long-term study be contemplated: researchers come and go, but the logs endure and the research lives on.

Plate 1. One of twelve logs in the Warra log-decay project. This is a 'regrowth'-sized log, encased in an emergence trap to sample saproxylic beetles (photo by the author).

At the same time as the log-decay project got under way, Marie Yee started her doctoral research at UTas, also in and around Warra. Marie's work focused on *E. obliqua* logs in an intermediate stage of decomposition, corresponding to what we now call decay-class three (on a scale of one to five). Logs at this stage can be thought of as being in their ecological prime of life: the chemical cocktail that the living tree produces to ward off pests and pathogens has largely gone, yet the log still retains most of its original volume and structure, but only half of its original mass. It's in logs like this that some of the most remarkable assemblages of beetles can be found – if you know how to look for them. Marie did, and her research was one of the first in Australia to document this fauna. She detected distinct differences between the species assemblages living in larger-diameter logs (derived from 'old-growth'-type trees) and smaller-diameter logs of a size typical of those derived from 'regrowth'-type trees. In doing so, she highlighted one possible conservation issue: if the future production forest becomes increasingly dominated by regrowth, where will the species that live in old-growth logs find a home? With Marie subsequently taking up a position as Conservation Planner at FT, this was a pertinent question.

Marie's research finding was a familiar story to me – but not in a Tasmanian context. I started working at FT in 2001, fresh from having finished my own doctoral research on saproxylic beetles in the lowland tropical rainforests of northeast Queensland, and with a background of working on similar themes in the woodlands of England. My English experience had taught me how dire could be the consequences of centuries of use and abuse of native forests on the dead-wood habitat, and on the species dependent on it. I could see the beginnings of a similar trend in the Daintree too, though this had been curtailed with the near-cessation of logging a decade previously.

My arrival in Tasmania coincided with a growing interest in renewable energy. Forestry Tasmania was actively exploring options for generating electricity from harvest residues. Irrespective of how the environmental credentials of fuelwood-harvesting stack up, it is a widely-accepted part of normal forest management in northern Europe and North America, so why not in Tasmania too? There was one snag. The experience of Fennoscandian ecologists was that their intensive forestry, including fuelwood-harvesting, had denuded their forests of CWD and had contributed to a high percentage of their 1400 saproxylic beetle species (plus many other life-forms) being red-listed; trying to get ecologically-useful amounts of CWD back into their forests through changed practices was proving expensive and not very effective. Considering the complications introduced to forest management in southern Tasmania by the single threatened saproxylic beetle species, the Mount Mangana stag beetle (*Lissotes menalcas*), we could scarcely imagine how having scores or hundreds of such species might impact on operations. Much better to get to grips with understanding the system now, so that we could explore ways to avert the risk of such a calamity while still maintaining a viable forestry industry.

And so a formal research programme was born, endorsed by FT management. It had the explicit aim of learning enough to make scientifically defensible policy decisions on fuelwood-harvesting. Along the way, the research would also build our understanding of fundamental forest ecology, and would help guide a range of other forestry-related management issues. The logical place to start with such a research programme was a review of the likely ecological impacts of fuelwood-harvesting – so this was the first thing that former FT Conservation Planner Jeff Meggs and I did. The review led to the recognition of some key research themes.

One focused on understanding the biodiversity associated with CWD, into which Marie's research and the log-decay project fitted neatly. These projects were soon augmented by those of two further doctoral students from UTas. Anna Hopkins explored the wood-rotting fungi of 'old-growth'-type and 'regrowth'-type *E. obliqua* trees at Warra, while Kate Harrison studied the saproxylic beetles living in the same trees. A little later, Genevieve Gates began her doctoral research on macrofungi associated with CWD and litter in forests of three different ages at Warra. These studies, like Marie's, were able to demonstrate that there was something quite special, ecologically, about old trees and the large logs derived from them. This seems to relate partly to their more complex, microclimatically-buffered internal structure. It also relates to time itself – older trees have endured more fungal and borer attacks and have accumulated more fire damage than have younger trees; the impacts of these events from the distant past are still played out in the logs arising from these trees. Additionally, all these studies – and many others besides, on taxa as diverse as liverworts and mites – documented the existence of a vast array of hitherto-unknown species associated with these habitats. Many of the beetles collected during these studies have ended up in FT's Tasmanian Forest Insect Collection (TFIC), which has consequently grown to become a comprehensive reference collection of databased Tasmanian forest beetles (118,479 specimens, comprising 1912 species, many of them new to science).

You may be wondering why we didn't just resolve the big management question by looking at what effect past fuelwood-harvesting had had. Well, we tried – but up to now, nobody had done much fuelwood-harvesting in Tasmania. We did find a few areas of the southern forests that had been subjected to experimental fuelwood-harvesting back in the 1980s, and we duly sampled these areas for saproxylic beetles, comparing them with similar areas that hadn't experienced fuelwood-harvesting. But the areas in question were so few and small that the findings, while strongly suggestive of an impact, lacked statistical power. In any event, 'snapshot' studies like this can only tell you so much when the subject is something as dynamic as dead wood – and so dead-wood dynamics became another major research theme for us.

Dead-wood dynamics? Surely that's an oxymoron: what could be dynamic about dead wood? Humans are ill-equipped to conceive of logs as doing anything other than just sitting there. If you blink, the log doesn't move. Return to your favourite picnic-spot summer after summer, and the logs your kids played on as toddlers will probably still be there when they're teenagers. But logs do change, even if we can't catch them in the act of doing so. As well as slowly decomposing over decades, logs pop into existence when the progenitor trees fall over. In the wet eucalypt forests, the usual reasons for trees doing so are periodic massive disturbance events, typically wildfires or logging. So to find out how long logs last, we used a so-called 'chronosequence' approach. We compared the decay-class composition of logs in forests differing in the number of years that had passed since the last big disturbance event (whether wildfire or logging). Retired FT Huon District Planner Chris Barry knew the recent disturbance history of the southern forests like the back of his hand, and undertook the fieldwork. We were guided by a report on the early timber-getters compiled for FT a few years previously by archaeologist Parry Kostoglou, which helped find sites that had been first logged a century or more ago. Each of the hundreds of logs that Chris assessed became a data-point on a graph that eventually told us how long it takes for *E. obliqua* logs to pass through the five decay-classes. The answer: there's a lot of variation, but decent-sized decay-class three logs tend to have been around for 50 years, while those in decay-class five (well on their way to becoming humus) are likely to have been around for over 150 years. This is much longer than logs in most other parts of the world.

We were fortunate at this stage to host a summer forestry student from Southern Cross University, Lee Stamm. Lee demonstrated an aptitude for deadwoodology that led to him staying on to complete Honours at UTas, and later to his appointment within FT as a Planning Forester. His particular research challenge was to uncover the missing pieces of the dead-wood dynamics puzzle, and build the whole thing into a computer model that would simulate this. This would enable us to play around with disturbance and management scenarios and forecast how these would affect CWD amounts over timescales of many centuries. Lee started by taking a chainsaw to dozens of logs at Warra, to extract 'biscuits', or slices, each comprising a particular decay-class. From these he figured out the component rotten-wood types, and took sub-samples of these back to the lab to work out their density. He used these density values to back-calculate the average density of logs in different decay-classes, and built these values into his computer model. The model started with a mature forest, stocked with a typical array of 'legacy' CWD whose composition accorded with what former FT research technicians Gabriel Warren and Darren McNeil had measured along eleven kilometres (yes, 11 km!) of line-intersect surveys conducted in and around Warra a few years previously. The model also incorporated FT's growth equations for the trees that would generate the CWD. It then simulated periodic wildfires that would kill these trees. The wildfires would simultaneously combust a proportion of the volume of every log, based on some relationships derived from Warra data a few years previously by former FT Fire Management Branch researcher Alen Slijepcevic. What was left would be fed into the next part of the model, comprising the five-stage decomposition process. The model would then spit out CWD volumes and masses for every decay-class and diameter-class combination for every year of the simulation.

The model demonstrated how some of the world's highest volumes of CWD could accumulate in Tasmania's lowland wet *E. obliqua* forests, and confirmed the role that periodic wildfires and slow decomposition rates play in this (Figure 2). These high volumes were in line with our field observations, including those derived from plot-based surveys in the set of 'wildfire chronosequence plots' that Perpetua Turner from UTas had established in and around Warra, in a collaborative project with FT. German forestry diploma students Julia Sohn and Eva Hilbig, alongside FT colleagues, had laboured (I use the term intentionally and with feeling) long and hard to come up with figures for CWD volumes in these plots that range from 351 to 1710 m^3/ha. By building on some of Lee's density analyses, and by incorporating data on the volumes of living stems in the same chronosequence plots from work by Australian National University Honours student Ian Scanlan, Eva's work was additionally able to convert volumes to masses and hence to total carbon. For the record, she estimated that the amount of carbon in trees, roots and CWD in the wildfire chronosequence plots ranged from 97 to 583 t/ha – well above accepted international benchmarks for temperate forests.

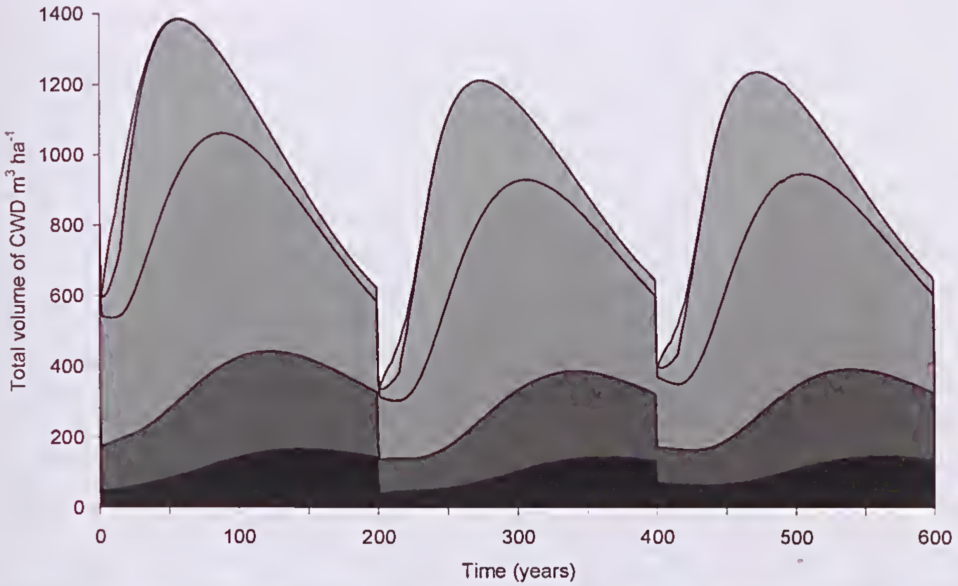

Figure 2. An example of output from Lee Stamm's model of dead-wood dynamics. The graph predicts how volumes of coarse woody debris may vary over time, and by decay-class, following periodic stand-replacing wildfires every 200 years.

I subsequently developed Lee's CWD dynamics model so that it can simulate logging and fuelwood-harvesting as well as wildfires. This has brought us to the point of being able to predict the likely impacts of fuelwood-harvesting on CWD, over and above those of clearfelling. The news is not good. Unconstrained fuelwood-harvesting, practiced at the time of clearfelling, would more-or-less eliminate CWD from affected coupes. The full impact would not be felt for many decades, however, because of the time taken for 'legacy' CWD and unharvested residue to decay away. The model also revealed that the focus on fuelwood-harvesting was to some extent missing the point, because fuelwood-harvesting only brings forward an inevitable loss. Clearfelling on its own is quite capable of producing a similar outcome, but this would only be manifested well into the second silvicultural rotation (i.e. about 150 years hence). This is because it would take that long for the system to respond to the lack of 'legacy' CWD after the second harvest, and to the fact that the new input of harvest residue at this time would comprise smaller-diameter CWD that would not last as long on the forest floor.

Knowing the effects of clearfelling and fuelwood-harvesting on CWD is not quite the same thing as being able to gauge its impacts on dependent biodiversity, which is where my interests really lie. The key missing ingredient is scale. While the model handles the time dimension admirably, it has no concept of space. On the other hand the real world, as we can all readily appreciate, has dimensions of space as well as of time. This calls for a very different research approach – one we are just embarking on. Essentially, we want to find out how much it would matter to the persistence of dead-wood dependent species if parts of our landscape (the bits comprising silvicultural regeneration) ended up lacking sufficient dead wood to sustain them. We know from our surveys that not every part of the forest is capable of supporting every species continuously even in the absence of forestry – there are some areas that naturally have very little CWD, while other areas periodically lack particular decay-classes, or diameter-classes, or combinations of these; some areas appear to have the right habitat, but it remains unoccupied. Species have presumably evolved to cope with this varying capacity of different parts of the landscape to support them. But we don't want to end up with a situation where we have introduced so many obstacles that species can no longer move around the landscape, and consequently become locally extinct. That's where northern Europe has got to, and it's not a good space to be in because it's so difficult to get back out of it.

Enter two further UTas doctoral students and former FT employees, Belinda Yaxley and Lynne Forster. Belinda has spent much of the past couple of years in and around Warra, trying to unravel the ecology of some of the key saproxylic beetle species that previous researchers had identified as potentially vulnerable to forestry activities. These include Mount Mangana stag beetle as well as some inhabitants of the 'mudguts' habitat that I wrote about in this journal in 2007, many of whose close relatives in Europe are on the verge of extinction. One of Belinda's aims is to collect sufficient information about these mostly flightless or otherwise rather immobile species (Plate 2) to be able to model their habitat relationships, and hence their probability of occurrence, across the southern forests landscape, and to relate this to forestry activities and wildfire. Lynne aims to build in a time dimension to Belinda's work, through taking a rather different approach. She will work with a postdoctoral researcher, Christina Schmuki, who has perfected the use of molecular techniques to study how the genetic relatedness among individual beetles varies with physical distance. Lynne and Christina's study also builds on some pilot molecular projects on individual beetle species carried out at Warra a few years back by Latrobe University students Sarah Nash and Simon Watson. Lynne and Christina will explore how the spatial arrangement of dead wood has affected the ability of these beetles to move around the landscape. Parallel to their studies, we will also be sampling saproxylic beetles (and other taxa) widely in the Warra area as part of a new landscape ecology project. The aim of this project is to test the effect that landscape context (i.e. how intensively the landscape is managed) has on the current distribution of species. Together, the findings of these projects should help us to understand at the spatial and temporal scale at which we would need to manage CWD (and the old trees from which CWD is derived) to ensure the long-term persistence of these species in the managed forest landscape.

