

Wound dressing in World War I - The kindly *Sphagnum* Moss

An unsung hero? **Peter Ayres** relates the wartime role of this useful moss

△ *Sphagnum fimbriatum* with capsules. Jeffrey G. Duckett

The doctors and the nurses
Look North with eager eyes,
And call on us to send them
The dressing that they prize
No other is its equal---
In modest bulk it goes,
Until it meets the gaping wound
Where the red life blood flows,
Then spreading, swelling in its might
It checks the fatal loss,
And kills the germ, and heals the hurt-
The kindly *Sphagnum* Moss

△ Mrs AM Smith (1917). A member of the Edinburgh War Dressings Supply organisation (Archives reference: RBGED #42)

Millions of wound dressings made from *Sphagnum*, or 'bog moss', were used during World War I (1914-1918). Dried *Sphagnum* can absorb up to twenty times its own volume of liquids, such as blood, pus, or antiseptic solution, and promotes antiseptis. *Sphagnum* was thus superior to inert cotton wool dressings (pure cellulose), the raw material for which was expensive and increasingly being commandeered for the manufacture of explosives.

Charles Walker Cathcart, an Edinburgh surgeon, organised collections of the moss throughout Scotland, and centres for its cleaning and preparation. Most collecting was done by women and children (often boy scouts or girl guides) working for long hours in cold, wet bogs. Cathcart's model soon spread to Ireland and to areas in England, such as Dartmoor, where bog moss was abundant. By 1917-18 collections were being made in Canada, mostly under contract from the British War Office, and in the USA, which had recently entered the war. The preferred species in all countries were *S. papillosum* and *S. palustre* (Fig. 1).



△Fig. 1: *Sphagnum palustre*. Jeffrey G. Duckett

Sphagnum and war wounds

Sphagnum moss has been used for centuries to bind wounds suffered in battle. Ancient Gaelic-Irish sources say warriors wounded in the battle of Clontarf, 1014, stuffed their wounds with moss, while Highlanders after the battle of Flodden, 1513, are said to have staunched their wounds by filling them with a mixture of bog moss and soft grass (McCutcheon, 1916; The Scotsman, 31 October 1916). In more recent times *Sphagnum* was used on a small scale as a means of first aid during both the Franco-Prussian and Crimean wars (Porter, 1917). However, it was during World War I that *Sphagnum* came to be employed on an unprecedented scale, with the manufacture of dressings and pads becoming highly industrialised on both the German (Hotson, 1921a,b) and, as recounted here, Allied sides of the conflict.

From small beginnings, initiated by Lieutenant-Colonel Charles Walker Cathcart RAMC (T) in late 1914, the number of dressings manufactured rose dramatically as the war progressed. Cathcart was an Edinburgh surgeon then on wartime duty as Consulting Surgeon to military hospitals in the Edinburgh region, in which he was able to conduct trials with *Sphagnum* dressings. After February 1916, when the Director General of Army Medical Services, Sir Alfred Keogh, placed *Sphagnum* on the list of materials approved by

the War Office as suitable for surgical dressings, supply could never keep up with demand (The Scotsman, 16 June 1916). In June 1916, Cathcart's 'Edinburgh War Dressings Supply' organisation sent out almost 20,000 dressings, its recipients including the 3rd London General Hospital in Wandsworth, the 2nd General Hospital, British Expeditionary Forces, France, and the 1st Canadian General Hospital, Etaples (RBGED #44). By the end of that year, Britain was producing 200,000 dressings per month, a figure which by the end of the war two years later had risen to 1,000,000 per month (Nichols, 1920). Testimonials flooded in from all theatres of war:

