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Stem rust of wheat in colonial Australia and the development of the plant pathology profession

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ABSTRACT

Grain production in the early years of the British colonisation of Australia was characterised by a lack of expertise of farmers, a paucity of farm animals and equipment and the poor work ethics of convicts. In 1803, just when wheat production was increasing and becoming less risky, stem rust of wheat caused by the fungus *Puccinia graminis* f.sp. *tritici* was discovered by an exiled Irish rebel Joseph Holt, on Captain William Cox's Brush Farm. Stem rust became an intermittent and often serious disease culminating in a series of epidemics in the latter part of the nineteenth century. Growing varieties less prone to rust was a key recommendation from a series of rust-in-wheat conferences held from 1891 to 1896. It was William Farrer who was the first in Australia to develop new wheat varieties that resisted the ravages of rust principally by maturing earlier. The rust outbreaks were also catalysts for the New South Wales and Victorian governments to employ Australia's first plant pathologists, Nathan Cobb and Daniel McAlpine, respectively. A year later, Henry Tryon was employed by the Queensland government as its first vegetable pathologist, although he had conducted plant disease investigations as early as 1889.

Keywords: Brush Farm, Daniel McAlpine, Henry Tryon, Joseph Holt, Nathan Cobb, Puccinia graminis f.sp. tritici, stem rust, William Cox, William Farrer.

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Introduction

In a history of British plant pathology, Ainsworth stated that: 'To trace the origin of a scientific concept of a critical phenomenon is frequently difficult' and that 'many fundamental observations were first made and recorded without their significance being realized'. Further, he lamented that 'in the history of science the records are falsified by oversimplification when prominence is given to certain dates as well as to discoveries and advances by outstanding workers.'[1]

Although several publications on the early history of plant pathology and mycology in Australia are available, they have generally focused on the twentieth century, with few, and short references, to the eighteenth and nineteenth centuries: Fish has a short section on early epidemics of wheat rust;[2] Parbery and Sheather wrote a short section on 'Mycology and agriculture';[3] while both Pascoe and Johnson made a few references to stem rust of wheat.[4]

In this paper we redress this omission in history by outlining the discovery of the wheat stem rust in Australia, and describe its impact on society in the early days of British settlement, including giving examples of where it is mentioned in colonial folklore. We also provide a brief overview of William Farrer's contribution to controlling the disease. Finally, we present short biographies of the first three professional plant pathologists in Australia, Daniel McAlpine, Nathan Cobb and Henry Tryon whose appointments were prompted by outbreaks of wheat stem rust.

[1] Ainsworth (1969) p. 13.
[2] Fish (1970).
[3] Parbery and Sheather (1990).
[4] Pascoe (1990). Johnson (2010).

We draw on information in the publications of members of the First Fleet, documents in *Historical Records of Australia*, the memoirs of William Cox,[5] and of Joseph Holt,[6] newspaper references sourced through the website 'Trove' (www.trove.nla.gov.au/newspaper), and other sources.

Wheat and the British settlement of Australia

The country now known as Australia was colonised by the British in January 1788 as a penal colony. The First Fleet of eleven ships contained 789 convicts and their children, 293 members of various ranks of the New South Wales Corps and their wives and children, and fifteen administrators of the colony.[7] During the voyage, stops were made at Teneriffe, Rio de Janeiro and the Cape of Good Hope for rest and re-provisioning of food, livestock, seeds and other articles. Among the provisions, seeds and plants brought to Australia on the First Fleet were 60 bushels of seed wheat, *Triticum aestivum* (1.6 t), 20 bushels of seed barley, *Hordeum vulgare* (434 kg), 10 bushels of Indian corn seed, *Zea mays* (approx. 254 kg) and 12 baskets of garden seed, as well as plants of fruit trees, grapes and sugarcane.[8]

The fleet sailed into Botany Bay on 18–20 January 1788, and it soon became evident that it was a poor site for a penal settlement, so the party moved to Port Jackson, about 20 km to the north, after Governor Arthur Phillip (1738–1814) had determined its suitability for a settlement.[9] Within four days of arriving on 25 January at Sydney Cove (now the site of Circular Quay), ground for the governor's garden was dug and a number of plants brought out by him planted.[10]

By late March 1788, government farms had been established on the east side of Sydney Cove and at the head of the next cove to the east, (later named Farm Cove) (Supplementary Map S1),[11] which is now part of the Royal Botanic Garden Sydney.[12] These were placed under the direction of Henry Edward Dodd (1752–91) who had worked on Phillip's farm at Lyndhurst in Hampshire, England.[13] Phillip later wrote that Dodd was the only person in the colony with 'a serious claim to agricultural proficiency'.[14] By July of 1788, the government farm had 'nine acres in corn [wheat]'.[15]

However, it soon became clear that the soil around Sydney Cove, being derived mostly from Hawkesbury Sandstone, was unsuitable for agriculture at the scale necessary to sustain the colony. Lieutenant-Governor Phillip Gidley King (1758–1808) described the soil as 'very bad, little better than black sand'.[16] There was another serious problem, too. Governor Phillip, in a dispatch to Lord Sydney dated 15 May 1788 wrote: 'The great labour of clearing will not permit more than 8 acres [3.2 ha] being sown this year with wheat and barley'.[17] The lack of people with knowledge of farming on the First Fleet and a reliance on convicts to do the backbreaking work of cultivating the land with picks and hoes meant that agriculture in the early days of the colony was always going to struggle.

The early attempts at agriculture did not go well. In a dispatch dated 28 September 1788 Phillip wrote that all the seed wheat and most of the other seed from England had been spoiled, as well as wheat from the Cape of Good Hope. Several acres had been sown twice with this wheat but very little had 'vegetated' and most of the barley and other seeds had rotted. The same thing occurred at Norfolk Island where there was barely enough wheat seed left to sow 1 acre (0.4 ha).[18]

In an attempt to find more fertile land for agriculture, Governor Phillip and a party travelled to the head of the harbour in November 1788 and selected the site for a farming settlement at Rose Hill, renamed Parramatta three years later. Within four years, virtually all cropping was being conducted in the vicinity of that settlement, at the Field of Mars, Toongabbie, Canterbury, Prospect Hill and other locations (Supplementary Map S2).[19] Nevertheless, the land at these places soon became exhausted from the practice of growing successive crops of wheat and maize as well as the lack of fertilising with manure and perhaps the lack of deep cultivation, which persisted for decades after.[20]

In February 1794, Lieutenant-Governor Grose (1758–1814) made grants of land to twenty-six settlers on the banks of the Hawkesbury River at Mulgrave Place (Supplementary Map

[5]Cox (1901).
[6]Croker (1838).
[7]Anonymous (2020).
[8]Anonymous (2020).
[9]Collins (1798) p. 12.
[10]King (1789) p. 87.
[11]Collins (1798) p. 13. Anonymous (2022).
[12]Maiden (1928) pp. 1–2.
[13]Mundle (2014) p. 330.
[14]Pembroke (2013) p. 204.
[15]Anonymous (2022).
[16]King (1789).
[17]Phillip (1892*a*) p. 126.
[18]Phillip (1892*b*) p. 188.
[19]Tench (1793) chapter 16.
[20]Atkinson (1826) p. 37.

S2). The rich soils of the Hawkesbury River soon became the 'bread basket' for Sydney, but Governor Hunter described most of the emancipist farmers there as being 'very idle and indifferent' and 'worthless'.[21] It was not until officers of the New South Wales were granted land from the end of Phillip's governorship (1792) to the start of the Macquarie era (1810), and later from 1817 onwards when grants of land were exchanged for significant cash payments, that the quality and output of the colony's farmers improved dramatically.[22]

The discovery of stem rust of wheat in Australia

In December 1794, much of the wheat in New South Wales was found to have been 'blighted' and the ground around Toongabee to be 'worn out' with wheat returning only 6–7 bushels/acre (403–470 kg/ha) rather than the usual 13–14 bushels/acre (806–940 kg/ha); on the northern farms wheat had also failed 'through a blight'.[23] In the twentieth century, the Australian agricultural scientist Walter Lawry Waterhouse (1887–1969) conjectured that this and other early records of blight in wheat may have been due to pathogens, perhaps even those that cause stem rust and or leaf rust.[24] Nevertheless, it is not possible to confirm or deny this suggestion.

