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Naming names: the first women taxonomists in mycology

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Abstract: The transition from amateur to professional in natural history is generally regarded as having taken place in the nineteenth century, but landmark events such as the 1917 appointment of mycologist Johanna Westerdijk (1883–1961) as the first female professor in the Netherlands indicate that the pattern of change for women was more varied and delayed than for men. We investigate this transition in mycology, and identify only 43 women in the Western World who published scientific mycological literature pre-1900, of whom twelve published new fungal taxa. By charting the emergence of these women over time, and comparing the output of self-taught amateurs and university graduates, we establish the key role of access to higher education in female participation in mycology. Using a suite of strategies, six of the self-taught amateurs managed to overcome their educational disadvantages and name names — Catharina Dörrien (the first to name a fungal taxon), Marie-Anne Libert, Mary Elizabeth Banning, Élise-Caroline Bommer, Mariette Rousseau, and Annie Lorrain Smith. By 1900, the professional era for women in mycology was underway, and increasing numbers published new taxa. Parity with male colleagues in recognition and promotion, however, remains an ongoing issue.

Key words: Amateurs, Fungi, Gender studies, History of science, Plant pathology.

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INTRODUCTION

In the history of Western science, the nineteenth century is generally regarded as the time when the great amateur tradition of natural history gave way to professional practice (Allen 2009). While this observation mostly holds true for men, the 1917 appointment of mycologist Johanna Westerdijk as the first female professor in the Netherlands indicates that the transition for women was much more uneven, varied and delayed (Abir-Am 2003, Whaley 2003: 99–116). A small group of women were able to make high-level contributions to mycology from the 1700s, but in most countries women like Westerdijk were still playing the part of female scientific pioneers well into the twentieth century.

Mycology was no different from other sciences in this regard, but the renaming of the Centraalbureau voor Schimmelcultures as the Westerdijk Fungal Biodiversity Institute provides a timely moment for reflection. Who were the first women participants in mycology? We answer this question with a focus on taxonomic mycology, a sub discipline with rich historical records. To become a taxonomist required access to education (including a knowledge of Latin), and to resources such as herbaria, colleagues and libraries, and the ability to publish. Modern mycological taxonomy began with Carl Linnaeus (1707–1778) in the eighteenth century, and his only comparable female contemporary was German governess, Catharina Dörrien (1717–1795), who was also the first woman to name a new fungal taxon. Her achievement was not repeated for another half century.

The struggle over access to education lies at the heart of why women's participation in science has been delayed compared to that of men. Universities were restricted to male students in most Western countries until the latter part of the nineteenth century, and in England women could not take degrees at Oxford and Cambridge until the twentieth century (Olesko 2003b: 814). The wonder is not so much that there were so few women scientists prior to 1900, but why there were any at all. We explore the importance of tertiary (i.e. post-secondary) education to participation in taxonomic mycology by reflecting on the careers of six exceptional amateur women who named new fungal taxa prior to 1900 in the context of an overall cohort of forty-three female contributors to scientific literature across mycology in general.

MATERIALS AND METHODS

The subject of the history of women in science has an established international literature. As a consequence, the broad features of this history have been outlined from ancient times to the present day (Kass-Simon & Farnes 1993, Alic 1986, Ogilvie & Harvey 2000, Whaley 2003, Des Jardins 2010). The major preoccupation of this literature has been Western science, and how women entered new fields as they emerged, and what they achieved. As Watts (2007) observes, the literature is 'a rediscovery of women who somehow had played a part in science and a discussion on the almost systematic exclusion of women from the higher echelons of science and why this should be so'.

Botany has been well served by historians of women in science due to cultural approval for women's participation in this discipline from the Enlightenment (Shteir 1996, Fara 2004). Creese (1998: 3) observes that papers in botany (in which she includes mycology), make up about 23 per cent of all journal publications by women indexed by the Royal Society from 1800 to 1900. Women's participation in other disciplines, such as zoology, astronomy and chemistry, has also received attention (e.g. Rayner-Canham and Rayner-Canham 2001, Brück 2009, Hill 2016). Creese observes regional variation in the entry of women into science. For example, the USA led the way for

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women in astronomy and zoology, while the UK was ahead in geology (Creese 1998: ix).

While mycology was initially part of botany, historical research on women's mycological contributions is not well developed. General histories of mycology such as Ainsworth (1976) and Dörfelt & Heklau (1998) do not distinguish female contributions *per se*. A rare book-length treatment is Ristaino and Peterson's collective biography *Pioneering women in plant pathology* (2008). A few biographies of individual female mycologists have also been written — Marie-Anne Libert (Lawalrée *et al.* 1965), Beatrix Potter (1866–1943) (Lear 2008), Westerdijk (Faasse 2012), Elizabeth Lee Hazen (1885–1975) and Rachel Fuller Brown (1898–1980) (Baldwin 1981), and an auto-biography — Carlene "Cardy" A. Raper (1925–) (Raper 2013).

We have also adopted a biographical approach, but in addition place a strong emphasis on comparison and analysis of biographies. As well as providing biographical notes on a cohort of 43 women who published mycological literature before 1900, we give longer biographical portraits of six amateur women taxonomic mycologists. We acknowledge that we have likely omitted some women from the larger group due to difficulties in identifying female authors in a scattered and, on occasion, difficult-to-find literature, but do not think that this affects the overall pattern of women's participation in mycology that we have identified.

Our first objective was to find as many women as possible who authored at least one scientific publication on fungi (including lichens) before 1900 (Table 1). The end date of 1899 was chosen after an initial survey of the literature indicated that women's admission to university education and participation in mycology dramatically increased after the turn of the century.

We based the entries in Table 1 on two overlapping analyses. The first detected women via their authorship of fungal names, the second via their publications. In the first analysis, we began by extracting a list of female authors of fungal names born prior to 1900 from *Authors of fungal names* (Kirk 2003, the online and updated version of Kirk & Ansell, 1992). We identified the female authors by forename. We amended and reduced this initial list by searching Mycobank (http://www.mycobank.org/) using the author abbreviation to (1) confirm that the authors did describe new taxa, (2) determine how many new taxa each woman introduced, and (3) identify those women where the date of first taxonomic publication was prior to 1900.

Authors of fungal names (Kirk & Ansell 1992, Kirk 2003) was initially derived from Brummitt & Powell's (1992) *Authors of plant names*. However, the latter includes authors who did not necessarily publish new taxa, because all authors included in Stafleu & Cowan (1976–2009) *Taxonomic literature* (TL-2) were also included in *Authors of plant names*, whether or not they had published new taxa. Therefore, on the one hand, the search for female authors via *Authors of fungal names* acted as a useful proxy for a search on female authors of publications in the seven volumes and seven supplements of TL-2. On the other hand, we had to confirm that female authors in *Authors of fungal names* did in fact introduce novel taxa.

In the search of *Authors of fungal names*, there remained 225 authors (mostly with only an initial provided) for which we were unable to establish gender. It is possible that some were women; but unlikely due to the very low proportion overall of women authors in the period under analysis.

Our second analysis captured women who published on mycology before 1900 (but not necessarily on taxonomic mycology) by a search of the bibliographies in the four historical volumes on women in science published by Creese (1998, 2004a, 2010, 2015). These bibliographies are based on entries in the *Catalogue of Scientific Papers 1800–1900* compiled by the Royal Society, London (Royal Society of London, 1867–1925), supplemented by additional research by Creese. We identified additional publications for the women in Table 1 using Lindau & Sydow (1908–1917) (LS) and via the search of *Authors of fungal names* and Mycobank.

Initial searching of names of authors of fungal names born prior to 1900 was necessary in order to identify those publishing before 1900 because Lindau & Sydow (1908–1917) do not consistently provide forenames for authors, and although comprehensive for women scientists, Creese (1998, 2004a, 2010, 2015) only included authors who had published journal articles (rather than books) as her initial sample.

The women included in Table 1 from these combined analyses published books and/or articles in scientific journals based on original observations and research on the taxonomy, morphology, physiology, chemistry, pathology and other aspects of fungi (including lichens). Our methodology has meant excluding women that we recognise made significant contributions to mycology prior to 1900 as collectors, and as unpublished illustrators. This is because readily available sources did not allow a comprehensive listing of this group, although they are covered in the British Isles (Hawksworth & Seaward 1977, Ainsworth 1996) and in Australia (Maroske & Vaughan 2014, Maroske 2014). Moreover, the women in Table 1 often included collecting and illustrating fungi as part of their contributions to the discipline. Notable exclusions from Table 1 include Josephine Kablíková (1787–1863) who collected and exchanged large numbers of plant specimens (including fungi), Beatrix Potter (1866–1943) who did not formally publish her research on lichens (Ainsworth 1996) and Guielma Lister (1860–1949) who was an active collaborator with her father, Arthur Hugh Lister (1830–1908), from the 1880s, but did not appear as a co-author on publications until after 1900. After Arthur's death, Guielma updated the second and third editions of *A monograph of the Mycetozoa* (Ainsworth 1996, Waterfield 2004).

Our second objective was to identify the subgroup of women in Table 1 who introduced novel fungal taxa prior to 1900. Among these women we further identified six who were amateurs, that is individuals who did not have a university education or have a position as a paid scientific professional. Amateur women were highly distinctive because while men or women could be amateurs, in the era of modern taxonomy male amateurs always co-existed with men who were professionals. In contrast, women did not have professional peers of their own gender until the last decades of the nineteenth century.

We provide detailed biographies of the six amateur women who published new taxa, including lists of their scientific publications before 1900 (mycological and any others – not repeated in the References) and eponymous names (provided with abbreviated author and date) and reflect on their achievements in the context of their larger female mycological cohort active prior to 1900.

Herbaria are abbreviated according to *Index Herbariorum* (Thiers, continually updated) and names of authors according to the *International Plant Names Index* (http://www.ipni.org) and *Authors of fungal names* (Kirk 2003). TL-2 refers to *Taxonomic Literature* (Stafleu & Cowan 1976–2009) and numbers in the form '31.113' to entries in TL-2.

Table 1. Women who published scientific mycological literature prior to 1900, arranged by time periods as discussed in text, and then by date of first mycological publication (mycol. pub.). Name: if married, married name is listed first, followed by forenames and unmarried surname (preceded by 'née') [standard abbreviation as author of fungal taxa in square brackets]. Number of mycological publications (No. mycol. pubs) is all pre-1900 or otherwise count is <1900/≥1900. Sources: LS = Lindau & Sydow (1908–1917) [name under which published in square brackets, if different to first surname in name column]; TL-2 = Stafleu & Cowan (1976–2009). For the six women with biographical entries, new fungal taxa are referred to there.

Period	Name	First mycol. pub.	No. mycol. pubs	Dates	Country	Education	Status	Married	Contributions	Sources
1700–1799	DÖRRIEN, Catharina Helena [Doerr.]	Dörrien (1777)	5	1717–1795	Now Germany	home, girls' school	amateur	no	See biographical entry, **described new fungal** taxa.	LS ['Doerrien, K.H.'], TL-2, Viereck (2000)
1800–1849	LIBERT, Marie-Anne [Lib.]	Libert (1827a)	8	1782–1865	Now Belgium	home, girls' school	amateur	no	See biographical entry, **described new fungal** taxa.	LS, TL-2, Creese (2004a)
	HUNTER, Anne	Hunter (1846)	2	fl. 1846–1868	UK	not known	amateur	not known	Self taught naturalist, published two articles on fungi, member Berwickshire Naturalists' Club, corresponded with Miles Berkeley (1803–1889).	LS, Creese (1998)
	HUSSEY, Anna Maria née Reed	Hussey (1847–55)	1	1805–1853	UK	home	amateur	1831	Self taught naturalist, author of *Illustrations of British mycology*, corresponded with Miles Berkeley.	LS ['Hussey, T.J.'], TL-2, Ainsworth (1996), Shteir (1996), Finn (2009)
1850–1887	FIORINI-MAZZANTI, Elisabetta	Fiorini-Mazzanti (1857–8)	c. 6	1799–1879	Italy	home?	amateur	1829	Self taught naturalist, contessa by marriage, numerous publications including on fungi, collected cryptogams, member of several European scientific societies, correspondents included Camille Montagne (1784–1866), **described new byrophyte and algal taxa**.	LS, TL-2, Creese (2004a)
	PRICE, Sarah	Price (1864–5)	1	fl. 1864	UK	home?	amateur	not known	Author of *Illustrations of the fungi of our fields and woods*.	LS, TL-2, Ainsworth (1996)
	PLUES, Margaret	Plues (1864)	2	1828–1901	UK	home?	amateur	no	Governess, also worked in charitable institutions, later entered convent. Author of popular and guide books on plants and fungi including *Rambles in search of flowerless plants and A selection of eatable funguses of Great Britain*.	TL-2, Ainsworth (1996), Hawksworth & Seaward (1977), Lawley (n.d.)
	LÜDERS, Johanna Elisabeth née de Boor	Lüders (1866)	2	1811–1880	Germany	home?	amateur	1831	Supported by scientists at Kiel University, including training from Christian Hensen (1835–1924) on use of microscope. Published original observations on controversial topic of the origin and development of the micro-organisms *Bacterium termo* Dujard and *Vibrio lineola* Ehrenb., in relation to fungi such as *Botrytis, Mucor* and *Penicillium*. Also published on algae and made contributions to Rabenhorst's *Kryptogamen-Flora*.	LS, Creese (2004a)
	RUSSELL, Anna née Worsley	Russell (1868)	2	1806–1876	UK	home	amateur	1844	Self taught naturalist, member Botanical Society of London, collected and illustrated fungi.	LS, TL-2, Ainsworth (1996), Allen (2004)
	BECKER, Lydia Ernestine	Becker (1869)	1	1827–1890	UK	home	amateur	no	Self taught naturalist, leader of British suffrage movement, published on effects of fungi on plant development, presented paper at British Association, corresponded with Charles Darwin (1809–1882).	Creese (1998), Walker (2004)

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Table 1. (Continued).