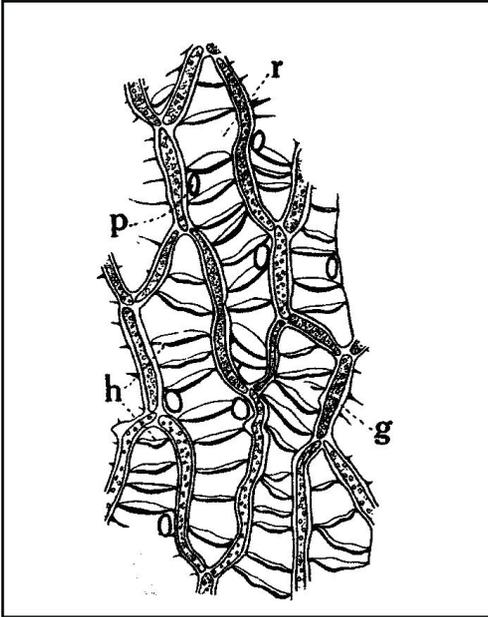
'I should be so glad to get more of both [sorts] if you can send them, particularly the Moss.'

W.E. Thompson, First British Ambulance Unit for Italy (RBGED #12)

'It is very absorbent, far more so than cotton wool, and has remarkable deodorising power. I consider it a valuable addition to the materials at our disposal for the dressing of wounds.'

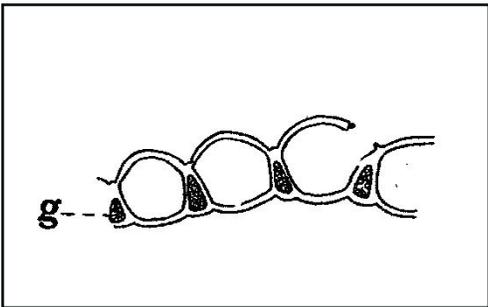
Lieut.-Col. E.P. Sewell, RAMC, No.15 General Hospital, Alexandria, Egypt (RBGED #12)

As well as providing its own forces with dressings, Canada became a major supplier to



<Fig. 2 top: a leaf of *Sphagnum palustre* as seen from above by Hotson (1921a)

<Fig. 3 bottom: a leaf of *Sphagnum palustre* in transverse section by Hotson (1921a)



British hospitals, the War Office ordering 20 million dressings from Canadian sources in 1918 (Riegler, 1989). In the United States, which had joined the war on 6 April 1917, the Seattle chapter alone provided US forces with 50,000 pads in 1918 (Hotson, 1918).

Cathcart, Balfour and the peculiar properties of *Sphagnum* moss

The enterprise might never have started and the benefits of *Sphagnum* might have remained unrealised by the Allies if it had not been for the combined efforts of Cathcart and his friend Professor Isaac Bayley Balfour, Regius Keeper of the Royal Botanic Garden, Edinburgh (RBGE) (Ayres, 2014). In November 1914 they wrote an anonymous article for *The Scotsman* newspaper

which told how the value of *Sphagnum* dressings had long been recognised in Germany. They pointed to the extraordinary capacity of *Sphagnum* to absorb and retain water, reporting that 10 ounces of dried moss could hold 70 ounces of water. It was subsequently found that the best dried moss would absorb 20 to 22 times its own weight of water before dripping (Porter, 1917). The moss could equally well absorb blood, pus, lymph, or other bodily fluids, being at least twice as absorptive as cotton wool. (Supplies of cotton wool – all of which had to be imported – were increasingly being commandeered by the military for the manufacture of gun cotton, or nitrocellulose explosive.)

Sphagnum moss was far from inert, for unlike cotton wool, it had antiseptic properties, which were of inestimable value to surgeons and nurses. Medical staff who had experience of the Boer War, only twelve years earlier, were shocked by the high rate of wound infections in WWI. A critical difference was that the uniforms of soldiers in WWI were relatively filthy, contaminated with soil bacteria from the muddy battlefields, mixed with sewage bacteria that commonly contaminated the trenches. Thus, as bullets and shrapnel penetrated flesh, they carried fragments of dirty uniform deep into the soldier's body, commonly resulting in infected, suppurating wounds that required limbs to be amputated to avoid septicaemia (*The Scotsman*, 16 June 1916). Unfortunately, the antiseptic chemicals available to surgeons were unreliable. Although many worked well in dilute aqueous solution, i.e. *in vitro*, they performed poorly in blood, body

fluids, or pus. They did not penetrate blood clots or tissues and were selective in the bacteria they killed. The antiseptic properties of *Sphagnum* could not be explained at the time, but that scarcely mattered.

