Rust fungi on ferns[1]

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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 their rusts.

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 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 sporulating stages of rusts have names, but are also referred to by roman numerals. Most fern rusts are the diploid stages, with uredinia (stage II) and telia (stage III) producing urediniospores and teliospores respectively. 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 urediniospores. 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 distinct records in FRDBI (www.fieldmycology.net/FRDBI/FRDBI.asp) on fern hosts[2]. 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 on the underside of fronds producing white powdery urediniospores (the spores are said to be erumpent).

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).

[1] This is a slightly modified version of an article to be published in *The Pteridologist* 6 (2), used with permission.
[2] With thanks to Paul Kirk for assistance with deduplicating FRDBI records.

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doi:10.1016/j.fldmyc.2015.04.006

Fern species	Rust species and spore stages	Alternate host(s)	Number of distinct records in FRDBI (Red list status)
Adiantum capillus-veneris (Maidenhair Fern)	*Hyalopsora adianti-capilli-veneris* II (III known outside British Isles)	unknown	1 (vulnerable)
Asplenium adiantum-nigrum (Black Spleenwort)	*Milesia magnusiana* II	unknown	2 (Ireland only)
Asplenium ruta-muraria (Wall-rue)	*Milesina murariae* II (III recorded from Switzerland)	unknown	21
Asplenium scolopendrium (Hart's-tongue)	*Milesina scolopendrii* II, III	*Abies alba*	336
Blechnum spicant (Hard-fern)	*Milesina blechni* II, III	*Abies alba, Abies cephalonica*	243
Cystopteris fragilis (Brittle Bladder-fern)	*Hyalopsora polypodii* II, III	unknown	40
Dryopteris aemula (Hay-scented Buckler-fern) *D. affinis* s.l. (Golden-scaled Male-fern), *D. dilatata* (Broad Buckler-fern), *D. expansa* (Northern Buckler-fern), *D. filix-mas* (Male-fern)	*Milesina kriegeriana* II,III	*Abies alba*, *A. cephalonica, A. grandis, A. nordmanniana*	500
Dryopteris filix-mas (Male-fern)	*Milesina carpatorum* II,III	unknown	31 (vulnerable)
Gymnocarpium dryopteris (Oak Fern)	*Hyalopsora aspidiotus* II, III	*Abies alba*	3 (extinct 1845)
Phegopteris connectilis (Beech Fern)	*Uredinopsis filicina* II,III	probably *Abies alba*	1 (extinct 1936)
Polypodium spp. (Polypody)	*Milesina dieteliana* II, III	*Abies alba*	217
Polystichum setiferum (Soft Shield-fern), *P. aculeatum* (Hard Shield-fern)	*Milesina whitei* II, III	unknown	96
	Milesina vogesiaca II,III	(*Abies alba* by inoculation)	7 (vulnerable)

Table 1. Fern hosts of rusts in Britain

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