In 1799, William Cox (1764–1837) (Fig. 1*a*), a lieutenant of the 68th Foot Regiment and 'General' Joseph Holt (1756–1828) (Fig. 1*b*), a farmer and Irish rebel leader who had been exiled to New South Wales by the British government, developed a close friendship on their voyage to Australia, and soon after arriving at Sydney Cove on 11 January 1800 agreed to collaborate on the management of Cox's farms, including Brush Farm (Supplementary Map S3).[25] Brush Farm House, which was originally built by Gregory Blaxland in 1820, still stands on land that was once part of Brush Farm, at 19 Lawson Street, Eastwood, City of Ryde, approximately 20 km north-west of the Sydney CBD (Supplementary Map S4).

In 1803, Brush Farm was the site of the first indisputable record of any disease on wheat in Australia. The first wheat crop grown on the farm failed due to a hailstorm,[26] but worse was to follow. Holt wrote in his memoirs that on 21 October 1803 a 266 acre (108 ha) wheat crop was fine and large, with 'ears that were full and plump, the straw clean and well coloured'.[27] However, within three days it had been completely destroyed by rust, which covered the entire straw and ear with 'a reddish powder like rust of iron, which falls off as you walk through the standing corn [wheat] and

Fig. 1. (*a*)—William Cox, circa 1797–8, State Library of New South Wales, Sydney; (*b*)—Joseph Holt, R. J. Hamerton lith., from an original picture in the possession of Sir William Bentham painted in 1798, Day & Haghe lithrs. to the Queen, Trove, https://trove.nla.gov.au/work/22823177. accessed August 2021.

[21] Hunter (1914) p. 596.
[22] Collins (1798) p. 225.
[23] Collins (1798) p. 240.
[24] Waterhouse (1936) p. ix.
[25] Croker (1838) p. 26. Bethel (1931).
[26] Croker (1838) p. 190.
[27] Croker (1838) p. 191.

iron-moulds cotton or linen articles like iron rust'[28] (Fig. 2). The crop was turned over to the neighbour's pigs, with a loss estimated at £3990 (equivalent to AUD$791000 in 2020).[29]

Holt experienced a similar fate—45 acres (18 ha) of wheat on a farm that he had recently bought was also devastated by rust, the harvest being worth no more than £5.[30] He blamed this 'blight' on 'fogs, which come on suddenly and obscure the sky for days; and if it happens when the wheat is ripe, inevitably destroys it'.[31] Cox said many believed that the rust was caused by growing the same crop in a field for many years without manure.[32] However, James Busby (1801–71), a pioneering viticulturist in Australia, wrote that many farmers believed rust was due to 'the nature of the soil, having so much ironstone in it'.[33] The wheat variety affected by this rust outbreak was probably 'Common Brown', which according to a list of non-indigenous plants in the colony on 20 March 1803 was the only variety grown at that time, although 'white bearded wheat [was grown] in the colony but is now lost.'[34]

Later in 1803, Cox's estates were placed in the hands of trustees due to his large liabilities, suspicion of extortion of New South Wales Corp's funds, and possibly the failure of his wheat crop. He returned to England to face trial over the alleged extortion, of which he was acquitted. When Cox returned to Australia in 1814, he was asked by Governor Macquarie to supervise the building of the 163-km-long road over the Blue Mountains from Sydney to Bathurst. Governor Macquarie was so pleased the project took only six months that he awarded 2000 acres (809 ha) of land to Cox beside the Macquarie River near Bathurst, the first grant of land west of the Blue Mountains. Later, Cox and his descendants became large landowners in New South Wales, Tasmania and Queensland, focusing mainly on pastoral interests.[35]

Cox was not the only one who experienced difficulties. On Christmas Eve 1803, Holt was charged with plotting to kill Judge-Advocate Richard Atkins (1745–1820), but that accusation was proved false, and the charge later dropped. However, in 1804, Holt was arrested after the Castle Hill uprising and sent to exile on Norfolk Island.[36] He ultimately recovered his fortunes, and eventually returned to Ireland, always regretting his decision to leave New South Wales.[37]

There can be no certainty about how and when *P. graminis* f. sp. *tritici* entered Australia. However, the most likely mode of entry is by the movement of urediniospores in upper atmosphere jet-streams, probably from Africa. This hypothesis is supported by a more recent genetic analysis of twenty-nine Australian and South African *P. graminis* f.sp. *tritici* races using microsatellite markers, which showed that there was a close genetic relationship between South African and Australian rust populations. Lagrangian particle dispersion model simulations using finely resolved meteorological data also show that long distance dispersal events between southern Africa and Australia are possible, albeit rare.[38] It is likely that isolates of the wheat stem rust pathogen entered Australia and became established on some susceptible indigenous grasses prior to 1803 and/or on wheat after 1788.[39]

Fig. 2. Uredinia (sori) of *Puccinia graminis* var. *tritici* on wheat stems. Courtesy of Robert Park.

Wheat rust in Australia post-1803

On 1 March 1804, Governor Phillip Gidley King (1758–1808) complained that there had been no change of seed for some time and: 'As our last year's crop of grain was much injured

[28]The 'reddish powder' would have consisted of extremely large numbers of spores (urediniospores) that were released from sori (uredinia) on the wheat stems.
[29]Croker (1838) p. 192.
[30]Croker (1838) p. 193.
[31]Croker (1838) p. 192.
[32]Cox (1901) p. 39.
[33]Winmill (2015) p. 67.
[34]King (1803) p. ix.
[35]Hickson (2020).
[36]Bolton (2020).
[37]Croker (1838) p. 439.
[38]Visser and others (2019).
[39]Waterhouse (1936), p. xx.

by rust and smut, about 500 or 1000 bushels (13.6 or 27.2 t) would be sufficient to bring the country into a general change of seed [supplied from England]'.[40]

We believe that Holt's description of 'rust on the entire straw' leaves little doubt that the pathogen was *Puccinia graminis* f. sp. *tritici* (Fig. 2). Sir Joseph Banks (1742–1820) had examined wheat rust samples sent to him from Australia soon after its discovery, reporting they: 'show that considerable mischief was done to the wheat crop there, in the year 1803, by a parasitic plant, very similar to the English one'.[41] This identification was supported by plant pathologist Daniel McAlpine (1849–1932). In *The Rusts of Australia* (1906) he stated there were only two known rusts in Australia, the 'injurious' *Puccinia graminis* and the 'harmless' *Puccinia triticina* (the cause of leaf rust).[42] McAlpine asserted that *P. triticina* was probably in Australia in 1825,[43] but did provide any support for this statement. It is possible that reports of 'rust' in wheat after 1825 were referring to either stem rust and/or leaf rust. However, some doubt remains, as argued by Large (2003): 'When it is reported in this or that territory there is a great deal of Rust, no one could say for certain which Rust was meant'.[44]

By 1805, there were further reports of rust (and smut) on wheat—a proclamation from Colonial Commissar, John Palmer (1760–1833), in December 1805 stated that:

> In consideration of the great loss sustained in the crops of wheat by the severe blights, smut, and rust, as well as the damage done by the late floods to that growing at the South Creek, HIS EXCELLENCY has directed that wheat and maize continue to be received into His Majesty's Store at the same prices on the respective accounts as were allowed last year.[45]

A week earlier, 'Agricula' had written about the disadvantages of growing wheat:

> His [the farmer's] crops are attacked by some secret diseases whose causes are hidden, whose destructive effects he cannot prevent, and which render all his labours abortive in a few days or hours and it [the crop] is soon destroyed while growing in the field by the blight, rust, smut, and caterpillar.[46]

Waterhouse (1936) provided a detailed account of recorded or suspected outbreaks of rust by others and from reports in the *Sydney Gazette* in New South Wales (1818, 1829–32, 1862–90), South Australia (1854–1879) and in all Australian states in 1889, and 1890.[47] By contrast, newspaper records of outbreaks of wheat smut showed that the disease was very common, being recorded in the colonies in 1805, 1808, 1810, and 29 of the 36 years from 1824 to 1859.[48] However, rust became more important than smut on wheat in the second half of the 1800s. A reporter in the *Geelong Advertiser* wrote in 1862: 'The wheat crop, except in few cases, is a complete failure in this district [Shoalhaven] in consequence of the rust, which does not appear to show on the Egyptian wheat, although growing in the same field as the diseased wheat'.[49]