We now know that cell walls of *Sphagnum* are exceptionally rich in a family of pectic polysaccharides, collectively called 'sphagnan'. Uronic acids, the monomers from which the polysaccharide chains are built, comprise 10-30% of the dry weight of the moss. These uronic acids become ionized at $\text{pH} > 2$. Ecologists have known for many years that *Sphagnum* has a high cation exchange capacity, exporting hydrogen ions (protons, H^+) and importing cations such as Na^+ , K^+ , Ca^{++} and Mg^{++} . The moss thus sequesters inorganic ions from its nutrient-poor environment, while acidifying its surroundings (Clymo, 1963; Clymo & Hayward, 1982). Recent evidence from Scandinavia where the moss is used to pack fresh fish – in the laboratory it has been shown to slow the onset of putrefaction of Zebra fish – points to the antiseptic properties of the moss being explained simply by the capacity of *Sphagnum* cell walls to lower the pH of their environment sufficiently to inhibit the growth of bacterial colonies (Stalheim et al., 2009). The pH of human blood is approximately 7.4, this value being close to the optimum for most pathogenic bacteria, so any lowering of the pH will serve to inhibit bacterial growth.

The medical properties of *Sphagnum* are further related to the plant's natural environment, those wet, highly acidic bogs which it helps to create. Its simple stems are tightly enclosed by small leaves, each one cell thick. As was recognised at the time, green photosynthetic cells are separated by relatively large, long, dead, achlorophyllous 'hyaline' cells (Fig. 2). The latter make up 90% of the leaf volume. Their function is to store water,

which is absorbed via surface pores, typically 10-15 μm in diameter, thereby protecting the plant from desiccation (Glime, 2007). Storage is facilitated because the walls of hyaline cells are spirally thickened, which helps prevent their collapse if the leaf begins to dry. Pathogenic bacteria (commonly 3 μm in diameter) can easily pass into these hyaline cells, as can human blood cells (erythrocytes average 8 μm diameter).

The absorbent properties of *Sphagnum* meant that it could be used not only in wound dressings and as surgical swabs but also in the form of larger and less compact cushions which kept beds dry while wounds were being irrigated to wash bacteria out of deep wounds. One of the most widely used and successful of such methods was the Carrel-Dakin method. Dakin's solution - a mixture of hypochlorous acid and boric acid - was pumped through perforated rubber tubes inserted into deep wounds. As one experienced nursing sister 'somewhere in France' told Cathcart in 1916, the method required lots of equipment and hard work on the part of nurses because, "the beds have to be arranged in the way of pads and mackintoshes to prevent a wet bed from the overflow of fluid. All this, however, is fully compensated when one sees how very quickly the wounds improve under the treatment, and how painless the dressings are. For keeping the beds dry the *Sphagnum* moss dressings are invaluable, and we are very grateful indeed to the workers who make them" (The Scotsman, 12 September 1917). There was one further use for moss pads, which was cushioning broken limbs.

Significantly, the pectin used in the study above (Ballance et al., 2012) was from *S. papillosum*, one of the species favoured for wound dressings, and its cation exchange capacity was increased in the presence of chlorite, which suggests that the effectiveness of *Sphagnum* dressings *in situ* was

enhanced by the presence of chlorine-generating antiseptics, such as in wound irrigation.

Sphagnum spp. around the world

Of the hundred or more *Sphagnum* species known, not all occur abundantly in northern Europe or North America. Moreover, the most readily available species were not equally suitable for the required purposes. Therefore, firstly in Scotland, and later in Canada and the USA after those countries had joined the war, much effort went into selecting the optimum species for use. In Scotland, those efforts were able to draw upon the resources of the Royal Botanic Garden, Edinburgh, of which Balfour was the head. He and his 'moss expert', R Chapman Davie, identified the many samples which The Scotsman article prompted would-be collectors to send to Cathcart. Thus, on 27 April 1915, Balfour wrote to Cathcart, "The moss is *Sphagnum* – *S.CUSPIDATUM* [sic], Ehr. - but it is not so good as the broader-leaved form *S.CYBIFOLIUM* [syn. *S. palustre*]. Its leaves are narrower and the tracheidal cells are narrower and it is not nearly so absorptive. As you evidently observed it crumbles much more easily and the leaves do not cover the stem so fully" (RGBEd #9).