In the interim, FT is taking a precautionary, yet pragmatic, approach to dead-wood management. The Warra research and modelling results have convinced FT management of the need to endorse a set of prescriptions that would put limits on the extent of fuelwood-harvesting in logging coupes, if and when it eventuates. These prescriptions specify that a third of the harvested area of every clearfelled coupe would be set aside as unavailable for fuelwood-harvesting, with the off-limits areas dispersed across the harvest area (to act as potential stepping-stones). The logic of choosing this particular proportion and spatial arrangement was based on experience that a similar proportion and spatial arrangement of retained forest is the typical outcome of aggregated retention silviculture. Aggregated retention is FT's replacement to clearfelling as the silvicultural system of choice in old-growth wet eucalypt forests. Research on this alternative system began at Warra, using the same coupes used for some of the deadwoodology research reported here. While research has already demonstrated that the retained aggregates continue to function pretty well, an additional prediction is that the regenerating harvested areas will continue to be ecologically influenced by the retained forest– including by the dead wood there. The effects should be scaleable, improving the chances of species' persistence across the landscape. FT researcher Sue Baker is planning on exploring this prediction in the coming three years.

Looking back, the fuelwood-harvesting issue that triggered this frenzy of deadwoodology was but one beneficiary of the research findings, and perhaps not the most important one. The new elephant in the room is carbon. The full implications for forestry of the growing awareness of carbon budgets have yet to play out. Deadwoodology at Warra is sure to play a part in developing our understanding.

Plate 2. A selection of saproxylic beetle species that are the focus of on-going studies at Warra. (top left) Mount Mangana stag beetle *Lissotes menalcas* and (top right) *Prostomis atkinsoni* (illustrations by Melanie Evans); (bottom left) *Neopelatops* TFIC sp 01 and (bottom right) *Dohrnia simplex* (photos by Lynne Forster).

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To view a list of the 24 Warra research projects conducted under the 'deadwoodology' theme, each hyperlinked to separate project web-pages, see http://www.warra.com/warra/research_projects/research_projects_Carbon_biomass_and_coarse_woody_debris.html. For a hyperlinked listing of the 27 publications arising from this work so far, see http://www.warra.com/warra/pub_html/publications_Carbon__biomass_and_coarse_woody_debris.html.

OBSERVATIONS ON THE DIET AND FEEDING HABITS OF THE SHORT -BEAKED ECHIDNA (*TACHYGLOSSUS ACULEATUS*) IN TASMANIA

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Data on feeding habits and invertebrate species eaten by Tasmanian echidnas have been collected over a number of years from direct observation of foraging individuals, both in field and captivity. The captive and extremely willing 'Puggles' (Trowunna Wildlife Park) provided the perfect opportunity to record detailed observations at very close range as she fed on invertebrates that were exposed to her by the rolling of stones and decaying wood on our many rambles into the bush during the filming of a wildlife documentary. This information has been supplemented by data collected from gut contents of road-killed specimens and from faecal sample analysis. Gut contents and faecal samples from road-killed animals were collected *in situ* and later processed in the laboratory along with faecal samples collected from latrine sites.

Echidnas in Tasmania occur Statewide and forage across all habitat types from the coast to alpine moors, gathering food as they wander in what appears to be a totally random fashion. They employ a number of strategies to maximise their capacity to capture and ingest food.

The beak is extremely sensitive to even the slightest touch and yet is a strong durable crow bar with a chiselled tip for prying apart decaying logs, as well as lifting and rolling logs and stones. A keen olfactory sense is put to good use as the foraging animal samples decaying logs, searches beneath stones and explores around and inside the bases of trees and dead stumps, often standing on hind legs as they reach up to sample the odours issuing from a log or tree. This method of foraging is an apparently effective strategy, as small mobile invertebrates are typically cornered in small cavities where escape is impossible and are drawn into the mouth, adhering to the tongue (Plate 1). In Tasmanian animals the organ can be up to 18 cm in length, which compares favourably with its mainland counterpart (Rismiller 1999). The tongue is strongly adhesive, extremely flexible and barbed with encircling ridges throughout its length, culminating in a hard pointed tip. This organ is superbly suited to process the food items targeted by the species, the generic name of which translates as 'fast tongue'.

Plate 1. Echidnas are not shy, and not much will escape this tongue! (© D. Parer & E. Parer-Cook).

Tasmanian echidnas eat a wide range of invertebrates, including some hard items. For example, native snails up to 12 mm diameter are taken, as are some potentially harmful items including arachnids, wasps, and stinging ants. Echidnas approach these food items by first crushing them using downward pressure from the beak before the body is repeatedly pierced with the tongue which removes gut contents and bodily fluids, reducing the prey to an ingestible size. Observations also indicate that echidnas are able to suck quite strongly, drawing in soft items that do not readily adhere to the tongue (e.g. slugs).

Despite having a keen olfactory sense, as previously recorded (Augee & Gooden 1993), Tasmanian echidnas are not put off by strong scent and appear to relish odoriferous animals. Dipteran larvae (maggots) exiting a decaying carcass are greedily taken, as are rove beetles, millipedes and mole crickets, the latter three of these invertebrate groups are all known to be distasteful to most other predatory species.

In addition to ingesting invertebrates, echidnas also consume large quantities of soil and exhibit a preference for gritty sand and fine gravel. On numerous occasions, 'Puggles' was observed greedily eating grit containing no food matter: such behaviour may aid in digestion, supply additional mineral salts or simply bulk up the scats, which are often composed of up to 70% soil. Echidna scats are not randomly deposited whilst foraging, instead, they are usually excreted in well used latrine sites (Sprent *et al.* 2006), which may be situated beneath boulders or large logs and within hollow logs (Grove *et al.* 2006). Latrine sites have been found to be used over extended periods by multiple individuals, seemingly as communal privies or meeting places (Plate 2).

Plate 2. Echidna latrine site at Maquarie Settlement (photo: C. Spencer/K. Richards).

The claws of the pes are curved sharply outwards and though used to some degree in excavating; their design appears to be primarily for scratching and grooming between the spines. The manus is equipped with very tough spade like claws that provide anchorage when bulldozing soil or debris aside and are also used to tear apart decaying wood, digging in search of food, or to escape predators as well as for climbing. In Tasmania, reports indicate that echidnas have been observed climbing over vertically over one metre high up cage wire in captivity (observation cited in Wapstra *et al.* 2000), which supports the mainland finding that in captivity they have scaled 2 metre high wire mesh barriers (Augee & Gooden 1993).

Utilising their highly evolved intelligence (Rismiller 1999) echidnas have developed diverse feeding strategies that enable them to cope with rugged terrain, potentially harmful prey and extreme environmental variables. Tasmanian echidnas have been found to consume a wide range of invertebrate fauna. Table 1 lists the species identified as prey by the authors to date.

Table 1. List of invertebrate species identified as prey of the Tasmanian echidna.

Species	Common name	Life stage of prey					Data source		
		Larvae	Adults	Eggs	Juv.	Pupae	Obs.	Guts	Faeces
Beetles									
Pyrgoides orphana	fireblight beetle		*				*		*
Diphucephala colaspidoides	green scarab beetle		*				*	*	*
Toxyutes arcuatus	longhorn beetle	*				*	*		
Lamprima aurata	golden stag beetle	*				*	*		*
Chrysoptharta nobilitata	leaf beetle		*				*	*	
Chrysoptharta agricola	leaf beetle		*				*		
Chrysoptharta bimaculata	leaf beetle		*				*		
Paropsis aegrota elliotti	leaf beetle		*				*		*
Phyllotocus rufipennis	nectar scarab beetle		*				*	*	*
Anoplognathus saturalis	christmas beetle		*				*		
Pharochilus politus	passalid beetle	*					*		
Aphodius tasmaniae	pasture chafer beetle	*	*			*	*		*
Aphodius howitti	pasture chafer beetle	*	*				*		*
Adoryphorus couloni	chafer beetle	*					*		
Heteronyx obesus	chafer beetle	*					*		
Diphucephala colaspidoides	green scarab beetle		*				*	*	
Staphylinidae	rove beetle		*				*		
Coripera deplanata	ground beetle	*	*				*	*	*
Carabidae spp.	carab beetle	*					*		
Syndesus cornutus	stag beetle	*	*			*	*	*	
Lepispilus sulcicollis	ground beetle	*	*				*		*
Lissotes launcestoni	stag beetle	*				*	*		
L. obtusatus	stag beetle	*	*			*	*	*	
Ants									
Myrmecia forficata	bull ant	*	*	*		*	*	*	*
M. esuriens	bull ant	*	*	*		*	*		*
M. fulvipes	jack jumper	*	*	*		*	*		*
M. pilosula	jack jumper	*	*	*		*	*	*	*
M. urens	jack jumper	*	*	*		*	*	*	
Iridomyrmex spp	ant	*	*	*		*	*	*	*

Species	Common name	Life stage of prey					Data source		
		Larvae	Adults	Eggs	Juv.	Pupae	Obs.	Guts	Faeces
Amblypone austrolis	ant	*	*	*		*	*		*
Camponotus spp.	ant	*	*	*		*	*	*	*
Myrmecorhynchus spp.	ant	*	*	*		*	*	*	*
Cerapachys lorvotus	ant	*	*	*		*	*		
Discothyrea bidens	ant		*					*	*
Hypoponero spp.	ant		*					*	
Plotythyrea turneri	ant	*	*	*		*	*		*
Termites									
Prototermes adamsonii	termite	*	*	*	*	*	*	*	*
Kolotermes convexus	termite	*	*	*	*	*	*	*	*
Stolotermes brunneicornis	termite	*	*	*	*	*	*		*
Moths									
Aenetus ligniverens	green swift moth	*	*				*	*	
Xylutes literata	wattle goat moth	*				*	*		*
Oxycanus diremptus	swift moth	*	*			*	*		*
Oncopera intricata	corbie grub	*	*			*	*	*	*
Spodoptera mauritia	army worm	*	*			*	*	*	
Flies									
Musca vetustissima	bush fly	*					*		
M. domestica	house fly	*					*		
Dasybasis spp.	march fly	*					*		
Crickets									
Gryllotalpa oustralis	mole cricket		*		*		*	*	
Kinemania ambulons	raspy cricket		*		*		*	*	
Slaters and earwigs									
Porcello scaber	slater		*		*		*	*	*
Forficulota auricularia	European earwig		*		*		*		*
Wasps									
Vespula germanica	European wasp		*						*
Slugs									
Arion intermedius	hedgehog slug		*				*		

Species	Common name	Life stage of prey					Data source		
		Larvae	Adults	Eggs	Juv.	Pupae	Obs.	Guts	Faeces
Cystopelta petterdi	slug		*				*		
Deroceras caruanae	slug		*				*		
Deroceras reticulatum	slug		*				*		
Snails									
Tasmaphena spp.	snails		*				*		*
Flatworms									
Temnocephala spp.	flatworm		*				*		
Scorpions									
Cercophonius squama	scorpion		*		*		*	*	*
Spiders and harvestmen									
Delena cancerides	huntsman spider		*	*	*		*	*	
Littodamus olga	red & blue spider		*				*		
Lycosa tasmanica	wolf spider		*	*	*		*		
Badumna insignis	black house spider		*		*		*		
Pholcus phalangioides	harvestman		*				*		
Millipedes									
Spirostrepsida spp.	millipede		*				*	*	*
Polydesmida spp.	millipede		*				*		*

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EUCALYPTUS RADIATA GOES FORTH: A "NEW" NAME FOR THE FORTH RIVER PEPPERMINT

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ABSTRACT

A peppermint species restricted to the Forth River valley and nearby catchments in the central north of Tasmania has a confused taxonomic and nomenclatural history. This paper clarifies the position of the 'forth river peppermint', until recently recognised as *Eucalyptus radiata* subsp. *robertsonii*, but now regarded as a disjunct population of the southern Victorian form of *Eucalyptus radiata* subsp. *radiata*.

INTRODUCTION

Tasmania has 30 indigenous species of *Eucalyptus* (Buchanan 2009), four of which are represented by infrataxa bringing the total number of taxa in the State to thirty-four. New taxa continue to be described, the most recent being *Eucalyptus nebulosa* A.M.Gray (Gray 2009), an endemic species of the peppermint group restricted to the serpentinite soils of the west coast region.

Eucalyptus radiata is one of eight "peppermint" eucalypts occurring in Tasmania, all but one of which are endemic (Buchanan 2009). The identity of the odd one out, the tall peppermint-barked forest tree from the middle and upper reaches of the Forth River catchment in northern Tasmania, has been open to debate for a number of years. These plants were first recorded by William (Bill) Jackson of the University of Tasmania in 1953. For many years the entity was recognised as *Eucalyptus radiata* subsp. *robertsonii* (Blakely) L.A.S.Johnson & Blaxell. The vernacular name 'forth river peppermint' has been applied to the species (e.g. Duncan 2000), in recognition of the distinct distribution of the taxon, a name that is now accepted as the preferred common name (Wapstra *et al.* 2005). On mainland Australia *E. radiata* is usually called 'narrow-leaved peppermint', as it has narrower leaves than *E. dives* (not present in Tasmania) but this name is not appropriate here as its leaves are broader than our more common endemic peppermints, *E. amygdalina* and *E. pulchella.*

TAXONOMIC AND NOMENCLATURAL HISTORY OF *EUCALYPTUS RADIATA*

Eucalyptus radiata Sieber ex DC was described in 1828 by Swiss botanist Augustin Pyramus de Candolle (1778–1841), in his *Prodromus Systematis Naturalis Regni Vegetabilis*, from specimens collected by Franz Sieber in New South Wales, presumably from the Blue Mountains, in 1823. Prior to this, narrow-leaved peppermints from New South Wales and Victoria were identified (along with various other mainland species such as *E. dives* Schauer, *E. elata* Dehnh. and *E. regnans* F.Muell.), as *E. amygdalina* Labill.

Bentham (1867) described a mainland peppermint as *E. amygdalina* var. *radiata*. However, this taxon and *E. radiata sensu* Woolls (1880) confusingly describe a smooth-barked 'river white gum' and refer to what is now recognised as *E. elata*. *E. amygdalina* var. *radiata sensu* Mueller (1879) does describe the 'narrow-leaved peppermint', rather than the 'river white gum' but Maiden (1904) did not consider this variety to warrant recognition and again referred to the 'narrow-leaved peppermint' of mainland Australia as *E. amygdalina*, considering these plants to be conspecific with the 'black peppermint' of Tasmania.

Baker & Smith (1912) described the 'narrow-leaved peppermint' of New South Wales and Victoria as *E. amygdalina* var. *australiana* and later elevated this taxon to species level as *E. australiana* (Baker & Smith 1915), while applying *E. radiata* to the 'river white gum'. Maiden (1917) recognised the 'narrow-leaved peppermint' as *E. radiata*, having previously accepted *E. numerosa* for the 'river white gum' over *E. radiata* or *E. amygdalina* var. *radiata* (Maiden 1904). However, this was not followed by Baker & Smith (1920), and for a number of years the 'narrow-leaved peppermint' was known as both *E. radiata* and *E. australiana*, and the 'river white gum' as *E. radiata* and *E. numerosa*.

