

Checklist of powdery mildew fungi (*Erysiphaceae*) in Pakistan

N. S. AFSHAN*, I. ZAFAR, A. N. KHALID

*Institute of Botany, University of the Punjab,
Quaid-e-Azam Campus, Lahore, 54590, Pakistan*

*CORRESPONDENCE TO: *pakrust@gmail.com, najamulshehar.botany@pu.edu.pk*

ABSTRACT — This paper presents a checklist of powdery mildews (*Erysiphaceae*) in Pakistan together with their known host plants. A total of 42 taxa belonging to 10 genera are included here. A host index is also provided.

KEY WORDS — angiosperms, *Ascomycota*, biotrophic parasites, *Erysiphe*

Introduction

Powdery mildew fungi are obligate biotrophic parasites of the order *Erysiphales* of phylum *Ascomycota*. The diseases caused by these fungi are cosmopolitan, globally diverse and recognized easily. High humidity and low water content favor the growth of these fungi. Like rust fungi, the mildews generally have a narrow and specific host range. From the literature, it is evident that about 10,000 plant species are attacked by these fungi worldwide and, interestingly, all of these plants are Angiosperms (Amano 1986; Braun & Cook 2012). From Pakistan, only 10 genera and 42 species of *Erysiphaceae* are known. Among these, *Erysiphe* R. Hedw. ex DC. is the largest genus in Pakistan, represented by 16 species. The remaining powdery mildew fungi include one species each of *Blumeria* Golovin ex Speer, *Cystotheca* Berk. & M.A. Curtis, and *Pleochaeta* Sacc. & Speg.; two species of *Neoerysiphe* U. Braun; three species of *Leveillula* G. Arnaud; four species of *Golovinomyces* (U. Braun) V.P. Heluta; five species of *Phyllactinia* Lév. and eight species of genus *Podosphaera* Kunze with one species of anamorphic genus *Euoidium* Y.S. Paul & J.N. Kapoor (Ahmad & al. 1997; Mukhtar & al. 2013a, b; Afshan & al. 2017; Ishaq & al. 2018; Anwar & al. 2020a, b; Riaz & al. 2020). It is clear from these data that the biodiversity of the *Erysiphaceae* is less explored in different regions of Pakistan, and we need more thorough surveys for exploration of this economically important group of plant pathogens. Currently, research work is underway on exploration of this group of fungi and many new records as well as new species are expected in the future.

The work of documenting the powdery mildew fungi in Pakistan began with Dr. Sultan Ahmad as he was the pioneer amongst the mycologists of Pakistan. He collected and described many species of powdery mildew fungi from Pakistan (1956a, b; 1960, 1969; 1978) followed by the studies of others (Khan & Kamal 1962, 1968; Ghaffar & Kafi 1968; Ahmad & Arshad 1972; Mirza & Qureshi 1978; Kakishima & al. 1993; Kaneko 1993; Burni et al. 2010; Mukhtar & al. 2012, 2013a, b).

Recently, a few taxa of powdery mildew fungi were added to our mycoflora (Afshan & al. 2017; Ishaq & al. 2018; Anwar & al. 2020a, b; Haelewaters & al. 2020; Riaz & al. 2020)

The checklist presented here provides a compilation of the available data of the *Erysiphaceae* reported from Pakistan. It also provides the first comprehensive overview of the powdery mildew fungi in Pakistan as most of the published records are not available online and

are 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 powdery mildew fungi in Pakistan and the additional specimens recently collected. The current names of fungi are given according to www.Indexfungorum.org. Names of host plants are provided according to gbif.org and www.ipni.org. Species treatment and nomenclature also follow recent monographs and articles on *Erysiphaceae* listed in the introduction.

List of Taxa

Genus *Blumeria* Golovin ex Speer

Blumeria graminis (DC.) Speer (≡ *Erysiphe graminis* DC.)

Poa pratensis L.

Stipa sibirica (L.) Lam.

Triticum vulgare L.

(Ahmad 1956ab, 1978; Malik & Virk 1968; Mirza & Qureshi 1978)

Genus *Cystotheca* Berk. & M.A. Curtis

Cystotheca lanestris (Harkn.) Miyabe (≡ *Sphaerotheca lanestris* Harkn.)

Quercus dilatata Lindl.