Period	Name	First mycol. pub.	No. mycol. pubs	Dates	Country	Education	Status	Married	Contributions	Sources
	BANNING, Mary Elizabeth [Banning]	Banning (1877)	8	1822–1903	USA	home	amateur	no	See biographical entry, **described new fungal taxa**.	LS, Creese (2004a), Ristaino & Peterson (2008)
	BOMMER, Élise Caroline née Destrée [E. Bommer, Destrée]	Bommer & Rousseau (1879)	14 / 21	1832–1910	Belgium	home	amateur	1865	See biographical entry, **described new fungal taxa**.	LS [Bommer, Destrée], TL-2, Creese (2004a)
	ROUSSEAU, Mariette née Hannon [M. Rousseau]	Bommer & Rousseau (1879)	6 / 3	1850–1926	Belgium	home	amateur	1871	See biographical entry, **described new fungal taxa**.	LS, TL-2, Creese (2004a)
	ZIBER-SHUMOVA, Nadezhda Olimpievna née Shumova, also 'Sieber'	Sieber (1881)	1	1856–1914	Russia	home, St Petersburg Higher Courses for Women, student Zurich, higher degree 1880 (Bern)	department head	c.1870s	Researched yeasts at university, published more than thirty papers on the chemistry of microorganisms. Co-founder of Institute of Experimental Medicine in St Petersburg, took part in expeditions to the Caucasus in 1895 and 1898, first female department head of the institute, founded a girls' school in Novgorod Province.	LS [Sieber], Creese (2015)
	HERRICK, Sophie McIlvaine Bledsoe	Herrick (1883)	2	1837–1919	USA	studied at John Hopkins University	teacher, magazine editor	1860	Writer for magazines such as *Popular Science Monthly* and *Century Magazine* published *The wonders of plant life under the microscope* which includes illustrated section on fungi, member of the American Association for the Advancement of Science (AAAS).	Hollis (1979), Reed (1992)
	FITZ-JAMES, Marguerite Augusta Maria née Löwenhjelm	Fitz-James (1885)	1	1830–1915	France	home	amateur	1851	Self taught naturalist, duchesse by marriage, conducted experiments on fungi in family vineyards, wrote several books on viticulture, some published in collaboration with the Bureau de Progrès Agricole et Viticole, presented papers at scientific meetings.	LS, Creese (2004a)
	MARTIN, Flora Mary née Campbell	Campbell (1886)	c. 15 / 1	1845–1923	Australia	home?, botany lectures at Ormond College 1885) no degree)	amateur, honorary assistant vegetable pathologist (Dept Ag. Vic.)	1888	Collected and illustrated fungi, attended botanical lectures by Daniel McAlpine (1849–1932), member Field Naturalists Club of Victoria and Australasian Association for the Advancement of Science, honorary assistant government vegetable pathologist.	LS [Campbell], Creese (2010), Maroske & Vaughan (2014)
	KNOWLES, Etta L.	Knowles (1887)	2	not known	USA	student 1885–9 (Michigan)	secondary school teacher	not known	Conducted research on plant pathology at university.	LS, Creese (1998)
	BUELL, Martha née Merry	Merry (1887)	1	b.1864	USA	BS 1885 (Cornell)	tertiary graduate	1890	Conducted research on plant pathology at university, teacher at St Joseph High School, Missouri.	LS [Merry], Leonard (1914), Creese (1998)
1888–1899	CUMMINGS, Clara Eaton [Cumm.]	Cummings (1888)	7 /c. 5	1855–1906	USA	Wellesley 1876 and Zurich 1886–7 (no degree)	professor (Wellesley)	no	Associated with Wellesley College for thirty years, researched and published on cryptogams including lichens, Hunnewell Professor of Cryptogamic Botany in 1906, **described new fungal taxa post 1900** (two new species of lichen). Harvard's Friends of the Farlow holds an annual Clara Cummins nature walk.	LS, TL-2, Creese (1998)

Table 1. (Continued).

Period	Name	First mycol. pub.	No. mycol. pubs	Dates	Country	Education	Status	Married	Contributions	Sources
	SPALDING, Effie Almira née Southworth [Southw.]	Southworth (1888)	c. 15	1860–1947	USA	BS 1885 (Michigan), MS 1923 (California)	assistant professor (Univ. Southern California)	1895	First woman scientist to be employed by United States Department of Agriculture (USDA), conducted research and published on plant pathology, **described new fungal taxa** (*Colletotrichum althaeae* Southw. and *C. gossypii* Southw.), assistant botanist at Barnard College, collaborated with botanist and husband Volney Morgan Spalding (1849–1918) and with Daniel MacDougal (1865–1958).	LS [Southworth], Leonard (1914), Creese (1998)
	GREGORY, Emily Lovira	Gregory (1889)	2	1841–1897	USA	BA 1881 (Cornell), Dr Phil 1886 (Zurich)	professor (Columbia)	no	Established and ran botany department at Barnard College for eight years, studied with eminent botanists in Zurich, first doctorate awarded to an American woman at a European university, teacher at Bryn Mawr College, and Barnard College, first woman on faculty at Columbia University, researched and published on lichens.	LS, Creese (1998)
	SEARING, Anna Hutchinson	Searing (1889–91)	1	1830–1912	USA	matriculated 1869 (Pennsylvania), MD 1872 (Michigan)	private medical practice	no	Clinician at New England Hospital for Women in, Boston, practised medicine in Rochester, New York, corresponding member of Rochester Academy of Science, at which she presented a paper on the life history of some fungi.	Creese (1998)
	BITTING, Katherine Eliza née Golden	Golden (1890)	5 / c. 5	1869–1937	USA	BSc 1890, MSc 1892, DSc 1895 (Purdue)	microanalyst (USDA)	1904	Known mainly as a bacteriologist and food scientist, researched and published on yeasts as a university student, at Purdue worked as assistant botanist, instructor in biology and assistant professor, resigned in 1904, microanalyst in Bureau of Chemistry (USDA) from 1907, worked in industry, including spell working for US Army during World War 1.	LS [Bitting and Golden], Creese (1998)
	DETMERS, Frederica (Freda)	Detmers (1891)	c. 10	1867–1934	USA	BS 1887, MS 1891, PhD 1912 (Ohio)	botanist (Ohio Ag. Exp. Stn)	no	Took first degree in botany at Ohio State University, assistant botanist then taxonomist and systematist at Ohio Agricultural Experiment Station, first woman to hold a scientific research position in Ohio, charter member of Ohio Academy of Science, MS thesis on rusts, **described new plant taxa post 1900**.	LS, TL-2, Creese (1998)
	THOMAS, Rose Helen née Haig	Thomas (1891)	1	1853–1942	UK	not known	amateur	1880	Published articles on natural history (including fungi), poetry, and children's books on spiders and dolls, husband John Howard Thomas (1853–1919) a director of collieries and railways.	Venn (1954), Creese (1998)
	WHITE, Mary Ann Clementina Margaret	White (1892)	1	b.1867	UK	home?	amateur	not known	Eldest daughter of Scottish entomologist and botanist Francis Buchanan White (1842–1894), published notice of a rare fungus.	LS [under entry for her father, 'F.B. White'], Creese (1998)
	ATCHISON, Ida May née Clendenin [Clendenin]	Clendenin (1894)	3	1860–1925	USA	BS 1886 (Missouri), MS 1893 (Michigan)	secondary school teacher	1906	Researched and published on plant pathology at university, **described new fungal taxon** (*Synchytrium geranii* Clendenin), teacher at Girls' High School in Brooklyn, New York.	LS [Clendenin], Creese (1998)
	PATTERSON, Flora née Wambaugh [F. Patt.]	Patterson (1894)	3 / c. 10	1847–1928	USA	AB 1865 (Antioch), AM 1883 (Wesleyan College, Cincinnati, Ohio)	mycologist (USDA)	1869	Began studying mycology after husband's death, **described new fungal taxa** (incl. *Loculistroma* F. Patt. & Charles, and 25 species and one variety in genera such as *Aspergillus, Hendersonia, Libertella, Stemphylium* and *Ustilago*), assistant curator of mycology at Gray Herbarium, Harvard, assistant pathologist, Division of Vegetable Pathology (USDA), Fellow of the AAAS and a member of several scientific societies.	LS, TL-2, Leonard (1914), Creese (1998), Rossman (2008)

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Table 1. (Continued).

Period	Name	First mycol. pub.	No. mycol. pubs	Dates	Country	Education	Status	Married	Contributions	Sources
	RABINOWITSCH-KEMPNER, Lydia née Rabinowitsch	Rabinowitsch (1894)	2	1871–1935	Now Lithuania, USA, Germany	student Bern & Zurich, Dr Phil 1894 (Bern)	bacteriologist, professor (Friedrich-Wilhelms University), research institute director	1898	Studied at Bern under Ludwig Fischer (1828–1907) and Eduard Fischer (1861–1939), doctoral thesis on the development of gasteromycetes, then a year at Royal Prussian Institute for Infectious Disease, where assisted Robert Koch (1843–1910), including work on pathogenic yeasts. International reputation as bacteriologist, including research on tuberculosis, head of bacteriological laboratory at Womens Medical College of Pennsylvania then at Pathological Institute, Charité Hospital, Friedrich-Wilhelms University, Berlin and Moabit Hospital Berlin. Active in women's movement, including German Lyceum Club and Union for the Protection of Mothers and Sexual Reform. First female editor-in-chief of a German scientific journal (*Zietschrift für Tuberkulose*). Member of several scientific societies.	LS [Rabinowitsch], TL-2, Creese (2004a)
	NUTTALL, Gertrude née Clarke	Clarke (1895)	2	1868–1929	UK	BSc [date, place not known]	degree student, married	not known	First woman to take a bachelor degree from a British university, researched and published on lichens.	LS [Clarke], Desmond (1994), Creese (1998)
	SMITH, Annie Lorrain [A.L. Sm.]	Smith (1895)	6 / 79	1854–1937	UK	home, lecture series 1878 (Royal College of Science, London) (no degree)	amateur, unofficial worker (British Museum)	not known	See biographical entry, **described new fungal taxa**.	LS, TL-2, Hawksworth & Seaward (1977), Ainsworth (1996), Creese (1998)
	BEELER, Lora Luvernia née Waters	Waters (1896)	1	1864–1935	USA	BS, MS (Kansas State Ag. College)	degree student, school teacher	1899	Researched powdery mildews at Kansas State Agricultural College, member Kansas Academy of Science, school teacher, ceased paid work on marriage.	LS, Creese (1998)
	COX, Mary Alice née Nichols	Nichols (1896)	3	1869–1951	USA	BL 1891, MSc 1893 (Iowa), DSc 1896 (Cornell)	secondary school teacher	1900	One of the first two women in USA awarded a DSc, researched and published on cryptogamic botany at university, including on development of pyrenomycetous fungi, teacher in Des Moines, Iowa and New York City, after marriage worked as principal of a Friends' private school, and director of children's school.	LS [Nichols], Leonard (1914), Creese (1998)
	HORN, Margaretha Elise Catherine	Horn (1896)	1	c.1866–1910	USA	BSc 1891 (Kansas State Ag. College), MS 1896 (Michigan)	secondary school teacher	no	Researched and published on plant pathology at university, teacher at Detroit high schools.	LS, Creese (1998)
	STONEMAN, Bertha [Stoneman]	Stoneman (1896)	2	1866–1943	USA, South Africa	PhB 1894, DSc 1896 (Cornell)	professor (Huguenot)	no	Researched and published on plant pathology at university in the USA, **described new fungal taxa** (incl. *Gnomoniopsis* Stoneman, *G. cingulata* Stoneman [*Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk, now known as *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc.] and four other species of *Glomerella*, and five species in *Gloeosporium* and *Volutella*), taught at Huguenot College, Wellington, where she established the first degree course on botany in South Africa, member of several scientific societies including the South African Association for the Advancement of Science.	LS, TL-2, Leonard (1914), Creese (2010)

Table 1. (Continued).

Period	Name	First mycol. pub.	No. mycol. pubs	Dates	Country	Education	Status	Married	Contributions	Sources
	CLIFFORD, Julia Blanche	Clifford (1897)	3	1864–1918	USA	student (Michigan) 1894–6 (no degree)	secondary school teacher	no	Conducted research on fungal physiology at university, teacher at East High School.	LS, TL-2, Creese (1998), MBL Data (n.d.)
	GREENE, Lillian née Snyder	Snyder (1897)	3	b.1874	USA	BS 1895, MS 1896 (Purdue)	degree student	1902	Researched and published on rusts and pear blight at university, presented to the Indiana Academy of Sciences.	LS [Snyder], Creese (1998)
	POPTA, Canna Maria Louise	Popta (1897)	2	1860–1929	Netherlands	student (Leiden), Dr Phil 1898 (Bern)	curator (Rijksmuseum van Natuurlijke Historie, Leiden)	no	First woman student at University of Leiden, doctoral research on fungi at Bern University uner Eduard Fischer, followed by several decade career as zoologist, Curator of Fishes at Rijksmuseum van Natuurlijke Historie, Leiden, published numerous articles on natural history.	LS, Creese (2004a)
	STANFORD, Mary Emma née Olson [Olson]	Olson (1897)	1	1871–1961	USA	BS (Minnesota)	degree student, teacher	not known	Researched and published on plant pathology at university, **described new fungal taxon** (*Acrospermum urceolatum* Olson).	LS [Olson], Creese (1998)
	DAKIN, Nora/Norra B. née Allin	MacBride & Allin (1898)	1	1876–1971	USA	BA 1897 (Iowa)	degree student	1903	Researched and published on puffballs at university under Thomas Macbride (1848–1934).	LS [Allin], Creese (1998)
	DUNN, Luella Cushing née Whitney	Whitney (1899)	1	1875–1941	USA	BS 1898 (Vermont)	degree student	1903	Researched and published on slime moulds at university.	LS [Whitney], Creese (1998)
	TSIKLINSKAIA, Praskoviia Vasilievna, also 'Tsiklinsky' and 'Tsiklinski' [Tsikl.]	Tsiklinsky (1899)	1	1859–1923	Russia	student (Paris), DSc 1903 (Geneva), honorary MD 1917 (Moscow)	professor (Moscow Univ.)	no	Attended science section of Higher Courses for Women in St Petersburg, enrolled in a bacteriology course at the Pasteur Institute and attended science lectures at Paris University, first woman to hold a lectureship at Moscow University, spent a year at Robert Chodat's Botanical Institute at Geneva University, doctoral thesis on thermophilic fungi, **described new fungal taxa** (*Thermomyces* Tsikl., *T. lanuginosus* Tsikl.), professor at Higher Courses for Women in Moscow, member of the Technical Committee after the 1917 October Revolution, member of several scientific societies.	LS [Tsiklinski], Creese (2015)

RESULTS

Female mycologists pre-1900

Table 1 includes forty-three women who published scientific literature on fungi prior to 1900. We arrange these women by date of first publication within four time periods — 1700–1799, 1800–1849, 1850–1887, 1888–1899 — that roughly coincide with major developments in science and education. We give the full name of each woman with any married name listed first, followed by forenames and unmarried surname. Table 1 also includes the approximate number of each woman's mycological publications, dates of birth and death, the country or countries in which she lived, details of her education, highest occupational status attained, and details of marital status. The final two columns contain a brief description of each woman's contribution to mycology, and the references for the information in the table.

The number of women in each chronological section increases over time (Table 1), as does the number of women attaining college or university degrees, and the number of women publishing new fungal taxa.

Of the forty-three women, at least twelve appear to have been entirely educated at home. For two of the women attendance at a boarding secondary school was their highest level of formal education. Six went as far as attending classes at a tertiary institution (without taking a degree). Twenty-one had degrees from tertiary institutions, and, of these, fifteen had higher degrees. The most well-attended universities by these women graduates were University of Michigan (5 graduates) and Cornell University (4), both in the USA. Of the 18 other institutions, all but three were in the USA. Higher degrees were obtained from nine institutions including Cornell University (2), University of Michigan (2) and Purdue University (2) in the USA and the Universities of Bern (3), Geneva (1) and Zurich (1) in Switzerland.