Baker & Smith (1920) subsequently recognised a further species of 'narrow-leaved peppermint', *E. phellandra*, distinguished from *E. australiana* solely on volatile oil composition. More important to this discussion, Blakely (1927) described the 'narrow-leaved peppermint' from the Southern Tablelands of New South Wales with glaucous foliage and buds as *E. robertsonii*. This new species included both *E. australiana* (in part) and *E. phellandra* (in part), *E. robertsonii* having populations with both the cineole-rich oils typical of *E. australiana* and the phellandrene-rich oils typical of *E. phellandra* (Rankin 1998).

Blakely (1934) subsequently reduced *E. australiana* (in part) to a variety of *E. radiata*, var. *australiana*, also describing var. *subplatyphylla* from the New England Tablelands of New South Wales, with *E. radiata* subsequently becoming accepted over *E. australiana* for this species. Pryor & Johnson (1971) absorbed these varieties and *E. phellandra* (in part) into *E. radiata*. Johnson & Blaxell

(1973) reduced *E. robertsonii* to a subspecies within *E. radiata*, while Johnson & Hill (1990) later returned it to species level with two subspecies, subsp. *robertsonii* representing the majority of the distribution of the taxon, and subsp. *hemisphaerica* being applied to a small population near Orange in New South Wales.

Johnson & Hill (1990) also described *E. radiata* subsp. *sejuncta* from the New England Tablelands of New South Wales, encompassing *E. radiata* var. *subplatyphylla* of Blakely, as well as describing *E. croajingolensis* for the glaucous narrow-leaved peppermint of Gippsland in eastern Victoria, previously inconsistently regarded as either *E. radiata* or *E. robertsonii*. With the publication of Johnson & Hill (1990), apart from some quibbling about the specific or subspecific status of the 'monaro peppermint' (as *E. robertsonii* or *E. radiata* subsp. *robertsonii* is commonly known in Victoria), the systematic delineation and nomenclature of the taxa within the *E. radiata* complex was mostly resolved.

Eucalyptus radiata Sieber ex DC is now recognised as a group of either four closely related taxa (two species, one with three subspecies, following Brooker & Kleinig 1999) or five closely related taxa (three species, two with two subspecies, following Johnson & Hill 1990).

Eucalyptus radiata Sieber ex DC subsp. *radiata* occurs on the ranges and coastal plains of southern and central Victoria and disjunctly in the Central and Southern Ranges and South Coast of New South Wales. *E. radiata* subsp. *sejuncta* L.A.S.Johnson & K.D.Hill occurs on the Northern Tablelands of New South Wales, just crossing into Queensland. *Eucalyptus croajingolensis* L.A.S.Johnson & K.D.Hill occurs on the ranges and coastal plains of Gippsland in eastern Victoria and adjacent parts of southeastern New South Wales. The remaining taxon, referred to as *E. radiata* subsp. *robertsonii* (Blakely) L.A.S.Johnson & Blaxell or *E. robertsonii* Blakely occurs in northeastern Victoria and on the western fall of the Southern Tablelands of New South Wales, except for the disjunct Orange population (subsp. *hemisphaerica*), mentioned above. However, this population appears to be founded on hybrid material (Rankin 1998) and may not warrant formal recognition.

The 'monaro peppermint' is most commonly recognised as a subspecies of *E. radiata* (e.g. Brooker & Kleinig 1999; Brooker & Slee 1996; Ross & Walsh 2003), and in light of the extensive introgression between this taxon and *E. radiata* subsp. *radiata* throughout northeastern Victoria (Rankin 1998), this taxonomic level seems most appropriate and is followed here.

While these taxa occur primarily along the Great Dividing Range and adjacent plains towards the coast of mainland southeastern Australia, the disjunction of plants currently recognised as *E. radiata* in northern Tasmania is a puzzle and is the topic of this paper.

TAXONOMIC POSITION OF THE FORTH RIVER PEPPERMINT

The presence of a tall mostly rough-barked peppermint from the forests of the middle and upper Forth River valley and nearby catchments in northern Tasmania, with affinities to other well known indigenous peppermints, has been long recognised. The entity now known as the 'forth river peppermint' was first noted by W.D. Jackson in 1953 and identified as *E. robertsonii*. Allowing for the systematic whims of taxonomists over the years, these plants have been mostly regarded as *E. robertsonii* (Jackson 1965) or *E. radiata* subsp. *robertsonii* (Curtis & Morris 1975; *sensu Census of Vascular Plants* versions prior to 2008). It has also been suggested that they may represent an undescribed species with affinities to *E. amygdalina* (e.g. Johnson & Blaxell 1973; Curtis & Morris 1975; Kirkpatrick & Backhouse 1997) and were regarded as *E.* aff. *radiata* by Williams & Potts (1996) pending further investigation. These plants were regarded by Rankin (1998) and Brooker & Kleinig (1999) as *E. radiata* subsp. *radiata*. Elsewhere *E. radiata* has been applied with no subspecific distinction (Duncan & Hopkins 2000; Hopkins 2000; Reid & Potts 1999). The 'forth river peppermint' is currently recognised by the Tasmanian Herbarium in the *Census of Vascular Plants* as *E. radiata* subsp. *radiata* (Buchanan 2009). Good examples of these plants can be observed in the immediate vicinity of the Lemonthyme power station.

In a similar manner to the patterns of subspecific variation found within *E. globulus*, the southern and central Victorian *E. radiata* subsp. *radiata* gradually intergrades with *E. radiata* subsp. *robertsonii* over a wide area in northeastern Victoria. In fact, wherever two members of the complex meet, similar widescale introgression is observed (Rankin 1998), blurring boundaries between the taxa. Such introgression, coupled with incomplete knowledge of the taxonomic status of individuals within this complex,-led to the taxonomic confusion about the disjunct Tasmanian occurrence.

The name *E. robertsonii* was initially applied to these plants by Jackson in 1953, presumably in recognition of the tall nature of these trees, the description of *E. robertsonii* available at the time describing a tall tree to 55 m (Blakely 1927) – much taller than the available description of *E. radiata* (Blakely 1934).

However, with the recognition of the glaucous peppermints from Gippsland as *E. croajingolensis* (Johnson & Hill 1990) and the introgression between the taxa, *E. radiata* subsp. *robertsonii* is recognised as a tree to 50 m tall with peppermint bark to the smaller branches. The leaves are glaucous with a thin "papery" feel. The glaucous buds are the most distinguishing feature of the taxon, having a conical operculum that is longer than the hypanthium. The fruit are typically cup-shaped with a depressed disc and a long, delicate pedicel.

The Tasmanian plants, while growing to 45 m (Duncan & Hopkins 2000), do not possess any of the morphological features characteristic of *E. radiata* subsp. *robertsonii*. The leaves and buds are green rather than glaucous, the disc of the fruit is level rather than depressed, and the buds have a short, rounded operculum, rather than a long conical operculum. It is therefore hardly surprising that these plants have often been considered an undescribed entity as it would be difficult to "shoe horn" them into *E. radiata* subsp. *robertsonii* as currently described.

These Tasmanian plants are, however, most similar to the morphologically variable *E. radiata* subsp. *radiata*. With the exception of tree height, they are morphologically indistinguishable from populations of this taxon from southern Victoria. *E. radiata* subsp. *radiata* ranges in height from small trees and mallee-form shrubs to 3m tall on northern Wilsons Promontory and on the coast at nearby Cape Liptrap, to tall trees in excess of 35 m on the Great Dividing Range.

Rankin (1998) reported five groupings within *E. radiata* based on a combination of adult and seedling morphological characters as well as the two chemical characters of leaf flavonoids and volatile oils. While these generally follow the currently recognised subspecific patterns based on morphology, the chemical characters further divide *E. radiata* subsp. *radiata* into three groups: populations from central eastern New South Wales, including plants from near the type locality; populations from far southeast New South Wales; and populations from central and southern Victoria within a radius of approximately 150 km of Melbourne. It is these latter plants from which the 'forth river peppermint' cannot be distinguished.

The Forth River plants have leaf volatile oils rich in phellandrene, common in the Victorian populations of *E. radiata* subsp. *radiata* rather than the cineole-rich oils found in the populations from New South Wales.-They also have a leaf flavonoid composition identical to that found in the Victorian populations, quite distinct from that found in the populations from New South Wales.

Interestingly, the less fire-prone situations along watercourses in relatively high rainfall areas occupied by the tall *E. radiata* subsp. *radiata* in Tasmania is occupied in eastern Victoria and southeastern New South Wales not by *E. radiata* subsp. *radiata*, but by the related 'river peppermint' or 'river white gum', *E. elata*, a tall (to 30 m) mostly smooth-barked tree.

Of the 30 indigenous species of eucalypt found in Tasmania, 17 are endemic (with several species with endemic infrataxa). The non-endemic species (and one subspecies) also occur in Victoria (and usually extend into New South Wales). The wider distribution of these species on the mainland suggests an origin there and that they have migrated into Tasmania across Bass Strait during one of the long periods of lowered sea levels during glacials.

The more restricted northerly distribution of *E. radiata* subsp. *radiata* in Tasmania suggests that it has "gone forth" across Bass Strait from Victoria into Tasmania comparatively recently, perhaps during the most recent glacial period, to become established in the Forth River enclave. It is yet to be seen if the 'forth river peppermint' will expand its range to become more widespread in Tasmania, or contract in range as it becomes genetically swamped by *E. amygdalina*.

CONSERVATION AND MANAGEMENT IMPLICATIONS

The recent change in taxonomic recognition of the 'forth river peppermint' has no implications for the conservation status of these plants, with *E. radiata* (as the parent entity) still regarded as threatened in Tasmania (irrespective of the taxonomic position of infrataxa).

Eucalyptus radiata is known to hybridise with *E. amygdalina* and *E. nitida** (Duncan 2000), and individuals will be found exhibiting characteristics intermediate between these taxa that will be difficult to assign to either species. The difficulty in being able to definitively assign specimens to a described taxon has implications for the conservation management of the entity in Tasmania. *E. radiata* is listed as a threatened species but its co-occurring relatives *E. amygdalina* and *E. nitida* are widespread and common. In the case of *E. radiata*, a Public Authority Management Agreement between the State government and Forestry Tasmania under the provisions of the Tasmanian *Threatened Species Protection Act 1995*, is in place for the management of the species on State forest, the tenure on which the species almost exclusively occurs. Non-forestry activities that disturb the species require permits under the Act.

This paper has deliberately focussed on clarifying the taxonomic and nomenclatural issues associated with *E. radiata* in Tasmania. A follow-up paper will examine the broader ecology, reservation and conservation status, threats and mitigation strategies surrounding the management of this taxon.

* *Eucalyptus nitida* Hook.f., *Fl. Tasman.* 1(2): 137 (1856), widely known as the 'smithton peppermint', has recently been provided with its historically correct name of *Eucalyptus ambigua* DC., *Prodr.* 3: 219 (1828) by Bean (2009).

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DETAILS OF FIVE SNARES PENGUINS *EUDYPTES PACHYRHYNCHUS ROBUSTUS* FROM TASMANIA, 1978–2009

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ABSTRACT

Further details are provided for five Snares Penguins *Eudyptes pachyrhynchus robustus* from Tasmanian coasts. Two were mentioned in press reports; four of five briefly listed in birdwatching journals. Their years of occurrence range from 1978 to 2009, and their seasonal range from July to September and early February, with four in winter and one in summer. Identification was primarily based on head features and plumage, all individuals being readily recognisable. No observer or carer is known to have taken basic measurements, although all five penguins were well photographed. A portrait of each is included for validation, future identification and reference purposes. An estimate of age has been tentatively assigned to each individual; considered to be three 2nd year and two 3rd year penguins. A revised list of Tasmanian Snares Penguin records is provided.

INTRODUCTION

This paper is to confirm the identity of five penguins, place them on more public record, and also to present evidence enabling field observers to become more confident and to improve identity decisions based on external (phenotypic) characters.

This paper is a continuation of the author's long term review of the identity and occurrence of rare penguins located on the southern continental Australian coast, especiallythat of juvenile and 2nd year *Eudyptes* penguins. For review purposes, 'rare penguins' are considered to be all penguin species other than the resident breeding Little Penguin *Eudyptula minor novaehollandiae*. For further details see Simpson (2008a, 2008b). The Snares Penguin is here treated as a subspecies of the Fiordland Penguin *E. p. pachyrhynchus*, following Christidis & Boles (2008).

Institutional Abbreviations

BARC	Birds Australia Rarities Committee, Melbourne.
BOAT	Bird Observers' Association of Tasmania (now Birds Tasmania)
DPIPWE	Department of Primary Industries, Parks, Water & Environment

QVMAG Queen Victoria Museum and Art Gallery, Launceston

TMAG Tasmanian Museum and Art Gallery, Hobart and Rosny Park

TNPWS Tasmanian National Parks and Wildlife Service, Hobart (now part of DPIPWE)

Biological Abbreviations

BWDL Black/white demarcation line between throat and breast plumage

OUFP Observable Underflipper Pattern

SS/C Superciliary Stripe/Crest

RUFP Residual Underflipper Pattern

The alternative 'RUFP' appears when the penguin is dead and dehydrated, or is a study skin, representing only the degree and extent of black melanin pigment in the feathering of the distal underflipper, i.e. the normal underwing pattern of a seabird and the individual pattern of any particular penguin (Simpson 2007). It is not applicable to these five penguins but is included for completenes

ORIGINAL OBSERVATIONS and COMMENTARY ON EACH

The five Snares Penguins are described in sequence of initial reporting, with at least one photo of each. Four were submitted to BARC (September-October 2009) for ratification. Two records are fully verified sight reports. The other three penguins were taken into care; two were released when deemed fit. An injured penguin was put down after surviving for nine weeks in care.

All five penguins correspond with descriptions by Oliver (1953) and Warham (1974); also with Figures 1-3 and Plate 10 in O'Brien (1990); with Plate 20 in Robertson & Heather (1999); and with plates in all four current Australian field guides: Morcombe (2003), Pizzey & Knight (2007), Simpson & Day (2004) and Slater, Slater & Slater (2003).

1978 Snares Penguin

WINTER: 26 August 1978. 'Beach at Port Arthur', Tasman Peninsula, SE Tasmania (43° 7'S, 147° 50'E). Found alive on rocks, and reported to wildlife authorities by two 8 year-old boys, Roger McGinniss and John McPherson, as being 'in poor condition'. The penguin was then taken for observation and care.

An account of the penguin and a photo taken at Sandy Bay, Hobart, was published in the Hobart *Mercury* (Phillips 1978), in which David Rounsevell (TNPWS) discussed the bird, confirming its identity as a Snares Penguin. Rounsevell took the penguin to his home for care and release when ready.

It was subsequently listed or mentioned without significant detail by Thomas (1980), Wall (1980), Sharland (1981), O'Brien (1990) and Woehler (1992).

