

Checklist of the rust fungi on *Poaceae* in Pakistan

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ABSTRACT — This paper presents a checklist of rust fungi on family *Poaceae* in Pakistan together with their known host plants. A total of 80 taxa are mentioned here including 65 species of genus *Puccinia* and 15 of *Uromyces*. A host index is also provided.

KEY WORDS — *Cyperaceae*, grasses, *Puccinia*, *Pucciniales*

Introduction

The *Pucciniomycotina* are a large and diverse group of fungi that constitutes one of the three subphyla of *Basidiomycota*. More than 8,000 species of this group have been described but the majority of these (~ 90%) belong to a single order, the *Pucciniales*, or rust fungi (Aime et al. 2007). More than 7000 species and 163 genera of rust fungi classified into 14 families are known worldwide (Kendrick 2000; Kirk et al. 2001, 2008). Most of the described *Pucciniomycotina* are biotrophic with a few saprotrophic ones as well. Members of the *Pucciniales* are especially important and widespread phytopathogens that have a major economic impact on the world's forest, cereal and agricultural crops (Aime et al. 2007). *Puccinia* Pers. is the largest genus of *Pucciniales*, with about 3000–4000 species. Species of *Asteraceae*, *Cyperaceae*, *Poaceae*, and *Liliaceae* serve as hosts for most species in the genus *Puccinia*, although some species of *Puccinia* infect other kinds of vascular plants (Perdomo-Sánchez & Piepenbring 2008). About 650 species of *Puccinia* occur on poaceous hosts worldwide (Afshan et al. 2008a). From Pakistan, about 80 species of rust fungi are reported on approximately 93 poaceous host plants.

The work of documenting the rust flora of Pakistan began with Butler and Bisby (1933) followed by the studies of others (Arthur & Cummins 1933; Sydow & Ahmad 1939; Cummins 1943; Malik & Khan 1944; Hasnain et al. 1959; Jørstad & S. H. Iqbal 1967). Dr. Sultan Ahmad has been a pioneer amongst the uredinologists of Pakistan. He collected and described 250 species of rust fungi from West Pakistan including many poaceous rusts (Ahmad 1956 a,b; Ahmad et al. 1997).

In Pakistan, studies about poaceous rust fungi were intensified between the years 1990–2006 (Ono 1992; Ono & Kakishima 1992; Izumi et al. 1992; Okane et al. 1992; Kaneko 1993; Khalid et al. 1993 a,b; Kakishima et al. 1993 a,b; Ono & Izumi 1995; Masood et al. 1995; Khalid & Iqbal 1995, 1996a,b, 1997; Iqbal & Khalid 1996; Ahmad et al. 1997; Sultan et al. 2006). Most recently, a large number of new species and new records of rust fungi on *Poaceae* have been added (Afshan 2009; Afshan et al. 2007, 2008a,b,c,d, 2009, 2010a,b, 2011a,b,c, 2012a,b,c; Afshan & Khalid 2008, 2009; Iqbal et al. 2008, 2009; Ishaq et al. 2011; Khalid & Afshan 2009; Saba & Khalid 2011; Saba et al. 2011; Sultan et al. 2008)

The checklist presented here provides a compilation of the available data on the poaceous rusts reported from, or known to occur, in Pakistan. It also provides the first comprehensive overview of the poaceous rust fungi in Pakistan. Before this, no comprehensive list of poaceous rusts is available. Most of the published record is also not available online and is present in scattered form. The aim of this checklist is to summarize and present the correct names of the species currently known from Pakistan. We hope that this paper will be a guide for future studies about the diversity of this group of fungi and a helpful source for a database about the Pakistani mycota.

Materials & methods

The checklist is based on published literature about rust fungi in Pakistan and recent additional specimens collected. The current names of fungi are given according to www.Indexfungorum.org. Names of host plants are given according to www.ipni.org. Species treatment and nomenclature also follow recent monographs and articles on poaceous rusts listed in the introduction.

List of Taxa

Genus *Puccinia* Pers.

Puccinia aeluropodis H. Richt.

Aeluropus macrostachyus Hack.