Much of their time was wasted by naive or overenthusiastic collectors. With his garden in mind, a County Medical Officer from Newcastle-upon-Tyne enquired via Cathcart whether "it would be advantageous to plant it [*Sphagnum*] around some ferns in a border which is liable to become too dry" (RGBEd #2). To which Balfour replied, "You must tell your correspondent that he can only grow *Sphagnum* if his garden is a swamp" (RGBEd #3). On 4 May 1915, Cathcart wrote to Balfour, "A man Gordon has sent us from Yell, Shetland, five large sacks of moss of which I enclose samples. We had 7s.8p [seven

shillings and eight pence] to pay for carriage and it seems to be useless, not *Sphagnum* at all. Am I right?" (RGBEd #5). Balfour's answer is not recorded.

Occasionally, Balfour gave advice about the way the collected moss should be treated. On 27 March 1916, he wrote to Cathcart, "It has occurred to me that if you receive much of the *Sphagnum* from collectors in the compressed state of which you showed me a sample and which breaks so much in the process of cleaning that if you thought it worthwhile you might get over the crumbling difficulty by placing the compressed mosses in water. The stem could then be readily separated and redried" (RGBEd #30). He added that drying at room temperature, rather than in an oven, might reduce brittleness – something he confirmed by experiment a few days later (RGBEd #31). Any measure to reduce brittleness would have been very important because one of the few complaints nurses had about moss dressings was that they were friable, leaving much dust in hospital wards.

As well as dealing with all the samples sent to him, Cathcart was busy organising trials of moss dressings in the large war hospitals in Scotland (Nichols, 1920). The 'War Dressing Supply (*Sphagnum* Moss)' organisation, with its headquarters at 37, Palmerston Place, Edinburgh, was formed in April 1915 (RGBEd #17), its purpose being not only to encourage more collection but to organise the timing of those collections. By midsummer 1916, Balfour's deputy at the RBGE, William Wright Smith, had completed a lengthy and detailed report on potential sites for the collection of *Sphagnum* throughout Scotland that would serve as a guide for collectors (RGBEd #16). There was also a brief Addendum containing instructions on the best methods for collecting the moss. Smith's recommendations were reworked in a



△*Sphagnum tenellum*. Jeffrey G. Duckett

separate leaflet produced by the Edinburgh War Dressings Supply organisation and reprinted in *The Educational News* (16 June 1916), where schoolteachers were urged to organise collecting parties of young people during the school holidays. *S. palustre* (syn. *S. cymbifolium*) was the species Smith recommended for collection, its leaves being a duller green than those of most other species and, therefore, more easily recognised. In both Britain and North America this species and *S. papillosum* were generally favoured on the basis of the efficacy of the wound dressings they produced, and of the ease with which those dressings could be prepared. In North America, *S. imbricatum* was a widely used acceptable alternative (Nichols, 1918).

Collecting *Sphagnum*

In September 1916, the *London Graphic* carried the headline “Are You Collecting *Sphagnum* Moss?”. It told its readers, “the collecting, drying and making into surgical dressings of *Sphagnum* moss has become a national industry in Scotland...the work is being extended all over Ireland, England and Wales”, noting that Sir Edward Ward, Director General of Voluntary Organisations, had established central depots all over Great Britain to receive and forward the material to war hospitals (Porter, 1917).