KNGS commentary: [Plate 1]. A copy of the press article and photo was supplied to the author by Lesley Kurck on 29 May 2007. From that single head-on photo, just enough of the features of a Snares Penguin are visible to be certain of its identity. They are: black cheeks, position of the narrow anterior tip of the SS/C, large bill (length not visible), and a trace of white tissue in the gape and along the proximal portion of the left mandible. Quoted from the descriptive text for Snares Penguin: 'Viewed from the front, the superciliary stripes form a V diverging from the base of the bill' (O'Brien 1990). This feature is exemplified in the press photo. However, when similarly viewed, Fiordland Penguins have a similar V, so caution is advised on this point.

The OUFP on the right side of the bird indicates a black distal area, *typical of many* Snares Penguins (Simpson 2007). However, some Snares Penguins have a *smaller* black area, concentrated mainly toward the mid-line from the flipper tip, and *more nearly the typical pattern* of the 'average' Fiordland Penguin. For such an example, see the left OUFP of the 2009 Snares Penguin from Tasman Island and Anchor Rock (Plate 8). There can be considerable overlap between the two subspecies, so that OUFP and RUFP cannot be regarded as diagnostic of either subspecies, but rather as one more useful clue to identity.

A set of five photos of this penguin was also taken by Hans and Annie Wapstra, copies being received by the author on 4 July 2008. Hans was employed by TNPWS, and took over custody of this penguin from Rounsevell for a short period. The photos were taken at Blackmans Bay, Hobart, just before its release there in early September, although the precise date was not recorded.

Plate 1. Snares Penguin ('Oscar') found 26 August 1978. Note plain black cheeks, anterior point of origin of the narrow SS/C and its wide lateral separation on the head. A hint of white skin shows in the gape. Considered a 2nd year penguin (see Plate 2 for further details). Photo: Press photographer; copyright Hobart *Mercury*.

[Plate 2]. A right side-face view, and the right OUFP. The penguin has a glossy black chin, throat and face, with no hint of the dullness, greyness or pale cheek striations that might indicate a juvenile. The reddish-brown bill is relatively long and more 'ovoid' or 'elliptical' when compared to Fiordland Penguins judged to be of similar age (this review). Pale pinkish skin of the gape and along the lower mandible edge does not extend distally as far as might be expected; in all the Wapstra photos apparently not quite reaching the most anterior chin feathering. Iris colour was dark and difficult to distinguish from the photos. On the right side the OUFP again shows the large black distal patch of Plate 1. Plumage overall appears to be in good condition and the penguin healthy. As a wintering individual, there is no sign of moult.

The SS/C is pale yellow and on the basis of its total length it is considered to be a factor indicating a 2nd year penguin (this review), being short but well established. See general discussion on age below. From the sum of features available in Plates 1 and 2, the penguin is certainly *robustus*.

Plate 2. The same Snares Penguin at the release site, Blackmans Bay, Hobart, in early September 1978. Note long bill, bill colour, pale gape and mandibular skin, total length of SS/C and the right side OUFP. Photo: Copyright Hans & Annie Wapstra.

1997 Snares Penguin

WINTER: 30 or 31 July 1997. Beach near Little Henty River, [south of] Trial Harbour, central west coast, Tas. (41° 57'S, 145° 12'E). Penguin found and reported by a member of the public, as 'alive but injured'. Ranger Eddie Furphy (TNPWS) went out and collected the penguin.

Listed by Eades (1997): 'Also in August an injured Snares Penguin' was found at Trial Harbour, …'. This is *contra* the July date of Wakefield & Wakefield (1997): *viz*. 'The 7th record for the state was of a bird with a broken leg at Trial Harbour in July …'. No other details were provided by these authors. This was the total sum of public knowledge concerning this penguin until 2007.

KNGS commentary: The following additional information was gathered between September 2007 and August 2009. The penguin had been placed in care of Tomoko Chida, on 1 August 1997. At the time, her husband was a Senior Ranger with TNPWS, based at Queenstown, central west Tasmania. Evidence of the penguin is a set of full-colour photos by T. Chida taken whilst the penguin was alive. The penguin had a badly broken leg. With veterinary and home care, it survived for just over nine weeks. However, no serious improvement in condition could be achieved and it was euthanased on 6 October 1997.

Tomoko Chida had informed me during 2007 that the body had been sent to QVMAG. On the author's earlier request, the museum's register, the freezer and also the skin, spirit and osteology collections had *already* been examined when searching their collection for rare penguins in 2006 but this individual was not found. I met Chida for the first time at the International Penguin Conference in Hobart held on 3-7 September 2007, when she showed me the photos. On request she gave me copies of the five best, received 6 September 2007. After the conference a return visit was made to QVMAG when another search was made but without result. Neither was it obviously at the TMAG, where similar searches had also been made in 2006 and 2007.

More recent discussion with Chida (2 August 2009), revealed that it had been kept in the TNPWS freezer in Queenstown, Tasmania, and was in good order. When opportunity offered during late 1997, she and her husband had driven the penguin's body to Launceston and handed it in to QVMAG. Since 1997 it has apparently not been sighted.

Discussions were then held with QVMAG staff Tammy Gordon (Technician) and Judy Rainbird (Collections Manager), on 14 and 18 August 2009, respectively. Further searches are to be initiated. A new curator (not a vertebrate specialist) had been appointed to the museum for a short time in that same 1996-1998 period approx. and it is not known how the penguin was treated after receipt.

[Plates 3 and 4]. Apart from its leg injury, the penguin was in excellent winter plumage. All features as described for the 1978 Port Arthur penguin (above) are similar in this penguin. Bill *length* is emphasised in Plate 3; Plate 4 gives a better idea of its real depth. To appreciate bill length, depth, and elliptical shape of sub-adult Snares Penguins, in comparison with the stubbier bill of a 2nd year Fiordland

Penguin, see also the side-face studies in Plates 2, 3 and 5 of Simpson (2008a), and compare them with the bills of the five penguins in this paper.

Plate 3. Left facial study which emphasises the length of the bill but not its true depth. Detail of anterior SS/C and dull red eye are well displayed. Considered a 3rd year penguin. Photo: Tomoko Chida.

Plate 4. Standing, showing right side. Note the better view of the bill, showing its depth, and also eye colour, the considerable development of the SS/C, and the distal blackness of the OUFP. Photo: Tomoko Chida.

It was initially estimated, from comparison of its relative SS/C plume length with other Snares Penguin photos and with photos of museum skins, to be in its 2nd year; *just possibly* in its 3rd year. The SS/C droops further down the side of the neck than those depicted in Plates 2 and 5; but is very similar in length to the two penguins in Plates 6, 7 and 8. No measurements seem to exist. Based on Plates 3 and 4, the penguin is certainly *robustus*. Based on the lengtn of the SS/C in particular, I now believe it to be a 3rd year penguin.

1997 Snares Penguin

WINTER: 31 August to 1 September 1997. Seen at two adjacent localities in the Eaglehawk Neck area, eastern side of Tasman Peninsula, SE Tas. (43° 03'S, 147° 57'E). The penguin was located from a boat chartered for pelagic birdwatching on 31 August 1997, just north of Waterfall Gully, and 3-4 km south of the Pirates Bay jetty. Observers were Chris Lester, John Barkla, W. (Bill) Wakefield, and eleven other birders. Sight record; excellent photos taken.; reported as '... a healthy bird in Waterfall Bay, … present at the Blow Hole the following day'.

On 1 September 1997, it was relocated by Mike Carter, John Males and Tony Palliser, having moved about 1.5 km further north to the Blowhole nearer to Pirates Bay (43° 02'S, 147° 57'E). Observed initially from the boat, then on land from a rock shelf. Sight record, with further good photos (Plate 5). There was rapid agreement among all observers in the field as to the penguin's identity. On 2 September 1997, Peter Lansley and Phil Macumber failed to find it.

Listed by Eades (1997), as being 'in immaculate adult plumage'. He considered it to be '*circa* the 7th Tasmanian Snares Penguin record'; report includes a photo by T. Palliser; listed also by Wakefield & Wakefield (1997).

KNGS commentary: The record was submitted to BARC by J. Barkla, C. Lester, and W. Wakefield on 23 June 2001, accompanied by three field sketches (head, leg and foot, and underflipper pattern); BARC Case no. 317. I redefined it in an unpublished report to BARC in July 2001 as 'sub-adult', based on SS/C length and other details. Record accepted as a Snares Penguin; notification given by Palliser (2002). A much reduced field note sketch by Barkla of this penguin's OUFP was reproduced in a poster presentation (Simpson 2007). In October 2007, the age of the penguin was provisionally revised to being in its 2nd year.

Two transparencies received from Mike Carter, dated 1 September 1997, very clearly show that the bill is bright red, the SS/C richly yellow and consistent in length to a 2nd year Snares Penguin. The tail is fully developed.

The observation by Eades (1997) that it was 'in immaculate adult plumage' is at apparent odds with the evidence. The photo by Tony Palliser in Eades (1997), shows less of the penguin's breast, and is a slight variant of the photos (Plate 5a and 5b), which show disturbed ventral feathering of the upper breast, with stains below that. These stains seem to emanate from a possible double puncture, better seen in Plate 5b. Any sign of disturbed contour feathering in wintering penguins usually indicates an external or internal injury, and may account for its presence on shore.

Plate 5a (left). Snares Penguin stretching, showing right OUFP. In both photos note a possible injury, with staining to the upper breast, 1 September 1997.

Plate 5b (right). The same Snares Penguin in a typical hunched attitude, displaying evenly-coloured red bill, pale gape, the total length of its bright yellow SS/C and long tail. Considered a 2nd year penguin. Photos: Copyright Mike Carter.

2008 Snares Penguin

WINTER: 12 July 2008. Eaglehawk Neck Beach, Tasman Peninsula, Tas. (43° 01'S, 147° 55.5' E). Found by W. (Bill) Wakefield, Els Haywood, Ruth Brozek and her son Milosh, also Hans and Ruth Steinhauser. Two photos were taken on the beach by Wakefield. Collected from the beach by David Irvine (DPIPWE), and taken to the veterinary practice of Dr. Barry Wells, Kingston Beach, Hobart, for assessment and treatment. The penguin had a deep cut to its back, and was reported as emaciated.

It was placed in care of David Pemberton (DPIPWE) and 'given a few weeks rehabilitation' in his backyard. Prior to release, two photos by a press photographer were published in the Hobart *Mercury* on 16 August 2008, with a short article (Glaetzer 2008). The penguin had originally been scheduled for release on 14 August 2008, but bad weather held it over until some time in the following week. Therefore, place of release and precise date is not known.

KNGS commentary: A copy of Wakefield's photo of this penguin (not published here) shows it on the beach in ankle-deep water. It is standing upright (slightly more so than the posture of the penguin shown in Plate 5b). The bill is red. No pale skin of gape or mandible is visible. There is no sign of the back injury in this photo. The SS/C is yellow and because of posture and possibly a controlled retraction of the plumes, it seems comparable with the SS/Cs shown in Plates 2, 5a and 8, *perhaps* a few millimetres longer and there fore a likely 2nd year penguin. The tail is long, as it should be by mid-year.

The selected photo (Plate 6) shows the important Snares Penguin features, including a well developed and drooping SS/C, leading to the author's previous expectation from Wakefield's photo of another 2nd year penguin, but *just possibly* a 3rd year penguin. The OUFP is extensive and extremely black; the pinkish central underflipper is the result of recent exercise. Although a sub-adult this penguin very clearly exhibits the 'adult' appearance of the typical Snares Penguin.

Plate 6. Snares Penguin with full 'adult' features on display despite being sub-adult. This penguin therefore obeys the observation by Warham (1974), that the 2nd years '… at about 15 months [of age] become indistinguishable from adults'. It holds true in this case, since it is considered to be a 3rd year penguin. The pinkish central underflipper area is flushed with blood from recent exercise; it would disappear with return to inactivity. Press photo by Sam Rosewarne: copyright Hobart *Mercury*.

However, a head photo, not illustrated here, taken at the Snares Islands, is clearly labelled in the caption as a 3rd year penguin (Warham 1974; his Fig. 3b) in which the SS/C length is almost identical with this paper's Plates 4 and 6. This virtually confirms the penguin from Eaglehawk Neck Beach being in its 3rd year, as also the Trial Harbour penguin (Plates 3 and 4).

2009 Snares Penguin

SUMMER: 6 to 14 February, 2009. Landing and haulage site, NE Tasman Island, and also immediately offshore on Anchor Rock, Tasman Peninsula, SE Tas. (43° 14.5'S, 148° 05'E). First sighted from an eco-tour boat, the penguin was photographed by Angela Anderson, with skipper Craig Parsey, other crew members and the passengers present. She also reported a 'technical' argument on the boat as to whether it was a Snares or Fiordland Penguin. For several days after the 6th February, further photos were taken by other observers from the same boat.

Listed by Dooley (2009), who noted: 'a Fiordland Penguin of the Snares race *robustus* was sighted on the Tasman Peninsula throughout early March' (*contra* February dates reported).

KNGS commentary: Initial information was received from Bill Wakefield, 27 March 2009, with two photos. Contact was made with Angela Anderson on the same day. She crewed regularly on the boat from which all sightings were made; had taken the two photos sent on by Wakefield and those later supplied.

Observations and deductions made from the set of photographs identify the bird as a typically-plumaged Snares Penguin with clearly defined bill and facial features. Little sign of potential moult was initially visible, but close examination indicates an apparent 'paling', a 'greyness', on the left dorsal flipper surface (Plate 7), plus a small patch of uneven contour feathering on the abdomen. The second photo (Plate 8) shows uneven contour feathering of the back and on the dorsal right flipper. Penguin flippers in fresh or little-worn condition are reflective in certain lights (c.f. Plate 4), but, as they become dull prior to annual moult, begin to lose that same intensity of reflection. I believe the penguin is just entering that condition, the earliest stage of moult, and the 'greyness' is not entirely a trick of the light.

In the photos, the SS/C is well developed and plumes certainly long enough to represent another 2nd year penguin (c.f. Plates 4 and 6). Prior to moult, SS/C feathers loosen (as do all the feathers) and are progressively pushed out, briefly increasing their apparent length and distorting any age determination. The tail is still longer than it would be immediately after a moult as moulted penguin tail feathers (rectrices) grow back slowly. The fact that the penguin was ashore in early February but not well into moult also indicates that the penguin is beyond its juvenile year. It is therefore a 2nd year, which after two or three weeks would become a 3rd year on completion of the moult. The dates that this penguin was ashore therefore fits neatly into the following summary of moult.