Geographically nearly all the women were from Europe, the UK or USA. Notably, three of the amateur women who published new taxa were from Belgium. Only Bertha Stoneman (who was educated in the USA and then lived in South Africa), and Flora Martin née Campbell (Australia) were from other regions.

Pre-1900, most European women mycologists with higher degrees obtained them at Swiss universities. Indeed, Johanna Westerdijk, after studying biology in the Netherlands at Amsterdam University, gained her doctoral degree in Switzerland in 1906 at Zurich (on mosses). Elsewhere in Europe, early doctoral theses on mycological subjects do not appear until the first two decades of the twentieth century: examples are for Germany, Gertrud Wolff (1877–1948, later Tobler-Wolff) in 1905 at Berlin (Wolff 1905) and for France, Valentine Moreau (1886–1974) in 1914 at Paris (Moreau 1914). Rose Stoppel (1874–1970), the first female professor of botany in Germany, described *Eremascus fertilis* Stoppel in 1907, but her doctoral thesis in 1910 at Freiburg concerned the influence of light on the opening and closing of flowers (Ogilvie & Harvey 2000). In Italy, Giuliana Luigia Evelina Mameli, later Calvino (1886–1978), first Italian female university professor, gained a degree in natural sciences at Pavia in 1907 and published in that year on the fungi of Sardinia (Migliore 2007).

Among the women who published on fungi pre-1900, eighteen are classed as amateurs, one (Herrick) had a professional career as an editor but does not appear to have graduated (although she attended university), and the remaining twenty-four were tertiary educated (mostly with higher degrees). Many of the tertiary-educated authors of scientific literature published soon after graduating, and then either married or commenced work as secondary school teachers. Six acquired positions in tertiary education institutions. Most of the women published only one or a few items of mycological literature. Exceptions among the amateurs include the six dealt with in detailed biographies below and Fiorini-Mazzanti and Martin née Campbell. Among the professional women, the most prolific authors were Bitting née Golden, Cummings, Detmers, Patterson née Wambaugh and Spalding née Southworth.

Twelve women published new fungal taxa pre-1900: in chronological order, Dörrien, Libert, Banning, Bommer née Destrée, Rousseau née Hannon, Spalding née Southworth, Atchison née Clendenin, Patterson née Wambaugh, Smith, Stoneman, Stanford née Olson and Tsiklinskaia. Although two new names in *Agaricus* were attributed to Anna Maria Hussey by Saccardo (1887), '*A. Prunulus* Hussey' and '*A. sublanatus* Huss.' [listed in synonymy, under *Clitopilus prunulus* (Scop.) P. Kumm. and *Cortinarius triumphans* Fr. respectively], in fact she attributed both to previous authors (*A. prunulus* Scop. and *A. sublanatus* Sow.), while discussing various interpretations of the first name, and admitting that the identification of her material as the second was debateable.

In all, the six amateurs (Dörrien, Libert, Banning, Bommer, Rousseau and Smith) described more than 600 new species and eighteen new genera of fungi (some by the latter three published after 1900). Banning only worked on macrofungi such as agarics and Smith was the only one to publish extensively on lichenised fungi. It is notable, that among the taxa dealt with by the five women other than Banning, there was a preponderance of microfungi, necessitating use of the compound microscope. In addition, these five worked on a wide range of taxa, from across the families of Ascomycota, Basidiomycota and Zygomycota.

Biographies of six amateur female taxonomic mycologists

Biographies are presented in chronological order of first scientific mycological publication.

1. *Dörrien/Doerrien, Catharina/Katharina Helena*
Dates: 1 March 1717–8 June 1795.

New taxa (2): *Lichen centrifugus* var. *major* Doerr., *Lichen centrifugus* var. *minor* Doerr. (Dörrien 1777).

Eponymy: Doerriena Borkh. (1793).

The first woman formally to name a fungal taxon in the modern scientific era was Catharina Helena Dörrien (Fig. 1), a German governess from Dillenburg, now in the state of Hesse, Germany. More properly regarded as a botanist than a mycologist, Catharina included fungi in her studies of local vegetation. She acquired some fame in her lifetime, but as her major work was never published she sank into obscurity after her death. In a recent biography, Regina Viereck emphasises the breadth of Dörrien's interests, describing her as an artist, botanist, author of children's books, of pedagogical literature, of practical household instructions, and a translator and editor (Viereck 2000).

Catharina Helena Dörrien was born in Hildesheim (about 260 km southeast of Dillenburg), the second of four children to Pastor Johann Jonas Dörrien and his wife Lucia Catharina née

Fig. 1. Catharina Helena Dörrien. Portrait by Friedrich Hauck. © Museum Wiesbaden.

Schrader. The Dörriens were a scholarly family; even so it was unusual for Catharina to share her brothers' lessons conducted by Pastor Dörrien at home. In this way she gained knowledge of geography, history, religion and 'ein wenig Latein' (a little bit of Latin). Catherina also learned about botany by observation with her father in the manse garden, a subject that became 'zu einem wahren Vergnügen' (a true pleasure) (Viereck 2000: 15).

After the death of her mother in 1733, Catherina, aged sixteen, took over responsibility for her father's household. When he died four years later, Catharina was probably taken in by relatives, and her brothers sent to boarding school. Catharina recalled this time in her life as 'mittelmäßig' (middling) (Viereck 2000: 18). With the death of her favourite brother, Melchior, in 1746, Catharina no longer had any strong ties to Hildesheim. In her thirtieth year, she decided to move to Dillenburg, and work as a governess in the home of childhood friend, Sophie Anna Blandina née von Alers, whose husband Anton Ulrich von Erath was a lawyer and academic.

Like the Dörriens, the von Eraths were a scholarly family, and supportive of female education. Anton von Erath undertook a series of historical research projects in which he enlisted the assistance of his household. Catharina's first independent publications were pedagogical, but as the von Erath children grew up, she was able to return to her botanical interests.

Initially she collected and painted the plants of the former principality of Orange-Nassau for pleasure, but encouraged by Anton von Erath and other 'Liebhaber der Botanik' (lovers of botany), she committed to producing an illustrated flora of the principality. She travelled around Dillenburg, visiting most places twice, in different seasons, and focussed on the lichens, mosses and fungi in the winter.

Anton von Erath died in 1773, but Dörrien continued the flora, finally publishing a 496 page catalogue of the plants of Orange-Nassau in 1777, with the intention of going on to issue an accompanying volume of illustrations. No other woman is known to have authored a similar catalogue in this period, and she was also one of the first botanists to use the Linnean systems of classification and nomenclature in Germany.

The catalogue is divided into four parts, with the final section dealing with Schwamme or mushrooms. Linnaeus only included a few dozen fungi in the first edition of *Species Plantarum* (Linnaeus 1753), and it is not surprising that Dörrien found additional species in Orange-Nassau. In most cases, she did not formally introduce novel taxa, although she did provide descriptions to the same level of detail as for the named taxa, designating each un-named species by an underscore after the generic name, without a species epithet. In the genus *Agaricus* alone she indicated 56 such un-named species that she could not match against previous literature. However, she did formally introduce two varieties in her catalogue, both within Linnaeus's *Lichen centrifugus* L. — *L. centrifugus* var. *major* Doerr., and *L. centrifugus* var. *minor* Doerr. In publishing these varieties, Doerrien became the first woman formally to name new fungal taxa.

Even before the catalogue, Dörrien's botanical research resulted in her election to a number of scientific societies. In 1766, with the assistance of Anton von Erath, she had become an honorary member of the Societatis Botanicae Florentinae (Botanical Society of Florence). Ten years later, she became an honorary member of the Gesellschaft Naturforschender Freunde zu Berlin (Berlin Society of Friends of Nature Research) and the first female member of the Berlinischen Gesellschaft (Berlin Society). In 1790 she was elected an honorary member of the newly formed Botanischen Gesellschaft zu Regensburg (Regensburg Botanical Society). These were extraordinary achievements in an era when only about 100 women, mostly from the nobility, belonged to German learned societies (Phillips 2012).

The fact of Dörrien being a female author ensured that her catalogue attracted attention, but regardless it was much praised in scientific journals. Johann Beckmann's *Physikalisch-Oekonomische Bibliothek*, a quarterly published in Göttingen, recommended the catalogue to connoisseurs and beginners. Nevertheless, he greeted Dörrien's discovery of so many new taxa with scepticism, as yet unwilling to acknowledge the great richness and diversity of this group of organisms (Viereck 2000: 74–76).

After the catalogue, Dörrien appeared once more in print on the subject of her scientific work, although she never published her plant illustrations (Dörrien 1785). In 1789, her friend Sophie von Erath died, and Dörrien moved into the household of the youngest of the von Erath sons, Justus Hieronymus. Two years before she died, Moritz Borkhausen (1760–1806), a German naturalist and forester, named a genus of chickweeds after her (*Doerriena*) (Borkhausen 1793).

Dörrien's illustrations were passed down in the von Erath family. A small collection was loaned to the Verein für Nassauische Altertumskunde und Geschichtsforschung (Nassau Society for Archeology and Historical Research) in 1875, where they were much admired. In 1890, the Museum of Wiesbaden acquired a collection of about 2,500 watercolours of plants painted by Johann Philipp Sandberger. This artist was a friend of Anton von Erath and a majority of his watercolours are now regarded as copies of Dörrien's originals. The museum purchased 34 authentic paintings by Dörrien in 1937 (possibly the ones exhibited in 1875).

The contrast between Dörrien's originals and Sandberger's copies, emphasizes what was lost to botanical art with the

disappearance of the bulk of her collection. In 1941 museum curator Friedrich von Heinbeck declared that the acuity of her paint strokes could be compared with the stitching of an embroiderer who worked with the finest threads (Heinbeck 1941: 53). The fate of Dörrien's herbarium and types is unknown (TL-2).

Dörrien's scientific publications (5)

Dörrien CH (1770a). Von der *Fragaria sterilis*. *Hannoverisches Magazin* 8(35): 557–560.

Dörrien CH (1770b). Von den Wurzeln der *Cuscuta*. *Hannoverisches Magazin* 8(56): 891–896.

Dörrien CH (1773). Erfahrung von verschiedenem Ungeziefer, welches den Salat verfolget, und den Mitteln dagegen. *Dillenburgische Intelligenz-Nachrichten* 5 June: 153–154.

Dörrien CH (1777) [as '1779']. *Verzeichniß und Beschreibung der sämtlichen in den Fürstlich Oranien-Naussauischen Landen wildwachsenden Gewäche*. Bey Christian Gottfried Donatius, Lübeck, Germany. [TL-2 31.113, 2 editions]

Dörrien CH (1785). Nachrichten von Katharina Helena Dörrien, von ihr selbst erzählt, in einem Briefe an Herrn Professor Seybold. *Magazin für Frauenzimmer* 1785(4): 125–135.

2. *Libert, Marie-Anne*

Dates: 7 April 1782–14 January 1865.

New taxa: Libert described more than 200 novel taxa including the genera *Ascochyta* Lib. (in which she introduced 34 species), *Ascoxyta* Lib., *Aulographum* Lib., *Cheilaria* Lib., *Desmazierella* Lib., *Discosia* Lib. and *Dothichiza* Lib. Other genera in which she introduced three or more species include: *Aulographum*, *Botrytis*, *Caeoma*, *Cheilaria*, *Cytospora*, *Dacrymyces*, *Dothidea*, *Leptostroma*, *Leptothyrium*, *Peziza*, *Phacidium*, *Psilonia*, *Puccinia*, *Sclerotium*, *Sphaeria*, *Stictis* and *Vermicularia*. Several of the species described by Libert are well-known today as plant pathogens, including *Leptothyrium fragariae* Lib. [now *Diplocarpon fragariae* (Lib.) Rossman], *Oidium radiosum* Lib. [now *Venturia radiosa* (Lib.) Ferd. & C.A. Jørg.] and *Peziza sclerotiorum* Lib. (1837) [now *Sclerotinia sclerotiorum* (Lib.) de Bary].

Eponomy: *Libertia* Dumort. (1822) *nom. rej.*, *Libertia* Spreng. (1824) *nom. cons.*, *Libertia* Lejeune (1825) *nom. illeg.*, *Libertella* Desm. (1830), *Libertiella* Speg. & Roum. (1880), *Myxolibertella* Höhn. (1903), *Asterolibertia* G. Arnaud (1918), *Libertina* Höhn. (1920), *Leptomitus libertiae* C. Agardh (1824) [=*Conferva libertiae* Bory ms.], *Diderma libertianum* Fresen. (1850), *Sclerotinia libertiana* Fuckel (1870), *Cyphella libertiana* Cooke (1880), *Lasiosphaeria libertiana* Speg. & Roum. (1880), *Sacidium libertianum* Thüm. (1880), *Tapesia libertiana* Roum. (1880), *Phoma libertiana* Speg. & Roum. (1881), *Pestalotia monochaeta* * *libertiana* Sacc. (1882), *Chaetomium libertiae* Roum. & Pat. (1883), *Cryptodiscus libertianus* Sacc. & Roum. (1884), *Menispora libertiana* Sacc. & Roum. (1884), *Helminthosporium libertianum* Roum. (1884), *Helotium libertianum* Sacc. & Roum. (1884), *Monilia libertiana* Roum. (1884), *Phyllosticta libertiana* Sacc. & Marchal (1885), *Vermicularia libertiana* Roum. (1886), *Tuberculariа libertiana* Paol. (1887), *P. libertiae* Sacc. (1892), *Sclerotium libertianum* Lindau (1910), *Macrodiplodia libertiana* Petr. (1921), Other epithets of fungal names in the form '*libertiae*' refer to the plant genus *Libertia* as a host.

The second woman formally to name a fungal taxon in the modern scientific era, Marie-Annie Libert (Fig. 2), did not do so until fifty years after Dörrien. A French-speaking resident of Malmedy,

Fig. 2. Marie-Anne Libert. Frontispiece to *La Beligique Horticole* vol. 18, accompanying Morren (1868). Downloaded from Biodiversity Heritage Library.

Libert regarded herself as Belgian despite her village being part of the Kingdom of Prussia most of her life (Du Mortier 1865). Unlike Dörrien, Libert self-consciously specialised in fungi and became a prolific author of fungal taxa in the first part of the nineteenth century. She was well-regarded by her scientific peers, and is an established figure in the history of mycology (Creese 2004a: 101).

Marie-Anne was the twelfth of thirteen children born to Henri-Joseph Libert and Marie-Jeanne-Bernadine née Dubois, who ran a tannery, and owned property in Malmedy. Recognising his daughter's academic potential, Henri-Joseph facilitated Marie-Anne's education. Initially, she was instructed by Sépulcrine nuns then, at age eleven, went to a girls' boarding school at Prüm (now part of Germany). After returning home, Libert became fascinated by nature, and taught herself Latin so that she could read the many books about plants, animals and minerals written in this language (Creese 2004a: 101).

