

Rust fungi on ferns¹

Summary

Rust fungi quite often parasitise species of fern, though they can be inconspicuous and are often overlooked. This article gives an overview of the species known from Britain and what they look like, and seeks to encourage recorders to take a closer look at ferns and look out for them.

Introduction

Fern fronds contain a mixture of sugars, proteins and other valuable nutrients, and although they are protected by a waxy cuticle and assorted chemical defences while they are alive, a number of groups of fungi and animals parasitise them, and a larger number of fungi use dead fronds as a substrate. One group of obligately parasitic fungi which are found on ferns is the rust fungi. Rusts have a very specialised lifestyle with up to five spore stages spread across possibly two different hosts, and occur on many plant species. Their common name comes from the generally brown or yellow spores. There are several species which parasitise British ferns, though most of these have colourless spores (under a microscope), which look white when seen in a mass on a fern leaf.

The different spore stages of rusts have names, but are also referred to by roman numerals. Most fern rusts are the diploid stages, represented by urediniospores (II) and teliospores (III). The teliospores produce a short-lived basidiospore stage (IV) which is rarely seen unless special steps are taken to germinate the teliospores, and these infect the alternate hosts, which for most fern rusts are conifers. Spermogonia (0) and aecia (I) are formed on the coniferous host, and the aeciospores infect the fern host again and produce a new generation of uredinia. It has often been considered that fern/conifer rusts are evolutionarily primitive, but there is an alternative hypothesis that tropical rusts are the most primitive (Termorshuizen & Swertz 2011, p25).

Although these five spore types represent the full cycle of spore stages ('macrocyclic'), some rusts have some of these stages missing ('microcyclic'), and even where the full cycle is present some species may persist in a single stage (normally uredinia) with the same spores reinfecting new hosts. So it is often possible to find rusts on ferns long distances from the nearest specimen of the alternate host.

Rusts on ferns

Table 1 shows which rusts are found on which host species. The final column counts all unique records in FRDBI (www.fieldmycology.net/FRDBI/FRDBI.asp) on fern hosts². There are additionally ten records on the alternate conifer hosts, all made by inoculation; the alternate hosts column covers known alternation anywhere, not just in Britain & Ireland. The Red List status is for Great Britain (not Ireland), taken from the unofficial red list (Evans 2006). Most rusts on ferns in Britain belong to the genus *Milesina*, which is relatively inconspicuous, though the uredinia can be abundant and then show as little volcanoes with white powdery urediniospores on the underside of fronds (the spores are said to be *erumpent*).

Table 1 Fern hosts of rusts in Britain

Fern species	Rust species and spore stages	Alternate host(s)	Number of unique records in FRDBI (Red list status)
<i>Adiantum capillus-veneris</i> (Maidenhair)	<i>Hyalopsora adianti-capilliveneris</i> II (III known)	unknown	1 (vulnerable)

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² With thanks to Paul Kirk for assistance with deduplicating FRDBI records.

Fern)	outside British Isles)		
<i>Asplenium adiantum-nigrum</i> (Black Spleenwort)	<i>Milesia magnusiana</i> II	unknown	2
<i>Asplenium ruta-muraria</i> (Wall-rue)	<i>Milesia murariae</i> II (III recorded from Switzerland)	unknown	21
<i>Asplenium scolopendrium</i> (Hart's-tongue)	<i>Milesia scolopendrii</i> II, III	<i>Abies alba</i>	336
<i>Blechnum spicant</i> (Hard-fern)	<i>Milesia blechni</i> II, III	<i>Abies alba</i> , <i>Abies cephalonica</i>	243
<i>Cystopteris fragilis</i> (Brittle Bladder-fern)	<i>Hyalopsora polypodii</i> II, III	unknown	40
<i>Dryopteris aemula</i> (Hay-scented Buckler-fern), <i>D. affinis</i> s.l. (Golden-scaled Male-fern), <i>D. dilatata</i> (Broad Buckler-fern), <i>D. expansa</i> (Northern Buckler-fern), <i>D. filix-mas</i> (Male-fern)	<i>Milesia kriegeriae</i> II,III	<i>Abies alba</i> , <i>A. cephalonica</i> , <i>A. grandis</i> , <i>A. nordmanniana</i>	500
<i>Dryopteris filix-mas</i>	<i>Milesia carpatorum</i> II,III	unknown	31 (vulnerable)
<i>Gymnocarpium dryopteris</i> (Oak Fern)	<i>Hyalopsora aspidiotus</i> II, III	<i>Abies alba</i>	3 (extinct 1845)
<i>Phegopteris connectilis</i> (Beech Fern)	<i>Uredinopsis filicina</i> II,III	probably <i>Abies alba</i>	1 (extinct 1936)
<i>Polypodium</i> spp. (Polypody)	<i>Milesia dieteliana</i> II, III	<i>Abies alba</i>	217
<i>Polystichum setiferum</i> (Soft Shield-fern), <i>P. aculeatum</i> (Hard Shield-fern)	<i>Milesia whitei</i> II, III	unknown	96
	<i>Milesia vogesiaca</i> II, III	(<i>Abies alba</i> by inoculation)	7 (vulnerable)

Fig. 1 Rusts on ferns. (a)-(c) from Coed Clwyd-gwyn, ST1472, vc41, (d) mortar of a ruined farmhouse, nr Cwm Twrch, NE Carmarthenshire, vc44. Photos © P.A. Smith except where noted.