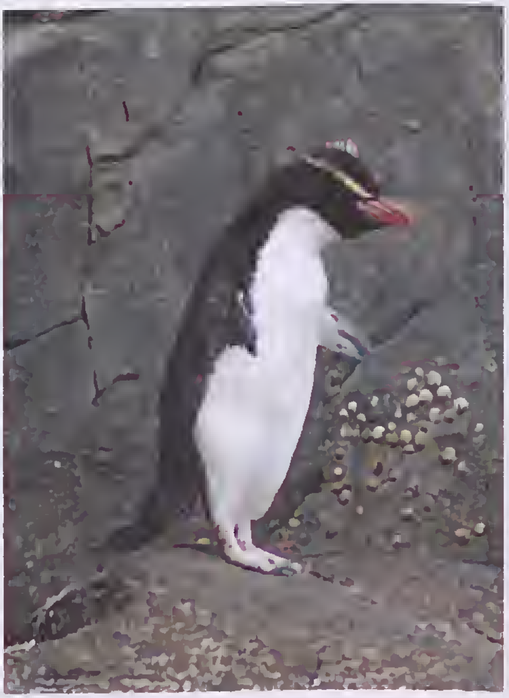

Plate 7 (LHS). Snares Penguin on rocks, with indications of pending moult in dorsal feathering of left flipper and loosening of white abdominal feathers. SS/C length is similar to two other penguins (Plates 1, 2, and 5), and is now considered a 2nd year penguin on the verge of moulting to 3rd year. Photo: Angela Anderson.

Plate 8 (RHS). The same Snares Penguin on rocks with its flippers extended. The OUFP has a lesser black area, which is concentrated in the distal flipper midline. By comparison, the other four penguins being discussed show a larger area of black. Considered a 2nd year penguin. Photo: Angela Anderson.

According to Warham (1974), most juveniles ('yearlings') at the end of their 1st year return to the breeding colonies in mid-November to December, and commence moulting on the Snares Islands during early January, with most completed by the end of January and departing by the first week of February. After that moult, the now 2nd years, at about '15 months [of age] become indistinguishable from adults' (based on Warham 1974; also summary in O'Brien, 1990). Most 2nd years on the Snares Islands commence moulting at some time during February, and leaving for sea again before or by the end of March.

IDENTIFICATION

Features of Snares Penguins beyond juvenile (1st) year

Medium-sized penguins (c. 51-60 cm; 3.5 to 4 kg). Stonehouse (1971) states: 'Adult [body] proportions are reached in yearlings, except in bill; adult size of bill probably achieved in both sexes during 3rd or 4th years' (see also summary in O'Brien 1990).

Head

Normally a uniform glossy black crown, throat, chin, face and nape, giving a virtually 'hooded' head. Rarely do white facial streaks or mottling persist after the juvenile year. Warham (1974) points out that 'some breeding adults exhibit a similar condition and may reveal cheek stripes during threat displays' and notes that such streaks are useful field characters but not absolutely reliable.

Eye

Iris colour changes from reddish to dull red as progression from immature to adult occurs (brown in juveniles). Penguin eyes are not very reflective and it is difficult to determine true colours from most field photos.

Bill

Bills are prominent, longer by comparison with Fiordland Penguins and larger in males. They are elliptical or oval-shaped when viewed laterally, the degree and length of dorsal curvature of the culminicorn from feathering of the frons to bill tip (the bill profile) reflects the upper portion of that long elliptical or oval shape, assisting discrimination between Snares and Fiordland Penguins. From 2nd year they are evenly reddish or red-brown in colour; occasionally described as 'orange-red'.

Gape and mandibular skin

Fleshy pink or white skin occurs at the gape (rictus) and a narrow, well defined line of prominent pinkish to white skin along the edge of the lower mandible (ramicorn). This is the feature considered diagnostic in the field for all practical purposes, from 2nd year on, when decisions have to be made between Snares and Fiordland Penguins, the latter having brown skin at the gape and lower mandible edge. Note that beyond the juvenile year (when there is brown to dark skin in all *Eudyptes*), Erect-crested Penguins *E. sclateri* and Eastern Rockhopper Penguins *E. chrysocome filholi* also have prominent pink to white skin in the gape and edging the mandible.

SS/C

In Snares, Fiordland and Erect-crested Penguins, the pale to bright yellow, silky-textured SS/C, is separated to each side of the head. All three Rockhopper Penguin subspecies also have such an arrangement, except that the SS/C is fibrous-textured and differently positioned anteriorly.

In Snares Penguins the anterior tip of the SS/C is positioned just back from the extension of the lores between culminicorn and latericorn. A few millimetres of it (c. 3-6 mm) parallels the upper half of the proximal end of the latericorn, separated from it by a narrow, well-defined gap (c. 3-4 mm) of short glossy black feathers (see Plates 2, 3, 6, 7).

The Snares Penguin SS/C may usefully be divided into four sections:
(1) narrow anteriorly, with its tip behind and parallel to the upper portion of the latericorn,
(2) then widening very slightly before the eye,
(3) narrowing again above the eye, and
(4) again widening to become the loose plumes that separate posteriorly, drooping a little to the side of the head. These lengthen with age; and from approx. late 2nd to 3rd year dangle spectacularly to the side of the neck and nape (Plates 4, 6). The head-on photo (Plate 1) also shows the shorter feather sections (1) to (3) on each side of the head. The different disposition of section (4), where the predilection of the longer plumes is to turn outward is clearly seen (also Plate 4).

'Observable' underflipper pattern

Common to all *Eudyptes* penguins, the underflipper pattern of these five Snares Penguins is regarded (this review) as being in the 'observable' or normal field condition, as it appears when the penguin is alive, active or quiescent. It is also present in dead but still 'wet' penguins, i.e. on a beach, frozen when fresh or when preserved in spirit. It represents the aggregate of fluids within the flipper tissue, *plus* the normal melanin of the feather pattern, and shows as a strongly blackish blurred area or pattern within the distal third of the underflipper. It is the 'OUFP' of Simpson (2007), as demonstrated here in Plates 1, 2, 4, 5, 6 and 8. The effect will be reduced slightly again by inactivity on land (Plate 7).

AGES

This review of Australian rare penguins has so far provided evidence that the majority of all taxa, species or subspecies, found here are 'young', i.e. ranging from their juvenile wintering and yearling moulting periods to about their 3rd-year and possibly their 4th. This is generally consistent (mirroring) with other seabird genera and species – the 'young' travel widely, sometimes erratically, and many come to grief.

When Australian observers are faced with a young vagrant *Eudyptes* penguin, there is often confusion not only between the identity of Snares and Fiordland subspecies but also their changing appearance with increasing age. It is almost akin to the dilemmas facing observers in the 1940s, 50s and 60s as they struggled with identity and moults of the juvenile and immature charadriiform waders.

Estimates of age of *Eudyptes* beyond the juvenile year remain somewhat problematical, unless the moult of individuals, from juvenile to 2nd year, or 2nd to 3rd year is actually witnessed and recorded. Reference points are required. It is one thing to stand in an overseas *Eudyptes* breeding colony and decide on penguin ages, but average Australian observers will encounter perhaps only one or two such penguins in a lifetime. To try to determine the age of one in the field is a challenge.

The recording period for wintering juvenile *Eudyptes* penguins of all species and subspecies in Australia is from early June until approximately mid-to late September. During their first winter foraging period, none are anywhere near being considered yearlings, let alone birds with dark faces, evenly-coloured reddish-brown bills, and respectably developed SS/C plumes. The wintering juveniles of both subspecies are about five to eight months of age (June to September). They become potential 'moulters' and hence yearlings at about eleven to twelve months. Any that do come ashore may appear from about mid-November and into December, and would be expected to moult in January.

The age estimates given here for the five Snares Penguin individuals were arrived at from several points:

(a) knowledge that none show any juvenile characteristics (see paragraph above);

(b) guidance from the extent and degree of blackness of the OUFP (and RUFP when applicable); there is great individual variation in the extent and degree of black in the underflipper patterns of *Eudyptes* penguins (this is a hallmark of the genus);

(c) bills are well and uniformly coloured with no patchy dark areas;

(d) the gape and mandibular skin is pale, not brown;

(e) a visual comparison of SS/C plume length in a range of photographs (including books) of other living Snares Penguins from Australia and New Zealand;

(f) by direct plume measurement of a small number of skins in Australian museums (n = approx. 20 to date) in the hope of applying it satisfactorily to many more examples; that technique is described below.

Total SS/C length

A straight-line measurement is made from the anterior tip of the SS/C just behind the latericorn, along the side of the head to the tip of the longest plume feather, then repeated for the opposite side of the head. Two such measurements are therefore required per penguin, and similarly for the successive measurements below. Minor variation in results is frequently found on the same penguin, and needs to evaluated carefully as it may be affected by the operator's technique (Figure 1a).

SS/C plume length

The straight length of the lateral SS/C plumes is measured from approx. 1 cm above and behind the eye, that point being centrally placed within the SS/C plumes. Duroselle & Tollu (1997) describe this point as being "at the root of the tassel". The measure extends from there to the tip of the longest plume feather present (Figure 1b).

Tentative age determination

The plume is pulled gently downward to an angle of 45° from the horizontal, toward the B/WDL between between throat and uppermost white feathering of the breast, and the distance from the same postorbital point is measured. Increasing age decreases the distance from plume base to demarcation line. Longer plumes reaching beyond that line normally suggest a 3rd to 4th year Snares Penguin (Figure 1c).

Rationale

The longer SS/C plume measurements when wintering or as pre-moult penguins (up to the time plume feathers commence to be pushed out), and again in post-moult, is deemed to provide an approximation of age. It is arbitrary, not definitive. Optimistically it may become one more useful indicator of relative age when compared with some other laterally- crested *Eudyptes* penguins of the same species or subspecies, whether in life, from skins or from photos. To date, I have attempted it with Snares and Fiordland Penguins, and with Eastern and Moseley's Rockhopper Penguins, *E. c. filholi* and *E. c. moseleyi*, respectively. No attempt has yet been made to try it with Erect-crested Penguins *E. sclateri*, or with the frontal crested Royal Penguin *E. chrysolophus schlegeli* or Macaroni Penguin, or nominate *E. c. chrysolophus*.

SEX

Without bill measurements, no critical attempt to nominate sex for these five Snares Penguins was contemplated.

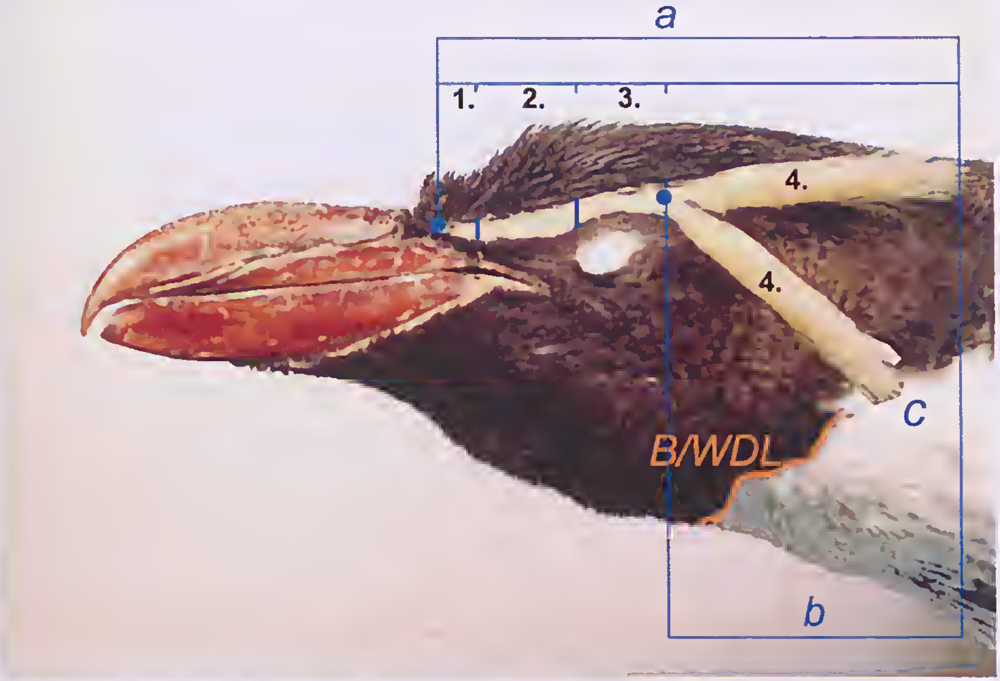

Figure 1. Plume measurement technique.

a = total length of SS/C in straight line.

b = total length of plume from feather base.

c = loose plume drawn down to 45 deg. toward or over B/WDL.

Numbers 1, 2, 3, 4 refer to the sections of the SS/C as described above.

Photograph by K.N.G. Simpson.

Illustrated in Figure 1 is the "root of the tassel", the point from which loose plume feathers begin to spread or droop. Using the orbit as a clockface, the pivot point appears approximately at 1300 hrs on the left side of the penguin's face and 1100 hrs on the right side.

The penguin chosen for the line drawing is South Australian Museum skin B1071, the Snares Penguin from Cape Banks, S.A., 8 January 1914, the first Snares Penguin identified in Australia (Simpson & McEvey 1971). Culmen length is 56.5 mm. The dorsal curvature of culminicorn represents the 'bill profile'. It is considered to be a 2nd year penguin just entering moult, as the dorsal plumage of the flippers is already brown and semi-transparent and the penguin has an overall brown hue as the old contour feathering is pushed out. The SS/C length is comparable to that of the Tasman Island/Anchor Rock penguin (Plates 7 and 8).

CONCLUSIONS

From the evidence presented, no problem exists with the identity of these five penguins, as each clearly exhibits the facial and other characteristics of typical *E. p. robustus*. All are beyond their yearling summer moult. Three are considered to be 2nd year penguins [1978 Port Arthur, 1997 Eaglehawk Neck, and 2009 Tasman Island/Anchor Rock] and two of them [1997 Trial Harbour and 2008 Eaglehawk Neck Beach] to be 3rd year penguins.

The age of the Snares Penguin from Safety Cove Beach (Simpson 2008a), has been retained as a 2nd year bird, as has the 1951 Seven Mile Beach Snares Penguin skin TMAG B2637 (Simpson & McEvey 1972; Simpson 2008a).

ACKNOWLEDGEMENTS

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I sincerely thank the museum collections' managers in Tasmania (Kathryn Medlock at TMAG and Judy Rainbird at QVMAG) for permission to study and photograph penguins in their respective collections. Zoë Wilson is gratefully thanked for constant assistance with photo scanning, editing advice and manuscript preparation.

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APPENDIX 1: A REVISED LIST OF SNARES PENGUINS CONSIDERED CONFIRMED FOR TASMANIA

Woehler (1992), summarising as many Tasmanian rare penguin records as he could at the time, listed six Snares Penguins. One, 15 December 1977, alive at South Bruny Island, listed by Wall (1980), was later rejected by BOAT, through lack of supporting evidence (Patterson 1982). For the same reasons, BARC rejected the 29 January 1987 penguin from Seven Mile Beach, Hobart, despite it being reported (Woehler 1992) as rehabilitated and released on 16 April 1987.