It was not until the 1860s that serious losses caused by wheat rust prompted action on the part of colonial governments. Commissions of enquiry were established in Victoria in 1864, and in South Australia in 1867 to investigate the influence of agricultural practices on the disease.[50] In response to the recurring rust epidemics, the Government Botanist of Victoria, Ferdinand von Mueller (1825–96) was appointed chair of a committee on rust and blight in cereals. In the committee's report he claimed that rust was caused by a fungus (*Uredo*) and provided the following recommendations for minimising the disease: early sowing; use of early maturing, hardy varieties 'armed with the strongest coat of epidermal silicious deposits'; use of the red varieties, for example, 'Red Tuscan', 'Uxbridge', 'Pedigree' (the most susceptible varieties were 'Golden Drop', 'White Prolific' and 'White Tuscan'); and addressing nutrient deficiency and poor drainage. Mueller also noted that maize (*Zea mays*) was 'free from the *Uredo*'.[51]

The South Australian government appointed a commission to enquire into the diseases of cereals, particularly 'red rust' of wheat, in late December 1867.[52] Just four months later the commissioners produced their report.[53] They concluded that the 'red rust' occurred on all soils, was not seedborne, was less severe on the varieties 'Tuscan' and 'Purple Straw', and was caused by '*Puccinia graminis*' (so written) and perhaps '*Puccinia straminis*' (so written). Most of their report was concerned with 'red rust', with only short sections on 'smut and black rust' and 'take all'. It cannot be

[40] King (1915) p. 492.
[41] Banks (1805) p. 520.
[42] McAlpine (1906) p. 64.
[43] McAlpine (1906) p. 42.
[44] Large (2003) p. 293.
[45] Palmer (1805) p. 1.
[46] Agricula (1805) p. 2.
[47] Waterhouse (1936) pp. x–xvi.
[48] https://trove.nla.gov.au/newspaper.
[49] Anonymous (1863) p. 2.
[50] Waterhouse (1936) p. xv. Pascoe (1990) p. 259.
[51] von Mueller (1865).
[52] Anonymous (1867).
[53] Barrow and others (1868).

determined with any certainty if the disease called 'red rust' in their report was caused by *P. graminis* f. sp. *tritici* or *P. triticina* (the cause of leaf rust).

Despite significant advancements in knowledge about the cause of rust (and smut) diseases on cereals in the last decade of the nineteenth century, and in the early twentieth century, information on their biology and management was not successfully disseminated to growers in Australia. In 1864, some farmers still believed that wheat stem rust was a 'plague sent by the Lord upon the inhabitants of this country for their sins'.[54] Almost 50 years later, McAlpine similarly recorded about wheat smut: 'It is still deeply rooted in the minds of many farmers that the smut spores are simply an exudation of the sap of the plant, blackened by exposure to the air, or that the fungus … has arisen spontaneously from the soil in some mysterious fashion'.[55]

Some state governments became desperate; in 1880 the Queensland government offered a £1000 reward for a cure of wheat rust,[56] but there is no evidence that this reward was ever collected. Finally, severe wheat rust epidemics in 1889 led to a series of five 'Rust in Wheat Conferences' (also called 'Red Rust Conferences' and 'Intercolonial Rust Conferences') between 1890 and 1896. In 1889, the combined loss due to wheat stem rust in all Australian states was an estimated £2–3 million (AUD$ 240–360 million in today's currency).[57]

The management options recommended from these conferences were: to breed and select plants less liable to be attacked by rust; plant early maturing varieties; and use the best agricultural methods to ensure a good crop.[58] These recommendations differed little from those given by 30 years earlier by von Mueller, indicating little had been done in the interim. At the final conference, Nathan Augustus Cobb (1859–1932), the New South Wales Vegetable Pathologist said: 'As for curing rust by treating seed, the idea is ridiculous. It would be just as reasonable to expect to prevent measles among mankind by soaking babies in some sort of pickle'.[59]

Some newspaper articles were, however, scathing of the outcomes and outputs from the conferences. The author of an article in the Melbourne paper *Weekly Times* of 6 June 1896 stated: 'It is unfortunate that the outcome of the long series of intercolonial rust conferences should be of so little practical value to farmers, who would have been almost, if not quite, as wise if these annual gatherings had never been held'. The author also complained that the recommendations from the conferences were based on past experience rather than 'recent investigations'.[60] Of course, some of the more prominent conference attendees jumped to their own defence; Daniel McAlpine carefully and concisely pointed out the reasons behind the recommendations that had been made and noted the 'inherent difficulty of the subject'.[61]

Scientific study of the plant pathogens affecting crops (particularly winter cereals) was lacking in Australia. In an article on fungi published by the Linnaean Society of New South Wales in 1880, Julian Edmund Tenison-Woods (1832–89) and Government Botanist of Queensland, Frederick Manson Bailey (1827–1915) wrote:

> In conclusion, we beg to draw attention to the very great importance which the study of fungi possesses for a young country like ours, which depends so much upon its agriculture. Sad experience has taught us how its prospects may be injured by blight, mildews, smuts, rusts, etc. Little or nothing is known about the origin and spread of these terrible pests, and it is equally certain that if they were known they would in a measure be provided against. Although by many mycologists the polymorphy of these blights has been doubted, yet experience seems to have decided that a blight of one kind affecting one class of plants may be transformed into a mildew or rust amongst cereal crops.[62]

Wheat rusts in Australian folklore

While wheat rust received little scientific attention in the 1800s and early 1900s, it was discussed in popular literature, revealing a broad public awareness of the disease. In a song published in 1905 called *The Stringy-Bark Cockatoo*, an anonymous author describes the experiences of 'a broken-hearted miner' toiling as a labourer for a 'stringy-bark cockatoo' (wheat farmer):

> When we started to cut the rust and smut was just beginning to shed,
>
> And all we had to sleep on was a dog and sheep-skin bed.
>
> The bugs and fleas tormented me, they made me scratch and screw;
>
> I lost my rest while reaping for the stringy-bark cockatoo.[63]

[54] McAlpine (1906) p. 64.
[55] McLeod (1864) p. 5.
[56] Anonymous (1880).
[57] McAlpine (1906) p. 64.
[58] McAlpine (1906) p. 71–74.
[59] McAlpine (1906) p. 73.
[60] Anonymous (1896*a*).
[61] Anonymous (1896*b*).
[62] Waterhouse (1936) p. 4.
[63] Paterson (1905) pp. 31–32.

Another reference to wheat rust was made in the book of short stories published in 1899 called *On Our Selection,* and written by Arthur Hoey Davis (1868–1935) (under the pseudonym of Steele Rudd).[64] Davis was the son of an ex-convict from Wales who took up a 140 acre (57 ha) selection of 'pastoral land' near Mt Sibley, approximately 25 km south of the Toowoomba central business district in 1870 for 2s 6d per acre. Davis left school at twelve, and worked on nearby properties, until he moved to Brisbane in 1885, where he eventually became a writer.[65]

The historian Richard Fotheringham considers that *On Our Selection* and Davis's later 'Dad and Dave' books were based on his own family's experiences, as well as of friends and relatives, stories 'heard over the fence' and fantasy.[66] At Dad's selection 'adjoining a sheep run on the Darling Downs' most of the early crops failed due to drought, grazing kangaroos or marauding black cockatoos. At the end of chapter 18—'We embark in the bear industry'—he wrote:

> And that season, when everyone else's wheat was red with rust—
>
> when Anderson and Maloney cut theirs for hay—when Johnson
>
> put a firestick in his—ours was good to see. It ripened; and the rain
>
> kept off, and we reaped 200 bags. Salvation!

'Steele Rudd' also mentioned wheat rust in the poem, *Going on the Land*, published in 1904. In it Rudd writes about 'Mr Towney' taking up 'a selection with the hope of growing rich, building castles in the air and rosy paradises', but after clearing his land, sowing seed, and praying for rain:

> should your wheat crop flourish, and it's fair to think it must, if
>
> the wallabies don't eat it, then it's blasted with the rust.[67]

There is even a reference to wheat rust in the famous bush ranger, Ned Kelly's (1854–80) 'Jerilderie letter'. Written while Kelly and his gang were under siege by the police in early February 1879, the document was intended for publication in Jerilderie's local newspaper.[68] The letter was a manifesto about Irish oppression by English overlords and the 'parcel of big, ugly, fat-necked, wombat-headed, big-bellied, magpie-legged, narrow-hipped, splaw-footed' Victoria police.