The collection of *Sphagnum* was, of course, restricted to the cooler, wetter parts of Britain

so, unsurprisingly, the main centres for the production of dressings in Britain were located in Edinburgh and Dublin. However, collections on a smaller scale were made wherever there were significant *Sphagnum* bogs, such as around Princetown on Dartmoor, in England, where the Prince of Wales provided and equipped a depot for moss collection on his Duchy of Cornwall lands (*The Times*, 23 February 1918). The depot, “sweet with whitewash and antiseptics, heated by hot air from a furnace, and full of women clad and capped in spotless white”, was a long way in spirit, if not in practice, from the unnamed man, knee-deep in the great bogs and mires of Dartmoor, whom *The Times* reported on 3rd September 1918 had collected nearly 5,000 sacks of moss since last spring.

The whole process of producing dressings, from collection of the moss to the despatch of prepared dressings, was labour intensive and carried out largely by volunteers. It being wartime, these were typically women, children, and elderly men. Collection of the moss was a relatively unskilled task and, given the presence of one person who could correctly identify the moss, it could be carried out by unskilled volunteers. The moss would often be picked clean of dirt and any adhering leaves and twigs on site before being partially dried, put into sacks and sent to one of a

small number of centres dedicated to producing dressings. At these centres, the more specialised activities of washing ('sublimating'), drying, and weighing, and the final preparation of dressings – sometimes incorporating antiseptics – were conducted under expert supervision. The moss could be made into a variety of dressings. Whereas most military hospitals in Britain and the large base hospitals in France preferred to sterilise their own dressings, smaller and more distant hospitals generally preferred ready prepared dressings (The Graphic, 2 September 1916). Mobile units favoured compressed dressings, something which the Edinburgh unit was readily able to supply after a new works, with powerful hydraulic presses, was opened in Easter Road (The Scotsman, 14 December 1915).

All three species recommended by Smith were abundant and could be collected with 'relative' ease, though, as one Scottish organiser noted, given the distribution of bog mosses, this often entailed "bare-legged lassie[s] working for hours in the cold driving rain, more than 1000 feet above sea level, with a 20 mile run home in the Transport ahead of them before they could thaw at their own firesides!" (RBGED #18). Expeditions were not always so grim. An Edinburgh Scoutmaster, Alexander McCutcheon, reported that, "On our May holiday [1915] I took the whole troupe on a prospecting outing over the hills (pipe band, side drums, etc.), and showed them the moss. On the top of Craig Buidh we had a tune on the pipes, then I gave them a lesson on *Sphagnum* moss" (McCutcheon, 1916). By midsummer, his most 'experienced' scouts were being used to guide groups of holidaymakers on moss-collecting excursions even though, as McCutcheon pointed out, the damp tablelands and glens (all above 1000 feet) were in summer the haunts of mosquitos and midges, "most undesirable pests when your hands are wet and

you are standing on a small tuft of grass with spongy moss holes all around." On 31 August 1917, The Scotsman reported that when the Chief Scout, Sir Robert Baden-Powell, had visited Edinburgh a day earlier he had been told that many guides and brownies had stopped working for 'Tenderfoot' and 'efficiency' badges in favour of war work, picking *Sphagnum* moss and gathering medicinal herbs. Sir Robert – an old soldier – gave his full approval.

Cathcart's example was to spread around the world. In Ireland – where one seventh of the country was bog – his work was noticed by Lady Waterford, President of the Irish Saint John's Ambulance Brigade, and John Lumsden, its Commandant. Among the main activists were Elsie Henry, wife of the professor of Forestry at the Royal College of Science of Ireland (RCScl) and a daughter of an eminent London doctor, and Mabel Wright, who had studied botany at the College. With others they travelled to Edinburgh to be instructed by Cathcart. On their return to Dublin they established in November 1915 at the RCScl an Irish Central Depot for *Sphagnum* collection, recognised by the War Office. The committee of the RCScl negotiated free or reduced charges with the Irish railways for the transportation of dried moss to Dublin. From the various railways termini in Dublin, lorries and carts were provided free by Dublin businesses to bring sacks and bales of dried moss to the Centre (Cullen, 2013). Dressings were dispatched to almost sixty hospitals in various theatres of war. Among those who worked briefly at the Centre while on a visit to Dublin was Elsie Henry's Canadian sister-in-law, whose father was Professor John B. Porter of McGill University, Montreal. Porter was at the time studying peat (derived from *Sphagnum*) as a fuel source for the Canadian government (Riegler, 1989). It was a seminal connection for it is Porter who, having

quickly recognised a new use for *Sphagnum*, is generally accepted as having introduced to North America the practice of collecting and preparing wound dressings from the moss (Nichols, 1920).