In this paper the author also rejects, from the original list, the 1985 Snares Penguin from Safety Beach, Port Arthur, on the similar grounds of insufficient supporting evidence. Enquiries since 2006 have not produced any concrete evidence concerning these 1985 and 1987 penguins. If this can be found, and is correct, they will certainly be re-instated. Therefore, at least for the present, Woehler's 1992 list is reduced to just three valid Snares Penguins, numbers 1-3. The other five were found later than 1992. It would be premature to try fixing a final number for Snares Penguin records in Tasmania at present. Several more have been located, two of which are currently in preparation for publication.

No.	Date	Locality	Nature of record	Published or Submitted to BARC
1	27 Aug. 1951	Seven Mile Beach, Hobart	Specimen TMAG (B2637)	Simpson & McEvey (1972)
2	26 Aug. to early Sept., 1978	Beach at Port Arthur	Sight/Care/Photos	Submitted to BARC
3	June 1979	Okehampton/ Triabunna	Specimen QVMAG (1979-2-338)	Green (1980)
4	30/31 July, to 6 Oct. 1997	Trial Harbour, W coast	Sight/Care/Photos	Submitted to BARC
5	31 Aug. to 1 Sept. 1997	Eaglehawk Neck (Waterfall Bay/Blowhole)	Sight/Photos	Accepted by BARC, Case 317 Palliser (2002)
6	6 to 17 to 20 Sept. 2000	Safety Bay/Port Arthur	Care/Photos/ Specimen TMAG C02432	Simpson (2008a) Submitted to BARC
7	7 to 12 July 2008	Eaglehawk Neck Beach	Sight/Care/Photos	Submitted to BARC
8	6 to 14 Feb. 2009	Tasman Island/ Anchor Rock	Sight/Photos	Submitted to BARC

HOW MANY SPINES DOES A TASMANIAN ECHIDNA *TACHYGLOSSUS ACULEATUS SETOSUS* HAVE?

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Have you ever wondered how many spines an echidna has? I found an echidna road-kill at Sorell Creek in December 2007. The echidna was of 'average' size and of unknown sex; the body was fairly intact and there was no damage to the spines. I collected the echidna, put it in a safe place in the garden and waited for it to decompose. I haven't always collected 'dead things' but since working with Parks and Wildlife as a Discovery Ranger since 2004, I've become even more curious about the world around me.

Once decomposed and every single spine collected and washed, I was ready for the big count. It was a one and a half hour process to count the spines and my final tally was 1757. I also measured some spines (n=50) and they ranged from 26 mm to 72 mm in length and from less than 0.5 mm to 4 mm in width. The smallest and finest of the spines lacked dark colouration at the tip but still retained 'spine characteristics' of being relatively sharp and pointy.

On its own, the fact that one echidna has 1757 spines is simply a fact and of no great ecological significance. I have found one reference which states that the spines on Tasmania's echidnas are 'relatively short and few' (Augee *et al.* 2006) which makes me wonder just how many spines do mainland echidnas have and how long are they? I have failed to find any reference to the actual number and size of spines on echidnas elsewhere.

Our echidnas are known to have thicker and longer fur than their mainland cousins and this is obviously useful in our cooler climate. I wonder if our echidnas have fewer spines than their cousins to make room for more fur to keep them warm. Alternatively, maybe our echidnas have a similar number of spines to their mainland cousins but the dense fur which obscures them, makes them look shorter and fewer.

Clearly, next time I've got nothing better to do, I may just have to collect the next unfortunate echidna road-kill I see and find out if all Tasmanian echidnas have 1757 spines.

REFERENCE

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DO PINE PLANTATIONS HAVE AN IMPACT ON THE DENSITY OF BRUSHTAIL POSSUMS IN KARST CAVES?

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During a survey of karst features on a property near Mole Creek in northern Tasmania, we located and explored five karst caves. The caves included short walk-in type horizontal passages as well as steep-sided vertical shafts up to about 10 m deep. The latter required caving ladders to descend. None of the caves contained flowing water, other than minor seepage flows.

In all five caves we encountered living individuals or pairs of brushtail possums, *Trichosurus vulpecula* (Plate 1). Abundant fur, scats, leaf-lined roosting niches and a pervasive possum aroma suggested that the possums had been living in these caves for some time. They were clearly 'in occupation' and not just occasional cave visitors.

Plate 1. A not so innocent-looking cave-dwelling brushtail possum in a cave near Mole Creek. Photo: R. Eberhard.

While it is not unusual to encounter possums in karst caves, the density of cave-dwelling possums on this property is unprecedented in our experience. The property was developed as a pine plantation approximately 30 years ago. We surmise that possums moving into the plantation from adjacent areas colonised the caves because young pine trees provide few if any opportunities for roosting in tree hollows. Forest remnants on adjacent slopes suggest that the original vegetation was dry grassy white gum.

A number of Tasmanian mammals are troglexenes – habitual users of karst caves, but not dependent on caves to complete their life cycles (troglophiles) or unable to survive outside caves (troglobites). In addition to brushtail possums, platypuses, wombats and Tasmanian devils are known to inhabit caves at Mole Creek and some other Tasmanian karst areas. Typically, however, possums appear to prefer roosting in tree hollows, which are likely to provide better protection from ground-based predators.

Mammals occupying caves can have significant effects on underground environments. Animals moving about and foraging or burrowing invariably disturb cave sediments, which may be compacted, mixed, displaced and otherwise altered. Wombats in particular can have quite intense effects due to their vigorous digging habits, which they engage in even when already underground inside a cave. Platypuses are known to use caves for nesting (Munks *et al*. 2004) and sometimes burrow extensively into the soft sediments of cave streamways. Mammals may displace other cave biota, such as invertebrates, or they may advantage them by bringing additional nutrients into otherwise nutrient poor cave environments. Under natural conditions, these are normal ecological processes.

We observed a range of impacts attributable to possums in the caves. In all cases there was abundant evidence of earthy sediments becoming hardened and compacted along well-developed 'pads' leading to entrances or nesting hollows (Plate 2); however, localised puddling and mixing had occurred where higher moisture content sediments were affected. A considerable amount of sediment had displaced to other parts of the cave, with stalagmites, flowstone and other substrates coated with dark greasy slicks over sizeable areas (Plate 2). The scale and intensity of muddying was reminiscent of the squalid conditions that can result in poorly managed caves subject to excessive recreational pressure. Possum faeces and urine were scattered throughout (Plate 3), as well as presumed nesting materials (sticks and leaves). Natural rates of change in caves are often very slow, implying limited or negligible capacity to recover from some of the impacts described above.

Broken stalagmites were also noted, although it is unclear whether possums were responsible for some or any of this damage. Possums are certainly capable of breaking off smaller stalactites. Elsewhere at Mole Creek, one of us had previously witnessed straw stalactites broken off when a cave-dwelling possum was startled by an approaching caver. This cave is located in sparse immature eucalypt regrowth, which may also have provided limited opportunities for nesting in tree hollows.

If our interpretation that conversion of native forest to pine plantation has potential to increase the density of cave-dwelling possums is correct, then the impact of the change in land use includes the effect within the caves of increased levels of activity by possums. While our observations are of a preliminary nature, we suggest that they raise questions concerning the use of caves by mammals under different land use regimes and are worthy of further investigation.

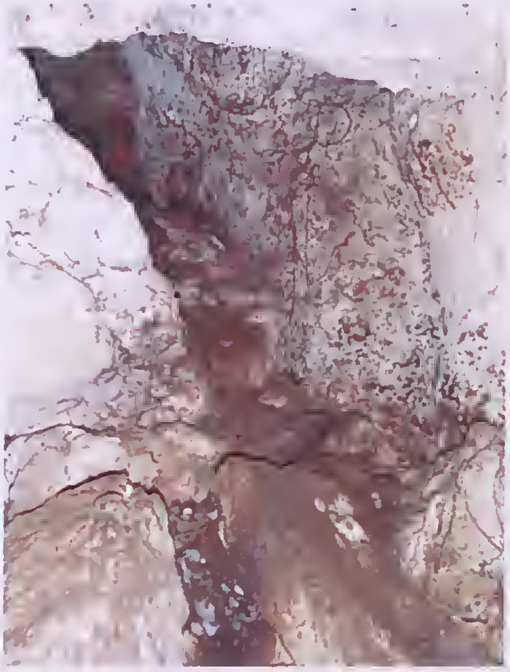

Plate 2 (LHS). Greasy slick across flowstone caused by possums. Photo: R. Eberhard.

Plate 3 (RHS). Leaf litter, possum faeces and urine staining on cave floor. Photo: R. Eberhard.

REFERENCE

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EDITORIAL NOTE

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DO VERTEBRATES GRAZE MOSS AFTER FIRE IN BUTTONGRASS MOORLAND?

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INTRODUCTION

The consumption of bryophytes (mosses, liverworts and hornworts) by vertebrate herbivores is widely documented for the Northern Hemisphere, mainly in boreal and arctic environments where nutrient sources are limited for at least part of the year (Prins 1981; Staaland & White 1991; Virtanen *et al.* 1997; van der Wal *et al.* 2001). Prins (1982) suggested that mosses provide little energy for herbivores but supply polyunsaturated fatty acids such as arachidonic acid that most likely increase the cold resistance of these herbivores and their young. Generally, moss-eating animals live permanently in cold environments, or migrate to these environments annually (Prins 1982). In Australia, the degree to which bryophytes are eaten by vertebrate herbivores is virtually undocumented.

Research into the effects of grazing on bryophytes in Australia has been carried out on the effects of trampling (Eldridge *et al.* 2000) and the nitrogen content of moss beds after the exclusion of grazing (Carr *et al.* 1980), rather than vertebrate consumption of moss. Given that bryophytes are mainly used as a food source by vertebrate herbivores when other nutrient sources are limited, such as in extreme cold conditions, we wondered whether bryophytes may be utilised by vertebrates as a food source in challenging habitats in Australia, such as in the buttongrass moorlands of Tasmania.

The buttongrass moorlands of Tasmania are burned often and are an extremely low nutrient environment. The foliage of the dominant plant (*Gymnoschoenus sphaerocephalus*) has high silica levels and the lowest recorded phosphorus levels in its foliage of any plant species (Bowman *et al.* 1986). The buttongrass moorlands are periodically inundated with water, yet the soil surface may be dry, cracked and hard in summer (Driessen 2007). Possibly due to the harsh and changeable conditions, only a few mammals are known to spend their entire lifecycle in the buttongrass moorlands: Swamp Antechinus (*Antechinus minimus*), Broad-toothed Mouse (*Mastacomys fuscus*) and the Swamp Rat (*Rattus lutreolus*) (Driessen 2007). Several other mammals use buttongrass moorland for feeding but usually shelter in other habitats: Common Wombat (*Vombatus ursinus*), Bennetts Wallaby (*Macropus rufogriseus*), Eastern Quoll (*Dasyurus viverrinus*) and the Short-beaked Echidna (*Tachyglossus aculeatus*) (Driessen 2007).

The lack of mammals that spend their entire lifecycles living in the buttongrass moorlands could also be a response to the regularity of fire. Buttongrass moorlands are frequently burned by naturally occurring and human induced fires. Following fire, patches of moss are often visible between the remaining short charred buttongrass tussocks. Given the loss of vegetation and potential food sources for the vertebrate herbivores that feed in the buttongrass moorlands, we decided to investigate whether vertebrate herbivores were grazing moss in recently burnt buttongrass moorland.

METHODS

A buttongrass moorland plain near Lake St. Clair burnt in spring 2005 was selected as the study site (Figure 1).

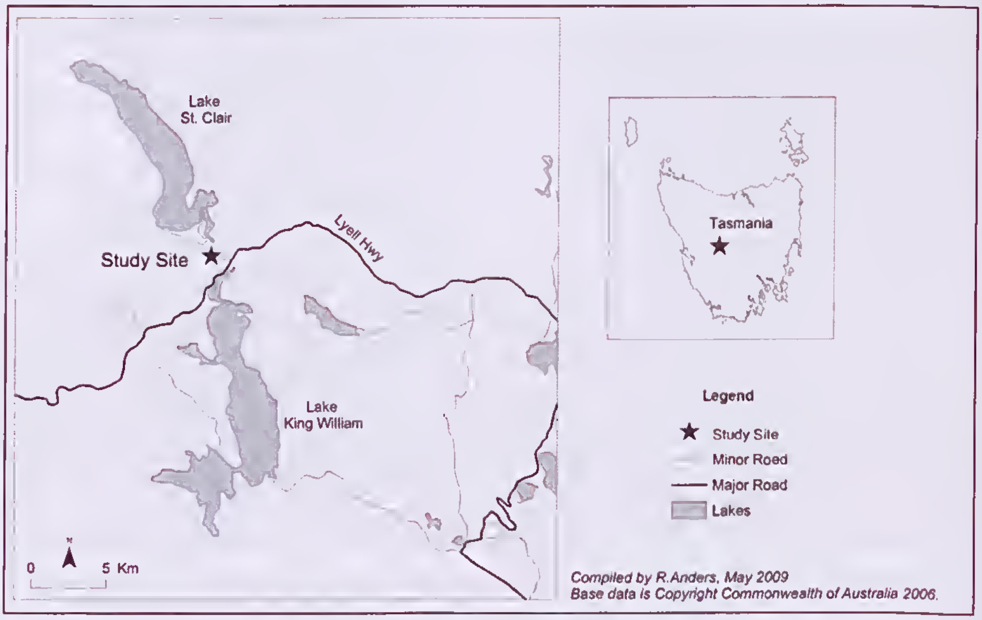

Figure 1. The study area.

Twenty wire cages (30 cm x 30 cm x 20 cm) were used as grazing exclosures, with a wire mesh of 1 cm that allowed invertebrate access but not vertebrate (Plate 1). In spring 2005, twenty patches of moss (either *Campylopus* spp. or *Dicranaloma* spp.) with a minimum diameter of ten centimetres were selected in the recently burnt buttongrass moorland. One cage was placed over half of each moss patch, so that one side of the moss patch was exposed to possible grazers, and one half was protected beneath the cage. Cages were dug down 3 cm below the ground surface and secured with four pegs. The height (taken as base of moss shoot at ground level to tip of shoot) of the moss patches was recorded as a baseline in 2005. The height of the moss patches was recorded yearly, concluding in spring 2008, with measurements being taken for each patch both inside and outside of the cage. Data was analysed using two-way ANOVA (Minitab 2000) to determine if grazers were significantly impacting on the growth of moss patches.

Plate 1. Grazing exclosures in the buttongrass moorland.

