

Mystery of the poisoned expedition

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The Burke and Wills expedition through the interior of Australia in the nineteenth century ended in calamity. But the cause of death was more pernicious than anyone at the time had imagined: beriberi due to thiaminase poisoning.

In 1860–61, the explorers Robert O'Hara Burke, William John Wills, John King and Charles Gray became the first Europeans to cross the Australian continent from Melbourne in the south to the Gulf of Carpentaria in the north. But all except King died on the return journey. The report of the Royal Commission of 1861–63 that "endeavoured to ascertain the true causes of this lamentable result" concluded that the "deplorable sufferings and untimely deaths" might have been averted had not the whole expedition been so badly organized, with insufficient and unreliable back-up.

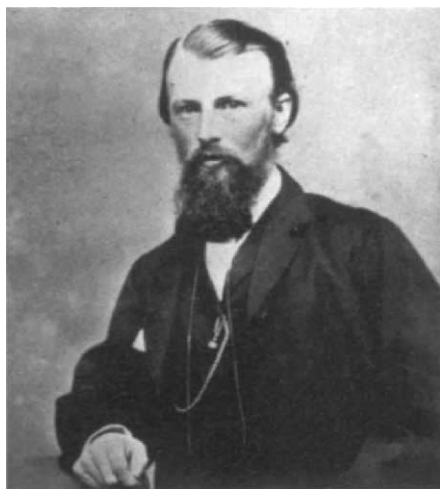
But what about the exact causes of death? It is now clear that the explorers suffered from beriberi, a disease caused by dietary deficiency of thiamine (vitamin B₁). They developed the disease while consuming foods containing large amounts of thiaminase I, an enzyme that breaks down thiamine. Wills's diary, recovered from their final camp at Cooper's Creek, contains a textbook account of the disease — probably the first and only complete description of thiaminase poisoning in humans.

Burke, the leader of the party, was a police inspector. His deputy, Wills, was a scientist who studied chemistry in 1852 with Dr John Stenhouse, a lecturer at St Bartholomews Hospital Medical School in London, England. Wills assisted Stenhouse with his work on food analysis and, after emigrating to Australia, was appointed to the Magnetic Observatory in Melbourne (1857–59) where he studied astronomy and meteorology¹.

The Burke and Wills expedition was set up by the botanist Ferdinand Mueller and other fellows of the Royal Society of Victoria "for transversing the unknown interior of the Australian continent". Its aims were to search for the lost expedition of scientist-explorer Ludwig Leichhardt, collect botanical specimens, identify new species of plants and animals and gather astronomical, meteorological and geographical data, to name but a few. The exploration committee prepared specific instructions for its team of specialists: "The Committee has caused the inclosed set of instructions to be drawn up, having relation to each department of science, and you [Burke] are requested to hand to each of the gentlemen a copy of the part more particularly relating to his department"¹.

On arriving at Menindie, the expedition

was, according to the Commission, "most injudiciously divided at that point by Mr. Burke", and at Cooper's Creek he split the party again, leaving behind all the scientists except Wills. Scientific aims were also abandoned as the expedition became a race to cross the continent



Wills — diarist of the explorers' disease.

before the south Australian expedition led by John McDouall Stuart¹. As the Commission pointed out:

Mr. Burke evinced a far greater amount of zeal than prudence in finally departing from Cooper's Creek before the depôt party had arrived from Menindie, and without having secured communication with the settled districts as he had been instructed to do; and in undertaking so extended a journey with an insufficient supply of provisions, Mr. Burke was forced into the necessity of overtaxing the powers of his party, whose continuous and unremitting exertions resulted in the destruction of his animals, and the prostration of himself and his companions from fatigue and severe privation".

With William Brahe left in charge of the relief party, only Burke, Wills, King and Gray set out from Cooper's Creek and successfully completed the journey to the north coast of Australia. Delayed by monsoons on their return journey and finding their rations depleted, the explorers began to live off the land. Freshwater mussels, abundant in the inland creeks, were gathered from the mud and roasted by Aborigines². As Wills observed: "The well worn paths, the recent tracks of natives, and the heaps of shells, on the contents of which the latter had feasted showed at once that this creek must be

connected with some creek of considerable importance". The explorers also consumed these mussels, although it is uncertain whether they roasted them or ate them raw: "proceeded up the creek; obtained some mussels near where [the camel] Landa died, and halted for breakfast"¹. The freshwater mussel *Velesunio ambiguus* contains a thiaminase I enzyme that breaks down thiamine³.