A. lagopoides (L.) Trin. ex Thwaites

(Ahmad 1960; Khan & Kamal 1968; Ahmad 1969)

Puccinia aestivalis Dietel

Microstegium sp.

(Kakishima et al. 1993b)

Puccinia agrostidis-caninae Afshan, Berndt, Khalid & Niazi

Agrostis canina L.

(Afshan et al. 2008c)

Puccinia apludae Syd. & P. Syd.

Apluda aristata L.

A. mutica L.

(Ahmad & Arshad 1972; Afshan et al. 2008b)

Puccinia aristidae Tracy

Aristida adscensionis L. var. *adscensionis*

(Ahmad 1956a,b)

Puccinia arthraxonis (Henn.) Syd., P. Syd. & E.J. Butler

Arthraxon sp.

A. lanceolatus Hochst.

(Ahmad & Arshad 1972; Afshan et al. 2008b)

Puccinia brachypodii* var. *arrhenatheri (Kleb.) Cummins & H.C. Greene

Helictotrichon virescens (Nees ex Steud.) Henrard

(Afshan et al. 2008b)

Puccinia brachypodii G.H. Otth var. *brachypodii*

Brachypodium sylvaticum (L.) P.Beauv.

Poa attenuata Trin.

(Ahmad 1969; Kakishma et al. 1993a,b)

Puccinia brachypodii* var. *major Cummins & H.C. Greene

Poa attenuata Trin.

(Afshan et al. 2012a)

Puccinia brachypodii* var. *poae-nemoralis (G.H. Otth) Cummins & H.C.

Greene

Agrostis munroana Aitch. & Hemsl.

Anthoxanthum odoratum L.

Poa nemoralis L.

P. pratensis L.

P. sterilis L.

(Ahmad 1956a; Kakishma et al. 1993 a,b; Masood et al. 1995; Afshan et al. 2012a)

Puccinia cacao McAlpine

Hemarthria compressa (L.f.) R. Br.

(Ahmad 1956 a,b; Khalid et al. 1995)

Puccinia cesatii J. Schröt.

Bothriochloa bladhii (Retz.) S.T. Blake

B. intermedia (R. Br.) A. Camus

Dichanthium annulatum (Forssk.) Stapf

(Ahmad 1956 a,b; Ahmad & Arshad 1972; Kakishma et al. 1993a,b)

Puccinia chrysopogoni Barclay [as '*chrysopogi*']

Chrysopogon echinulatus (Nees ex Steud.) Will. Watson

(Ahmad 1969)

Puccinia coronata* var. *avenae W.P. Fraser & Ledingham

Elymus repens (L.) Gould

Saccharum ravennae (L.) L.

(Afshan et al. 2008a; Iqbal et al. 2008)

Puccinia coronata* Corda var. *coronata

Agrostis gigantea Roth,

Agrostis sp., *Festuca* sp.

Lolium persicum Boiss.

(Malik & Khan; 1944; Ahmad 1956 a,b; Jorstad & Iqbal 1967; Ghaffar & Kafi 1968; Malik & Virk 1968; Malik et al. 1968; Ono & Kakishima 1992; Afshan et al. 2011a)

Puccinia coronata* var. *gibberosa (Lagerh.) Jørst.

Phalaris minor Retz.

(Afshan et al. 2008a)

Puccinia coronata* var. *himalensis Barclay

Piptatherum vicarium (Grigorj.) Roshev. (= *Oryzopsis microcarpa* Pilg.)

(Afshan et al. 2010a)

Puccinia crandallii Pammel & H.H. Hume

Poa tibetica Munro ex Stapf

(Khalid & Afshan 2009)

Puccinia cynodontis Delacr. ex Desm.

Cynodon dactylon (L.) Pers.