RESULTS

There was no significant difference in moss growth beneath the grazing exclosures compared to the moss exposed to grazers across the three years (Year: $P = 0.345$; $r^2 = 2.15\%$; $df = 2$; Grazing: $P = 0.986$; $r^2 = 2.15\%$; $df = 1$). After years one and two, no differences were recorded in moss growth on either side of the grazing barriers at any of the twenty grazing exclosures. During the third and final survey of the grazing exclosures, three of the twenty cages had disappeared entirely. However, no difference was recorded in bryophyte height between the enclosed and exposed bryophyte patches of the seventeen remaining grazing trials (Table 1). The potential moss grazer, the wombat, was sited at dusk, and wombat scats were found throughout the study site (Plate 2).

Plate 2. Wombat scats provide evidence of the presence of this mammal in the study area.

Table 1. Change in height of moss from 2005–2008.

Cage number	Base height 2005 (cm)		Height 2006 (cm)		Height 2007 (cm)		Height 2008 (cm)	
	inside cage	outside cage	inside cage	outside cage	inside cage	outside cage	inside cage	outside cage
1	18	18	18	18	19	19	19	19
2	15	15	15	15	17	17	17	16
3	12	12	14	14	14	14	14.5	14.5
4	21	21	21.5	21.5	21	20	0	0
5	25	25	25	25	25	25	27	27
6	13	13	13	14	14	14	14	14
7	17	17	15	14	15	15	17	17
8	24	24	24	25	28	28	28	28
9	16.5	16.5	17	17	19	19	19	19
10	11	11	11	11	14	14	15	15
11	19	19	21	21	21	21	21	21
12	25	25	24	24	24	24	0	0
13	20	20	22	22	22	22	23	23
14	15.5	15.5	16.5	16.5	17	17	17.5	17.5
15	18	18	17	17	18	18	18	18
16	14	14	13	13	15	15	0	0
17	26	26	25	25	26.5	26.5	27	27
18	22	22	22	22	22	22	23	23
19	24	24	26	26	26	26	28	28
20	17	17	19	19	20	20	22	22

It is possible that herbivores may only consume the fruiting capsules of moss. In another buttongrass moorland plain we observed capsules of the moss *Tayloria tasmanica* that appeared to have been grazed (Plate 3). The patches of moss used in this study were never observed to fruit, and any herbivory of sporophytes went unrecorded. The moss *Pleurophascum grandiglobum*, endemic to the Tasmanian buttongrass moorlands, is known for its pale green ball-like capsules. Whilst not seen in the study site, in other buttongrass moorlands the capsules of this moss sometimes appeared ragged, as if they had been grazed. However, it is possible that this is due to the manner in which the capsule releases its spores – it simply breaks open at the side.

Plate 3. *Tayloria tasmanica* with grazed capsules.

DISCUSSION

Patches of moss persisting from pre-burn vegetation are often one of the only remaining groundcovers besides charred and much-reduced buttongrass tussocks in burnt buttongrass moorlands. However, native grazers were not eating the moss patches we monitored. It is possible that the cages were somehow deterring the grazers from approaching the moss patches, but we did not observe any other evidence of moss being grazed at the site despite the presence of wombat scats and extensive moss cover.

The presence of a potential grazer, the wombat, was confirmed at the study site. The main food source of wombats are native grasses, with shrubs, roots, sedges, bark and herbs also eaten, with moss supposedly being a particular delicacy (Parks & Wildlife Service 2008). It has been observed that some moss species are favoured by wombats when they are green and moist, but usually ignored when dry (Triggs 1996). Triggs (1996) suggested that mosses are primarily eaten for their water content because mosses have little nutritional value. Wombats and other vertebrates found in buttongrass moorland may access adequate food by roaming into neighbouring scrub and forests to feed, where food sources can be found that have a greater nutrient content than moss. Wombats are known to roam many kilometres at night and would have no difficulty moving into adjacent habitats (Parks & Wildlife Service 2008). If snow lie and the cold-adapted vegetation are important limiting factors for grazers in Northern Hemisphere winters, vertebrate herbivores would be not be able to roam into more favourable feeding environments. It may be the difference between the scale of the buttongrass plains and the scale of the arctic tundra or boreal forests that has necessitated the

Northern Hemisphere vertebrate herbivores to adapt to consuming any available food source, such as mosses and lichens.

Mosses are difficult to digest, although their calorie value is in the same range as that of higher plants (Hegneuer 1962 in Prins 1982). Due to a high concentration of a polyphenolic lignin-like compound, the cellular contents of mosses are less accessible to the digestive enzymes of herbivores (Prins 1982). Polyphenols in some mosses can also have an antibiotic action which is likely to impede the digestion of ruminants or hindgut fermenters (Prins 1982). Given that wombats are hindgut fermenters (Hume 1999) it is possible that this is why wombats avoid consuming the mosses in buttongrass moorland.

Little is known about the consumption of bryophytes by vertebrates in Australia. No quantitative studies investigating the direct consumption of bryophytes by vertebrate herbivores have been performed that we are aware of, and any references to mammals grazing on bryophytes are purely observational. The dispersal of bryophytes by the spectacled flying fox (*Pteropus conspicillatus*) in the wet tropics of Queensland was established by Parsons *et al.* (2007), although they suggested that bryophytes were consumed indirectly with grooming, rather than directly grazed as a food source.

While our study did not include any trials to determine which, if any, invertebrates consumed bryophytes in buttongrass moorlands, overseas few invertebrate species have been found to eat moss plants readily (Davidson *et al.* 1990), although many invertebrates use bryophytes for shelter (Gerson 1982). Insects are the most commonly found arthropod sheltering in bryophyte communities, with some insects feeding on bryophytes by sucking the juices from leaf cells (Schofield 2001).

It appears that bryophytes are probably not eaten by many vertebrate animals in Australia. Studies are needed to confirm whether wombats do eat moss and under what conditions, and whether there are other animals, vertebrate or invertebrate, that also consume moss on occasion. In terms of buttongrass moorland, the close proximity of more benign feeding environments may mean that animals have not needed to use the unpalatable food source moss presents. More comprehensive studies are needed that look at landscape scale grazing dynamics and the possibility of moss being consumed in other environments, if only to establish that bryophytes are a last resort for hungry vertebrates in Australia.

ACKNOWLEDGEMENTS

We wish to acknowledge Jayne Balmer of the Biodiversity Conservation Branch, Department of Primary Industries and Water, Tasmania, for financial support; Tony Williamson for cage design and construction; and Rob Anders, University of

Tasmania, for map production. M.J. is supported by a Tasmania Graduate Research Scholarship.

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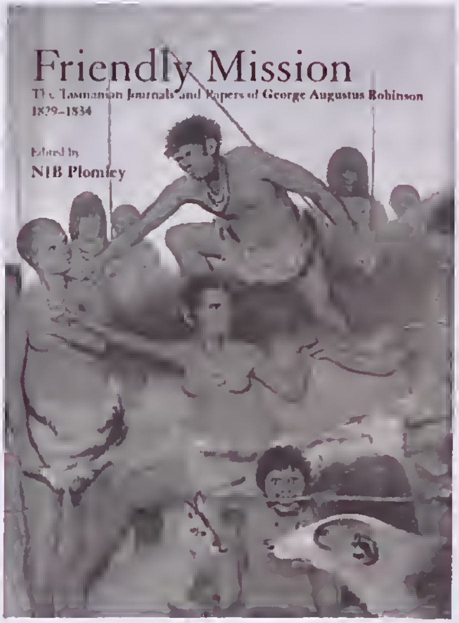
BOOK REVIEWS

Friendly Mission: the Tasmanian Journals and Papers of George Augustus Robinson, 1829–1834 *Edited by N.J.B. Plomley, Queen Victoria Museum and Art Gallery (Launceston) and Quintus Publishing (Hobart), 2nd edition (2008), hardback, 1162 pages (ISBN 978 0 9775572 2 6)*

REVIEWED BY: Bob Mesibov, PO Box 101, Penguin, Tasmania 7316, email: mesibov@southcom.com.au



The late Brian Plomley first published this scholarly presentation of Robinson's writings in 1966. *Friendly Mission* is more like an ore deposit than a book: it's been enthusiastically mined by historians, linguists, anthropologists, ethnographers and genealogists over the past four decades, and its lodes are far from exhausted.

I suspect that *Friendly Mission* is less familiar to naturalists than to historians, which is unfortunate. Like *Immense Enjoyment**, the extraordinary 1987 compilation of Wells family writings from the Don, *Friendly Mission* has natural history observations on almost every page. Robinson walked over a great deal of coastal and northern Tasmania (see map) and recorded landforms, vegetation, fire, flora, fauna and weather as he went. He also noted what Aboriginals and colonists said about things natural. If you abstracted all of Robinson's brief notes and commentaries, you would have a book of Tasmanian natural history far more comprehensive and readable than anything published by his long-winded colonial contemporaries.

Friendly Mission is rich in *plus ça change, plus c'est la même chose* moments. Here are two of my favourites:

> Oatlands, 3 November 1831
>
> *The trees in the low land and small hills are fast decaying, that in a few years there will be no trees left. I am informed that at the Clyde and Shannon it is the same and that the settlers say that they*

commenced falling to decay about three years ago. Probably their stated period for growth had arrived as they are for the chief part stunted trees, or it might be blight, or the continual burnings of the natives have tended to hasten it. So fast are they falling to decay that the ground is covered with dead timber and the top branches of trees was heard falling as we journeyed along. The natives caught numerous opossums today. This animal is in abundance. (p. 533)

Some of Robinson's journeys (heavy black lines), compiled from route maps in *Friendly Mission*.

Circular Head [Stanley], 30 May 1832

It rained incessant during the whole of this night and whilst at Circular Head there had been continual rains. Mr Curr said for the whole time he had been at Circular Head he had never known so much rain as there had been this season. (p. 643)

The new edition of *Friendly Mission* is very reasonably priced (8.5 cents a page!) and I recommend it highly to Tasmanian naturalists State-wide.

*Gardam, F. (ed.) *Immense Enjoyment. The Illustrated Journals and Letters of William L. Wells 1884-1888. The Life of an Early Quaker Family in Tasmania*. Devon Historical Society, Devonport). ISBN 0 9593219 1 8.

Wings: An Introduction to Tasmania's Winged Insects *by Elizabeth Daley, Riffles Pty Ltd, 2007, softback, 236 pages (ISBN 978 0 9804006 2 5)*

REVIEWED BY: Simon Grove, 25 Taroona Crescent, Taroona, Tasmania 7053, email: groveherd@bigpond.com

In this eclectic book the author, Elizabeth Daley, has made a valiant attempt to give us a compact introduction and field guide to Tasmania's bewildering array of winged insects. There was a gap in the market, and this book fills it. In any other developed nation, there would have been no gap by this stage of the twenty-first century, and this book would have had to compete with many others on a similar theme. But this is Australia – biologically megadiverse (even the tiny portion of its land surface that is Tasmania), yet chronically under-endowed with taxonomists able to formally describe our fauna, and with a restricted market of naturalists into which to sell books of this nature.

As the author tells us in the introduction, she is fascinated by insects, and we are the beneficiaries: if you weren't interested in insects when you picked up this book, you will be before you put it down again. She is wise to subtitle the book 'an introduction'. Otherwise, she would have set herself a hopeless task: Tasmania's insects are just so diverse that no single tome could do them justice. Her work-around to this is to refer the reader to other, more weighty, works on individual insect-groups as required.

The photos collectively depict an extraordinary range of creatures that go about their lives more or less under our very noses. The choice of subjects for the photos is a little quirky, and may to some extent reflect the species that the author came across serendipitously while out-and-about. But if she came across them in the course of a naturalist's wanderings, then so might the reader. Image quality also varies enormously – some are spot-on, while the most charitable thing to say about others is that they do a great job of conveying the truth that insects are for the most part small, constantly-moving and difficult-to-photograph creatures. The text accompanying each photo is rather minimalist, sometimes leaving the reader hungry for more information (e.g. why is the cattle-poisoning sawfly so-called?). However, each insect-group gets more expansive coverage as a whole, detailing typical life-cycles, feeding and other aspects of natural history, plus how to find some of the species.

But despite my appreciation that a book like this has finally come along, I remain ambivalent about its likely impact on a generation of Tasmanian naturalists. In covering a topic of this complexity, it's difficult to strike a balance between being overly scientific and dumbing down; between ensuring comprehensive coverage of particular taxa, and giving people a little taster of everything. This book has tried to capture both ends of the market as well as the ground in between – perhaps an impossible feat without compromising some of the science and something of the appeal for the interested layperson. So on the one hand, the book has the potential to inform and to inspire, while on the other, it has the potential to misinform, and leave readers under the misapprehension that they can use the book to put a name to some insects which are essentially only identifiable by experts.

The author makes a welcome attempt at inclusiveness through the use of English names for insects, but sometimes these result in a 'folk-taxonomy' that is not only unscientific, it's actually undermining of science. For instance, there is one section dedicated to beetles, but then another on weevils. Being arranged in alphabetical order at this level, beetles come near the beginning of the book (after bees), while weevils are at the end. Any naturalist worth their salt (including the author of this book) knows that weevils are a taxonomic sub-set of beetles. It doesn't do anybody any favours pandering to ignorance by pretending they are two different sets of life-forms of equal rank. A similar logic (or lack of it) applies to the separation of cicadas from the rest of the bugs, while bees, ants and wasps are given separate treatment despite their taxonomic relatedness to each other, as are butterflies and moths, and crickets, grasshoppers and katydids. And talking of which, do we have to suffer the use of that peculiar word 'katydid'? While it sounds almost scientific, it is no more than alliteration – it refers to the sound made by one particular species living thousands of kilometres from these shores in North America. What's wrong with 'bush-cricket'? Though English in origin, it could have bee made for the Australian environment.