The last page of the document gives a warning to:

> all those that have reason to fear me had better sell out and give £10 of every hundred to the widow and orphan fund and do not attempt to reside in Victoria … [or suffer] the consequence which shall be worse than rust in wheat in Victoria or the drought of a dry season to the grasshoppers in N.S. Wales *I am a widow's son, outlawed and my orders must be obeyed*.[69]

William Farrer and early Australian wheat breeding

Despite the apparent inaction of the scientific community to find a solution to the rust problem, one individual took up the challenge. William James Farrer (1845–1906) (Fig. 3) was an educated gentleman from England, who migrated to Australia due to ill-health. He hoped to purchase a sheep farm in New South Wales, but after losing his money in mining speculations he became a surveyor in 1875.[70]

After retiring in 1886, Farrer experimented with wheat breeding on three acres (1.2 ha) of land at Lambrigg in greater Queanbeyan (now in the Australian Capital Territory). Prior to the 1850s, wheat varieties in Australia included Red and 'White Lammas imported from England, 'Talavera' imported from Spain, and 'White Tuscan' and 'Purple Straw' of unknown origins.[71] Farrer was appointed to the New South Wales Department of Agriculture in 1898, where he worked as a wheat experimentalist until his death in 1906.[72]

Farrer introduced wheat from South Africa and India for its adaptability and from Canada for quality, as well as assessing breeding lines for rust, smut and drought 'resistance', milling quality, and climatic adaptability. Some of his varieties were the rust 'resistant' varieties—'Johnathan', 'Cleveland' and 'Genoa', and the smut and rust 'resistant' varieties—'Cedar' and 'Florence'.[73] The later-popular variety 'Federation' ('Canadian Fife' crossed with early maturing

[64] Rudd (1899).
[65] Fotheringham (1995) pp. 32, 33, 39.
[66] Fotheringham (1995) p. 37.
[67] Putnis (1988) pp. 31, 35.
[68] Kieza (2014) p. 256.
[69] Kelly (1879).
[70] Guthrie (1922) para. 6, lines 3–4.
[71] Spennemann (2001) pp. 105, 111, 128, 141, 144.
[72] Guthrie (1922) para 11, lines 1–3.
[73] Although the term 'resistant' was used to describe these varieties, most scientists believe that the rust 'resistance of these varieties was not true genetic resistance to the rust pathogen; rather, the varieties were less prone to stem rust due to physiological traits, such as early maturing.

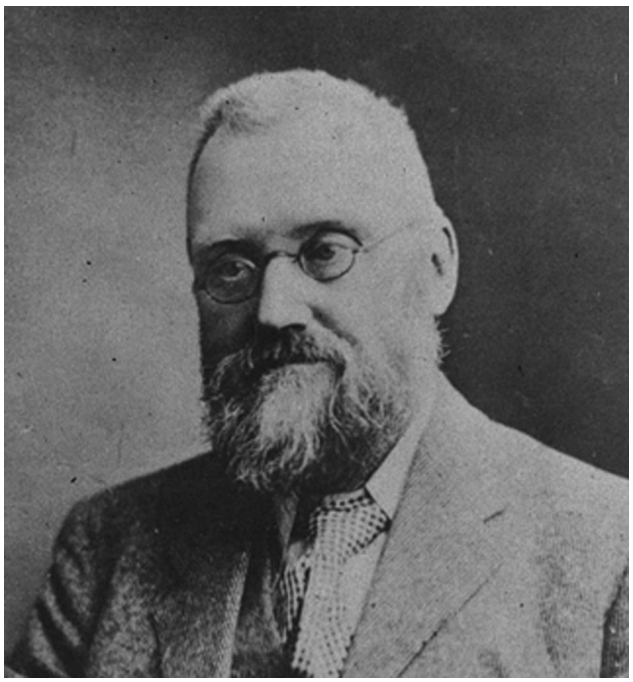

Fig. 3. William Farrer, wheat experimentalist, date unknown but post-1898, State Library of New South Wales, Sydney.

Indian wheats and 'Purple Straw') was released in 1903 and although some workers later disputed that 'Federation' had no effective rust resistance genes, the Australian cereal pathologist McIntosh provided evidence to the contrary. Unfortunately, it was susceptible to flag smut caused by *Urocystis tritici*.[74]

Frederick Bickell Guthrie (1861–1927) agricultural chemist in the New South Wales Department of Agriculture believed that Farrer was unaware of the Mendelian Principles of Inheritance[75] (first published in 1866) until a year before his death, but that he had been conducting his breeding 'along Mendelian lines'.[76] MacIndoe (1940) also defended Farrer's work, noting that although the variety 'Federation' fell short of the rust resistance and baking quality that Farrer would have preferred, it was bred mainly for its stem strength and high yield under drought conditions, which were prevalent in the early 1900s.[77]

Farrer contributed significantly to rust-in-wheat conferences in the 1890s, either via letter (1890) or attendance (1891, 1892, 1894), and 'the master mind of Farrer eventually dominated the proceedings'.[78] Guthrie further stated that: 'He practically ploughed the furrow alone, and yet the practical application of his theories in a short period of time revolutionised wheat-growing in this State and throughout Australia, and in fact, the success of his work did much for wheat-growing throughout the whole wheat world'.[79]

The first three professional plant pathologists in Australia

In the first century after the British colonisation of Australia, state governments apparently did not value or appreciate the need to employ scientists to study the diseases and disorders of crops. It was not until the early 1890s that the situation was rectified. Two of these scientists, Daniel McAlpine and Nathan Cobb were appointed directly in response to the huge losses experienced by growers due to outbreaks of stem rust on wheat in Victoria and New South Wales respectively. The career of the third, Henry Tryon in Queensland, took a different course.

Daniel McAlpine (1849–1932)

Daniel McAlpine (Fig. 4), and his family migrated to Australia from Edinburgh in early 1884 after the death of their infant son. He had received an excellent grounding in the biological and physical sciences at the Royal College of Science, London between 1873 and 1875, in that year being appointed lecturer in agriculture, biology, botany and geology at the Watt Institute and School of Arts, Edinburgh.[80] In Melbourne, he was hired to provide practical classes in botany at Ormond College at the University of Melbourne and in 1886 began teaching botany to students at the Victorian College of Pharmacy.[81] Following a severe epidemic of wheat rust in 1889, the Victorian government appointed him as a consulting Vegetable Pathologist effective from 12 May 1890.[82] A newspaper article published soon after his death stated that his was the 'first fulltime appointment of its kind in the [British] empire'.[83]

He played a significant role in the five intercolonial rust-in-wheat conferences and worked with William Farrer to develop new wheat varieties that were less liable to rust

[74]McIntosh (2007) p. 551.
[75]Gregor Mendel (1822–84) developed three principles of inheritance (dominance, segregation and independent assortment of genetic traits) after experimenting with garden peas, Miko (2008).
[76]Guthrie (1922) para 4, lines 1–2.
[77]MacIndoe (1940).
[78]Guthrie (1922) Commercial value of Farrer wheats, paragraph 2, line 4.
[79]Guthrie (1922) Commercial value of Farrer wheats, paragraph 2, lines 4–5.
[80]Parbery (2015*a*).
[81]Anderson (1933) p. iv.
[82]Anonymous (1890*a*).
[83]Anonymous (1932).

Fig. 4. Participants in the 1891 Rust-in-Wheat Conference. Back, left to right—Daniel McAlpine, William Farrer, H. Kelly, G. Inglis, Nathan Cobb, H. E. Anderson; front, left to right—Mr. Knight, E. M. Shelton, S. Smith, P. McLean, A.W. Pearson. Courtesy of Robert Park.

infection. McAlpine also instructed farmers, horticulturalists and politicians on the roles that fungal pathogens played in diseases of grain, vegetable and fruit crops and he wrote prolifically, including books on fungal diseases of fruit trees, stone fruit and potato, as well as a compilation of plant diseases, and the biology, taxonomy and management of smuts and rusts in Australia.[84]

His illustrious career, however, was affected by disputes with colleagues in the latter years of his working life. After a series of devastating nationwide outbreaks of bitter pit of apples, McAlpine was appointed in 1911 by the Commonwealth and Victorian governments to lead investigations on its cause and control.[85] He negotiated with the then Victorian Minister of Agriculture that he would resume his role as Government Pathologist on the completion of his secondment. After five years experimentation he concluded that the disease was a physiological one and attributed it to the 'extra pressure of the sap in the outer layer of the pulp cells (of apple fruit)' resulting in their bursting, collapse and death as well as the surrounding vascular network, which caused the pits on the surface of the fruit.[86]

He never identified the cause of bitter pit [which we now know to be due to calcium (Ca) deficiency], but the practices that he recommended were enthusiastically accepted by orchardists around the world.[87] Unwittingly, his fertiliser recommendations would have at least partly alleviated the deficiency of calcium in the soil, because superphosphate [probably triple superphosphate] contains 13–15% Ca.[88]

[84]McAlpine (1895, 1899, 1902, 1906, 1910, 1911).
[85]White (2022).
[86]McAlpine (1916).
[87]Parbery (2015*a*).
[88]McLaughlin (2021).

