UNIVERSITY OF Southampton

UK FUNGUS DAY

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Exploring plant parasitic fungi

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Recorder, vc110 Outer Hebrides

Welsh Parasitic Microfungus Group

Outline

- Getting started, getting hooked
- Wales and wider
  - Red Lists and id guides
  - A cornucopia of groups of plant parasitic microfungi
- Modern species concepts and nomenclature
  - Effects on id and field recording/technique
- Naturalists' contributions to knowledge
- Conclusions

Getting started… rusts

- Knowing your plants gives you a big advantage
  - Many parasitic microfungi species-specific or species-limited
  - If host known, easier than mushroom-shaped fungi
- "Find me a rust!" "Has it got a rust on it?"

Puccinia urticata aecia (I) on common nettle

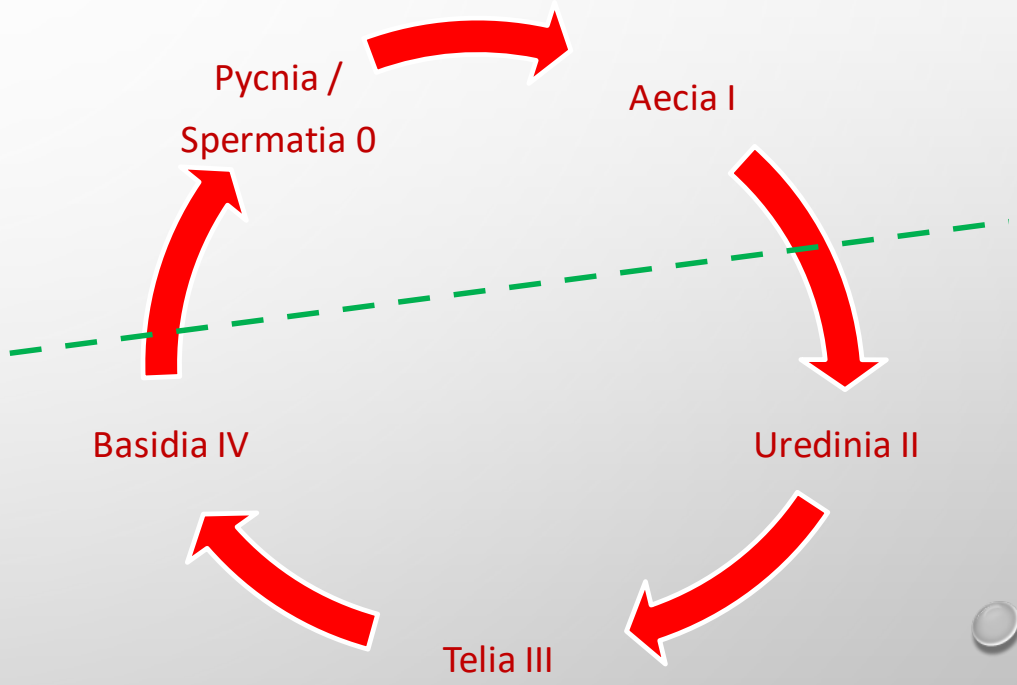
Rusts are common

- Practical to go for a walk and find several to many rusts
  - walk slowly
  - hands and knees for herbs, but upright OK for taller plants, trees and shrubs
  - turn leaves over (especially manky-looking ones)

Puccinia coronata II on Yorkshire fog (*Holcus lanatus*)

Rust life cycles

- Five spore stages but basidiospores (IV) short-lived… special searching needed
- Alternation between two (unrelated) hosts
  - Ferns and conifers
  - A conifer (*Pinus nigra*) and Coltsfoot (*Tussilago*)
  - Lords and ladies (*Arum maculatum*) and Reed Canary-grass (*Phalaris arundinacea*)
- Some species with single hosts and/or reduced life cycles ("micro-forms")



Coleosporium tussilaginis s.l. (I) on *Pinus nigra* and (II) on *Euphrasia* sp.

Getting hooked

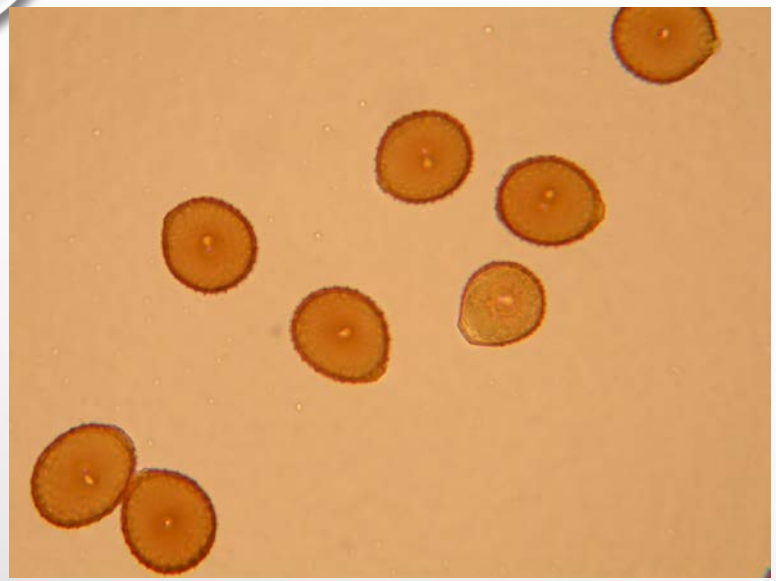
- Some species are rarely found/recorded
  - Some genuinely uncommon
  - Some are inconspicuous
  - Some at low density
  - Some are taxonomically challenging (always some groups like this!)
- "Tenacity"
- Be prepared to search known hosts

Puccinia oxyriae uredinia (II) on Mountain sorrel (*Oxyria digyna*)

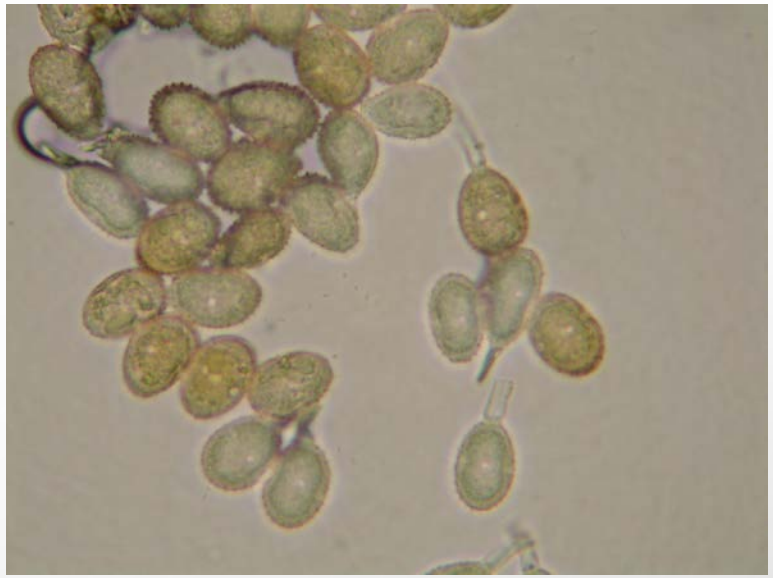
Commoner than expected

- Diligent searching shows some “rare” species aren’t
- Substantial scope for field mycologists to make significant scientific contributions through observation (more later)

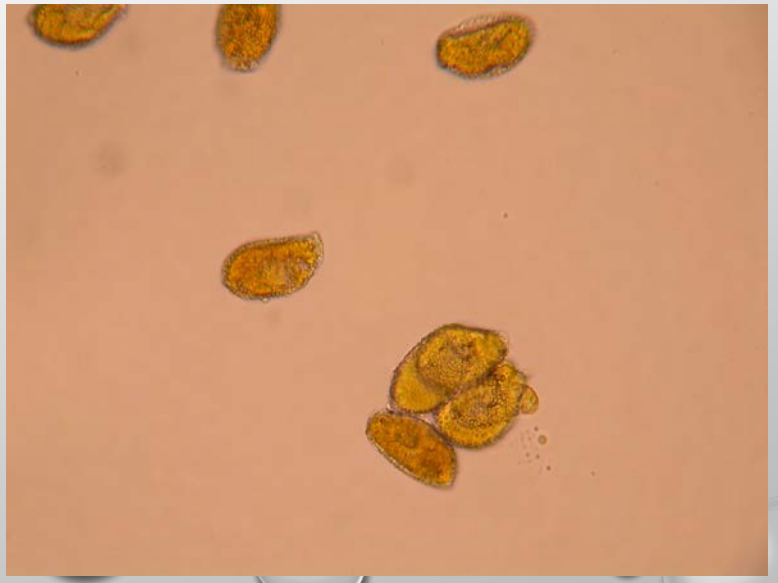
Chrysomyxa empetri II on Crowberry (*Empetrum nigrum*)

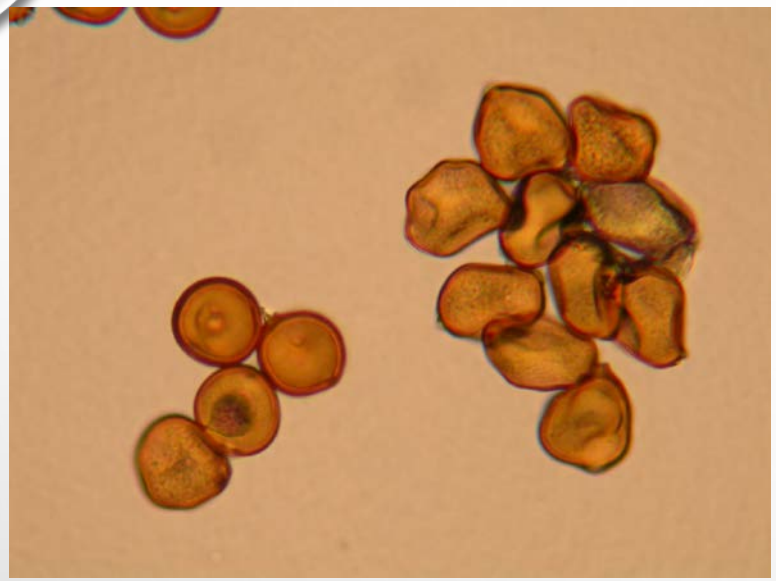


Spores - uredinia (II)

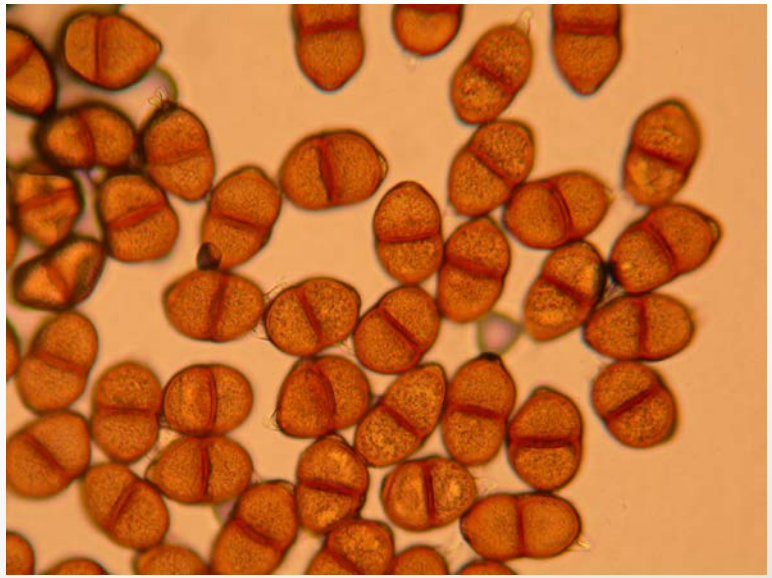


- Microscope work with spores
  - Easily lifted with a pin
  - Mount in water





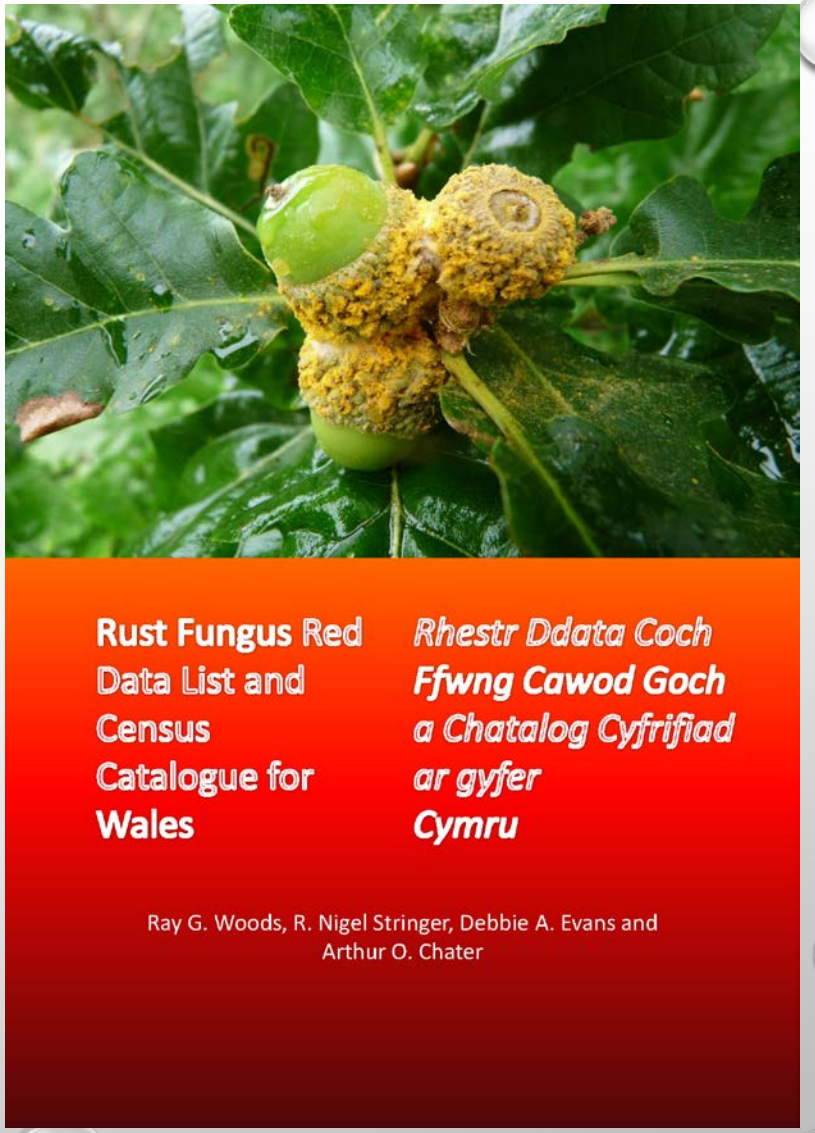
Spores - telia (III)



- “perfect” form… this is the stage that gets a name
- determines genus

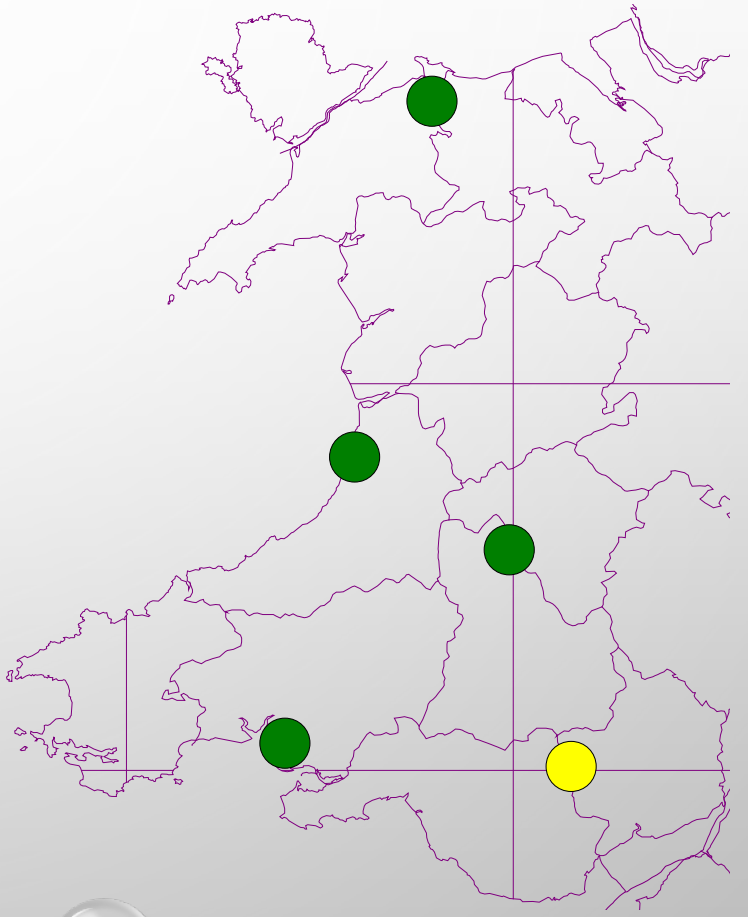
Wales and wider

- Loose network of field mycologists interested in rust fungi – Welsh Parasitic Microfungus Group
  - Started with individual field recording, and then informal links
  - Solidified with putting together records for rust fungi in Wales
  - Census catalogue
  - Red Data List assessment
  - Well-being of Future Generations (Wales) Act 2015



Welsh Parasitic Microfungus Group

- Good geographical coverage of Wales
  - Especially Carmarthenshire and Cardiganshire
  - Systematic recording projects
- Wales has wide range of interesting habitats



Red list challenges

- Red List criteria not specially designed for fungi
  - based on “individuals”… hard to count
  - “mature individual” taken to be a single infected plant
  - measures of decline problematic… recent recording greatly increased by Welsh Parasitic Microfungus Group
  - approximated by extent
- Red Listing only possible for rusts and smuts where knowledge of distributions acceptable

Puccinia bistortae I on Pignut (*Conopodium majus*) and II, III on Bistort (*Persicaria bistorta*) – Critically Endangered in Wales

Conservation

- First step in conservation is knowing what you have
  - Assessments for Wales for rusts and smuts on current knowledge
- IUCN has specialist groups for
  - rusts and smuts
  - chytrid, zygomycete, downy mildew and myxomycete
- PlantLife main interest group in UK
- Statutory protection and management for *Urocystis colchici* (a smut) in Wales

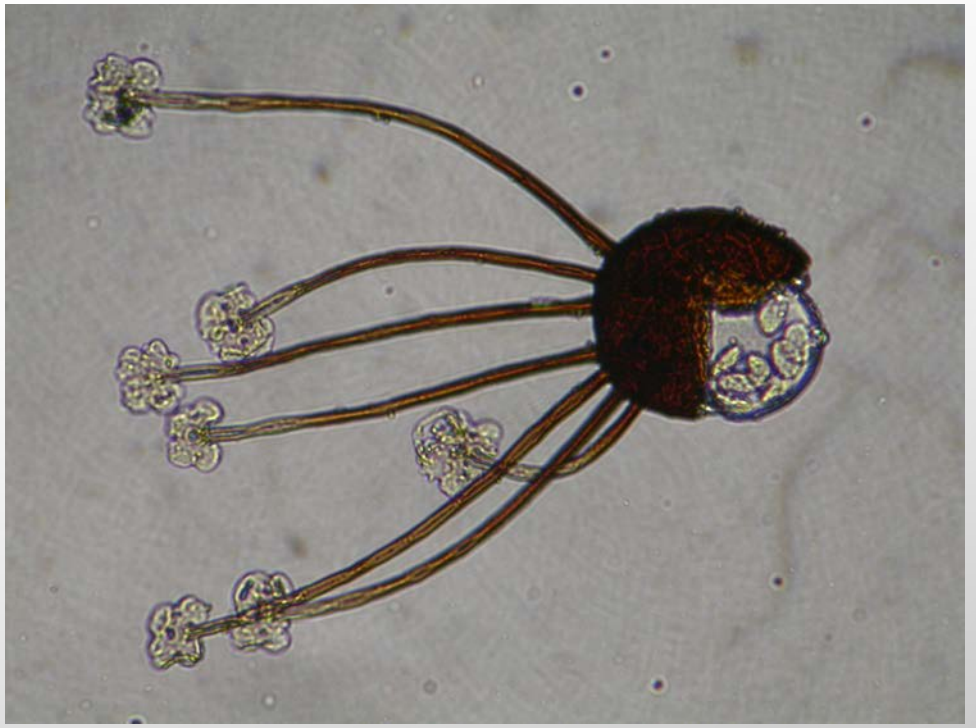
Urocystis colchici on Autumn crocus (*Colchicum autumnale*)

What parasitic microfungi are there?

- Welsh Parasitic Microfungus Group has produced five publications so far
- Already introduced **rusts** (Uredinales) : 232 taxa in census catalogue for Wales
- Second RDL for **smuts**: 78 taxa for Wales
    - "Smuts" as generally used are polyphyletic – anther smuts are taxonomically rusts (Uredinales), most others are Ustilaginales, plus Exobasidiales, Entorrhizales
- ID guide and census catalogue for **powdery mildews** (Erysiphales): 127 taxa for Wales
- ID guide and census catalogue for **downy mildews** and **white blister rusts** (Peronosporales): 132 taxa for Wales
- ID guide and census catalogue for **white moulds** (*Ramularia* and *Phacellium*): 85 taxa for Wales

Powdery mildews … or lunar modules?

Neoerysiphe galeopsidis on Marsh woundwort (*Stachys palustris*)



Podosphaera myrtillina on Bilberry (*Vaccinium myrtillus*)

Downy mildews

Paraperonospora leptosperma on Sea mayweed (*Tripleurospermum maritimum*)

Peronsopora grisea on Speedwell (*Veronica* sp.)

"Get a pin or a sharply-pointed knife and put an atom in a drop of water on a glass for examination under the microscope, and if you see no beautiful plants there, as well-developed as an oak tree, and as perfect in structure as the oak, bless your stupidity. You have been born in vain."

(Vize 1894)

White moulds - *Ramularia*

- Not well-covered by general books on parasitic microfungi
- But there is a recent monograph
- Superficially like powdery mildews, but no mycelial mat, just spores/synnemata emerging from stomata

Ramularia lamii on Yellow archangel (*Lamium galeobdolon*)

White moulds and dark spots

Ramularia carneola on Water figwort (*Scrophularia auriculata*)

- Wide range of fungi and other organisms cause dark spots on leaves
- *Ramularia* often invisible but can be found by incubating leaves – causes sporulation
- Trying to identify causers of spots can be challenging!

Yet more parasites

- *Taphrina* (Taphrinales)
- Chytrids (Chytridiomycota)
  - *Synchytrium*
  - *Physoderma*
- Parasitic ascomycetes
- Deuteromycota

Taphrina alni on Alder (*Alnus glutinosa*)

Chytrids

Synchytrium succisae on Sheeps-bit scabious (*Succisa pratensis*)

Synchytrium stellariae on Lesser chickweed (*Stellaria pallida*)

Physoderma potteri

- Described from Northumberland 1926
- Known from two sites there, and three in New Zealand (introduced?)
- More recently from Germany & Italy
- Discovered in Outer Hebrides in 2011… gall, looks insect-induced, but fungal spores inside
- Since found in several more places. How common is it?

Physoderma potteri on Bird's-foot trefoil (*Lotus corniculatus*)

Effects of concentrated effort

- Welsh Parasitic Microfungus Group started with reasonable data on rusts
- With each successive group field efforts required
- *Entyloma helosciadii* first recorded for Wales in 2011, now in >30 sites
- Big efforts with *Ramularia*, as low base
- Current field work on *Taphrina* and chytrids

Entyloma helosciadii on Hemlock water-dropwort (*Oenanthe crocata*)

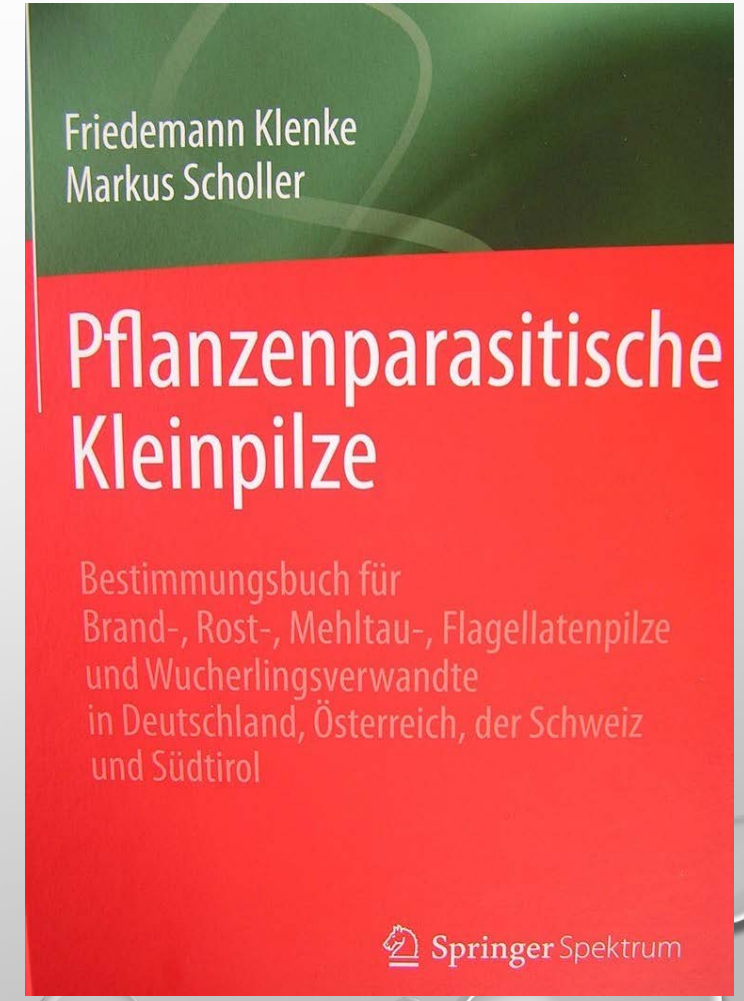
Taxonomy

Taxonomists to the rescue…

- Identifying plant parasitic fungi is often challenging
  - Fungi are reduced
  - Often only spores available for identification, sometimes a few other bits too
  - But I said they were easier than mushroom-shaped things…
- One big advantage… you can see what it is parasitising (and hopefully identify it!)
- Have been two schools of taxonomy
  - Britain started out leading rust research (Plowright, late 19th century), but lost this status. Later Henderson worked particularly with sedge (*Carex*) rusts. Largely resulted in aggregate taxonomy
  - Continental workers (Germany, Sweden, Switzerland) much experimental inoculation, followed later by extensive DNA work (especially in Germany). Much more divided taxonomy

Narrowly host-specific species

- DNA results suggest many species narrowly host-limited
- …that is, different host means different parasite species (not always, but often)
- Older records can be hard to assign, but not too bad if host identified or specimen preserved
- Welsh Parasitic Microfungus Group has used taxonomy from Klenke & Scholler, *Pflanzenparasitische Kleinpilze* (except *Ramularia*)
- Welsh RDLs and ID Guides provide id help, poorest for rusts
- Working on a Hand List to bring British nomenclature in line and make accessible identification guide



A naturalist's contributions to knowledge of smuts

Starting out

- Rusts seemed like a good extra activity for botanising in the Outer Hebrides
  - recordable
- Smuts more challenging
  - often only 2 or 3 in a day
- Some habitats species-poor, so makes extra things to look at/for
- When you look, it doesn't take long to find interesting things…

Anther smut on spring squill (*Scilla* [*Tractema*] *verna*)

- I had done some reading, so knew some names of people working with smuts
- Contacted Matthias Lutz in Tübingen and sent specimen
- Turns out to be one of those narrowly host-limited species… a new one! *Antherospora tractemae*
- Arthur Chater had it in Cardiganshire too
- Result… joint authored paper with Matthias and Marcin Piątek (Krakow)

Now I'm enthusiastic… what else can I find?

- *Anthracoidea scirpi*, one of a genus of (narrowly host-limited) smuts of the utricles of the sedge family (Cyperaceae) – this one on Hybrid deergrass (*Trichophorum* x *foersteri*)
- Frequent on moorland in N Lewis on one visit, but few records for Britain
- Short note for *Field Mycology*
- Turns out (from further observations) that it has occasional boom years

NTB

- Collected manky leaf of Flote-grass (*Glyceria fluitans*) from a very species-poor tetrad in Lewis, hoping for a rust
- No rusts, but a smut, *Ustilentyloma fluitans* new for Britain…
- …another short note, with Matthias Lutz (DNA checked!)

- [*U. fluitans* has spores embedded in the host tissue and is completely un-photogenic
- Relatively few records anywhere
- Probably widely overlooked]

Western and wet

- Wales and Outer Hebrides are in wet and windy north and west
- Good conditions for infection! Relatively lots of species and specimens
- Not so easy in the south and east?

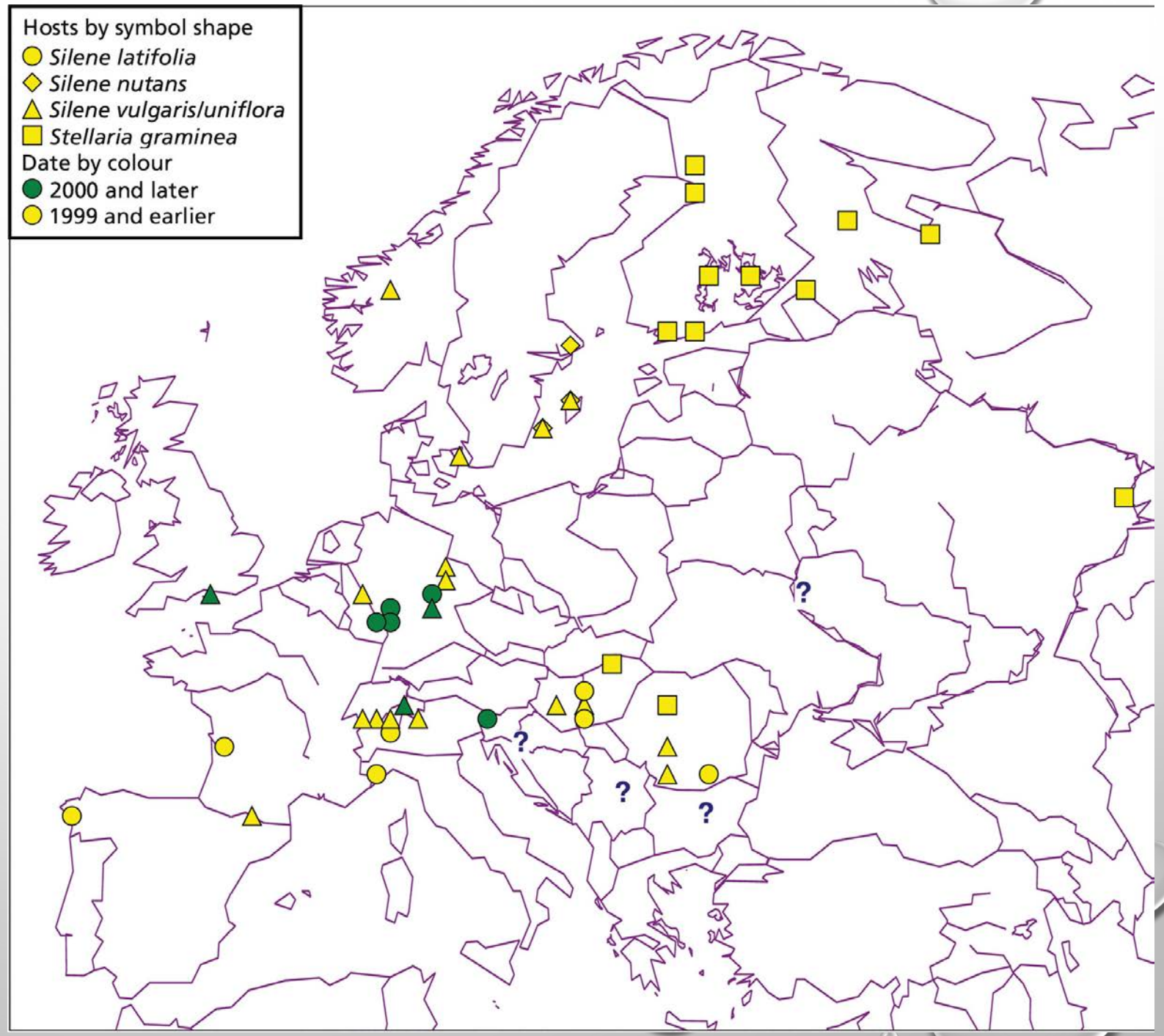
Gymnosporangium cornutum III on Juniper (*Juniperus communis* ssp *nana*)

Sailing lessons

- My daughter takes sailing lessons in the summer
- Walk along the sea front by the sailing club
- Another of those funny-looking insect galls, in flowers of Sea campion (*Silene uniflora*)… but with *spores*
- *Thecaphora melandrii* NTB
- It has multiple hosts, but DNA all the same (Matthias again!). World distribution
- Paper in Kew Bulletin, and world redlist assessment

Thecaphora melandrii distribution

Required considerable searching in old, but largely publicly accessible literature to compile this!



Root smuts (Entorrhizales)

- Several species infect species in sedge (Cyperaceae) and rush (Juncaceae) families
- Found some on rushes (*Juncus*) in Outer Hebrides
- Arthur Chater became very enthusiastic, and searched for different species
  - Turn out to be frequent, not just in N and W
  - Project to examine DNA of several species
- Paper in Field Mycology

Entorrhiza raunkiaeriana on roots of Floating club-rush (*Eleogiton fluitans*)

Unresolved *Entorrhiza*/*Juncorrhiza* questions

- Probably some undescribed (narrowly host-specific) species
- Relationships within genera – few specimens available for DNA analysis until recent investigations
- Entorrhizales are evolutionarily ancient in fungal lineages… but are species more recent?

Anther ‘smuts’

- Many species of *Microbotryum* on different hosts and in different plant organs
- Many anther smuts, including one on Butterwort (*Pinguicula vulgaris*)
- I failed to find, it so set it as a challenge for Welsh Microfungus Recording Group
  - Ray Woods
  - Commonly found in Wales
  - Extra distributional and life cycle details
- DNA and paper with Matthias, Arthur & Ray
- Several others have searched, turns out to be widespread

Microbotryum pinguiculae on Butterwort (*Pinguicula vulgaris*)

Conclusions

- I have been well and truly parasitised…
- There is an amazing amount that is still unknown about many plant parasitic fungus species
  - Naturalists' observations are endlessly valuable
  - More important than ever in a world where observational research not fashionable or funded
  - Requires application to do background research
- Endless hours of fun… and easier than mushroom shaped things!

Puccinia punctiformis 0, I on Creeping thistle (*Cirsium arvense*)

Thanks

Welsh Parasitic Microfungus Group

- Arthur Chater (far left)
- Ray Woods
- Nigel Stringer
- Debbie Evans

- Matthias Lutz and Marcin Piątek

- Many people and organisations who have helped us!

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