On returning to Cooper's Creek the explorers found that the relief party had deserted them. With supplies low, they began to eat nardoo, a flour prepared from the sporocarps of the nardoo fern *Marsilea Drummondii* by the local Aboriginal tribes¹. The clover-like fronds of the nardoo fern contain a hundred-fold more thiaminase than bracken-fern fronds, and the sporocarps of nardoo have two to three times more thiaminase activity than bracken-fern fronds³. Bracken poisoning due to consumption of bracken fern causes the staggers in horses⁴, and sheep that feed on nardoo in western New South Wales develop a similar thiamine-deficiency disease³.

Wills meticulously observed and recorded the explorers' symptoms and suffering in his journal. Gray, a British sailor, was the first to succumb on the return journey: "Halted 15 minutes for Gray who pretended he could not walk". Gray instinctively seemed to know he needed more of the precious flour ration, the party's main source of thiamine. "I found Gray behind a tree eating Skilligoollee. He explained that he was suffering from dysentery and had taken the flour without leave". Wills thought Gray was malingering but later notes: "This morning about sunrise Gray died. He had not spoken a word distinctly since his first attack"⁵.

Even before they began to eat nardoo, the other three explorers were showing preliminary signs of beriberi:

Our legs almost paralysed so that each of us found it a most trying task only to walk a few yards. Such a leg bound feeling I never before experienced and hope I never shall again. The exertion required to get up a slight piece of rising ground, even without any load, induces an indescribable sensation of pain and helplessness, and the general lassitude makes one unfit for anything. Poor Gray must have suffered very much, many times when we thought him shamming. It is most fortunate for us that these symptoms which so early affected him, did not come on us until we were reduced to an

exclusively animal diet of such an inferior description as that offered by the flesh of a worn out and exhausted horse [ref. 5].

The explorers recovered remarkably on the rations left by their relief party. But once they began collecting nardoo and preparing their own nardoo flour, their health progressively deteriorated. From weakness and pain in the legs, they developed metabolic insufficiency, muscle wasting and hypothermia until they were completely unable to move. Burke and Wills eventually died:

King out collecting nardoo. Mr. Burke and I at home, pounding and cleaning. I still feel myself, if anything, weaker in the legs, although the nardoo appears to be more thoroughly digested. . . found myself altogether too weak and exhausted; in fact, had extreme difficulty in getting across the numerous little gullies, and was at last obliged to camp from sheer fatigue. . . . The cold plays the deuce with us from the small amount of clothing we have. . . . Mr. Burke suffers greatly from the cold and is getting extremely weak. . . . My pulse are at forty-eight, and very weak, and my legs and arms are nearly skin and bone. I can only look out, like Mr. Micawber 'for something to turn up', but starvation on nardoo is by no means very unpleasant, but for the weakness one feels, and the utter inability to move oneself, for as far as appetite is concerned, it gives me the greatest satisfaction. Certainly, fat and sugar would be more to one's taste, in fact, those seem to me to be the great standby for one in this extraordinary continent, not that I mean to depreciate the farinaceous food, but the want of sugar and fat in all substances obtainable here is so great that they become almost valueless to us as articles of food, without the addition of something else [ref. 5].

In his last letter to his father, Wills writes that their food does not nourish them: "These are probably the last lines you will ever get from me. We are on the point of starvation, not so much from absolute want of food, but from the want of nutriment in what we can get". Wills was left alone to die in his humpy with a supply of nardoo¹.

King, the only member of the party to survive, also described the effects of thiaminase poisoning in his report to the Commission:

We gathered some nardoo and boiled the seeds as we were unable to pound them. . . . I had now to gather and pound for all three of us. I continued to do this for a few days but finding my strength rapidly failing, my legs being very weak and painful, I was unable to go out for several days. . . . From the time we halted Mr. Burke seemed to be getting worse, although he ate his supper. That night he spoke very little, and the following morning I found him speechless, or nearly so, and about eight o'clock he expired.