Also, both limestone and bone contain some calcium. McAlpine believed that the continual selection of apple varieties for palatability and size had 'weakened the constitution' of apple fruit at the expense of the integrity of the vascular system.

Unfortunately, during these investigations he was relentlessly challenged by Alfred Ewart (1872–1937), Professor of Botany at the University of Melbourne and Victorian Government Botanist, who was apparently jealous of McAlpine's appointment, mainly on personal grounds.[89] Ewart believed that bitter pit was caused by low concentrations of toxic micronutrients such as mercury, lead and copper, some of which were used in insecticides in orchards at the time.[90] McAlpine had rejected Ewart's hypothesis early in his investigation just as Ewart had rejected McAlpine's conclusions as to the cause of bitter pit. The Australian plant pathologist Douglas Parbery has written a comprehensive and informative book on McAlpine's life and bitter pit investigations.[91]

At the completion of his bitter pit investigations McAlpine sought to be re-instated to his previous government position, but through a combination of the retirement of the agriculture minister who made that promise and Ewart's written attacks, he was neither reappointed nor provided with a pension by the government. He died on 12 October 1932 at Leitchville, Victoria, 'his brilliance [being] overshadowed by perception of failure'.[92]

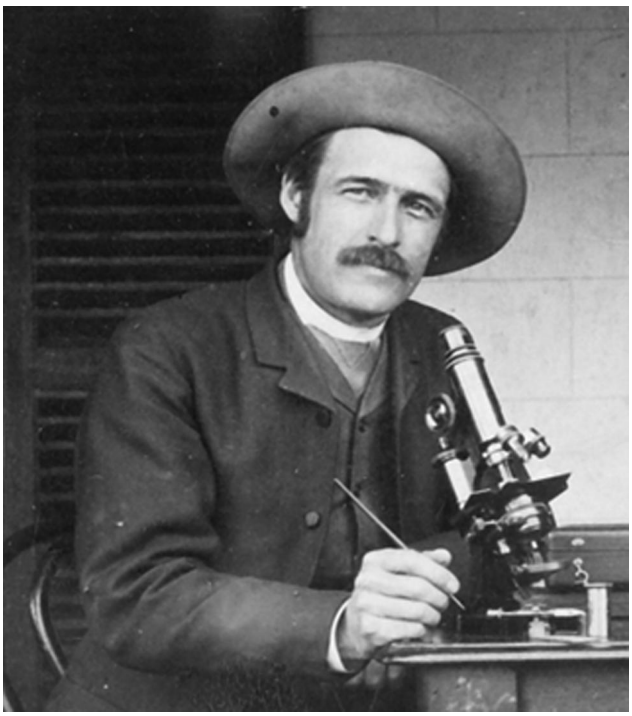

Fig. 5. Nathan Cobb. Photographer and date unknown but taken in Australia. Courtesy of Nathan B. Cobb and the American Society of Nematology.

Nathan Augustus Cobb (1895–1932)

Another of the early plant pathologists in Australia, Nathan Cobb (Fig. 5) also died in 1932 (4 June), but in Baltimore, USA. In his early years in America he progressively worked as a farm labourer with his father, groundskeeper and stable boy, school teacher and science teacher. After marrying in 1881 he and his wife moved to Germany where he studied for, and received a doctorate degree from, the University of Jena in 1887.[93] After he and his family arrived in Sydney on 7 March 1889, Cobb worked in several low-paid jobs including drawing watches, soaps and oils for advertisements for an importer, until being appointed a temporary professor of biology at the University of Sydney in early 1890.[94]

There is some confusion in the literature about when Cobb was appointed to the position of Vegetable Pathologist in the new Department of Agriculture. His daughter, the American animal and plant geneticist Frieda Cobb Blanchard, wrote that he was the first full time plant pathologist in Australia, but that assertion can be challenged.[95] One of his biographers, the Australian cultural heritage academic Dirk Spennemann wrote that he was appointed by the New South Wales Department of Agriculture as a temporary consulting pathologist in March 1890, which was changed to a fulltime position on 1 August of that year.

The evidence suggests that Spannemann's assertion is correct. A newspaper article stated that 'Professor Cobb from the University of Sydney' was appointed as the consulting Vegetable Pathologist in the New South Wales Department of Agriculture in March 1890.[96] His salary in that position was £100.[97] In the *New South Wales Government Gazette* published on 9 September 1890, the appointment of N. A. Cobb BSc, PhD to the Department of Agriculture, effective from 1 August 1890, is acknowledged in proclamation # 7218.[98]

[89] Parbery (2015*a*).
[90] Ewart (1913).
[91] Parbery (2015*b*).
[92] Anderson (1933) p. iv. Parbery (2015*a*).
[93] King (2006). Huettel and Golden (1991) pp. 16–17.
[94] King (2006). Spennemann (2006) p. xix.
[95] Blanchard (1955) p. 232.
[96] Anonymous (1890*b*).
[97] Anonymous (1890*c*).
[98] Anonymous (1890*d*).

As outlined above, Daniel McAlpine was appointed as the Victorian government's consulting Vegetable Pathologist in May 1890 and it can be assumed that it was a fulltime position, because there are no proclamations in the *Victorian Government Gazette* after May 1890 to imply otherwise. So, the available evidence suggests that McAlpine's was the first fulltime appointment of a plant pathologist in Australia. However, Cobb did not waste any time publishing his first scientific paper on plant pathology. It appeared in the July issue of volume 1 of the *Agricultural Gazette of New South Wales* (1890).[99]

Cobb conducted research on the biotic diseases caused by fungi, bacteria, and insects of a wide range of grain, vegetable and fruit crops, but his passion was undoubtedly diseases caused by nematodes. His observations and conclusions on the causes and management of particular diseases were in most cases without question, but it can be said that the study of fungal taxonomy was not one of his passions. He diagnosed the causes of plant diseases from a multitude of farmers, published many papers in the *New South Wales Agricultural Gazette* and also managed the Government Experimental Farm at Wagga Wagga in southern NSW for two years.[100]

In the early 1890s, sugarcane farmers in some of the river valleys in northern New South Wales began to see a new disease which they called 'checked arrowing'. Despite visits to affected crops by some officers of the New South Wales Department of Agriculture its cause remained elusive until Cobb began a thorough investigation in mid-1893. He concluded that the disease was caused by a bacterium whose cells blocked vascular tissue in the stems, naming it *Bacillus vascularum* (now *Xanthomonas axonopodis* pv. *vasculorum*). For a time the disease was known as 'Cobb's gumming disease of sugarcane' but since, Cobb's name has been omitted.[101] The full story of Cobb's discovery is discussed in another article in this issue of *Historical Records of Australian Science*.

A succession of stem rust outbreaks on wheat crops on the eastern seaboard of Australia stimulated various state departments of agriculture to focus on the management of the disease, as outlined above. Like McAlpine, Cobb participated in the rust-in-wheat conferences from 1891 until 1896 and collaborated with Farrer in his quest to develop varieties that were less liable to rust. He published a series of papers on a range of subjects titled 'Contributions to an economic knowledge of Australian rusts (Uredineae)' in the *Agricultural Gazette of New South Wales*. Cobb wrote 568 publications over his career, with over 370 published in Australia.[102]

Cobb found that the nomenclature of wheat varieties in the late 1890s was confused, with the same name applied to different varieties of wheat, and in other cases, different names were applied to the same variety. Consequently, he undertook rigorous observations on the morphological characteristics of different varieties and brought some order to their names.[103] His internationally acclaimed publication *Universal Nomenclature of Wheat* was the culmination of that work.[104] Cobb was also a practical scientist, publishing papers on the use of scientific instruments including the microscope, laboratory techniques, designing agricultural experiments, photography and drawing illustrations.[105]

Cobb's publications on nematodes are considered to be amongst his greatest achievements whilst resident in Australia. His descriptions and drawings of the nematodes that he studied were of the highest quality and accuracy. In 1890 he wrote a short (five-page) article titled 'A nematode formula' in which he proposed the use of a new formula to provide some clarity to the measurements that were used by 'nematelminthologists' in their descriptions of nematodes.[106] During his career, Cobb identified over 1000 nematode species.[107]

However, at least one of Cobb's nematode papers in the *Agricultural Gazette of New South Wales* did not please every reader. The author of one newspaper article took umbrage to a 31-page paper on *Tylenchus* and root gall published in the *Agricultural Gazette of New South Wales*.[108] The writer's sarcasm was fierce—using the phrases 'science run mad', 'may be very well for the classroom', 'little less than humbug', and 'over-scientific'. Cobb's later papers in the journal were of far more practical use to farmers and less 'scientific', so the message must have reached him.