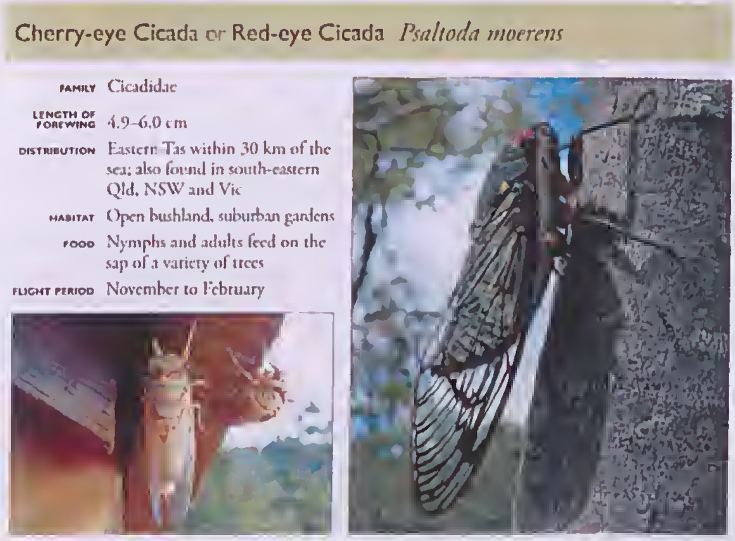
I digress. The use of folk-taxonomy continues down to the level of individual species – or perhaps I should say species-groups, because the use of English names is indiscriminate. I'm all for inventing apposite English names for species that lack them, but in this book, their use is inconsistent. Sometimes the English name is as unique as a species binomial; sometimes it looks that way but then further on the same name is used for another species (e.g. jewel beetle; Christmas beetle). The matter is further complicated by the level of precision of the scientific name itself. Sometimes a photo is accompanied by a full species binomial, sometimes just by a generic name. I deliberately use the word 'precision' rather than 'accuracy', because not every photo is ascribed its correct and current scientific name (and in the case of the 'carpetbag geometrid moth', no scientific name at all). I concede that this is inevitable in a book of this nature, and I am sure the author has done her best to minimise misidentifications. Sometimes I suspect that, in any case, the photos lack the necessary identification features (bristles on forelegs, teeth on mandibles, etc.) for even an expert to name with any certainty, so I have to assume that the author followed her own advice about collecting the specimen for later formal identification by an expert. In any book likely to be used as an identification guide, incorrectly named species can spawn many subsequent misidentifications, which can undermine the natural-history-recording endeavours of a generation. The author recognises this as a possibility and warns against relying too much on the names – but I fear many users will miss this piece of advice by skipping over the introduction.

A case in point is the beetle *Echnolagria rufescens*, which in this book (and in many reference collections) is known as *E. grandis*. It transpires, however, that that name is correctly applied to a species occurring on the Australian mainland only. This book was not the source of the error, but it perpetuates it. More pertinently, this book introduces several new naming errors. I am informed by Lynne Forster that the flea-beetle species named on page 38 as the introduced *Altica pagana* is actually a native, probably undescribed, species (which in the Tasmanian Forest Insect Collection at Forestry Tasmania goes by the code-name *Arsipoda* TFIC sp 02). Likewise the leaf-beetle on page 37 is *Calomela curtisi*, not *C. maculicollis*. Lynne mentioned some other species to me which also appear to be misidentified in this book. Meanwhile, Michael Driessen informs me that the photo on page 139 is not a yellow-winged locust but is a species of *Austroicetes*, and that this is but one of several errors in the Orthoptera department.

On the plus side, I found very few spelling errors, but I did notice two in a caption accompanying some photos of weevils on page 233 (*Aoplocnemis* is misspelled *Aoplacnemis*, and *Laemosaccus* is misspelled *Laemossaccus*. Fortunately both species are given their correct spelling in the text accompanying their main photos on pages 228 and 229 respectively. Lynne additionally picked up a misspelling on page 50, where *Ptilocnemus femoralis* is spelt as *P. femoratus*.

Back to the book's title – *Wings*. It's the sort of title that would suit a novel about an obsessive butterfly-collector, or a book of insect poetry perhaps. But for the current book, what would be wrong with promoting the subtitle to full title status in lieu of the existing one? Ah, there is one problem – not all the insects in the book are winged, or at least capable of flight (e.g. the similarly-named yet different Tasmanian grasshopper and Tassie hopper).

In summary, this book admirably delivers what its subtitle promises – it introduces the reader to Tasmania's winged insects (and a few others besides). But if your intention is to put a name to some of Tasmania's wonderful insect fauna, then use this book with caution.

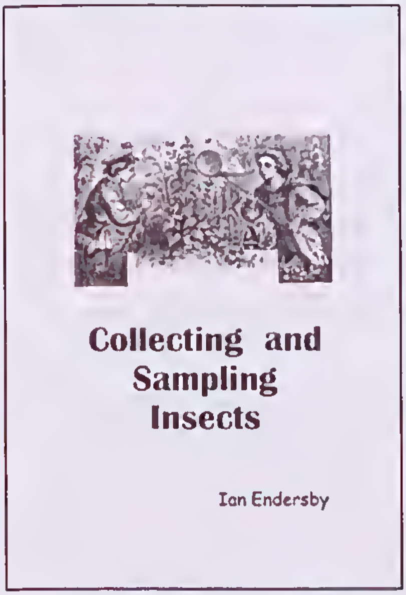


Collecting and Sampling Insects *by Ian Endersby, Entomological Society of Victoria, Montmorency, 2009, paperback, 28 pages (ISBN 978 0 9805802 1 1)*

REVIEWED BY: Lynne Forster, 17 King Street, Sandy Bay, Tasmania 7005, email: lynette.forster@utas.edu.au

At first this 28 page booklet looks like yet another enumeration of methods for collecting insects, making it easy to miss the new territory that it treads.

Indeed, most of the booklet catalogues collecting methods such as direct (beating, sweeping, breeding cages), intercept (pit, malaise, sticky), aquatic (kick sampling, net towing, hess sampler) and litter/soil (handpicking, sieving, tullgren funnel). These methods are covered in more detail in the volume it aims to complement – *Methods for Collecting, Preserving and Studying Insects and Allied Forms* by Murray Upton (Aust. Ent. Soc., 1991). Endersby updates a few methods, such as pointing out that smearing fermented sugars, beer and honey on tree trunks to attract insects contravenes protection of the apiary industry from disease. Yet the author endorses use of ethyl acetate to kill insects without promoting less toxic alternatives in use these days such as freezing specimens.



Many traditional sampling methods are outlined without innovative solutions to improve them. For instance window traps notoriously consume a large quantity of preserving liquid in the trough below. In Europe a successful adaptation is an upside-down triangle shaped window that funnels insects into a collecting bottle at the bottom apex. While the booklet focuses on techniques that target commonly sampled microhabitats such as the ground and air, there is potential to broaden these techniques to sample others such as saproxylic and trunk insects.

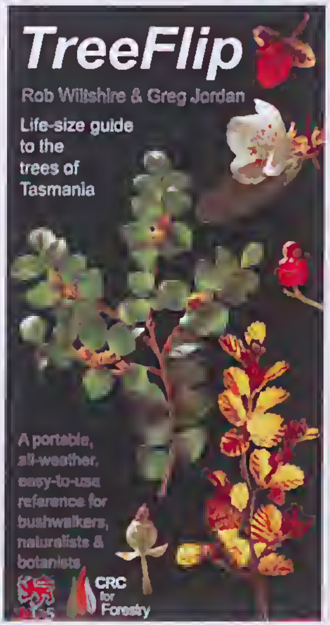
A guide to the target taxa that each trap may catch would be invaluable. A collector interested in flying beetles would appreciate knowing not to bother with malaise traps because samples are dominated by a soup of diptera and hymenoptera whereas window traps mainly catch beetles. There is no doubt, however, that it is difficult to juggle the included and excluded when compiling a book of such short length.

What, then, of the new territory that the booklet treads as an accompaniment to Upton (1991)? 'Sampling' in the title provides the clue.

'Collecting' refers to museum-style qualitative collection of insects to 'see what's out there'. 'Sampling' systematically applies the same chosen method to the collection of each sample. This replicated sampling enables quantitative analysis of the results from which information about the ecology or life history of species or communities of insects may be gleaned. Endersby introduces sampling methods through an innovative 'Qualitative versus Quantitative' segment at the end of each section where he suggests sampling strategies such as length of time of collection or area sampled. This, says the author, allows differences in populations, habitats, etc to be compared and may require measurement of environmental variables (weather, plant species etc) at the same time. As an introduction to sampling strategies the booklet would be useful for high school classes and novice collectors.

It would be an impossible task for a booklet of this size to provide the detail required to make the leap to well designed sampling methods, though the introductory outline of species accumulation curves hints that there is more to investigate for those who are interested, while a modest list of references provides a starting point for further investigation. Hopefully it stimulates the reader's appetite to inquire further.

To quote the author: "*It is important to have a reason for collecting; having sacrificed an insect's life for the purpose, some positive use must be made of the collection*".



TreeFlip *by Rob Wiltshire & Greg Jordan, School of Plant Science, University of Tasmania & CRC for Forestry, unique flip-open booklet-poster (ISBN 978 1 86295 496 0)*

REVIEWED BY: Fred Duncan, Forest Practices Authority, 30 Patrick Street, Hobart, Tasmania 7000, email: fred.duncan@fpa.tas.gov.au

Many field naturalists will be users and admirers of *EucaFlip* – the ingenious, field-friendly guide to Tasmania's eucalypt species. Now the School of Plant Science at the University of Tasmania has followed up with *TreeFlip* – a guide to Tasmania's non-eucalypt tree species.

The result is fantastic. The producers of *TreeFlip*, Rob Wiltshire and Greg Jordan, have done a fantastic job. Thirty-one species from a range of Tasmanian environments are featured, with sharp photographs of diagnostic features (leaves and branches, fruits, flowers, bark, etc.), with the images being augmented by good distribution maps and concise information on each species. The photos are life-size, which makes it easy to check your specimen against the photo.

TreeFlip is designed to cope with adverse field conditions – it is solidly laminated with reinforced folds. The handy format – *TreeFlip* folds into a booklet size package (about 12 X 24 cm) – means that it can be readily stored in a pack, jacket, glovebox or Christmas stocking.

TreeFlip is more than a ***resource*** for those who want to know about Tasmania's natural environment – it is a ***catalyst*** to head out into the wild to start identifying a few more trees. *TreeFlip* and its older sibling *EucaFlip* retail for $9.95 each. They are available from many bookshops, map centres, and the School of Plant Science at the University of Tasmania.

Flora of Tasmania Online *Tasmanian Herbarium (Tasmanian Museum and Art Gallery), www.tmag.tas.gov.au/FloraTasmania*

INFORMATION SUPPLIED BY: Marco Duretto, Tasmanian Herbarium, Private Bag 4, Hobart, Tasmania 7001, email: marco.duretto@tmag.tas.gov.au

The *Flora of Tasmania Online* (FTO) is a publicly available web-based resource for the identification of plants and the dissemination of modern taxonomic information. FTO was launched on 9 June 2009 by Michelle O'Byrne MHA (Minister, Department Environment Parks Heritage and the Arts). It will be published in parts, each covering one family.

FTO contains keys, descriptions, synonymy, distributional and habitat data for all taxa with appropriate referencing. For now, the focus of the FTO will be on the angiosperms (flowering plants, 139 families), especially the dicotyledons (100 families). The first 45 accounts (all dicotyledons) have now been published. These include families, e.g. Griseliniaceae, that have never had treatments for Tasmania (or indeed Australia!) published before. Other families have had major changes since the *Student's Flora of Tasmania* was published and the FTO accounts outline new concepts, species and genera. Families that will be published later in 2009 include Amaranthaceae (includes Chenopodiaceae), Elaeocarpaceae (includes Tremandraceae - *Tetratheca*), Ericaceae (includes Epacridaceae), Malvaceae (includes Sterculiaceae) and Myrtaceae (*Eucalyptus*).

FTO combines the scientific value of citable and permanently available documents with the speed and accessability of the internet. FTO is notable in that:

- family accounts are provided free of charge (web pages & PDF files);
- each account is a stand alone, citable, scientific document with unique version and ISBN numbers;
- all accounts will remain publicly available even when superseded by new and revised accounts;
- public feedback is encouraged;
- there is commitment to continuously update and improve the FTO by assimilating public feedback, new research and new discoveries;
- for the first time the flora for the entire State of Tasmania (including Macquarie Island) will be covered;
- all documents will also be electronically archived (and publicly available) at the State Library of Tasmania.

To assist workers with the new classification system used in the FTO there is an interface to determine what family a genus is placed in. In addition, there are mechanisms for feedback [strongly encouraged as this will help improve and refine the FTO] and adding your name to a notification system. This last system will be used to notify users when new accounts are published and of any other changes to the website.

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.; or review recent publications that are relevant to the study of Tasmanian natural history.

Submission of manuscripts

Manuscripts should be sent to the editor, Mark Wapstra, preferably electronically (email: mark@ecotas.com.au) as Word documents. Alternatively they can be mailed to 28 Suncrest Avenue, Lenah Valley, Tasmania 7008. Graphs, illustrations or maps should also be provided electronically by preference, generally in TIFF or JPEG format. Figures, especially photographs, should be supplied in high resolution (ideally 300 dpi) to ensure high quality reproduction.

Formal articles should follow the style of similar articles in recent issues. Informal articles need not fit any particular format (abstract needed only for formal articles). References cited in the text should be listed at the end of the paper in the following format:

Ratkowsky, A.V. & Ratkowsky, D.A. (1976). The birds of the Mt. Wellington Range, Tasmania. *Emu* 77: 19–22.

Watts, D. (1993). *Tasmanian Mammals. A Field Guide*. Peregrine Press, Kettering.

Ponder, W.F. (1993). Endemism in invertebrates in streams and rivers as demonstrated by hydrobiid snails. In: *Tasmanian Wilderness: World Heritage Values*. Eds. S. Smith & M. Banks. Royal Society of Tasmania, Hobart.

Bryant, S.L. (1991). *The Ground Parrot* Pezoporous wallicus *in Tasmania: Distribution, Density and Conservation Status*. Scientific Report 1/91. Department of Parks, Wildlife and Heritage, Hobart.

Formal articles are normally sent to at least one independent referee for comment. This is undertaken to try to ensure accuracy of information and to improve the quality of presentation. It should not be seen by prospective authors as a means for their work to be criticised but rather as a service to help them improve their manuscripts. The editor is willing to assist any prospective authors who have little experience in writing articles.

Tasmanian Field Naturalists Club

G.P.O. Box 68, Hobart, Tas. 7001

Founded 1904

Objectives

The Tasmanian Field Naturalists Club aims to encourage the study of all aspects of natural history and to advocate the conservation of our natural heritage. The club is comprised of both amateurs and professionals who share a common interest in the natural world.

Activities

Members meet on the first Thursday of each month in the Life Sciences Lecture Theatre 1 at the University of Tasmania at Sandy Bay. These meetings include a guest speaker who provides an illustrated talk. An excursion is usually held on the following weekend to a suitable site to allow field observations of the subject of that week's talk. The Club's committee coordinates input from members of the Club into natural area management plans and other issues of interest to members.

The Tasmanian Naturalist

The Club publishes the journal *The Tasmanian Naturalist*. This annual journal provides a forum for the presentation of observations on natural history, and views on the management of natural values, in both formal and informal styles.

Membership

Membership of the Tasmanian Field Naturalists Club is open to any person interested in natural history. Members receive *The Tasmanian Naturalist* annually, plus a quarterly bulletin with information covering forthcoming activities, and the Club's library is available for use.

Prospective members should either write to the Secretary at the above address, phone our President Michael Driessen on (03) 62 29 6382, or visit our web site at: http://www.tasfieldnats.org.au/.

Membership rates

Adults	$30
Families	$35
Concession	$25
Junior	$25

Subscription rates for *The Tasmanian Naturalist*

Australia	$20
Overseas	$25

[GST is not applicable—ABN 83 082 058 176]