(Sydow & Ahmad 1939; Ahmad 1956 a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968; Khan & Kamal 1968; Malik & Virk 1968; Malik et al. 1968; Afshan & Khalid 2009)

Puccinia dichanthii Afshan & Khalid

Dichanthium annulatum (Forssk.) Stapf
(Afshan et al. 2010a)

Puccinia digitariae-velutinae Vienn.-Bourg.
Digitaria ciliaris (Retz.) Koeler
(Hafiz et al. 1957; Hasnain et al. 1959; Ghaffar & Kafi 1968)

Puccinia duthiei Ellis & Tracy [as '*duthiae*']
Bothriochloa bladhii (Retz.) S. T. Blake
Dichanthium annulatum (Forssk.) Stapf
(Ahmad 1956 a,b; Ahmad 1976; Ahmad & Arshad 1972)

Puccinia eragrostidis-superbae Doidge
Eragrostis sp.
(Masood et al. 1995)

Puccinia graminis* var. *stakmanii A. L. Guyot, Massenot & Saccas ex Z.
Urb.
Bromus japonicus Thunb.
(Afshan et al. 2007)

Puccinia graminis Pers.
Agropyron sp.
Calamagrostis sp.
(Masood et al. 1995)

Puccinia graminis* Pers. subsp. *graminis
Agropyron semicostatum (Steud.) P. Candargy
Agrostis munroana Aitch. & Hemsl.
Bromus japonicus Thunb.
Cynodon dactylon (L.) Pers.
Hordeum vulgare L.
Triticum aestivum L.
(Ahmad 1956 a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968; Khan & Kamal 1968; Malik & Virk 1968; Malik et al. 1968; Khalid et al. 1993)

Puccinia helictotrichi* var. *pakistanica Afshan & Khalid
Helictotrichon virescens (Nees ex Steud.) Henrard
(Afshan et al. 2010b)

Puccinia hordei G.H. Otth (as *Puccinia recondita* f.sp. *tritici* C.O. Johnson)
Triticum aestivum L.

(Ahmad 1956a,b)

Puccinia isiacae (Thüm.) G. Winter

Phragmites karka (Retz.) Trin. ex Steud.

(Ahmad 1956 a,b; Malik & Virk 1968; Malik et al. 1968)

Puccinia invenusta Syd.

Phragmites karka (Retz.) Trin. ex Steud.

(Ahmad 1956 a,b; Khalid et al. 1993)

Puccinia khanspurica Khalid & Afshan

Sorghum halepense (L.) Pers.

(Khalid & Afshan 2009)

Puccinia kuehnii (W. Krüger) E.J. Butler

Erianthus ravennae (L.) P. Beauv. (≡ *Saccharum ravennae*)

Saccharum bengalense Retz.

S. munja Roxb.

S. officinarum L.

S. spontaneum L.

(Ahmad et al. 1997; Iqbal et al. 2008)

Puccinia leersiae Khalid & Afshan

Leersia oryzoides (L.) Sw. (= *Leptatherum royleanum* Nees)

(Afshan et al. 2010a)

Puccinia levis (Sacc. & Bizz.) Magnus **var. levis**

Digitaria bicornis (Lam.) Roem. & Schult.

(Ahmad 1956a,b)

Puccinia levis* var. *panici-sanguinalis (Rangel) Ramachar & Cummins

Digitaria bicornis (Lam.) Roem. & Schult.

D. radicata (C. Presl) Miq.

Setaria glauca (L.) P.Beauv.

(Ahmad 1956 a,b; Afshan et al. 2008b)

Puccinia melanocephala Syd. & P. Syd.

Eranthes elegans (Jesw.) Rumke

Narenga porphyrocoma (Hance ex Trin.) Bor

Saccharum spontaneum

(Ono 1992; Ono & Kakishima 1992; Kakishima et al. 1993a,b)

Puccinia miscanthi Miura
Saccharum ravennae L.
 (Iqbal et al. 2008)

Puccinia oahuensis Ellis & Everh.
Digitaria radicata (C. Presl) Miq.
 (Ahmad & Arshad 1972; Khalid et al. 1993)

Puccinia penicillariae Speg.
Pennisetum americanum (L.) K.Schum.
 (Khan & Kamal 1968)

Puccinia penniseti-lanati S. Ahmad
Pennisetum lanatum Klotzsch
 (Ahmad 1969)

Puccinia persistens* subsp. *agropyrina (Erikss.) Z. Urb. & J. Marková
Elymus semicostatus (Nees ex Steud.) Melderis (\equiv *Agropyron*
semicostatum Nees ex Steud.)
 (Afshan et al. 2011a)

Puccinia poarum P. Nielsen
Agrostis sp.
Poa pratensis L.
P. annua L.
 (Ahmad 1956 a,b; Kakishima et al. 1993b)

Puccinia polypogonis Speg.
Polypogon monspeliensis (L.) Desf.
 (Masood et al. 1995)

Puccinia polysora Underw.
Zea mays L.
 (Kakishima et al. 1993b)

Puccinia praegracilis Arthur
Agrostis stolonifera L.
 (Afshan et al. 2009)

Puccinia pseudostrüiformis M. Abbasi, Hedjar. & M. Scholler
Poa ampla Merr.

P. annua L.
(Afshan et al. 2008d)

Puccinia purpurea Cooke
Sorghum vulgare Pers.
(Ahmad 1956a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968; Kakishima et al. 1993a,b)

Puccinia pygmaea* var. *angusta Cummins & H.C. Greene
Calamagrostis epigejos (L.) Roth
(Afshan et al. 2011b)

Puccinia pygmaea Erikss. var. *pygmaea*
Agrostis gigantea Roth
(Ahmad 1956a,b; Afshan & Khalid 2009)

Puccinia recondita Dietel & Holw.
Agropyron orientale Roem. & Schult.
Agrostis gigantea Roth
Brachypodium sp.
Lolium perenne L.
Triticum aestivum
(Ahmad 1956 a,b; Hasnain et al. 1959; Jorstad & Iqbal 1967; Ghaffar & Kafi 1968; Khan & Kamal 1968; Malik & Virk 1968; Malik et al. 1968; Ahmad & Arshad 1972; Ono & Kakishima 1992; Ono 1992; Ishaq et al. 2011)

Puccinia rufipes Dietel
Imperata cylindrica (L.) P.Beauv.
(Ahmad 1956 a,b; Khalid et al. 1993)

Puccinia sessilis J. Schröt. var. *sessilis*
Calamagrostis pseudophragmites (Haller f.) Koeler
Phalaris minor Retz.
(Khalid & Iqbal 1996; Ishaq et al. 2011)

Puccinia sorghi Schw.
Zea mays L.
(Ahmad 1956a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968; Khan & Kamal 1968; Malik & Virk 1968; Malik et al. 1968; Ono 1992; Ono & Kakishima 1992; Kakishima et al. 1993a,b)

Puccinia sporoboli-arabici Afshan, Berndt, Khalid & Niazi

Sporobolus arabicus Boiss.
(Afshan et al. 2008c)

Puccinia sporoboli-coromandeliani Afshan, Khalid & Niazi
Sporobolus coromandelianus (Retz.) Kunth
(Afshan et al. 2010a)

Puccinia stipae (Opiz) Arthur **var. *stipae***
Stipa sp.
(Ishaq et al. 2011)

Puccinia stipae* var. *stipina (Tranzschel) H.C. Greene & Cummins
Stipa himalaica Roshev. (Ahmad 1969)

Puccinia striiformis Westend. **var. *striiformis***
Dactylis glomerata L.
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Puccinia substriata* var. *indica Ramachar & Cummins
Pennisetum orientale Rich.
(Afshan et al. 2012a)

Puccinia substriata* var. *insolita (Syd.) Ramachar & Cummins
Panicum antidotale Retz.
(Afshan et al. 2008a)

Puccinia substriata* var. *penicillariae (Speg.) Ramachar & Cummins
Pennisetum americanum (L.) K.Schum.
(Hasnain et al. 1959)

Puccinia striiformoides M. Abbasi, Hedjar. & M. Scholler
Lolium perenne L.
(Afshan et al. 2007)

Puccinia trabutii Roum. & Sacc. **var. *trabutii***
Phragmites karka (Retz.) Trin. ex Steud
(Khan & Kamal 1968; Kakishima et al. 1993b)

Puccinia versicolor Dietel & Holw.