The Flanders Poppy

The Flanders poppy (*Papaver rhoeas*), which thrived in the battlefields of the Western Front as exploding shells brought its dormant buried seeds to the surface, will forever be associated with remembrance of the dead of that conflict thanks to its celebration in John Mc Crae's poem, In Flanders Fields. After the war it was adopted as the badge of war veterans' organisations in America, France, and then Britain. However, there is another plant deserving equal celebrity because of the life-saving practical role it played in the war, it is the humble *Sphagnum* or bog moss. The significance of this small, unglamorous, lower plant has been undeservedly overlooked.

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References

- RBGE**. Archives of the Royal Botanic Garden, Edinburgh, Balfour letters (number #).
- Ayres, P.G. (2014)** Isaac Bayley Balfour, *Sphagnum* moss, and the Great War. *The Linnean* (submitted).
- Ballance, S., Kristiansen, K.A., Skogaker, N.T., Tvedt, K.E. & Christensen, B.E. (2012)** The localisation of pectin in *Sphagnum* moss leaves and its role in preservation. *Carbohydrate Polymers* **87**: 1326-1332.
- Clymo, R.S. (1963)** Ion exchange in *Sphagnum* and its relation to bog ecology. *Annals of Botany* **27**: 309-324.
- Clymo, R.S. & Hayward, P.M. (1982)** The ecology of

Sphagnum, in Smith A.J.E.ed. *Bryophyte Ecology*, pp.229-289. London: Chapman and Hall.

- Cullen, C. (2013)** *The World Upturning. Elsie Henry's Irish Wartime Diaries, 1913-1919*. Dublin: Irish Academic Press.
- Glime, J.M. (2007)** Bryophyta-Sphagnopsida, chapter 2.5 in *Bryophyte Ecology*, volume I, *Physiological Ecology*. Michigan Technical University and the International Association of Bryologists. (an ebook available at www.bryocol.myu.edu).
- Hotson, J.W. (1918)** *Sphagnum* as a surgical dressing. *Science*, **48**: 203-208.
- Hotson, J.W. (1921a)** *Sphagnum* used as a surgical dressing in Germany during the World War. *The Bryologist*, **24**: 74-78.
- Hotson, J.W. (1921b)** *Sphagnum* used as a surgical dressing in Germany during the World War. *The Bryologist*, **24**: 89-96.
- McCutcheon, A. (1916)** The harvesting of *Sphagnum* moss. *The Pharmaceutical Journal and Pharmacist*. 23 December, 587-589.
- Nichols, G.E. (1918)** The American Red Cross Wants Information. Regarding supplies of surgical *Sphagnum*. *The Bryologist* **21**: 81-83.
- Nichols, G.E. (1920)** *Sphagnum* moss: war substitute for cotton in absorbent dressings, in *Annual Report of the Board of Regents of the Smithsonian Institution 1920*, pp.221-234. Washington: Government Printing Office.
- Porter, J.B. (1917)** *Sphagnum* moss for use as a surgical dressing: its collection, preparation and other details. *Canadian Medical Association Journal* **7**: 201-207.
- Riegler, N. (1989)** *Sphagnum* moss in World War I: the making of surgical dressings by volunteers in Toronto, Canada, 1917-1918. *Canadian Bulletin of Medical History/ Bulletin canadien d-histoire de la médecine* **6**: 27-43.
- Stalheim, T., Ballance, S., Christensen, B.E. & Granum, P.E. (2009)** Sphagnan – a pectin-like polymer isolated from *Sphagnum* moss can inhibit the growth of some typical food spoilage and food poisoning bacteria by lowering the pH. *Journal of Applied Microbiology* **106**: 967-976.
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