(a) *Milesina kriegeriana* uredinia on *Dryopteris affinis*



(b) *Milesina dieteliana* uredinia on *Polypodium interjectum*



(c) *Milesina whitei* uredinia on *Polystichum setiferum*



(d) *Hyalopsora polypodii* uredinia on *Cystopteris fragilis* (photo ©R.N. Stringer)

The fungal infection on a fern originates from a spore, either an aeciospore landing from an alternate host, or a urediniospore originating from a fern (either the same individual being reinfected or spreading from another individual). The spore germinates, and forms a hypha which penetrates the fern cuticle (often through a stoma). It gathers its nutrients directly from the host's cells, and the infection spreads. The spores are formed in pustules, which are generally all there is to be seen of the rust. Urediniospores of *Milesina* are colourless under the microscope, usually with scattered spines (echinulate; Fig. 2) (many other rusts have either more densely-spined or smooth urediniospores).

The teliospores are generally the overwintering stage of rusts, and in *Milesina* they are intracellular, formed within the cells of the epidermis (Fig. 3). They form brown areas on fronds, but are not erumpent like urediniospores, and are only liberated by decay of the frond. It usually requires careful examination of excised pieces of the epidermis under the microscope to locate them.

Although *Milesina* species are rather inconspicuous, the rust *Hyalopsora polypodii*, which parasitises *Cystopteris fragilis* has urediniospores which are a much more characteristic (for rusts) orange colour (Fig. 1(d)). It is an uncommon rust, but may well be under-recorded. Keep an eye open for it in upland areas.

Because they often grow on dying or dead fronds, fern rusts are especially findable in winter and early spring, and so give an excuse for fieldwork in an otherwise slack season.

How do I identify a fern rust?

Naming the host species is usually the best start, as most rusts are very host-specific (there are interesting and unresolved questions about what happens with some fern hybrids, though...). At first glance ferns can all look similar, but there aren't that many species in Britain, and <http://fernid.info/> is one website that will help, or try Hutchinson & Thomas (1996) which covers nearly everything you're likely to meet in Britain. It's important to look at some spores from your rust specimen under a microscope to confirm your record – there are many things which look a bit like fern rusts (notably some *Ramularia* spp), and it's easy to record in error otherwise. For the few cases in Table 1 where there are two species on the same host, I give short keys below, summarised from Henderson (2004).

On *Dryopteris*:

urediniospores subglobose, 14-17 × 11-17 µm
 urediniospores ellipsoid, 23-48 × 15-22 µm



Fig. 2: Urediniospores (IIs) of *Milesina dieteliana* on *Polypodium vulgare* s.s., Caslub, S. Uist, NF84, vc110. Photo © P.A. Smith.

Milesina carpatorum
Milesina kriegariana

On *Polystichum*:

urediniospores smooth

urediniospores echinulate

Milesina vogesiaca

Milesina whitei

For more general rust identification, there is a booklet of summary keys (Henderson 2004) which is out of print but available to download from www.aber.ac.uk/waxcap/downloads/Henderson2004-BritishRustFungiHostPlantGuide.pdf. For more details you could look at Ellis and Ellis (1997) which covers microfungi (not just rusts) on land plants. For rusts in more detail, Wilson & Henderson (1966) was reprinted in 2011 and so is generally available and not reliant on second-hand copies. Termorshuizen & Swertz (2011) has good descriptions and illustrations of the spores.



Fig. 3: (a) Brown patches like these on the pinnules are where telia form in the epidermal cells (*Milesina kriegeriana* on *Dryopteris dilatata*, Lacasdail, Stornoway, vc110, NB427545, 28 April 2014). Photo © P.A. Smith

image available at

www.bioimages.org.uk/html/r163162.html

(b) Telia of *Milesina scolopendrii* (the faint walls) within large, multilobed epidermal cells of *Asplenium scolopendrium*, SK58, vc63. Photo ©Malcolm Storey www.bioimages.org.uk.

One or two rusts have been recorded on imported ferns (Henderson (2004) reports one, *Uredinopsis americana*, on *Onoclea sensibilis*, for example), and these are likely to be harder to identify, since many more rusts species are known on ferns outside the British Isles (Index fungorum, www.indexfungorum.org, shows 63 species of *Milesina* and 31 of *Uredinopsis*, for example).

Distribution of fern rusts

Fern rusts follow their host species fairly closely; in a few cases the rusts are much rarer than their hosts. There is a general tendency for rusts to be found where humidity assists the germinating spores, and where the host plants are stressed (often on dry soils), but it would be worth looking anywhere where the appropriate hosts are found. The Fungal Records Database of the British Isles (FRDBI, www.fieldmycology.net) shows where they have been recorded, but as so often with smaller organisms, there is certainly a considerable amount of under-recording. When you make records, the best thing to do in general is to send them to your local county or district fungus group.

So do keep an eye open for rusts on moribund fern fronds on your forays – and if you want a real challenge, find the rare or locally extinct ones on *Phegopteris connectilis*, *Asplenium adiantum-nigrum*, or *Gymnocarpium dryopteris*.

References

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