Heteropogon contortus Beauv. ex Roem. & Schult.

Panicum antidotale Retz.

(Ahmad 1956a,b, 1976; Khalid & Afshan 2009)

Puccinia virgata Ellis & Everh.

Panicum antidotale Retz.

(Khalid & Afshan 2009)

Genus *Uromyces* (Link) Unger

Uromyces clignyi Pat. & Har.

Andropogon annulatus Forssk.

Bothriochloa bladhii (Retz.) S.T.Blake

Dichanthium annulatum (Forssk.) Stapf

Heteropogon contortus Beauv. ex Roem. & Schult.

(Ahmad 1956a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968; Khan & Kamal 1968; Ahmad & Arshad 1972; Khan & Kamal 1968; Ahmad 1976; Afshan et al. 2008d)

Uromyces dactylidis* var. *poae (Rabenh.) Cummins

Agrostis gigantea Roth

(Afshan et al. 2008d)

Uromyces eragrostidis Tracy

Desmostachya bipinnata (L.) Stapf

(Ahmad 1956a,b; Khan & Kamal 1968; Ghaffar & Kafi 1968)

Uromyces glycyrrhizae (Rabenh.) Magnus

Glycyrrhiza glabra L.

Glycyrrhiza sp.

(Ahmad 1969)

Uromyces graminicola Burrill

Panicum antidotale Retz.

(Afshan et al. 2008d)

Uromyces ignobilis (Syd. & P. Syd.) Arthur

Sporobolus arabicus Boiss.

(Ahmad 1956 a,b; Masood et al. 1995)

Uromyces inayati Syd. & P. Syd.

Apluda mutica subsp. *aristata* (L.) R.D.Gaur
(Ahmad 1969; Jorstad & Iqbal 1967)

Uromyces peglerae Pole-Evans ex Syd. & P. Syd. **var. *peglerae***

Digitaria adscendens (Kunth) Henrard (= *D. ciliaris* (Retz.) Koeler)
(Ahmad et al. 1997; Afshan et al. 2008d)

Uromyces penniseti S. Ahmad

Pennisetum lanatum Klotz.
(Ahmad 1969; Saba et al. 2011)

Uromyces schoenanthi Syd. & P. Syd.

Apluda mutica L.
(Ahmad 1956a,b)

Uromyces setariae-italicae (Diet.) Yoshino

Brachiaria ramosa (L.) Stapf.
Brachiaria reptans (L.) C. A. Gardner & C. E. Hubb.
Setaria geniculata (Lam.) P.Beauv.
S. glauca (L.) P.Beauv.,
S. lutescens (Weigel) C. E. Hubb.
S. verticillata (L.) P.Beauv.
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(Ahmad 1956a,b; Hasnain et al. 1959; Khan & Kamal 1968; Ghaffar & Kafi 1968; Ahmad 1976; Kakishma et al. 1993a,b; Afshan et al. 2008d)

Uromyces sporobolicola J.C. Lindq.

Sporobolus marginatus Hochst. ex A. Rich.
(Ishaq et al. 2011)

Uromyces superfluus P. Syd. & Syd.

Panicum antidotale Retz.
(Ahmad 1956a,b; Hasnain et al. 1959; Ghaffar & Kafi 1968)

Uromyces tenuicutis McAlpine

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(Ahmad 1976; Masood et al. 1995)

Uromyces vossiae Barcl.

Phacelurus speciosus (Steud.) C.E. Hubbard

(Ahmad 1962, 1969; Afshan et al. 2008a; Saba et al. 2011)

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Sporobolus coromandelianus: *Puccinia sporoboli-coromandeliani*
Sporobolus marginatus: *Uromyces sporobolicola*
Stipa sp.: *Puccinia stipae* var. *stipae*
Stipa himalaica: *Puccinia stipae* var. *stipina*
Triticum aestivum: *Puccinia graminis* subsp. *graminis*, *Puccinia hordei*,
Puccinia recondita, *Puccinia striiformis* var. *striiformis*
Zea mays: *Puccinia polysora*, *Puccinia sorghi*

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