Libert's first and most enduring mentor was Alexandre Louis Lejeune (1779–1850), a physician and botanist, who lived nearby. In exchange for plant specimens, Lejeune gave her encouragement, acknowledgement for new records and taxa, and introduced her to famous Swiss botanist Augustin Pyramis de Candolle (1778–1841). Impressed by her botanical abilities, de Candolle encouraged Libert to focus on the rich but poorly known cryptogamic flora of Malmedy. As her reputation grew, other botanists came to visit and be taken on excursions in local forests (Creese 2004a: 102).

Among Libert's early collections was a new genus of liverwort, which she lacked the confidence to publish. A French colleague finally arranged for her description of *Lejeunia* Lib. (now conserved with spelling '*Lejeunea*') to appear in *Annales Générales des Sciences Physiques* (Libert 1820). Other taxonomic papers followed. Her most important mycological undertaking was a cyptogamic flora of the Ardennes, although she only managed to complete a four-volume *exsiccata* (Libert 1830–7). Her obituarist, B.-C. Du Mortier (president of the Société Royale

de Botanique de Belgique, Royal Botanical Society of Belgium), deeply regretted that she was not able to finish this work (Du Mortier 1865: 407).

Libert's first new fungal taxon—*Asteroma rosae*—was a leaf spot (Libert 1827c) and Libert was the first to name to species the fungal cause of potato murrain, the late season blight that caused widespread famine in the Low Countries, Ireland and England in the middle of the nineteenth century (Widmark 2010: 16). In a letter to the *Journal de Liège*, published on 19 August 1845, Libert ascribed the cause of the devastating potato blight recently observed in Belgium to a fungus, providing details of hyphae and spores as observed under the microscope. She identified the fungus as *Botryis farinosa* Fr., described in 1832; but in light of the damage caused by the fungus, proposed to change the specific epithet to *vasatrix*. Under current nomenclatural rules, *Botrytis vasatrix* Lib. is an illegitimate name. Nevertheless, Libert was the first to provide a name to the fungus now known as *Phytophthora infestans* (Mont.) de Bary, based on *Botrytis infestans* Mont., described later in 1845. Her naming of pathogenic fungi contributed to a growing awareness among botanists that fungi were a major cause of plant diseases, and to the beginnings of the new discipline that became known as plant pathology.

In recognition of her contributions to mycology, Libert was elected an associate member of the Société Linnéenne de Paris (Linnean Society of Paris) in 1820, and was awarded a gold medal of merit by Emperor Friedrich-Wilhelm III. At a scientific congress in Liège in 1836, she was unanimously elected president of the natural sciences section and special note was made of the fact that she had 'carried out her work without benefit of being close to any large scientific center or even to a large library' (Creese 2004a: 103). In 1862, she became the first woman invited to join the Société Royale de Botanique de Belgique, and was elected a corresponding member of several other western European scientific societies.

At 55, Libert retired from field-work, and turned her attention to the archaeology and history of Malmedy. Lack of access to relevant research materials hampered her investigations, and she did not receive as much acclaim for this work as for her botany. She was also active in civic affairs, and her opinions were taken seriously thanks to her scientific reputation.

Libert never married and lived with five unmarried siblings in the family home, sharing in managing the tannery and running a modest household. A few months short of her eighty-third birthday, she died at Malmedy after an illness of three days.

Four genera were named for Libert during her lifetime, and three after her death. The many species epithets commemorating her name reflect the ongoing use of her collections after her death. She was also honoured in the name of a street in Malmedy in 1925 (Rue Marie-Anne Libert), and in 1951 a society dedicated to making known and defending the heritage of the Malmedy region (Cercle Royal Marie-Anne Libert) (http://cercle-ma-libert.be/).

Libert's library was sold by a Brussels bookseller in 1871, her herbarium was bought by the Jardin Botanique National de Belgique (BR), Brussels, and her exsiccatae survive at a number of herbaria. Specimens from the Libert herbarium were distributed as *Reliquiae Libertianae* by BR. Libert's specimens have been a valuable resource for other scientists, and many of her collections formed the basis for new species described later, including in a number of publications on the *Reliquiae* by mycologists Casimir Roumeguère (1828–1892), Pier Andrea Saccardo (1845–1920) and Felix von Thümen (1839–1892). Libert's specimens also constitute an early, relatively comprehensive record of the mycota of Malmedy, providing a baseline for assessment of the impact of subsequent environmental changes (Creese 2004a: 104, TL-2).

Libert's scientific publications (9)

Libert M-A (1813). Cryptogamie, In *Flore des environs de Spa …* vol. 2 (ALS Lejeune). Chez Duvivier, Liège, Belgium: 272–285.
Libert M-A (1820). Sur un genre nouveau de'Hépatiques, *Lejeunia*. *Annales Générales des Sciences Physiques* 6: 372–374.
Libert M-A (1827a). Mémoires sur des cryptogames observées aux environs de Malmedy. Secrétariat de la Société Linnéenne, Paris, France [preprint of Libert (1827b) and (1827c) combined, TL-2 4496].
Libert M-A (1827b). Illustration du genre *Inoconia*, dans la famille des Algues. *Mémoires de la Société Linnéenne de Paris* 5: 402–403. [Some details from Libert's description of *Inoconia* are reproduced by Du Mortier (1865)]
Libert M-A (1827c). Observations sur le genre *Asteroma*, et description de deux espèces appartenant à ce genre. *Mémoires de la Société Linnéenne de Paris* 5: 404–406.
Libert M-A (1829). Description d'un nouveau genre de champignons nommé *Desmazierella*. *Annales des Sciences Naturelles* 17: 82–83.
Libert M-A (1829–1830). Mémoire concernant les plantes cryptogames qui peuvent être réunies sous le nom d'*Ascoxylacei*. *Mémoires de la Société Royale des Sciences, de l'Agriculture et des Arts de Lille*: 174–176.
Libert M-A (1830–1837). *Plantae cryptogamicae quas in Arduenna collegit M.A. Libert …*, 4 vols. Typis Jacobi Desoer, Leodii [Liège, Luik], Belgium [TL-2 4497].
Libert M-A (1836). Précis des observations sur la famille des Hypoxylons. *Annales des Sciences Naturelles* 7: 121–125.

Note that Du Mortier (1865) refers to a publication by Libert. "Sur le genre *Aschochyta*; notice envoyée" in *Mémoires de la Société Royale de Botanique de Belgique*, but according to Morren (1868), this was not published.

3. *Banning, Mary Elizabeth*
Dates: 6 April 1822–28 February 1903.

Portrait: photograph reproduced by Haines (1995: 54) and Matta (2008: 12) [current whereabouts not traced, possibly held by the Natural History Society of Maryland].

New taxa: Banning described 21 new species (all but five described in collaboration with Peck) in genera such as *Agaricus*, *Collybia*, *Inocybe*, *Polyporus*, *Russula* and *Tricholoma*, including *Polyporus beatiei* Banning, *Russula variata* Banning and *Tricholoma magnum* Banning & Peck.

Eponomy: *Hypomyces banningiae* Peck (1879a,b).

Another fifty-plus year gap lay between Libert's first described fungal taxon, and the next woman to emulate her achievement, Mary Elizabeth Banning (Fig. 3). While the years that the two women were active overlapped, there is no evidence that they knew of one other, and as Libert was situated in western Europe and Banning in rural USA, it is most likely that they did not. The female taxonomist as an isolated eccentric continued to be the norm in the second half of the nineteenth century (Ristaino 2008: 2), and, like Libert, Banning relied on male mentors for support. Her mycological efforts were clearly circumscribed by the amateur tradition.

Born in Talbot County, Maryland, Mary Elizabeth Banning was the youngest of nine children in the family of Robert Banning and

Fig. 3. Illustration of *Agaricus brownei* by Mary Elizabeth Banning (unpublished, 'plate 32', catalog i-542). Courtesy New York State Museum, Albany, NY.

second wife Mary/Maria née Macky. Robert Banning also had seven children from his first marriage. Moderately well off, the family lived on a small plantation on the shore of Chesapeake Bay, from where Mary's father engaged in community affairs, and served as a member of the Maryland House of Delegates.

The details of Banning's early education are unknown, but included nature study, religious instruction, and possibly Latin. She also cultivated an early interest in natural history, including the study of 'toad stools' that she observed in rambles in woods and fields around her home (Creese 2004a: 217). While tertiary education was available for women in some parts of the USA in the 1850s (Creese 2004a: 3), it arrived too late for Banning in Maryland (even had her family been able to afford it) (Matta 2008: 11).

After the death of her father in 1845, Mary, her mother and half-sister Catherine moved to Baltimore. Despite the burden of domestic duties, Mary remained curious about natural history, and, finding numerous unknown fungi nearby, sought advice about identifications from Charles Horton Peck (1833–1917), curator of the cryptogam collections at the New York State Museum of Natural History (NYS). Although they never met, the two mycologists corresponded for thirty years, with Banning becoming a member of Peck's network of collectors, and Peck assuming the role of teacher and mentor to Banning. As Banning wrote to Peck in 1879, 'You are my only friend in the debatable land of fungi' (Haines 1995: 60).

Peck oversaw the publication of Banning's first fungal taxon—*Polyporus beatiei*—in his botanical report of the NYS for 1879. In a note attached to the description, Peck stated that two gentlemen had also sent in specimens of this species but that he chose to typify the one received from Banning, 'who sent it under the name here given' (Peck 1879a: 36). Peck also published sixteen taxa with Banning based on her specimens.

Banning described five species in her own right (e.g. Banning 1881a). In related text she included observations on the morphology, taxonomic relationships, and life cycle of fungi, and tales of her adventures in finding specimens. These included dealing with rugged terrain, and the suspicion of locals about her activities. On one excursion, she asked a passing workman for advice on where to find fungi, and he replied in amazement, 'What does anybody want with them pison [i.e. poison] things?' Under his breath he added, 'Poor thing, crazy, certain sure'. For her part, Banning felt sorry for the workman, pitying the ignorance that kept him from appreciating fungi (Haines 1989).

In 1868, Banning began to prepare an illustrated book on the fungi of Maryland. Like Dörrien before her, she saw natural history as a means to teach children about faith and morality, and asked, 'what more common objects to the poor boy and girl who roam through the forests and over meadows' could be found? (Haines 1995: 55). Although she completed the manuscript in 1888, it was never published, and languished for nearly a century at the NYS before a selection of her colourful illustrations, accompanied by her entertaining field-notes was put on exhibition (Haines 1995: 61).

Banning spent the final years of her life in boarding houses in Virginia, becoming increasingly isolated and constrained by ill health and poverty. She died in 1903 in her eighty-first year and was buried in Baltimore (Creese 2004a: 218).

Apart from the manuscript of 'The fungi of Maryland', the NYS holds the specimens and letters that she sent to Peck. Her own collection of drawings and specimens seems to have been lost when she was obliged to move out of her mother's home in Baltimore. Peck named a species of fungus for her in 1879 based on one of her collections (*Hypomyces banningiae* Peck 1879b). In 1994, she was given posthumous recognition for her pioneering work in mycology when she was elected to the Maryland Women's Hall of Fame (Creese 2004a: 218).

Banning's scientific publications (7)

Banning ME (1877). Notes on the fungi of Maryland. *Field and Forest* 3: 42–47, 59–63.

Banning ME (1880). Notes on fungi. *Botanical Gazette* 5(1): 5–10.

Banning ME (1881a). New species of fungi found in Maryland. *Botanical Gazette* 6(1): 165–166.

Banning ME (1881b). Maryland Fungi, I. *Botanical Gazette* 6(4): 200–202.

Banning ME (1881c). Maryland Fungi, II. *Botanical Gazette* 6(5): 210–213.

Banning ME (1882a). The Tuckahoe. *Bulletin of the Torrey Botanical Club* 9: 125–126.

Banning ME (1882b). [Preservative for fungi.] *Bulletin of the Torrey Botanical Club* 9: 153.

See also: Banning (1868–1888). The fungi of Maryland, unpublished manuscript, 174 colour illustrations. New York State Museum.

4. *Bommer, Élise-Caroline (Élisa) née Destrée*
Dates: 19 January 1832–17 January 1910.

New taxa: Bommer described more than 200 new fungal taxa, including the genera *Chitonospora* E. Bommer, M. Rousseau & Sacc., *Marchaliella* G. Winter ex E. Bommer & M. Rousseau, *Pteromyces* E. Bommer, M. Rousseau & Sacc. and *Trichosphaerella* E. Bommer, M. Rousseau & Sacc. Almost all novelties

were published in collaboration with Mariette Rousseau (see below), and many also with Pier Andrea Saccardo. Bommer described three or more species in the genera *Belonidium*, *Camarosporium*, *Diaporthe*, *Diplodia*, *Leptosphaeria*, *Microthyrium*, *Peziza*, *Phoma* and *Septoria*. Many of the new species came from Belgium and the Netherlands, but also from around the globe, as far afield as Lapataia in Tierra de Fuego, from whence came *Chalara cyttariae* E. Bommer & M. Rousseau on the host *Cyttaria darwinii* Berk. (collected on the Belgian Antactic Expedition of 1897–1899).

Eponomy: *Bommerella* Marchal (1885), *Lophiostoma bommerianum* Sacc. & Roum. (1883), *Massaria destreeae* Oudem. (1889), *Psammina bommerae* Sacc. & M. Rousseau (1891), *Cucurbitaria destreeae* Oudem. (1894), *Onygena bommerae* M. Rousseau & Sacc. (1913), *Sphaeronaema bommerae* Illman (1985).

Like Libert, the fourth and fifth women to name fungal taxa in the modern era, Élise-Caroline Bommer née Destrée (Fig. 4), and Mariette Rousseau née Hannon, were French speaking Belgians. Together this trio make up half the initial group of six amateur female mycological taxonomists. Libert died before her Belgian successors became active in mycology, but they were aware of her contributions (Rousseau 1910: 259). Bommer and Rousseau were also female pioneers in taxonomic mycology in their own right, being the first married women to name new fungal taxa, and the first pair of women to make up a mycological partnership.

Élise-Caroline Destrée was born in 1832 at the Royal Castle of Laeken (the official residence of the King of the Belgians) on the outskirts of Brussels. Her father worked at the castle, and growing up Élise-Caroline enjoyed the freedom of the grounds. Her early education was provided by one of the palace governesses, and from the age of ten she attended a boarding school in Vilvorde for six years. Although disliking school discipline, Élise-Caroline excelled in music, and dreamed of travelling the world like Ida Laura Pfeiffer (1797–1858), an Austrian explorer (Rousseau 1910: 258).

Fig. 4. Élise-Caroline Bommer. *Bulletin de la Société Royale de Botanique de Belgique* vol. 47, p. [151], accompanying Rousseau (1910). Downloaded from Biodiversity Heritage Library.

As the Destrées could not afford to support their daughter at home, when Élise-Caroline turned twenty she was apprenticed to a firm in Brussels. Long hours and monotonous work undermined her health, but she began studying botany to satisfy her intellectual curiosity. The Destrée's family doctor introduced her to Jules Édouard Bommer (1829–1895), a professor of botany at Brussels University, and he provided her with intellectual guidance and assistance with identifications.

Professor and student married in 1865, and they had at least two sons. Despite her new domestic responsibilities, Élise-Caroline continued to study botany with her husband's support. In 1873, she joined forces with another professor's wife, Mariette Rousseau, and decided to focus on fungi after Jean-Édouard Bommer observed that this subject had been neglected in Belgium since Libert, Jean Kickx (1803–1864) and Gérard Daniel Westendorp (1813–1868) (Rousseau 1910: 259).

Although they had access to the library of the Brussels Botanic Garden, it took Bommer and Rousseau hours of painful study to feel confident in their mycology. Like their female predecessors, these two friends decided to produce a fungal flora of their region, and published a 195-page catalogue (1879) and a 350-page mycological flora (1884) for the fungi around Brussels followed by several papers on the fungi of Belgium in the journal of the Société royale de botanique de Belgique (Royal Botanical Society of Belgium). In addition, Bommer published a 317-page handbook to the higher fungi of the Netherlands (Destrée 1901).

Recognised as expert mycologists by their peers, Bommer and Rousseau began to be entrusted with the enumeration of other collectors' fungal herbaria. These included Henri Pittier (1857–1950), a swiss-born scientific explorer in South America (Bommer & Rousseau 1896), and the collector on the Belgian Antarctic expedition, 1897–9 (Bommer & Rousseau 1905). In addition, Élise-Caroline published a number of contributions on the fungi of the Netherlands under her maiden name Destrée.

In her later years, Bommer took up painting flowers and mushrooms, and otherwise occupied her time with poetry and music. She died two days before her seventy-eighth birthday. In an obituary, Mariette Rousseau was careful to emphasise that her friend was always a woman before she was a scientist, and only took up botanical work in the evening after her domestic duties were completed (Rousseau 1910: 256).

At her own request, Bommer's fungal herbarium and types were left to the Jardin Botanique National de Belgique (BR), Brussels (Rousseau 1910, 259; TL-2). The genus *Bommerella* was named for her by fellow Belgian botanist and mycologist Élie Marchal (1839–1923) in 1885. Bommer's son, Charles (1866–1938), also contributed to his parents' botanical legacy, graduating with a doctorate in botany from the Brussels University in 1894, and having a career as a botanist and paleobotanist (Creese 2004a: 104).

Bommer's scientific publications: 14 before 1900, 21 after (total 35)

Bommer E, Rousseau M (1879). Catalogue des champignons observé aux environs de Bruxelles. *Bulletin de la Société Royale de Botanique de Belgique* 18(3): 61–219 [reprinted, TL-2 627].

Bommer E, Rousseau M (1884). Florule mycologique des environs de Bruxelles. *Bulletin de la Société Royale de Botanique de Belgique* 23(1): 13–365 [reprinted, TL-2 628].
Bommer E, Rousseau M (1886). Contributions à la flore mycologique de Belgique. *Bulletin de la Société Royale de Botanique de Belgique* 25(1): 13–365.
Bommer E, Rousseau M (1887). Contributions à la flore mycologique de Belgique, II. *Bulletin de la Société Royale de Botanique de Belgique* 26(1): 187–241.
Bommer E, Rousseau M (1890). Contributions à la Flore Mycologique de Belgique, III. *Bulletin de la Société Royale de Botanique de Belgique* 29(1): 205–302.
Bommer E, Rousseau M (1896). Primitiae Florae Costaericensis par Th. Durand et H. Pittier. Troisième fasicule. Fungi. *Bulletin de la Société Royale de Botanique de Belgique* 35: 151–166.
Destrée C (1891a). Première contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 2, 5: 341–347. [series reprinted, TL-2 29.925]
Destrée C (1891b). Deuxième contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 2, 5: 625–632.
Destrée C (1895a). Troisième contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 2, 6: 169–194.
Destrée C (1895b). Quatrième contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 2, 6: 356–365.
Destrée C (1895c). Cinquième contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 2, 6: 594–619.
Destrée C (1895d) Révision des *Geaster* observés dans les Pays-Bas. *Nederlandsch Kruidkundig Archief*, ser. 2, 6: 488–501. [reprinted, TL-2 29.926]
Destrée C (1896). Dernière contribution au catalogue des champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 3, 6: 127–138.
Destrée C (1897). Supplément au catalogue des Champignons des environs de la Haye. *Nederlandsch Kruidkundig Archief*, ser. 3, 7: 232–239.
Selected post-1900 references:
Bommer E & Rousseau M (1905). Champignons. Résultats Voyage du S. Y. Belgica en 1897–1898–1899 … Rapports scientifiques …. 6: 1–15, pl. 1–5. [TL-2 629]
Destrée CE (1901). Handleiding tot het bepalen van de in Nederland groeiende hoogere Zwammen. F.E. Macdonald, Nijmegen, Netherlands. [TL-2 29.927]

5. *Rousseau, Mariette née Hannon*
Dates: 20 March 1850 – 14 January 1926.

New taxa: see Bommer, above.

Eponomy: *Roussoella* Sacc. (1888), *Roussoellopsis* I. Hino & Katum. (1965), *Nectria rousseauana* Sacc. & Roum. (1883), *Fabraea rousseauana* Sacc. & E. Bommer (1886).

Scientific publications: nine (see Bommer's publications, above).

Élise-Caroline Bommer's partner in mycology, Mariette Rousseau née Hannon (Fig. 5), was born into an educated middle-class family in the Belgian municipality of Ixelles in 1850. Her father, Joseph Hannon, was a professor of zoology and comparative anatomy at Brussels University (Bestor_NL 2016).

Fig. 5. Mariette Rousseau. Detail from photograph '*Mariette Rousseau and James Ensor in the Rousseau family garden in Brussels*', *c. 1888*, presumably taken by Ernest Rousseau. Courtesy Mu.ZEE en Permekemuseum, Ostend.

The details of her schooling are unknown, but were sufficient to allow her to live in Germany for a year where she studied languages and worked as a teacher (Bestor_NL 2016).

In 1871, she married Ernest Rousseau, a professor of zoology and rector at Brussels University. He was also a friend of her father's, and 28 years her senior. A sociable couple, their house became a well-known salon for the city's left-wing, intellectual and artistic elite, such as artist James Ensor. They had at least one son, Ernest Rousseau Jr who became a zoologist (De Bont 2015: 179).

Mariette Rousseau credited Élise-Caroline Bommer with sparking her interest in mycology, adding gratefully that, 'La conformité de nos goûts, le parallélisme de certains côtés de nos caractères, furent la base d'une entente complète et d'une collaboration dont l'activité ne devait jamais se ralentir' (The conformity of our tastes, the similarity of certain aspects of our characters, formed the basis of a complete agreement and a collaboration whose activity could never be slowed down) (Rousseau 1910: 259).

All of Rousseau's publications were with Bommer, and she stopped collecting after Bommer's death in 1910. Thereafter she used her time to curate the mycological collection at the Brussels Botanic Garden, where she was given space to work. Her obituarist claimed that she reigned silently in room VIII, almost ignored, and surrounded by cupboards and mountains of herbarium sheets (Beeli 1926: 19).

Outside the garden, Rousseau organized public exhibitions of fungi and led fungal forays into the Sonian Wood for Les Naturalistes belges (Belgian Naturalists) (founded by her son) (Bestor_NL 2016). Known for her fungal expertise, she encouraged younger workers to take up mycology, and welcomed all comers to her work-room (Beeli 1926: 19).

In 1924 two years before her death, Rousseau was made a Knight of the Order of Leopold, Belgium's highest order. She was imortalized in the genus *Roussoella* by Italian mycologist Pier Andrea Saccardo who was part of the Rousseau-Hannon scientific circle (Bestor_NL 2016). More recently she was commemorated in the genus *Roussoellopsis*. Her herbarium and types are at BR and other material is at the Plant Pathology Herbarium, Cornell University, Ithaca, New York (CUP) [TL-2] and the US National Fungus Collection, Beltsville, Maryland (BPI).

6. *Smith, Annie Lorrain*
Dates: 23 October 1854–7 September 1937.

New taxa: *novel taxa* introduced by Smith include the family *Cryptotheciaceae*, and the genera *Ampullaria* A.L. Sm., *Boydia* A.L. Sm., *Discocera* A.L. Sm. & Ramsb., *Lepidoleptogium* A.L. Sm., *Stemphyliopsis* A.L. Sm., *Stirtonia* A.L. Sm. and *Xyloceras* A.L. Sm. In all she described more than 200 novel taxa, including more than two new species in each of the genera *Aecidium*, *Arthopyrenia*, *Ascochyta*, *Coniothyrium*, *Dothidella*, *Lachnella*, *Lecanora*, *Lecidea*, *Libertella*, *Phyllosticta* and *Stagonospora*.

Eponomy: *Pseudophacidium smithianum* Boud. (1909), *Cytospora smithiae* Sacc. & Trotter (1913), *Verrucaria lorrain-smithiae* M. Knowles (1913).

The sixth and final woman to become a taxonomic mycologist before the turn of the century, despite lacking a tertiary education, was Annie Lorrain Smith (Fig. 6). By the 1890s, when Smith coined her first fungal taxon, she had a small cohort of well-educated female peers, mainly in the USA, who had university degrees. Some of these women even had professional positions, and new taxa to their names. In the UK, access to tertiary education remained problematic and while a number of amateur British women continued to publish on fungi, Smith did not have female peers who contributed to taxonomic mycology until after the turn of the century.

Fig. 6. Annie Lorrain Smith. © The Trustees of the Natural History Museum, London.

Annie Lorrain Smith was born at Half Morton, Scotland into the large and talented family of the Rev. Walter Smith and Annie Lorrain née Brown. While her brothers attended the University of Edinburgh (and three later became professors), Annie was not able to do so. In 1869, when she was fifteen, the Edinburgh Seven became the first group of matriculated undergraduate female students at a British university, but were prevented from graduating after a hostile and at times violent campaign by opponents to female higher education (Elston 2004). Nevertheless, Annie's parents supported her study of French in Orléans and German in Tübingen, and for a time she worked as a governess (Creese 2005).

In 1878, she took Dunkinfield Henry Scott's (1854–1934) botany classes at the Royal College of Science, London (later part of Imperial College). Established to train teachers, this college nonetheless only permitted women to enroll in courses as 'Occasional Students' (Barrett 2017: 3, 418). Smith impressed Scott with her abilities, and through his influence she was hired to curate Anton de Bary's collection of slides of microscopical fungi at he Natural History Museum, London (BM). Although Smith worked in the cryptogamic herbarium for the rest of her life and received a salary, she was only ever classified as an 'unofficial worker', because women were not allowed to hold museum positions (Creese 2005).

Dedicating herself to mycology, Smith soon became responsible for identifying most of the incoming collections of fungi. Her first new taxon, *Cycloderma apiculatum* A.L. Sm., appeared with a handful of others in an article on collections made by three members of the Church Missionary Society in Kenya (Smith 1895). Numerous new taxa from overseas and the UK followed. From 1906, Smith worked on lichens, finalising the second volume of James Crombie's *Monograph of the British Lichens* (1911), and revising a second edition (1918, 1926). In her own right, she published a *Handbook of British Lichens* (1921) and *Lichens* (1921), a standard text book for more than fifty years.

A member of the Essex Field Club, Smith was also a founding member of the British Mycological Society (of which she was twice president). In 1904, she was in the first group of female fellows of the Linnean Society (along with Guielma Lister, see below), and served on its council, 1918–21. In 1914, she attended the eighty-fourth meeting of the British Association for the Advancement of Science that was held in Australia and also visited the USA (Creese 2005).

Smith was honoured in a lichenised fungus by friend and colleague Irish cryptogamic botanist Matilda Cullen Knowles (1864–1933). Described in 1913, *Verrucaria lorrain-smithiae* M. Knowles was based on a specimen collected at Balscadden Bay, Ireland (Knowles 1913). Knowles herself became an early contributor to mycology, but did not begin publishing in this discipline until after the turn of the century (Creese 2004a: 256).

Smith never married and lived with a sister for fifty years. Retiring on a civil service pension in 1934, she was also awarded an OBE for her contributions to cryptogamic botany. After a few years of poor health, she died at home in her eighty-third year. Her herbarium and types are at BM, fungi at K, and other specimens at DBN. There are also manuscripts at BM, and letters (to Farlow) at the Farlow Library and Herbarium of Cryptogamic Botany, Harvard University, Cambridge, Massachusetts (FH) (TL-2).

Smith's scientific publications: 6 before 1900, 79 after (total 85)
Smith AL (1895). East African fungi. *Journal of Botany, British and Foreign* 33: 340–344 [TL-2 12.178].
Smith AL (1896). Nomenclature of British *Pyrenomycetes*. *Journal of Botany, British and Foreign* 34: 358–9.
Smith AL (1897). Microscopic fungi new to, or rare in, Britain. *Journal of Botany, British and Foreign* 35: 7–8, 100.
Smith AL (1898a). Supplement to Welwitsch's African fungi. *Journal of Botany, British and Foreign* 36: 177–180.
Smith AL (1898b). New or rare British fungi. *Journal of Botany, British and Foreign* 36: 180–182.
Smith AL (1899a). British mycology. *Transactions of the British Mycological Society* 1: 68–75.

DISCUSSION

The Enlightenment: eighteenth century

The history of women in taxonomic mycology begins in the Enlightenment, or Age of Reason that was well under way in Western Europe by the latter part of the seventeenth century. Scholars of this era rejected traditional reliance on received wisdom or scripture, and new ideas and ways of thinking influenced all disciplines of knowledge (Jacob 2003). Botany (which included the study of fungi), was revolutionised by the discovery of plant sexuality, and Linnaeus used it as the basis for a system of classification, and also introduced binomial nomenclature (Frängsmyr 2003). Few attempts were made to include women in scientific developments, but feminists began their first great battles for equal access to education. Progress, however, was slow, and Catharina Dörrien is the only woman known to have named a new fungal taxon in the eighteenth century.

Female education, in so far as it existed in the Enlightenment, usually took place in the home. At best, girls in upper and middle-class families might be taught the same lessons as their brothers, although daughters were more likely to be given instruction in the domestic and decorative arts. These were subjects thought to be the most relevant to girls' expected future roles as wives and mothers. Attendance at female-only boarding schools for a year or two to be 'finished' was also an option for 'better off' families (Simonton 2005: 41–45). Almost without exception there was no access for women, or most men, to tertiary education (Brockliss 2008: 52).

Writer and philosopher Mary Wollstonecraft (1759–97) argued for more inclusivity in education. Believing girls and boys to be equally endowed with reason, she recommended that they share a basic primary schooling, to be followed by secondary education for the most talented (Wollstonecraft 1792: 221). This was a radical position, even for the Enlightenment, and other educationists proposed separate institutions and curriculums.

Boys' schools remained focussed on Greek and Latin, the traditional languages of scholarship. Science was in fact more likely to be taught at girls' schools as a practical and sensible antidote to frivolous female pastimes (Tolley 1996: 129). Botany was especially valued 'on the basis of traditional associations from myth and literature that linked flowers and gardens with women and nature and with femininity, modesty, and innocence' (Shteir 1996: 2–3). The new systems of binomial nomenclature and classification introduced by Linnaeus in the middle of the eighteenth century greatly facilitated the study of plants (Shteir 1996: 50–51).

Not everyone agreed with this direction in female education, and critics claimed that it was against all notions of propriety to allow girls to study botany using a system of classification based on sexual organs (George 2005: 2). Scottish encyclopedist William Smellie (1740–1795) exclaimed in 1768 that, 'Obscenity is the very basis of the Linnaean system' (Calé 2000). The term Linnaeus coined for the group that included fungi was a case in point. Cryptogamia meant 'clandestine marriage', a notion considered by many not fit to put before the 'fair sex' (Kelley 2012: 5).

Although limited educational advances were made during the Enlightenment, these advances did impact women's lives, and gave a growing number access to paid employment in teaching and pedagogical writing (Shteir 1996: 4–5). Catharina Dörrien was both a governess and the author of textbooks for children and women. It was almost unheard of, however, for a woman to move from learning about, to undertaking original research in, botany. Dörrien was only able to make the transition because she was born into a progressively minded family, and obtained employment as an adult in another such family.

While Dörrien was not regarded as a mycologist (because fungi at this time were still the province of botanists), the fact that she expended considerable effort on fungi was unusual for a botanist in the Enlightenment. Fellow German, Jacob Christian Schäffer (1718–1790), published a four-volume work focussed on fungi between 1762 and 1764, but it was not until the latter part of the eighteenth century that multiple scholars followed his example such as August Batsch (1761–1802), Georg Franz Hoffmann (1760–1826) and Christiaan Hendrik Persoon (1761–1836) and the study of fungi began to emerge as a distinct scientific discipline (Ainsworth 1976).

There were no other female scholars of Dörrien's time who replicated her botanical or mycological achievements, but she has been compared to German-speaking Maria Sibylla Merian (1647–1717), and Scottish-born Elizabeth Blackwell (1707–58), scientific illustrators from the previous generation (Viereck 2000: 7). In so far as botanical art is concerned this assessment is a fair one, but neither Merian nor Blackwell coined new plant names leaving Dorrien as the first, and for fifty years the only, female taxonomic mycologist.

First half of the nineteenth century: 1800–1849

By the end of the eighteenth century, the Western world was transforming once again. This time the Industrial Revolution led to the mechanisation of methods of production and increased economic prosperity. In the sciences, new disciplines emerged and there was an emphasis on research for practical and commercial ends (Jacob 2003, Olesko 2003a). Miles Joseph Berkeley (1803–1889), an English clergyman, coined the terms 'mycology' and 'mycologist' in 1836, and the first paid careers in fungal research became a reality (Ainsworth 1976). Progress for women in science, however, remained slow and, as in the previous era, only one woman, Marie-Anne Libert, managed to name a new fungal taxon in the first half of the nineteenth century.

While the preferred option for the daughters of upper-class families was still an education at home, increasing numbers of girls benefitted from at least some years of primary schooling in the nineteenth century. In consequence there was a steady rise in literacy rates across the decades (Lyons 1999: 313–314). By 1870 in the USA, women had nearly equalled men in basic literacy (Hobbs 1995: 2). Being able to read and write created

more opportunities for women to educate themselves in natural history, and to participate in the growing number of field naturalists' groups that were among the first scientific societies open to both genders and all ages (Allen 1976, Browne 2003).

Universities, too, expanded in response to the needs of industrialising economies, but almost universally remained closed to women. The German states led the way in reforming tertiary education for men, founding new universities and extending professorial appointments into the natural sciences (Olesko 2003b: 813–814). Staff and students were involved in the transmission and the enlargement of knowledge, and original research in the form of a thesis or dissertation became a necessary qualification for an academic career in Europe (Brock 2003: 216–217).

As men entrenched their hold on higher education and the professions, women and amateurs experienced a decline in the status of their activities. John Lindley (1799–1865), the first professor of botany at the University of London was careful to distinguish 'polite botany' (that he defined as an 'amusement for ladies'), from 'botanical science', (that he regarded as 'an occupation for the serious thoughts of man') (Shteir 1996: 5). With no opportunity to study natural science at university, women struggled to disprove the prejudices of men like Lindley, and were largely restricted to self-education and unpaid research (Ogilvie 2008: 660).

In this inauspicious context, Marie-Anne Libert was able to become a taxonomic mycologist due to a combination of special circumstances. Like Dörrien she lived in a supportive family, and one that had been enriched through the industrial revolution. She attended a girls' boarding school for several years and extended her education with the support of male mentors such as Lejeune and De Candolle (both tertiary educated). Supported by the family business, and not required to care for any children (either her own or those of another woman), Libert was able to make mycological research central to her life.

Libert's mycological efforts also contributed to the establishment of plant pathology. This kind of mycology made use of the latest scientific equipment, and laboratory experimental techniques to produce original insights into the life history of fungi, and to provide advice for combatting crop losses. Male mycologists such as Anton de Bary (1831–1888) and Miles Joseph Berkeley are well known early contributors to plant pathology, but this scientific speciality was to offer important career pathways for women in the second half of the nineteenth century.

As with Dörrien there were no female peers for Libert's mycological achievements in the first part of the nineteenth century, but with the overall improvement in female education a couple of other women came close (Shteir 1996: 210). Anne Hunter, a member of the Berwickshire Naturalists' Club, published detailed descriptions of two new records of fungi for the UK in the club's bulletin (Hunter 1846, 1868), and fellow British woman Anna Maria Hussey produced the two-volume *Illustrations of British mycology* (1847–55) with beautiful hand-coloured plates. Hussey's introduction indicated she understood ancient Greek and Latin, and could read the latest fungal research in several European languages. In 1847, Miles Joseph Berkeley named the genus *Husseia* Berk. 'after my friend, Mrs Hussey, whose talents well deserve such a distinction' (Berkeley 1847).

Mid to late nineteenth century: 1850–1887

By the middle of the nineteenth century, Western science had spread beyond Europe and the UK, and taken root in colonies and former colonies in the so-called 'New World'. While the 'Old World' retained pre-eminence in most disciplines, the discovery of natural wonders in Africa, Asia, the Americas and Australasia challenged the abilities of taxonomists and taxonomies to accommodate and to explain them (Naylor 2003). Ongoing restrictions on female education and participation in society limited female contributions to the work of enumerating the multitude of new taxa, but nonetheless two amateurs still managed to name names.

While substantial gains had been made in female participation at the primary and secondary levels of education, access to tertiary education remained elusive. The first nation to permit significant female entry into public colleges and universities was the USA. Notably, from 1862, women were allowed to attend the so-called Land Grant universities of the Midwest, although it was only because they were not specifically excluded in the relevant federal legislation (Solomon 1985: 44). The agricultural and engineering focus of these universities also inadvertently promoted the study of mycology, due to growing commercial concerns about fungal pathogens (Creese 2004a: 29).

From the point of view of mycological publications, the female beneficiaries of developments in US higher education did not fully emerge for several decades. Etta Knowles and Martha Buell née Merry published a couple of fungal articles on the basis of bachelor degree research in 1887, but did not go on to higher degrees. Flora Patterson née Wambaugh is also exemplary in this regard. Although she graduated a bachelor of arts from Antioch College in 1865, she married four years later and was occupied with family life. It was only after her husband became an invalid that she was compelled to earn her living (Creese 1998; Rossman 2008). In 1883, she received a master of arts degree from Wesleyan College, Cincinnati, and became an active mycologist in the final decade of the century.

Meanwhile, the amateur tradition remained the dominant way for women to contribute to mycology. Maryland resident Mary Banning was too poor, and lived too remotely from the new American universities to access them. Nevertheless, she managed to become the first woman in the USA, and in fact in the entire New World, to name a fungal taxon. As with her predecessors in Europe, Banning found the necessary support from family, mentors and contacts with scientific societies.

Banning remained unique in the USA for ten years, but in Australia another amateur, Flora Martin née Campbell, came close to emulating her achievement. Already an adult when women were admitted into Australian universities in the 1880s, Martin developed her expertise in mycology through the Field Naturalists' Club of Victoria, and a scientific friendship with Daniel McAlpine (1849–1932), the colony's first government vegetable pathologist. Martin collected dozens of fungal types, wrote mycological articles, acted as an honorary assistant to McAlpine (i.e. unpaid), and became the first woman to present a paper to the Australasian Association for Science (Martin 1890).

In the Old World, Bommer and Rousseau were able to take advantage of living and working in the milieu of the university and botanic garden to build up an expert knowledge of mycology. With the support of fathers and husbands who were academics, they were able to go beyond the efforts of their Belgian predecessor, Marie-Anne Libert, and gain the necessary authority to work on fungal taxa within their own country, and from collections made overseas. Their experience suggests the importance of women having female role models and collaborators to inspire

them with the confidence and courage to learn and practise science.

Neither of these women seems to have complained about not being able to attend university like their fathers, husbands and sons, or notes any instance of hostility toward their mycological ambitions. In her obituary of Bommer, Rousseau was careful to stress her friend's 'modestie profonde' (profound modesty), and that she only took up scientific work each day after fulfilling all her family duties (Rousseau 1910). In turn, the author of Rousseau's obituary stressed the quiet way in which she lived, and her 'grande modestie' (great modesty) (Beeli 1926). Scientific research might be added to the domestic activities of a respectable married woman, but apparently could not replace them, or become the source of renown.

A handful of European countries opened universities to women in this period including Switzerland (1867), Sweden (1873), Netherlands (1876) and France (1880) (Timeline 2017). From the 1850s, Russia developed a series of advanced secondary schools for women, and briefly allowed their graduates to attend university between 1859 and 1863. Thereafter, increasing numbers began to travel west for tertiary education. In 1872, Nadezhda Ziber-Shumova née Shumova went to Zurich University in Switzerland with her husband, and moved to Bern University when the tsarist government forbade women to attend at Zurich. She graduated from the medical faculty in 1880 based on a thesis titled 'Beiträge zur Kenntnis der Schimmelpilze' (Contributions to knowledge on yeasts) (Sieber 1881). She went on to publish over thirty articles on the chemistry of micro-organisms and co-found the Institute of Experimental Medicine in St Petersburg (Creese 2015: 49–50).

While there were no other tertiary-educated female mycologists in Europe or Britain between 1850 and 1887, a diverse group of amateurs was active. Britain produced the largest group including Lydia Ernestine Becker and Anna Russell née Worsley, who wrote articles about fungi (Russell 1868, Becker 1869; Creese 1998: 34), and Sarah Price and Margaret Plues who published illustrated fungal hand-books (Plues 1864, Price 1864–5). In France, the Duchesse de FitzJames conducted experiments on fungal pathogens in her family's vineyards, and published her findings (FitzJames 1885; Creese 2004a: 72). In Italy, countess Elisabetta Fiorini-Mazzanti collected and published on cryptogams (including lichenised fungi), and described new species of moss and algae (Fiorini-Mazzanti 1857–1858; Creese 2004a: 193–4). In Germany, Johanna Lüders collected and published on cryptogams, including papers on the relationship between flagellate micro-organisms (in genera such as *Vibrio*) and fungi (Lüders 1866; Creese 2004a: 123). In the USA, Sophie Herrick wrote popular articles on science for magazines and published a book that included drawings of micro-characters of fungi (Hollis 1979).

Late nineteenth century: 1888–1899

By the end of the nineteenth century, many Western countries admitted women to university, with notable exceptions being Germany, Russia, and Spain (Timeline 2017). The idea of the 'New Woman' emerged in popular literature and was applied to educated independent-minded individuals who pursued careers of their own choice. While the experience of most women did not nearly attain to this ideal, the possibility of female self-determination gained legitimacy (Ledger 1997: 1–8). The first professional women taxonomic mycologists became active in the late 1880s and in the 1890s, although they continued to co-exist with a shrinking female amateur tradition.

The first professional taxonomic mycologists came out of universities in the USA. Their careers are not dealt with in detail here, as we are focussing on self-educated individuals, but they demonstrate the increasing importance of research degrees to high-level scientific research. Effie Spalding née Southworth graduated BS from the University of Michigan in 1885, and in 1887 became the first female plant pathologist hired by the US Department of Agriculture (USDA). She added a MS degree to her qualifications from the University of California in 1923. Clara Eaton Cummings attended university (without taking a degree), but became a professor of cryptogamic botany at Wellesley. Flora Patterson AM (mentioned above) was appointed assistant pathologist at the USDA 1895. Bertha Stoneman was educated in the USA (DSc), before moving to South Africa where she established the first degree course in botany.

While scientific positions were expanding in the western world at the end of the nineteenth century, there was strong competition for them among male candidates, and women were not necessarily welcome to apply. In a letter to a mycological colleague in 1909, George Perkins Clinton (1867–1937) expressed his dismay over the 'feminisation' of botany. Consoling himself that most of the new professional women were confined to making cultures and cutting sections, he added: 'It wasn't bad when Patterson was the only one but now they have spread out into a dozen or more!' (Ristaino 2008: 1). As far as mycology is concerned, as Rossman (2011: 38) points out, it took more than a century after Patterson's appointment before the USDA had appointed more than a dozen female mycologists.

Most female graduates in the USA who published on fungi prior to 1900 made modest contributions based on their thesis research (Creese 2004a: 17). The most common reason they did not go on to have scientific careers was marriage and motherhood, which curtailed the mycological output of Dakin, Dunn, Greene and Stanford (see Table 1). Another group of women found employment that did not require, or allow, them to continue mycological research. Teaching continued to be the most common career available to educated women in this era, and provided a living for Beeler, Buell, Clifford, Cox, Horn and Knowles (Table 1). At least one of these women (Beeler) retired upon marrying, probably due to convention as formal marriage bars were not introduced into the USA until after the turn of the century (Goldin 1988).

A single tertiary-educated European scientist coined a new fungal taxon before the turn of the century. Praskovia Vassilievna Tsiklinskaia was born and went to secondary school in Russia before attending the world's first microbiology course at the Pasteur Institute in France in 1889, and auditing science lectures at Paris University. She returned to Russia, commencing work as a laboratory assistant at Moscow University, but rose to become the first Russian woman professor (Creese 2015: 34). In 1899, she described *Thermomyces lanuginosus*, only the second known thermophilic fungus (i.e. one that can grow actively at temperatures as high as 50° C). Tsiklinskaia is regarded as regarded as a pioneer in the field of thermophily (Mouchacca 1999: 44).

Several women in the 1890s made initial contributions to mycology but went on to have careers in different disciplines. After submitting a thesis on yeasts to Purdue University and taking up a position there, Katherine Golden married in 1904,

ceased working at Purdue and subsequently changed discipline to food science. From 1907, with her husband, Arvill Bitting, made important contributions to food preservation (Smith 2007). Lydia Rabinowitsch-Kempner was born in what is now Lithuania, then part of imperial Russia, and attended Bern and Zurich Universities, graduating in 1894 with a thesis on the development of gasteromycetes (Rabinowitsch 1894). Subsequently, Rabinowitsch-Kempner made significant contributions to the study of tuberculosis and other public health issues, directing research institutes in the USA and Germany (Creese 2004a: 129–138). Dutch-woman Canna Maria Popta wrote an article about fungi on sugar cane (Popta 1897) and a doctoral thesis at Bern University in Switzerland on *Hemiasci*, dealing with ascomycetous yeasts such as *Ascoidea* (Popta 1899). Afterwards she changed focus to the study of fishes, and published over forty papers while a curator at the Rijksmuseum van Natuurlijke Historie (National Museum of Natural History), Leiden (Balon *et al.* 1994: 13–14).

The female amateur tradition persisted longer in the UK than in many countries due to strong local resistance to co-education, and to expanding the number of degree granting bodies (Eschbach 1993). This was augmented by resistance to female membership in the premier scientific societies, and individual sexist attitudes. Beatrix Potter might have continued her studies of lichens if not for the hostile reception she received from William Thiselton Dyer, the Director of Kew Botanic Garden (Potter called him 'something of a misogynist') (Lear 2008). Rose Helen Thomas née Haig and Mary Ann White (Table 1) made small contributions to mycological literature.

Annie Lorrain Smith's contributions stand out in this context. The number of her publications exceeded the combined total of the five other amateur women taxonomic mycologists. Of all the amateurs, Smith came closest to making the transition to professional status, but was never accorded a proper title or salary. The most accessible form of higher education for British women in the second half of the nineteenth century took the form of a lecture series (such as attended by Smith), but this mode of instruction was informal and did not lead to enhanced status (Eschbach 1993). The University of London became the first to award degrees to women in 1880, and the last British university to award women degrees was Cambridge in 1947. Gertrude Nuttall née Clarke, who published on lichens, was reputedly the first women to obtain a bachelor degree from a British university, but uncertainty remains about when and where she graduated (Ogilvie & Harvey 2000).

Annie Lorrain Smith's lack of confidence in her qualifications undoubtedly contributed to her long apprenticeship in mycology. She did not begin publishing new taxa until she was 41. The career of her friend and colleague at the British Museum, Guielma Lister (1860–1949), followed a similar trajectory. Lister spent a year at Bedford College, the first higher education institution open to women in the UK, although not permitted to award degrees. As a young woman, she actively assisted the mycological research of her father [Arthur Lister (1830–1908)] but did not become an author in her own right until after the turn of the century, and the death of her father, when she was in her forties (Creese 2004b).

CONCLUSION

When Linnaeus named the first fungal taxa at the start of the modern era of taxonomy in 1753, there was no notion of mycology as a discipline let alone of a mycological career. Both came into existence in the Western world over the next two hundred years, but were taken up unevenly between the sexes. Taxonomic mycologists have always comprised a relatively select group within mycology, but more men than women have contributed to this field and from an earlier date.

The first substantial barrier to women's participation was a lack of, or restricted access to, education. While botany was promoted as a suitable subject of study for girls in the Enlightenment, the most girls could hope for was informal tuition and opportunities for self-improvement. Boys tended to be taught the classical languages commonly used in botanical literature, and enjoyed the possibility if not the certainty of attending university where they would be instructed by leading professional botanists. Women were not expected to be scholarly or to produce research of note and were usually excluded from the learned societies in which amateur male scientists discussed and published their work.

Despite these obstacles, six self-taught women managed to describe fungal taxa between 1753 and the turn of the twentieth century when educational and professional opportunities for women began to open up: Catharina Dörrien, Marie-Anne Libert, Élise-Caroline Bommer née Destrée, Mariette Rousseau née Hannon, Mary Elizabeth Banning and Annie Lorrain Smith. Each of these women was exceptional in that she exceeded what society expected of her, but found a supportive community of family and friends who encouraged and facilitated her scientific endeavours.

Dörrien, Libert and Banning were the sole female taxonomic mycologists working within an overwhelmingly male milieu, and each a generation apart. The next two women, Bommer and Rousseau were colleagues and collaborated in their publications. Smith, the final amateur, also enjoyed the friendship of another female mycologist, Guielma Lister, but while Smith began publishing in the 1890s, Lister's own solo efforts did not begin until after 1900.

It is remarkable that three of the six women were from Belgium. The degree to which the pioneering work of Marie-Anne Libert paved the way for and/or stimulated the mycological research of Bommer and Rousseau is uncertain. With such a small sample size, care must be taken with generalizations. However, while each of the six amateur women is unique, they shared some common strategies in their pathways to productivity. All were born and raised in progressive families (when it came to education), were directed and encouraged by male mentors, and established links to a scientific society, museum or university. In this way they were able to acquire the specialist knowledge necessary to make an original contribution to taxonomic mycology.

Nevertheless, in addition to attracting supporters, the first women taxonomic mycologists also had to withstand active opposition to their activities by social conservatives and hostile male colleagues. Attempts to confine them to the amateur sphere and to resist the 'feminisation' of botany were backed by long-term established conventions and prejudices. While female mycologists rarely openly acknowledged the disadvantages they faced, the emphasis on Bommer and Rousseau's femininity in their obituaries is tacit recognition that respectability required them to fulfil the traditional duties of their gender.

The turning point for women's participation in taxonomic mycology came with their admission to universities, and especially to higher or research degrees. The USA led the way with Land-Grant universities, but Switzerland was also an important centre for female higher education. By the late 1880s, a group of tertiary educated women, who in some cases were scientific professionals, began to publish new fungal taxa including

Spalding née Southworth, Atchison née Clendenin, Patterson née Wambaugh, Stoneman, Greene née Snyder, Stanford née Olson and Tsiklinskaia. Many of the early women professional mycologists were not only pioneers in mycology, but in science in general, in gaining degrees and in taking up positions in universities and government research organisations.

The cohort of professional women just managed to equal the amateurs in number by the turn of the century, and would rapidly outpace them thereafter. However, the lack of higher degree students in mycology in European universities outside of Switzerland until after 1900 is notable, especially in regions where mycology has a long tradition, such as France, Germany, Italy and the Scandinavian countries. Further comparative analysis across scientific disciplines may shed light on the reasons for regional differences.

The ability for women to name fungal names prior to 1900 rested on the existence of a rare set of circumstances and ambitions. In order to appreciate fully the significance of the achievements of Dörrien, Libert, Banning, Bommer, Rousseau and Smith, it is necessary to acknowledge and understand the restrictions on participation in science that they faced. Their contributions, and those of the female cohort who published around them, also hint at what is lost by restricting access to scientific education and careers to half the population.

While improvements in access to education and professional appointments for women since 1900 have resulted in more opportunities for women to participate in mycology, parity with male professional colleagues is a goal yet to be reached (Branca & Vellinga 2015). The recent election of a special additional cohort of female members to the Koninklijke Nederlandse Akademie van Wetenschappen (Royal Netherlands Academy of Arts and Sciences), 'in honour of … Johanna Westerdijk, who gave her inaugural address as professor one hundred years ago this year', offers an example of innovative ways of increasing equity in representation of women, in the case of the Dutch Academy, from the current level of 13 % of academicians (Koninklijke Nederlandse Akademie van Wetenschappen 2017).

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REFERENCES*

Abir-Am PG (2003). Women in science. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 827–829.

Ainsworth GC (1976). *Introduction to the history of mycology*. Cambridge University Press, Cambridge, UK.

Ainsworth GC, Webster J, Moore D (eds) (1996). *Brief Biographies of British Mycologists*. British Mycological Society, Stourbridge, UK.

Alic M (1986). *Hypatia's heritage: a history of women in science from antiquity through the nineteenth century*. The Women's Press Limited, London, UK.

Allen DE (1976). *The naturalist in Britain: a social history*. Allen Lane, London, UK.

Allen DE (2004). *Russell, Anna (1807–1876). Oxford dictionary of national biography online edition*. http://www.oxforddnb.com/view/article/56451. Accessed 20 April 2017.

Allen DE (2009). Amateurs and professionals. In: *The Cambridge history of science* (Bowler PJ, Pickstone JV, eds), *The modern biological and earth sciences*, **vol. 6**. Cambridge University Press, Cambridge, UK: 13–33.

Baldwin RS (1981). *The fungus fighters: two women scientists and their discovery*. Cornell University Press, Ithaca, USA.

Balon EK, Bruton MN, Noakes DLG (eds) (1994). *Women in ichthyology: an anthology in honour of ET, Ro and Genie*. Springer, Dordrecht, Netherlands.

Barrett A (2017). *Women at Imperial College; past, present and future*. World Scientific Publishing Europe Ltd., London, UK.

Becker LE (1869). On alteration in the structure of *Lychnis dioica*, observed in connection with the development of a parasitic fungus. *Report of the British Association for the Advancement of Science* **39**: 106.

Beeli M (1926). Madame Rousseau. *Les Naturalistes Belge* **7**: 18–20.

Berkeley MJ (1847). Decades of fungi. *London Journal of Botany* **6**: 508.

Bestor (2016). *Hanon (Rousseau), Mariette (1850–1926)*. https://www.bestor.be/wiki_nl/index.php/Hannon_(Rousseau)_Mariette_(1850–1926). viewed August 2017.

Borkhausen M (1793). Flora der obern Grafschaft Catzenelnbogen nach dem System vom Stande, der Verbindung und dem Verhältnisse der Staubfaden. *Rheinisches Magazin zur Erweiterung der Naturkunde* **1**: 393–607.

Branca S, Vellinga E (2015). Gender balance in mycology. *Inoculum* **66**(5): 1–4.

Brock WH (2003). Dissertation. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 216–217.

Brockliss L (2008). Science, the universities, and other public spaces: teaching science in Europe and the Americas. In: *Cambridge history of science* (Porter R, ed), *Eighteenth-century science*, **vol. 4**. Cambridge University Press, Cambridge, UK: 44–86.

Browne J (2003). Natural history. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 559–563.

Brück M (2009). *Women in early British and Irish astronomy: stars and satellites*. Springer, Dordrecht, Netherlands.

Brummitt RK, Powell CE (1992). *Authors of plant names: a list of authors of scientific names of plants, with recommended standard forms of their names, including abbreviations*. Royal Botanic Gardens, Kew, London, UK.

Calé L (2000). 'A female band despising nature's law': botany, gender and revolution in the 1790s. *Romanticism on the Net 17*. http://id.erudit.org/iderudit/005889ar. Accessed 20 April 2017.

Campbell FM (1886). Victorian fungi. *Victorian Naturalist* **2**(2), 139 [as '127'].

Clarke G (1895). On lichens. *Transactions of the Leicester Literary and Philosophical Society* **3**: 267–274.

Clendenin I (1894). *Synchytrium* on *Stellaria media*. *Botanical Gazette* **19**: 296–297.

Clifford JB (1897). Notes on some physiological properties of a Myxomycete plasmodium. *Annals of Botany* **11**: 179–186.

Creese MRS (1998). *Ladies in the laboratory. I: American and British women in science, 1800–1900: a survey of their contributions to research*. Scarecrow Press, Lanham, USA & London, UK.

Creese MRS (2004a). *Ladies in the laboratory. II: West European women in Science, 1800–1900: a survey of their contributions to research*. Scarecrow Press, Lanham, USA & London, UK.

Creese MRS (2004b). *Lister, Gulielma (1860–1949). Oxford dictionary of national biography* online edition. http://www.oxforddnb.com/view/article/46417. Accessed 20 April 2017.

Creese MRS (2005). *Smith, Annie Lorrain (1854–1937). Oxford dictionary of national biography* online edition. http://www.oxforddnb.com/view/article/46420. Accessed 20 April 2017.

Creese MRS (2010). *Ladies in the laboratory. III: South African, Australian, New Zealand, and Canadian women in science: nineteenth and early twentieth centuries*. Scarecrow Press, Lanham, USA, Toronto, Canada & London, UK.

Creese MRS (2015). *Ladies in the laboratory. IV: Imperial Russia's women in science, 1800–1900: a survey of their contributions to research*. Rowman & Littlefield, Lanham, USA.

*For works by Banning, Bommer (née Destrée), Dörrien, Libert, Rousseau and Smith, see the lists of references under the respective entries in the section Biographies of six amateur female taxonomic mycologists