Q. ilex L.

(Ahmad 1960, 1969)

Genus *Erysiphe* R. Hedw. ex DC.

Erysiphe adunca (Wallr.) Fr. (≡ *Uncinula adunca* (Wallr.) Lév.)

Populus ciliata Wall. ex Royle

(Ahmad 1978)

Erysiphe aquilegiae DC. (= *Erysiphe ranunculi* Grev.)

Thalictrum elegans Wall.

(Ahmad & Arshad 1972)

Erysiphe astragali DC. (≡ *Microsphaera astragali* (DC.) Trevis)

Astragalus coluteocarpus Boiss.

Oxytropis mollis Royle ex Benth.

(Ahmad 1956b, 1978)

Erysiphe betae (Vaňha) Weltzien
Chenopodium ambrosioides L.
 (Anwar & al. 2020a)

Erysiphe convolvuli DC.
Convolvulus arvensis L.
 (Ahmad 1956ab, 1978; Malik & Virk 1968; Mirza & Qureshi 1978; Burni et al. 2010)

Erysiphe cruciferarum Opiz ex L. Junell Schltdl.
Brassica napus L.
 (Malik & Virk 1968; Mirza & Qureshi 1978)

Erysiphe heraclei DC.
Bunium persicum (Boiss.) B. Fedtsch.
Torilis leptophylla (L.) Rchb. fil.
 (Ahmad 1978)

Erysiphe necator Schwein. (≡ *Uncinula necator* (Schwein.) Burrill)
Vitis vinifera L.
 (Malik & Virk 1968)

Erysiphe pisi DC.
Medicago lupulina L.
Pisum sativum L.
 (Ahmad 1956b; Malik & Virk 1968)

Erysiphe polygoni DC.
Polygonum aviculare L.
P. amplexicaule D. Don
Rumex nepalensis Spreng.
R. orientalis Bernh. ex Schult. f.
 (Ahmad 1978; Mirza & Qureshi 1978; Burni et al. 2010)

Erysiphe quercicola S. Takam. & U. Braun
Ziziphus jujuba Mill.
 (Haelewaters & al. 2020)

Erysiphe sambuci S. Ahmad
Sambucus ebulus L.
 (Ahmad 1969, 1978)

Erysiphe urticae (Wallr.) S. Blumer
Urtica dioica L.
 (Haelewaters & al. 2020)

Erysiphe viburni Duby

Viburnum grandiflorum Wall.

(Ishaq & al. 2018)

***Erysiphe* sp.** (as *Erysiphe communis* (Wallr.) Schltldl.)

Cucumis melo L.

C. sativus L.

Cucurbita pepo L.

Lagenaria vulgaris Ser.

Momordica charantia L.

(Malik & Virk 1968; Mirza & Qureshi 1978)

***Erysiphe* sp.** (as *Uncinula adunca* (Wallr.) Lév.)

Salix sp.

(Ahmad 1978)

Genus *Euoidium* Y.S. Paul & J.N. Kapoor

Euoidium vernoniicola (Bappamm., Hosag. & Udaiyan) U. Braun & R.T.A. Cook

Vernonia elaeagnifolia DC.

(Afshan & al. 2017)

Genus *Golovinomyces* (U. Braun) V.P. Heluta

Golovinomyces asperifoliorum (Grev.) U. Braun & H. D. Shin (≡ *Erysiphe asperifoliorum*

Grev.)

Cynoglossum lanceolatum Forssk.

Lindelophia sp.

(Ahmad 1978)

Golovinomyces cichoracearum (DC.) Heluta (≡ *Erysiphe cichoracearum* DC.)

Centaurea calcitrapa L.

Dahlia variabilis Hort.

(Ahmad 1956a,b, 1978; Khan & Kamal 1968; Mirza & Qureshi 1978; Mukhtar & al. 2013a)

Golovinomyces sordidus (L. Junell) Heluta (≡ *Erysiphe sordida* L.)

Plantago major L.

(Ahmad 1969)

***Golovinomyces* sp.** (as *Golovinomyces cichoracearum* (DC.) Heluta)

Cucurbita moschata (Duchesne) Duchesne ex Poir.

(Mukhtar & al. 2012)

Genus *Leveillula* G. Arnaud***Leveillula lappae*** (Castagne) U. Braun

Tricholepis stewarti C.B. Clarke ex Hook.f.
(Riaz & al. 2020)

Leveillula taurica (Lév.) G. Arnaud

Haloxylon recurvum Bunge ex Boiss.
Heteropogon contortus (L.) P.Beauv. ex Roem. & Schult.
Peganum harmala L.
(Ahmad 1956b; Ghaffar & Kafi 1968; Khan & Kamal 1962, 1968; Malik & Virk 1968; Mirza & Qureshi 1978)

Leveillula contractirostris V. P. Heluta & Simonyan (as *Leveillula taurica* f. *althaeae* Jacz.)

Althaea rosea Hohen. ex Boiss.
(Malik & Virk 1968)

Genus *Neoerysiphe* U. Braun***Neoerysiphe galeopsidis*** (DC.) U. Braun (≡ *Erysiphe galeopsidis* DC.)

Nepeta spicata Benth.
Phlomis bracteosa Royle ex Benth.
Ph. stewartii Hook.f.
(Ahmad 1978)

Neoerysiphe galii (S. Blumer) U. Braun (≡ *Erysiphe galii* S. Blumer)

Galium aparine L.
(Ahmad 1978)

Genus *Phyllactinia* Lév.***Phyllactinia babayani*** Simonyan (as *Phyllactinia mespili* (Castagne) S. Blumer)

Prunus amygdalus Batsch
(Ahmad 1956b, 1978)

Phyllactinia dalbergiae Piroz.

Dalbergia sissoo Roxb. ex DC.
(Ahmad 1956b, 1978; Ghaffar & Kafi 1968; Khan & Kamal 1968)

Phyllactinia guttata (Wallr.) Lév. (= *Phyllactinia corylea* (Pers.) P. Karst.)

Betula utilis D. Don
Jasminum humile L.
Lonicera quinquelocularis Hardw.
Salix tetrasperma Roxb.
(Kaneko 1993, Khan & Kamal 1968)

Phyllactinia mali (Duby) U. Braun (= *Phyllactinia mespili* (Castagne) S. Blumer)
Cotoneaster bacillaris Wall.
(Ahmad 1956b, 1978)

Phyllactinia moricola (Henn.) Sawada (as *Phyllactinia corylea* (Pers.) P. Karst.)
Morus alba L.
(Khan & Kamal 1968)

Genus *Pleochaeta* Sacc. & Speg.

Pleochaeta shiraiana (Henn.) Kimbr. & Korf (≡ *Uncinula polychaeta* (Berk. & M.A. Curtis)
Tracy & L.D. Galloway)
Celtis australis L.
C. eriocarpa Decne.
C. tetrandra Roxb.
(Ahmad 1956b, 1978; Kaneko 1993)

Genus *Podosphaera* Kunze

Podosphaera curvispora Y. Nomura
Sorbus tianschanica Rupr.
(Kaneko 1993)

Podosphaera erigerontis-canadensis (Lév.) U. Braun & T.Z. Liu
Erigeron bonariensis hort. ex Link
(Anwar & al. 2020b)

Podosphaera ferruginea (Schltdl.) U. Braun & S. Takam. (≡ *Sphaerotheca ferruginea* (Schltdl.)
L. Junell)
Spiraea vestita Wall. ex G. Don
(Ahmad 1978)

Podosphaera fuliginea (Schltdl.) U. Braun & S. Takam. (≡ *Sphaerotheca fuliginea* (Schltdl.)
Pollacci)
Euphrasia rostkoviana Hayne
Lagenaria vulgaris Ser.
Scrophularia polyantha Royle ex Benth.
(Ahmad 1956b, 1978; Khan & Kamal 1968; Malik & Virk 1968)

Podosphaera leucotricha (Ellis & Everh.) E.S. Salmon
Pyrus malus L.
(Ahmad 1956b; Khan & Kamal 1968; Malik & Virk 1968)

Podosphaera macularis (Wallr.) U. Braun & S. Takam. (\equiv *Sphaerotheca macularis* (Wallr.) Magnus)

Rosa corymbifera Borkh.
(Ahmad 1978)

Podosphaera pannosa (Wallr.) de Bary (\equiv *Sphaerotheca pannosa* (Wallr.) