

# A call for a renewed and pan-European strategic effort on the taxonomy of rust fungi (*Uredinales*)

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**Abstract.** This paper is a call for new research on European rust fungi, initiated by the participants of the EURED (European *Uredinales* Initiative) meeting, a satellite workshop of the 9<sup>th</sup> International Mycological Congress in Edinburgh 2010.

**Key words:** biodiversity, Europe, rust fungi, taxonomy

## Rusts in ecosystems

Being economically important parasites the *Uredinales* (*Pucciniales*) have long attracted considerable interest in agriculture, horticulture and forestry. Their taxonomic position as an order of the *Basidiomycota* is well supported (e.g. Aime *et al.* 2006). Depending on interpretation there are 1500–2000 species of *Uredinales* in Europe. Rust fungi causing crop disease are intensively studied (Gomez *et al.* 2006; Szabo 2006; Barnes & Szabo 2007), but these represent only ca 15% of currently known European rust diversity (Farr & Rossman 2010). The taxonomy of rusts affecting wild plants receives little attention, resulting in a still patchy knowledge of their systematic relationships, distribution, conservation status and ecology.

- Without reliable taxonomy, the distribution, biogeography and ecology of rusts in natural habitats cannot be fully understood.
- As antagonistic symbionts of plants, rusts play a key role in the evolutionary process and in regulating ecosystem

dynamics: among many other examples Eviner & Likens (2008) report a number of ecosystem changes affected by rust fungi in natural grasslands.

- Species interactions have been shown to modify the response of natural communities to environmental change (Tylianakis *et al.* 2008). Accordingly, the response of rusts to changed ecological conditions may feedback to affect ecosystem dynamics.

During a period of global environmental change, the EURED group proposes that an improved knowledge of rust taxonomy is a critical step in informing and widening the global conservation response.

## Rusts in conservation

Obligations under the Convention on Biodiversity require the study of all organisms, including parasitic fungi (e.g. Article 7 CBD). While few rusts species themselves appear to be threatened on a European scale (however, see Helfer

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1993; Evans 2006) some are possibly extinct or very rare in parts of Europe and more common elsewhere, mainly linked to their host plant distribution. According to Scholler (1996) numerous rusts and other plant parasitic microfungi have suffered decline (e.g. *Xenodochus carbonarius* on *Sanguisorba* sp.), irrespective of host plant abundance. The reasons for this are not yet known. Conversely, a number of rust species parasitise threatened host plants, such as *Puccinia lagenophorae*, a common introduced rust on *Senecio cambrensis* (Near threatened Welsh endemic) or *P. saxifragae* and *Melampsora hirculi* on *Saxifraga hirculus* (internationally scheduled; BAP rank 3) and others. Rusts can also contribute significantly to conservation as biological control agents against invasive plant species in sensitive ecosystems (Van Driesche *et al.* 2010). Examples of their use as part of a conservation solution include the application of strains of European *Phragmidium violaceum* against *Rubus* species in Australia and Chile and the consideration of *Gymnoconia* species in Hawaii (St. Quinton *et al.* 2010). Such projects require the availability of authoritative taxonomic data (phenotypic and genotypic). These are essential for the selection, study and potential deployment of organisms as biocontrol agents.

## The EURED project

This project will organise taxonomic data as an enabling resource, facilitating our understanding of the biology of rusts, and their regulatory role in ecosystem dynamics and response to environmental change. It brings together a consortium of European rust taxonomists with long-standing interests and experience in rust fungi research. Herbarium collections in Europe represent some 800,000 specimens, sampled mainly within Europe, but also including type specimens and exsiccatae globally. Therefore, one starting point for this effort is a new European specimens database of rusts: this is housed at the Royal Botanic Garden Edinburgh, and represents documented specimens from major European herbaria (B, E, L, CP, PC) furthermore name records are available for Z+ZT (incl. BERN). This resource is complemented by on-line data from other European and US herbaria (e.g. BR, BPI<sup>1</sup>, EAA/TAAM/TALL<sup>2</sup>, KR, O<sup>3</sup>, S). Previously, poor knowledge on specimen location has been a rate-limiting step in accurately documenting European rusts, and this knowledge on specimen location will facilitate the work of European rust taxonomists.

**Table 1.** Rust specimen holdings of major European herbaria

Herbarium	Acronym	Types	Specimens (est.)	Notes and online access
Stockholm	S	5547	40541	types and 38 % of non-types registered and searchable <sup>a</sup>
Kew	K	2812	61300	estimates
Berlin	B	1677	114000	type specimen and genera labels searchable <sup>b</sup>
St Petersburg	L	750	50000	type specimen labels searchable <sup>b</sup>
Paris	PC	608	32214	type specimen and genera labels searchable <sup>b</sup>
Zürich	Z+ZT, BERN	400	60000	currently names only
Graz	GZU	350	21000	estimates
Munich	M	300	40000	estimates
Vienna	W	300	14000	estimates
Hamburg	HGB	220	35000	Feuerer (2008) specimen numbers online <sup>c</sup>
Belgium	BR	202	12878	specimens searchable <sup>d</sup>
Edinburgh	E	50	22000	specimen labels searchable <sup>b</sup>
Netherlands	L/U/WAG	35	20000	specimens searchable <sup>e</sup>
Karlsruhe	KR	22	11500	specimens searchable <sup>f</sup>
Copenhagen	CPH	10	3000	specimen labels searchable <sup>b</sup>

<sup>a</sup> [http://www.nrm.se/en/menu/researchandcollections/collections.179\\_en.html](http://www.nrm.se/en/menu/researchandcollections/collections.179_en.html)

<sup>b</sup> <http://elmer.rbge.org.uk/fungi/>

<sup>c</sup> <http://www.biologie.uni-hamburg.de/bzf/syst/herbar2.htm>

<sup>d</sup> <http://www.br.fgov.be/RESEARCH/COLLECTIONS/HERBARIUM/advancedsearch.php>

<sup>e</sup> <http://www.nationaalherbarium.nl/virtual/>

<sup>f</sup> <http://www.smnk.de/SMNK/02-Forsch-I/02-01-Botanik/2-1-1-2/2-1-1-2-A/2-1-1-2-A-Inhalt.html>

<sup>1</sup> <http://nt.ars-grin.gov/fungalatabases/index.cfm>

<sup>2</sup> <http://unite.ut.ee/EestiLiigid/otsing.php>

<sup>3</sup> <http://www.nhm.uio.no/botanisk/sopp/kartlegging/index.htm>

## Objectives

1. To publish taxonomic accounts of European rusts based on morphological and molecular data. This stems from advances in rust taxonomy using rDNA (e.g. Aime *et al.* 2006) and complementary techniques (e.g. AFLP, Gomez *et al.* 2006). Recent studies have made significant advances in this area (Aime 2006, Aime *et al.* 2006 and literature cited therein) but a consortium effort is required to deal with the scale of existing synonymy and to document rust diversity across Europe.
2. To publish regional (national) checklists for European rusts, host plant information, and distribution, accompanied by on-line keys. At present only local mycotas of rust fungi exist (e.g. Gäumann 1959; Wilson & Henderson 1966; Minkevicius & Ignataviciute 1993). Many of these are out of print and in need of revision.
3. To combine new taxonomic information (pt. 1 above) and regional biodiversity information (pt. 2 above) into a checklist to European *Uredinales*, including distributional and host plant information. Further taxonomic output may follow.
4. To use the data obtained for the conservation of rust fungi and for other conservation efforts.

These objectives will create better access to biodiversity information on European rust fungi, an increased understanding of their taxonomy and an opportunity therefore, to develop robust ecological research and conservation strategies. Our ultimate goal is to make the results of taxonomic research available as a tool, thereby activating projects which explore and explain the importance of rusts as a regulatory feature in natural plant communities and ecosystems.

Although this initiative deals primarily with European *Uredinales*, the combining and accessibility of information (pt. 3 above) will produce a much-valued resource which will greatly facilitate the research, world-wide, of those engaged in taxonomy, systematics, plant pathology and multidisciplinary fields. A combined effort from researchers with an interest in European rusts will help provide a stimulus for new infrastructure initiatives, useful for future investigation and investment in this exciting subject. All interested mycologists in European rusts are invited to join this initiative.

## References

- Aime, M.C. 2006. Toward resolving family level relationships in rust fungi (*Uredinales*). — *Mycoscience* 47: 112–122.
- Aime, M.C., Matheni, P.B., Henk, D.A., Frieders, E.M., Nilsson, R.H., Piepenbring, M., McLaughlin, D.J., Szabo, L.J., Begerow, D., Sampaio, J.P., Bauer, R., Weiß, M., Oberwinkler, F. & Hibbett, D. 2006. An overview of the higher level classification of *Pucciniomycotina* based on combined analyses of nuclear large and small subunit rDNA sequences. — *Mycologia* 98: 896–905.
- Barnes, C.W. & Szabo, L.J. 2007. Detection and identification of four common rust pathogens of cereals and grasses using real-time polymerase chain reaction. — *Phytopathology* 97: 717–727.
- Evans, S. 2006. The Red Data List of threatened British fungi: a preliminary assessment (Version 1.0). British Mycological Society.
- Eviner, V.T. & Likens, G.E. 2008. Effects of pathogens on terrestrial ecosystem function. — In: R.S. Ostfeld, F. Keesing & V.T. Eviner [eds]. *Infectious disease ecology. Effects of ecosystems on disease and disease on ecosystems*, pp. 260–283, Princeton University Press, Princeton.
- Farr, D.F. & Rossman, A.Y. 2010. Fungal databases. Systematic Mycology and Microbiology Laboratory, ARS, USDA.
- Feuerer, T. 2008. Collections and collectors in the Herbarium Hamburgense (HBG). Version 1 November 2008. <http://www.biologie.uni-hamburg.de>
- Gäumann, E. 1959. Die Rostpilze Mitteleuropas. — *Beiträge zur Kryptogamenflora der Schweiz* 12: 1–1407.
- Gomez, D.R., Evans, K.J., Harvey, P.R., Baker, J., Barton, J., Jourdan, M., Morin, L., Pennycook, S.R. & Scott, E.S. 2006. Genetic diversity in the blackberry rust pathogen, *Phragmidium violaceum*, in Europe and Australasia as revealed by analysis of SAMPL. — *Mycological Research* 110: 423–430.
- Helfer, S. 1993. Rust fungi – a conservationist's dilemma. — In: D.N. Pegler, L. Boddy, B. Ing & P.M. Kirk [eds]. *Fungi of Europe: investigation, recording and conservation*, pp. 287–294. Royal Botanic Gardens, Kew.
- Minkevicius, A. & Ignataviciute, M. 1991. *Uredinales* 1. *Mycota* Lithuaniae. Vol. 5. Lietuvos MA Botanikos Instituto, Vilnius.
- Scholler, M. 1996. Die *Erysiphales*, *Pucciniales* und *Ustilaginales* der Vorpommerschen Boddenlandschaft. Ökologisch-floristische, florensgeschichtliche und morphologisch-taxonomische Untersuchungen. — *Regensburger Mykologische Schriften* 6: 1–325.
- St. Quinton, J.M., Helfer, S., Döring, H. & Faull, J. 2010. Protecting oceanic island biodiversity: Evaluation of fungal pathogens for the biocontrol of the invasive weed *Rubus niveus*. — IMC9 Poster Abstract nr. P2.052.
- Szabo, L.J. 2006. Deciphering species complexes: *Puccinia andropogonis* and *Puccinia coronata*, examples of differing modes of speciation. — *Mycoscience* 47: 130–136.
- Tylianakis, J.M., Didham, R.K., Bascompte, J. & Wardle, D.A. 2008. Global change and species interactions in terrestrial ecosystems. — *Ecology Letters* 11: 1351–1363.
- Van Driesche, R.G., Carruthers, R.I., Center, T., Hoddle, M.S., Hough-Goldstein, J., Morin, L., Smith, L., Wagner, D.L., Blossey, B., Brancatini, V., Casagrande, R., Causton, C.E., Coetzee, J.A., Cuda, J., Ding, J., Fowler, S.V., Frank, J.H., Fuester, R., Goolsby, J., Grodowitz, M., Heard, T.A., Hill, M.P., Hoffmann, J.H., Huber, J., Julien, M., Kairo, M.T.K., Kenis, M., Mason, P., Medal, J., Messing, R., Miller, R., Moore, A., Neuenschwander, P., Newman, R., Norambuena, H., Palmer, W.A., Pemberton, R., Perez Panduro, A., Pratt, P.D., Rayamajhi, M., Salom, S., Sands, D., Schooler, S., Schwarzländer, M., Sheppard, A., Shaw, R., Tipping, P.W. & van Klinken, R.D. 2010. Classical biological control for the protection of natural ecosystems. — *Biological Control* 54: S2–S33.
- Wilson, M. & Henderson, D.M. 1966. *British rust fungi*. Cambridge University Press, Cambridge.