Cummings CE (1888). Lichens. In: *Flora of Middlesex County, Massachusetts* (Dame LL, Collins FS, *et al*., eds). Middlesex Institute, Malden, USA: 165–174.
De Bont R (2015). *Stations in the field: a history of place-based animal research, 1870–1930*. The University of Chicago Press, Chicago USA & London UK.
Des Jardins J (2010). *The Madame Curie complex: the hidden history of women in science*. The Feminist Press, New York, USA.
Desmond R (1994). *Dictionary of British and Irish botanists and horticulturists*. Taylor & Francis, London, UK & Bristol, USA.
Detmers F (1891). Diseases of the raspberry and blackberry. *Bulletin of the Ohio Agricultural Experiment Station, ser. 2* **6**: 124–129.
Dörfelt H, Heklau H (1998). *Die Geschichte der Mykologie*. Einhorn-Verlag E. Dietenberger, Schwäbisch Gmünd, Germany.
Du Mortier BCJ (1865). Notice sur Mlle M.-A. Libert. *Bulletin de la Société royale de botanique de Belgique* **4**: 403–411.
Elston MA (2004). *Edinburgh seven. Oxford dictionary of national biography* online edition. http://www.oxforddnb.com/view/article/61136. Accessed 28 July 2017.
Eschbach ES (1993). *The higher education of women in England and America, 1865–1920*. Garland, New York, USA.
Faasse P (2012). *Een beetje opstandigheid: Johanna Westerdijk de eerste vrouwelijke hoogleraar van Nederland*. Atlas Contact, Netherlands.
Fara P (2004). *Pandora's breeches: women, science and power in the Enlightenment*. Pimlico, UK.
Finn EA (2009). *Hussey [née Reed], Anna Maria (1805–1853). Oxford dictionary of national biography* online edition. http://www.oxforddnb.com/view/article/96688. Accessed 20 April 2017.
Fiorini-Mazzanti E (1857–1858). Sulla identità del *Nostoc* con il *Collema*. *Atti della Reale Accademia dei Lincei* **11**: 1–10, 103–113.
Fitz-James, de 'Mme la Duchesse' (1885). Action de la chaux sur les vignes atteintes du mildew. *Comptes Rendus hebdomadaires des Séance de l'Académie des Sciences* **101**: 1049–1050.
Frängsmyr T (2003). Linnaeus, Carl (1707–1778). In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 468–469.
George S (2005). Linnaeus in letters and the cultivation of the female mind: 'Botany in an English dress'. *British Journal for Eighteenth-Century Studies* **28**: 1–18.
Golden KG (1890). Fermentation of bread. *Botanical Gazette* **15**: 204–209.
Goldin C (1988). *'Marriage bars: discrimination against married women workers, 1920s to 1950s'*. Working paper no. 2747. National Bureau of Economic Research, USA.
Gregory EL (1889). Notes on some botanical reading done in the laboratory of Prof. Schwendener in Berlin, in June and July, 1889. *Bulletin of the Torrey Botanical Club* **16**: 297–304 [Includes discussion on mycorhizae].
Haines JH (1989). Mary Banning: the woman who painted mushrooms. *Maryland Naturalist* **33**: 43–56.
Haines JH (1995). Mushrooms to cultivate minds and morals: the works of Mary Banning. *McIlvainea: Journal of American Amateur Mycology* **12**(1): 54–62.
Hawksworth DL, Seaward MRD (1977). *Lichenology in the British Isles 1568–1975*. The Richmond Publishing Company, Richmond, UK.
Heinbeck F von (1941). Die Pflanzenbilder der Catharina Helena Dörrien und Johann Philipp Sandbergers. *Jahrbücher des Nassauischen Vereins für Naturkunde* **87**: 4–73.
Herrick SB (1883). *The wonders of plant life under the microscope*. G.P. Putnam's Sons, New York, USA.
Hill K (2016). *Women and museums, 1850–1914: modernity and the gendering of knowledge*. Manchester University Press, UK.
Hobbs C (1995). Introduction: cultures and practices of US women's literacy, pp. 1–33. In: *Nineteenth-century women learn to write* (Hobbs Catharine, ed). University Press of Virginia, USA & UK.
Hollis CC (1979). Sophia Bledsoe Herrick. In: *Southern writers: a biographical dictionary* (Bain R, Flora JM, Rubin Jr LDJr., eds). Louisiana State University Press, Baton Rouge USA and London, UK: 222–223.
Horn MEC (1896). The organs of attachment in *Botrytis vulgaris*. *Botanical Gazette* **22**: 329–333.
Hunter A (1846). Description of an agaric (*Agaricus caperatus*), new to the British flora. *Transactions of the Berwickshire Naturalists' Club* **2**: 174–175.
Hunter A (1868). Notice of Morchella semilibera. *Transactions of the Berwickshire Naturalists' Club* **5**: 359.
Hussey AM (1847–1855). *Illustrations of British mycology*: **2 vols**. Reeve & Co., UK.
Jacob M (2003). Enlightenment and industrial revolution. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 265–266.
Lüders J (1866). Ueber Abstammung und Entwickelung des *Bacterium Termo* Duj., *Vibrio lineola* Ehrb. *Botanische Zeitung* **24**: 33–39, 41–46.
Kass-Simon G, Farnes P (eds) (1993). *Women of science: righting the record*. Indiana University Press, USA.
Kelley TM (2012). In: *Clandestine marriage: botany & romantic culture*. The Johns Hopkins University Press, USA.
Kirk PM (2003). *Authors of fungal names*. Version 2. http://www.indexfungorum.org/Names/AuthorsOfFungalNames.htm. Accessed April 2017.
Kirk PM, Ansell AK (1992). *Authors of fungal names: a list of authors of scientific names of fungi, with recommended standard forms of their names, including abbreviations, Index of fungi supplement*. CAB International, Wallingford, Oxford, UK.
Knowles EL (1887). The 'curl' of peach leaves: a study of the abnormal structure induced by *Exoascus deformans*. *Botanical Gazette* **12**: 216–218.
Knowles MC (1913). The maritime and marine lichens of Howth. *Scientific Proceedings of the Royal Dublin Society* **14**: 79–143.
Koninklijke Nederlandse Akademie van Wetenschappen (2017). *Royal academy selects 26 new members*. https://www.knaw.nl/en/news/news/royal-academy-selects-26-new-members.
Lawalrée A, Lambinon J, Demaret F, Lang M (1965). *Marie-Anne Libert, 1782–1865: biographie, généalogie, bibliographie*. Cercle de naturaliste, Malmedy, Belgium.
Lear L (2008). *Beatrix Potter: a life in nature*. Penguin, UK.
Ledger S (1997). *The New Woman: fiction and feminism at the fin de siècle*. Manchester University Press, Manchester, UK & New York, USA.
Leonard JW (ed) (1914). *Woman's who's who of America: a biographical dictionary of contemporary women of the United States and Canada, 1914–1915*. The American Commonwealth Company, New York, US.
Lindau G, Sydow P (1908–1917). *Thesaurus literaturae mycologicae et lichenologicae*: **5 vols**. Fratres Borntraeger, Lipsiis [Leipzig], Germany.
Linnaeus C (1753). *Species plantarum*, : **2 vols**. Laurentius Salvius, Holmiae [Stockholm], Sweden.
Lyons M (1999). New readers in the nineteenth century: women, children, workers. In: *A history of reading in the west* (Cavallo G, Chartier R, Cochrane LG, trans, eds). University of Massachusetts Press, Amherst, USA: 313–344.
MacBride TH, Allin N (1898). The saprophytic fungi of eastern Iowa: the puffballs. *Bulletin from the Laboratories of Natural History of the State University of Iowa* **4**: 33–36.
Maroske S (2014). 'A taste for botanic science': Ferdinand Mueller's female collectors and the history of Australian botany. *Muelleria* **32**: 72–91.
Maroske S, Vaughan A (2014). Ferdinand Mueller's female plant collectors: a biographical register. *Muelleria* **32**: 92–172.
Martin Mrs W (1890). Disease of plants. In: *Report of the second meeting of the Australasian Association for the Advancement of Science held at Melbourne, Victoria, in January 1890* (Spencer B, ed). Published by the Association, Sydney, Australia: 553.
Matta C (2008). Mary Elizabeth Banning (1822–1903): the forgotten mycologist. In: *Pioneering women in plant pathology* (Ristaino JB, ed). APS Press, St Paul, USA: 11–17.
MBL Data (n.d.). History of the Marine Biological Laboratory. https://amphora.asu.edu/mbl-data/about/. Accessed 20 April 2017.
Merry M (1887). The identity of *Podosphaera minor*, Howe, and *Microsphaera fulvo-fulcra*, Cooke. *Botanical Gazette* **12**: 189–191.
Migliore L (2007). Mameli, Giuliana Eva. In: *Dizionario biografico degli Italiani*, **vol. 68**. Istituto dell'Enciclopedia Italiana, Roma, Italy: 376–378.
Moreau [V] as 'Mme Fernand' (1914). *Les phénomène de la sexualité chez les Urédinées*. Thèse de Doctorat de Sciences Naturelles. Société Française d'Imprimerie et de Librairie, Poitiers, France, Paris.
Morren E (1868). Prologue a la mémoire de Marie-Anne Libert. 1782–1865. *La Beligique Horticole* **18**: v–xiv [Followed on p. xv by 'Bibliographie de Marie-Anne Libert']. [Reprinted as '*Marie-Anne Libert de Malmedy, sa vie et ses ouvres*'].
Mouchacca J (1999). Thermophilic fungi: present taxonomic concepts. In: *Thermophilic moulds in biotechnology* (Johri BN, Satyanarayana T, Olsen J, eds). Kluwer Academic Publishers, Dordrecht, Netherlands: 43–83.
Naylor S (2003). Exploration and fieldwork. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 288–291.
Nichols M (1896). Studies in the development of the ascospores of certain *Pyrenomycetes*. *Botanical Gazette* **22**: 234.
Ogilvie MB (2008). Natural sciences. In: (Smith BG, ed), *The Oxford encyclopedia of women in world history*, **vol. 3**. Oxford University Press, Oxford, UK and New York, USA: 657–661.

Ogilvie M, Harvey J (eds) (2000). *The biographical dictionary of women in science: pioneering lives from ancient times to the mid-20th century*, : **2 vols**. Routledge, Abingdon, UK & New York, USA.
Olesko K (2003a). Disciplines. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 213–214.
Olesko K (2003b). University. In: *The Oxford companion to the history of modern science* (Heilbron JL, ed). Oxford University Press, Oxford, UK: 812–815.
Olson ME (1897). *Acrospermum urceolatum*, a new discomycetous parasite of *Selaginella ruprestris*. *Botanical Gazette* **23**: 367–371.
Patterson FW (1894). Species of *Taphrina* parasitic on *Populus*. *Proceedings of the American Association for the Advancement of Science*, 293–294.
Peck CH (1879a). Report of the botanist. *Thirty-first annual report on the New York State Museum of Natural History* **31**: 36.
Peck CH (1879b). New species of fungi. *Botanical Gazette* **4**: 137–139.
Phillips D (2012). *Acolytes of nature: defining natural science in Germany: 1770–1850*. University of Chicago Press, USA.
Plues M (1864). Rambles in search of flowerless plants. *Journal of Horticulture & Cottage Gardener Office*. London, UK.
Popta CML (1897). Schimmels gevunden op doode stengels van het West Indisch Suikerriet. *Archief voor de Java Suiker Industrie* **5**: 1075–1076.
Popta CML (1899). Beitrag zur Kenntniss der *Heimiasci*. *Flora* **86**: 1–46.
Price S (1864–1865). *Illustrations of the fungi of our fields and woods*. Lovell Reeve & Co, Covent Garden, UK.
Rabinowitsch L (1894). Beiträge zur Entwickelungsgeschichte der Fruchtkörper einiger Gastromyceten. *Flora* **79**: 385–418.
Raper C (2013). *A woman of science: an extraordinary journey of love, discovery, and the sex life of mushrooms*. Hatherleigh, USA.
Rayner-Canham M, Rayner-Canham G (2001). *Women in chemistry: their changing roles from alchemical times to the mid-twentieth century*. Chemical Heritage Foundation, Philadelphia, USA.
Reed EW (1992). *American women in science before the Civil War*. http://www.catherinecreed.com/assets/writings/women_in_science.pdf.
Ristaino JB (2008). Introduction. In: *Pioneering women in plant pathology* (Ristaino JB, ed). APS Press, St Paul, USA: 1–7.
Ristaino JB, Peterson P (2008). Effie A. Southworth. In: *Pioneering women in plant pathology* (Ristaino JB, ed). APS Press, St Paul, USA: 19–27.
Rossman AY (2008). Flora W. Patterson. In: *Pioneering women in plant pathology* (Ristaino JB, ed). APS Press, St Paul, USA: 29–39.
Rousseau E (1910). Madame J.-E. Bommer, née Destrée. *Bulletin de la Société Royale de Botanique de Belgique* **47**: 256–261.
Royal Society of London (1867–1925). *Catalogue of Scientific Papers (1800–1900)*. Compiled and published by the Royal Society of London. 19 vols. Royal Society, London, UK.
Russell A (1868). List of some of the rarer fungi found near Kenilworth. *Journal of Botany, British and Foreign* **6**: 90–91.
Saccardo PA (1887). *Sylloge fungorum omnium hucusque cognitorum. Vol. 5. Vol. I. Agaricinae*. Sumptibus auctoris, Typis seminarii, Patavii, Italy.
Searing AH (1889–91). The life history of some fungi. *Proceedings of the Rochester Academy of Science* **1**: 56 [title only].
Shteir AB (1996). *Cultivating women, cultivating science: flora's daughters and botany in England 1760–1860*. The Johns Hopkins University Press, Baltimore, USA & London, UK.
Sieber N (1881). Beiträge zur Kenntnis der chemischen Zusammensetzung der Schimmelpilze. *Zeitschrift für praktische Chemie N. F.* **23**: 412–421.
Simonton D (2005). Women and education. In: *Womens history: Britain, 1700–1850* (Barker H, Chalus E, eds). Routledge, London, UK & New York, USA: 33–56.
Smith AF (2007). Bitting, Katherine. In: *The Oxford companion to American food and drink* (Smith AF, ed). Oxford University Press, Oxford, UK and New York, USA: 54.
Snyder L (1897). The *Uredineae* of Tippecanoe county, Indiana. *Proceedings of the Indiana Academy of Science*, 216–224.
Solomon BM (1985). *In the company of educated women: a history of women and higher education in America*. Yale University Press, New Havenm USA & London, UK.
Southworth EA (1888). Leaf-blight and cracking of the pear: *Entomosporium maculatum*. Lév. *Report of the Commissioner of Agriculture, Washington*, 357–362.
Stafleu FA, Cowan RS (1976–2009). *Taxonomic literature: a selective guide to botanical publications and collections with dates, commentaries and types*, 7 vols and 7 suppl. vols. Bohn, Scheltema & Holkema, Netherlands.
Stoneman B (1896). A comparative study of the development of some anthracnoses in artificial cultures. *Botanical Gazette* **22**: 226–227.
Thiers B [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/science/ih/. Accessed 20 April 2017.
Thomas RH (1891). Attractive characters in fungi. *Nature* **43**: 79–80.
Timeline of women's education. https://en.wikipedia.org/wiki/Timeline_of_women%27s_education, viewed 2017.
Tolley K (1996). Science for ladies, classics for gentlemen: a comparative analysis of scientific subjects in the curricula of boys' and girls' secondary schools in the United States, 1794–1850. *History of Education Quarterly* **36**(2): 129–153.
Tsiklinsky P (1899). Sur les Mucédinées thermophiles. *Annales de l'Institut Pasteur* **13**: 500–505.
Venn JA (1954). *Alumni Cantabrigienses: a biographical list of all known students, graduates and holders of office at the University of Cambridge, from earliest times to 1900*: **2(6)**. Cambridge University Press, Cambridge, UK.
Viereck R (2000). *'Zwar sind es weibliche Hände': Die Botanikerin und Pädagogin Catharina Helena Dörrien (1717–1795)*. Campus Verlag, Germany.
Walker L (2004). *Becker, Lydia Ernestine (1827–1890). Oxford dictionary of national biography* online edition. http://www.oxforddnb.com/view/article/1899. Accessed 20 April 2017.
Waterfield A (2004). The Listers and the myxomycete collections at the Natural History Museum (BM), London. *Systematics and Geography of Plants* **74**: 289–291.
Waters [as 'Walters'] L (1896). *Erysipheae* of Riley County, Kansas. *Transactions of the Annual Meetings of the Kansas Academy of Science* **14**: 200–206.
Watts R (2007). *Women in science: a social and cultural history*. Routledge, London, UK & New York, USA.
Whaley LA (2003). *Women's history as scientists: a guide to the debates*. ABC-CLIO, Santa Barbara, USA & UK.
White MB (1892). *Strobilomyces strobilaceus* in Perthshire. *Annals of Scottish natural history* **1**: 274.
Whitney LC (1899). List of Vermont Myxomycetes with notes. *Rhodora* **1**: 128–130.
Widmark A-K (2010). *The late blight pathogen, Phytophthora infestans interaction with the potato plant and inoculum sources*. Doctoral thesis. Department of Forest Mycology and Plant Pathology, Sweden.
Wolff GP (1905). Beiträge zur Entwicklungsgeschichte der Flechtenapothecien. *Flora* **95**: 31–57.
Wollstonecraft M (1792). *A vindication of the rights of woman: with strictures on political and moral subjects*. Printed for J. Johnson, London, UK.