In 1898, Cobb planned to resign from the department and gain experience overseas, but the New South Wales Government appointed him as a part-time special commissioner to visit and report on the state of agriculture and other industries in Europe and America.[109] He returned to his old position in New South Wales in 1901, but then accepted a United States Department of Agriculture (USDA) post in Hawaii in 1905 where he worked mainly on sugarcane pests and diseases for two years. He moved to Washington

[99] Cobb (1890*a*).
[100] Blanchard (1955) p. 232.
[101] Cobb (1893, 1894, 1905*a*).
[102] Spennemann (2006) pp. 1–76.
[103] Spennemann (2006) p. xxii.
[104] Cobb (1905*b*).
[105] Eisenback and Blanchard (2022) p. 147.
[106] Cobb (1890*b*).
[107] Huettel and Golden (1991) p. 15.
[108] Anonymous (1890*e*). Cobb (1890*c*).
[109] Eisenback and Blanchard (2022) pp. 144–146.

where he was appointed an agricultural technologist and in 1918 became the first head of the division of nematology in the USDA.[110] He is recognised as the first scientist to acknowledge nematology as a separate science.

Henry Tryon (1856–1943)

Henry Tryon (Fig. 6) was born on 20 December 1856 in a small town in Devon, England and later abandoned his study at University College, London to pursue his interests in science in Sweden, New Zealand and northern Queensland. He donated his plant and insect collections to the Queensland Museum 1882–3 during which time he became an honorary clerical and scientific assistant, later a permanent employee in that position in September 1883 and then the assistant curator at the museum two years later.[111]

Between 1887 and 1889 he was seconded to the Queensland Department of Agriculture and to a New South Wales royal commission, during which he worked on the control of rabbits, pleuro-pneumonia vaccines, the fruit fly problem and mange-affected livestock.[112] A combination of the time he spent away from his museum duties and aspects of his personality led to a 'fractious' relationship with others at the museum.[113]

His plant pathology work started in 1889 when he published the book *Report on Insect and Fungus Pests No. 1*, which provided the results of surveys of insects and fungal diseases of fruit crops in the Toowoomba region of Queensland.[114] In the following year he reported a serious outbreak of downy mildew of tobacco (caused by *Peronospora hyoscyami*) around the town of Texas in southern Queensland, the first record of that disease in the world.[115] He recommended that growers use preventative sprays of copper sulfate solution, applied before the appearance of the disease, to control the disease.

Tryon was appointed Queensland Government Entomologist in 1894 and Queensland Government Vegetable Pathologist in 1901.[116] Until 1894, the Queensland Colonial Botanist Frederick Manson Bailey had provided plant disease information (mostly new records of fungal pathogens on different hosts or significant outbreaks of disease) for the *Annual Reports of the Department of Agriculture,* when Tryon took over that role as well as reporting on outbreaks of insects on cultivated plants. He was ahead of his time in many aspects. For example, in the 1894–5 *Annual Report* he discussed, at some length, the potential use of fungi to kill insect pests, including scale insects, house flies and cut worms.[117]

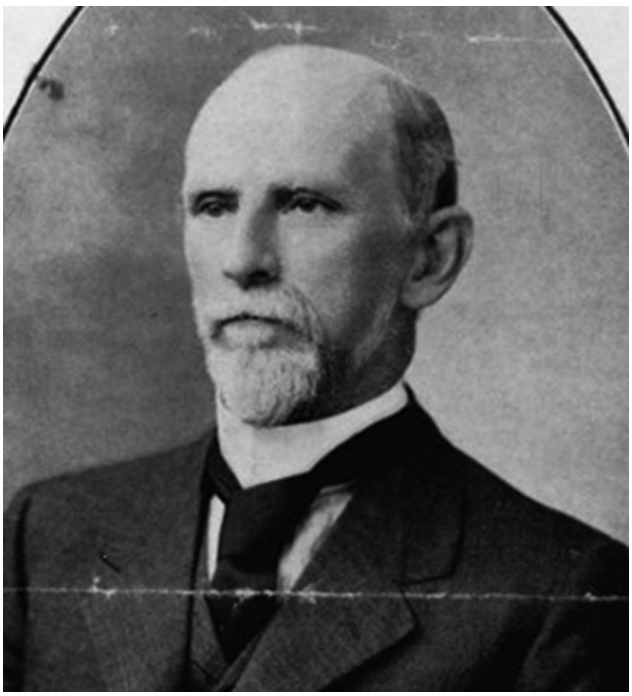

Fig. 6. Henry Tryon, former chief Government Entomologist and Vegetable Pathologist, 1929, John Oxley Library, State Library of Queensland, Brisbane.

Tryon is credited as discovering two new potato diseases in Australia. In 1894 he discovered a disease new to the world (which was dubbed 'Tryon's disease') that was affecting potato crops in several locations in southeastern Queensland. He described the symptoms and signs of the disease, which included a ring of slightly translucent tissue just below the surface of the tuber from which an ooze often exuded. Tryon recognised the causal agent to be a bacterium, naming it *Bacillus vascularum solani* (now known as *Ralstonia solanacearum*).[118]

Thirteen years later he identified late blight (also known as brown rot and Irish blight), caused by the oomycete *Phytophthora infestans* in potato crops in southern Queensland, the first time in Australia. Those crops had been planted using tubers imported from Tasmania where a disease called 'brown rust' was common; late blight and 'brown rust' were the one and same disease.[119] In spite of

[110]Eisenback and Blanchard (2022) p. 155.
[111]Logan (2023).
[112]Logan (2023).
[113]McCarthy and Cohn (2022).
[114]Tryon (1889).
[115]Anonymous (1890*f*).
[116]Logan (2023).
[117]Tryon (1895).
[118]Tryon (1899).
[119]Tryon (1909).

concerted criticism and denials from Tasmanian authorities, Tryon was ultimately proved to be correct in his diagnosis. The full stories of these discoveries are given in this special issue.

Tryon had a long and tumultuous relationship with members of the Philosophical Society of Queensland and its successor the Royal Society of Queensland, due mainly his 'sarcastic tongue, cantankerous nature' and terrorisation of 'inexperienced or ill-prepared speakers' according to one of his contemporaries.[120] Despite his frequent disagreements with the society he was awarded life membership in 1929.[121] Perhaps his nature got him in trouble at times, because in late December 1923 he was assaulted by three men, resulting in a broken nose, contusions and missing teeth.[122] He was taken in a serious condition to the Brisbane general hospital but soon recovered.

Tryon was due to retire from the department in 1921 because of the 65-year age limit at the time, but his services were retained due to his 'special qualifications'[123] and probably because there was no succession plan. He finally retired on 31 December 1925, but stayed on in the department until late June 1929 where he was engaged in 'special entomological work'.[124] Afterwards he lived in 'some poverty as a quasi-pensioner of the State' until his death on 15 November 1943.[125]

Conclusion

It is somewhat unexpected that an exiled 'Irish rebel', Joseph Holt, was the first person to recognise stem rust of wheat in Australia. He was the manager of a number of Captain William Cox's farms, including Brush Farm where he initially found the rust, and in 1803 both he and Cox lost a considerable amount of money to the disease. Rust epidemics became a familiar feature of wheat growing in Australia over the next century and no one had an answer to the problem.

However, some good was to come out of the rust epidemics. In the latter part of 1880s, William Farrer did not wait for governments to act, beginning his own breeding efforts to identify wheat varieties less liable to be severely rusted, at the same time breeding varieties with better drought tolerance and milling qualities. His work laid the groundwork for future wheat breeding in Australia.

Other significant outcomes of the rust epidemics were the appointments in 1890 of Daniel McAlpine and Nathan Cobb as the Vegetable Pathologists in Victoria and New South Wales respectively. These appointments were the first of their kind in the British empire, with both scientists, as well as Henry Tryon, making significant advances in plant pathology knowledge in Australia during their working lives. As modern-day plant pathologists we need to recognise and be proud of their contributions to the development of our profession in Australia.

[120]Simmonds (1991).
[121]Logan (2023).
[122]Anonymous (1923).
[123]Anonymous (1921).
[124]Anonymous (1925, 1929).
[125]Logan (2023).

Supplementary material

Supplementary material is available online.

References

Agricula (1805) To the printer of the Sydney Gazette, *The Sydney Gazette and New South Wales Advertiser* (Sydney), 1 December, p. 2.

Ainsworth, G. C. (1969) History of plant pathology in Great Britain, *Annual Review of Phytopathology*, **7**(1), 13–30. doi:10.1146/annurev.py.07.090169.000305

Anderson, C. (1933) Presidential Address, *Proceedings of the Linnaean Society of New South Wales*, **58**, i–xxv.

Anonymous (1863) New South Wales, state of the crops, *Geelong* Advertiser, December, 2.

Anonymous (1867) Monthly summary, *South Australian Register* (Adelaide), 28 December, p. 4.

Anonymous (1880) Rust in wheat, *The Telegraph* (Brisbane), 8 April, p. 2.

Anonymous(1890*a*) Expert as consulting vegetable pathologist, *Victorian Government Gazette*, **45**, 1978.

Anonymous (1890*b*) Department of Agriculture, *Evening News*, 16 April, p. 3.

Anonymous (1890*c*) The Department of Agriculture, *The Daily Telegraph*, 6 June, p. 4.

Anonymous(1890*d*) Government Gazette appointments and employment, *New South Wales Government Gazette*, **494**, 7008.

Anonymous (1890*e*) The agriculturalist and grazier, *Clarence and Richmond Examiner* (Grafton), 30 August, p. 3.

Anonymous (1890*f*) Tobacco disease, *Brisbane Courier*, 25 June, p. 2.

Anonymous (1896*a*) The rust conference, *Weekly Times* (Melbourne), 6 June, p. 30.

Anonymous (1896*b*) Rust in wheat conference, *Chronicle* (Adelaide), 20 June, p. 41.

Anonymous (1921) Government entymologist: appreciation of Mr Tryon, *Daily Standard* (Brisbane), 2 November, p. 5.

Anonymous (1923) Victim of assault Mr Henry Tryon condition critical, *The Daily Mail* (Brisbane), 29 October, p. 7.

Anonymous (1925) Mr Henry Tryon retiring, *Daily Standard*, 18 December, p. 1.

Anonymous (1929) Fifty years' service, *Toowoomba Chronicle and Darling Downs Gazette*, 3 July, p. 5.

Anonymous (1932) Australia's best, *The Telegraph* (Brisbane), 13 October, p. 11.

Anonymous (2020) *List of Livestock, Provisions, Plants, and Seeds*, First Fleet Fellowship Victoria Inc., https://firstfleetfellowship.org.au/library/first-fleetlist-livestock-provisions-plants-seeds/, viewed January 2020.

Anonymous (2022) *1788 Government Farm established*, Australian Food Timeline, https://australianfoodtimeline.com.au/government-farm/, viewed February 2022 (Note – the location of the government farm on the map in this document is incorrect)

Atkinson, J. (1826) *An Account of Agriculture and Grazing in New South Wales, and of Some of Its Most Useful Natural Productions, with Other Information, Important to Those Who Are About to Emigrate to That Country, the Result of Several Years' Residence and Practical Experience*, 1 edn, J. Cross, London.
Banks, J. (1805) Account of the mildew, *Annals of Agriculture and Other Useful Arts*, **43**, 514–527.
Barrow, J. H., Hogarth, T., Everard, W., Carr, J. and Cavenagh, W. (1868) Report of the rust commission, *South Australian Register*, 10 April, p. 3.
Bethel, W. E. (1931) Hero of 1798—Joseph Holt, Irish chief, *Sun* (Sydney), 3 October, p. 7.
Blanchard, F. C. (1955) Nathan A Cobb, botanist and zoologist, a pioneer scientist in Australia, *The Asa Gray Bulletin*, **3**, 205–272.
Bolton, G. C. (2020) 'Holt, Joseph (1756–1826)', in *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, Canberra, ACT, http://adb.anu.edu.au/biography/holt-joseph-2194/text2831, viewed January 2020.
Cobb, N. A. (1890*a*) Nematode among root crops, *Agricultural Gazette of New South Wales*, **1**, 121–122.
Cobb, N. A. (1890*b*) A nematode formula, *Agricultural Gazette of New South Wales*, **1**, 131–135.
Cobb, N. A. (1890*c*) *Tylenchus* and rootgall, *Agricultural Gazette of New South Wales*, **1**, 155–184.
Cobb, N. A. (1893) Microbe diseases of sugarcane—gumming of cane (*Bacillus vascularum*)', in diseases of the sugar-cane, plant diseases and their remedies, *Agricultural Gazette of New South Wales*, **4**, 777–799.
Cobb, N. A. (1894) The cause of gumming in sugar-cane, *Agricultural Gazette of New South Wales*, **5**, 683–686.
Cobb, N. A. (1905*a*) *Third Report on Gumming of the Sugar-Cane*, Division of Pathology and Physiology Bulletin No. 3, Report of Work of the Experiment Station of the Hawaiian Sugar Planter's Association.
Cobb, N. A. (1905*b*). *Universal Nomenclature of Wheat*, Miscellaneous Publication 539, New South Wales Department of Agriculture, Sydney, NSW.
Collins, D. (1798) *An Account of the English Colony in New South Wales: with Remarks on the Dispositions, Customs, Manners &c of the Native Inhabitants of That Country*, T. Cadell Jun. & W. Davies, London.
Cox, W. (1901) *Memoirs of William Cox, J. P., Lieutenant and Paymaster of N.S.W. Corps, or 102nd Regiment, Late of Clarendon*, Windsor, William Brooks and Co., Sydney, NSW.
Croker, T. C. (ed.) (1838) *Memoirs of Joseph Holt General of the Irish Rebels*, vol. 2, Henry Colburn, London.
Eisenback, J. D. and Blanchard, F. C. (2022) chapter 5, 'The life of Nathan A. Cobb', in *Nematology 101 Unit One: Introduction and History*, ed. J. D. Eisenback, Mactode Publications, Blacksburg, VA, USA and Amazon Kindle Press, pp. 128–182.
Ewart, A.J. (1913) *On Bitter Pit and the Sensitivity of Apples to Poison*, Royal Society of Victoria, Melbourne, VIC.
Fish, S. (1970) The history of plant pathology in Australia, *Annual Review of Phytopathology*, **8**(1), 13–36. doi:10.1146/annurev.py.08.090170.000305
Fotheringham, R. (1995) *In Search of Steele Rudd*, UQP, St Lucia, Qld.
Guthrie, F. B. (1922) *William J. Farrer and the results of his work*, Department of Agriculture, New South Wales.
Hickson, E. (2020) 'Cox, William (1764-1837)', in *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, Canberra, ACT.
Huettel, R. N., and Golden, A. M. (1991) Nathan Augustus Cobb: the father of nematology in the United States, *Annual Review of Phytopathology*, **29**(1), 15–27. doi:10.1146/annurev.py.29.090191.000311
Hunter, J. (1914) Governor Hunter to the Duke of Portland, 29 August 1796, *Historical Records of Australia, Series 1 (Governor's Despatches to and from England)*, **1**, 591–198.
Johnson, G. I. (2010) Shield the young harvest from devouring blight—Charles Darwin, Joseph Banks, Thomas Knight and wheat rust: discovery, adventure and 'getting our message out, *Australasian Plant Pathology*, **39**(1), 1–22. doi:10.1071/AP09068
Kelly, N. (1879) Jerilderie letter, Hanlon copy at https://www.nma.gov.au/explore/features/ned-kelly-jerilderie-letter, original e-copy in State Library of Victoria https://www.slv.vic.gov.au/, viewed February 2020.
Kieza, G. (2014) *Sons of the Southern Cross*, HarperCollinsPublishers Australia, Sydney, NSW.
King, P. G. (1789) *Remarks & Journal Kept on the Expedition to Form a Colony in His Majesty's Territory of New South Wales, etc, Kept by Lieutenant Phillip Gidley King, Second Lieutenant of his Majesty's Ship Sirius Employed on ye Above Expedition*, https://archival.sl.nsw.gov.au/details/archive/110316474, viewed January 2020.
King, P. G. (1803) *List of Plants in the Colony of New South Wales That Are Not Indigenous*, 20 March 1803, King to Banks, SAFE/BANKS PAPERS/SERIES39.83, https://collection.sl.nsw.gov.au/record/9Bv6V3L9, viewed March 2020.
King, P. G. (1915) Governor King to Lord Hobart, 1 March 1804, Historical Records of Australia, Series 1 (Governor's despatches to and from England) 4, 477–495, https://nla.gov.au/nla.obj-475651544/view?partId=nla.obj-475731742#page/n500/mode/1up, viewed March 2020.
King, C. J. (2006) 'Cobb, Nathan (1859-1932)', in *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, https://adb.anu.edu.au/biography/cobb-nathan-augustus-5697, viewed February 2021.
Large, E. C. (2003) *The Advance of the Fungi*, The American Phytopathological Society, St Paul, USA.
Logan, G. N. (2023) 'Tryon, Henry (1856 1943)', in *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, https://adb.anu.edu.au/biography/tryon-henry-8864, viewed July 2023.
MacIndoe, S. L. (1940) William Farrer's contribution to our knowledge of inheritance, *Agricultural Gazette of New South Wales*, **51**, 63–64.
Maiden, J. H. (1928) History of the Sydney botanic gardens, *Journal and Proceedings of the Royal Australian Historical Society*, **14**(1), 1–22.
McAlpine, D. (1895) *Systematic Arrangement of Australian Fungi*, Department of Agriculture, Victoria, Robert S Brain, Government Printer, Melbourne, Vic.
McAlpine, D. (1899) *Fungus Diseases of Citrus Diseases in Australia and Their Treatment*, Department of Agriculture, Victoria. Robert S Brain, Government Printer, Melbourne, Vic.
McAlpine, D. (1902) *Fungus Diseases of Stone-Fruit Diseases in Australia and Their Treatment*, Department of Agriculture, Victoria. Robert S Brain, Government Printer, Melbourne, Vic.
McAlpine, D. (1906) *The Rusts of Australia, Their Structure, Nature, and Classification*, Department of Agriculture, Victoria, Robert. S. Brain, Government Printer, Melbourne, Vic.
McAlpine, D. (1910) *The Smuts of Australia, Their Structure, Life History, Treatment, and Classification*, Department of Agriculture, Victoria, J. Kemp, Government Printer, Melbourne, Vic.
McAlpine, D. (1911) *Handbook of Fungus Diseases of the Potato in Australia and Their Treatment*, Department of Agriculture, Victoria. J Kemp, Government Printer, Melbourne, Vic.
McAlpine D. (1916) *The Cause and Control of Bitter Pit, with the Results of Experimental Investigation*, 5th Report. Albert J Mullett, Melbourne, Vic.
McCarthy, G. J. and Cohn, H. (2022) Tryon, Henry (1856–1943), in *Encyclopedia of Australian Science and Innovation, Centre for Transformative Innovation*, Swinburne University of Technology, https://www.eoas.info/biogs/P000842b.htm, viewed July 2023.
McIntosh, R. A. (2007) From Farrer to the Australian cereal rust control program, *Australian Journal of Agricultural Research*, **58**(6), 550–557. doi:10.1071/AR07148
McLaughlin M. (2021). *Main Characteristics and Agronomic Performance of Triple Superphosphate Fertiliser*, Fertiliser Technology Centre, University of Adelaide, SA.
McLeod, D. (1864) To the acclimatisation society, New South Wales, *Maitland Mercury and Hunter River General Advertiser* (Maitland), 16 July, p. 5.
Miko, I. (2008) Gregor Mendel and the principles of inheritance, *Nature Education*, **1**(1), 13.
Mundle, R. (2014) *The First Fleet*, HarperCollinsPublishers, Sydney, NSW.
Palmer, J. (1805) Commissary's office, *The Sydney Gazette and New South Wales Advertiser* (Sydney), 8 December, p. 1.
Parbery, D. G. (2015*a*) Daniel McAlpine—Father of Australian Plant Pathology, https://appsnet.org/History/DANIEL%20MCALPINE.pdf

Parbery, D. G. (2015*b*) *Daniel McAlpine and the Bitter Pit*, Springer, Cham, Switzerland.
Parbery, I. H., and Sheather, W. H. (1990) 'Aspects of Australian mycology: 1800–1900', in *History of Systematic Botany in Australasia*, ed. P. S. Short, Australian Systematic Botany Society Inc., South Yarra, Vic., pp. 253–258.
Pascoe, I. G. (1990) 'History of systemic mycology in Australia', in *History of Systematic Botany in Australasia*, ed. P.S. Short, Australian Systematic Botany Society Inc., South Yarra, Vic, pp. 259–264.
Paterson A. B. (1905) 'The Old Bush Songs—composed and sung in the Bushranging, Digging and Overlanding Days', in *Old Bush* Songs—Australian digital collections, http://adc.library.usyd.edu.au/data-2/v00030.pdf, viewed March 2020.
Pembroke, M. (2013) *Arthur Phillip: Sailor, Mercenary, Governor, Spy*, Hardie Grant Books, Richmond.
Phillip, A. (1892*a*) Governor Phillip to Lord Sydney, 15 May 1788, *Historical Records of New South Wales*, **1**(2), 121–136.
Phillip, A. (1892*b*) Dispatch from Governor Phillip to Lord Sydney, 28 September 1788, *Historical Records of New South Wales*, **1**(2), 185–193.
Putnis, P. (1988) *Steele Rudd's Australia*, Darling Downs Institute Press, Toowoomba, Qld.
Rudd, S. (1899) On Our Selection, Bulletin, Sydney, NSW.
Simmonds, J. H. (1991) A short history of the early years of plant pathology in Queensland, *Queensland Naturalist*, **31**(1–2), 4–12.
Spennemann, D. H. R. (2006). *Nathan Augustus Cobb, Plant Pathologist—a Bibliography of his Work*, Retrospect, Albury, NSW.
Spennemann, D. H. R. (2001) *Wheat Varieties Grown in 19th Century Australia: a Handlist of Varieties*, The Farrer Centre, Faculty of Science and Agriculture, Charles Sturt University, Wagga Wagga, NSW.
Tench, W. (1793) *A Complete Account of the Settlement at Port Jackson, in New South Wales*, G Nichol, London.
Tryon, H. (1889) *Report on Insect and Fungus Pests No. 1*, Department of Agriculture (Queensland), Brisbane, Qld.
Tryon, H. (1895) 'Report of the entomologist', in *Annual Report of the Department of Agriculture* (Queensland), 1894–95, pp. 36–42.
Tryon, H. (1899) Potato disease, *Queensland Agricultural Journal*, **5**, 57–63.
Tryon, H. (1909) The potato disease [*Phytophthora infestans* (Mont.) deBary], *Queensland Agricultural Journal*, **23**(2), 118–127.
Visser, B., Meyer, M., Park, R. F., Gilligan, C. A., Burgin, L. E., Hort, M. C., Hodson, D.P., and Pretorius, Z. A. (2019) Microsatellite analysis and urediniospore dispersal simulations support the movement of *Puccinia graminis* f. sp. *tritici* from southern Africa to Australia, *Phytopathology*, **109**(1), 133–144. doi:10.1094/PHYTO-04-18-0110-R
von Mueller, F. (1865) Report of the committee on rust and blight in cereals, *The Age* (Melbourne), 24 August, 6.
Waterhouse, W. L. (1936) Presidential address, delivered at the sixty-first Annual General Meeting, 25th March, 1936, *Proceedings of the Linnaean Society of New South Wales*, **56**(1, 2), i–xxxvii.
White, N H. (2022) 'McAlpine, Daniel (1849–1932)', in *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, https://adb.anu.edu.au/biography/mcalpine-daniel-7283, viewed August 2022.
Winmill, M. (2015) *George & Sarah Suttor, Pioneers of Early Australian Agriculture*, Legion Office Works, Castlemaine, Vic.

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