King was cared for by local Aborigines, living on nardoo, fish and game such as

crows⁵, until he was eventually rescued. From the description by Wills's father, Dr William Wills, it is clear that even after King had returned to Melbourne and regained his strength on a normal diet, he remained crippled. "On reaching Government House, King was assisted upstairs, for although he looked very healthy and robust, he was scarcely able to stand"¹. King had developed a permanent peripheral neuropathy as a result of prolonged thiamine deficiency.

Burke and Wills prepared nardoo in the traditional European way for grains by grinding and cooking. But the nardoo fern is well adapted to the extreme temperatures of inland Australia and its thiaminase enzyme is very resistant to heat³; nardoo spores will still germinate from sporangia that have been boiled in water for 15 minutes⁶.

By contrast, Aborigines of the Cooper's Creek area prepared nardoo by grinding it to a thin paste with water and keeping it out of contact with other organic material, a custom described by B. Kerwin: "Then there is the nardoo; they crush it and then rock it in a coolamon. Then they pour water on it and eat it with the water. What then? Well, they eat it by spooning it into their mouths with a mussel (shell), not with a coolibah leaf or with bark, only with a mussel (shell)"⁷. The Aborigines drank the water used in the preparation and apparently used the raw flour to make cakes and bread. "On our arrival at the camp, they led us to a spot to camp on and soon afterwards brought us a lot of fish and bread, which they call nardoo". The flour was also stored for later consumption. "I found some gunyahs where the natives had deposited a bag of nardoo sufficient to last me a fortnight"⁵.

The thiaminase I of nardoo requires endogenous co-substrates such as proline, hydroxyproline or adenine; scarcity of these substances in nardoo severely restricts the enzyme's action³. The kinetics of nardoo thiaminase³ shows that dilution with water rapidly diminishes the enzyme's activity: enzyme, thiamine and co-substrates are all diluted out. The Aboriginal method of preparing nardoo — grinding with water and preventing contamination by extraneous sources of co-substrates — would have reduced the enzyme's action. (One of us (J. W. E.) tried to get hold of samples of nardoo from Cooper's Creek but was prevented by floods. Plants have now been obtained from a nursery in Sydney, and as soon as they produce sporocarps it should be possible to compare the amounts of thiamine in different preparations).

Unfortunately, Wills failed to appreciate the need for leaching of nardoo flour with water, even though the technique had been demonstrated to him by an Aborigine he referred to as Pitchery:

The fish being disposed of, next came a supply of nardoo cake and water until I was so full as to be unable to eat any more, when Pitchery, allowing me a short time to recover myself, fetched a large bowl of the raw nardoo flour mixed to a thin paste, a most insinuating article, and one that they appear to esteem a great delicacy [ref. 5].

Wills was nevertheless aware of the need for essential nutrients. He identified the portulac plant *Portulacae oleraceae* and convinced the other explorers to eat its leaves to prevent scurvy or "Barcoo rot".

Half a century after the Burke and Wills expedition, a substance termed "vitamine", which could cure the weakness of beriberi, was isolated from rice, bran, yeast and other foods⁸. Thiamine occurs in the outer husks of most cereal grains and its discovery led to rapid progress in isolating and identifying other vitamins. But in 1861, stranded at the edge of the desert in central Australia, Wills, carefully observing his situation, glimpsed and recorded in his diary a fundamental truth:

We were not long in getting out the grub that Brahe had left, and we made a good supper off some oatmeal porridge and sugar. This, together with the excitement of finding ourselves in such a peculiar and almost unexpected position, had a wonderful effect in removing the stiffness from our legs. Whether it is possible that the vegetables can so have affected us, I do not know, but both Mr. Burke and I remarked a most decided relief and a strength in the legs greater than we had for several days. I am inclined to think that but for the abundance of portulac that we obtained on the journey, we should scarcely have returned to Cooper's Creek at all [ref. 5]. □

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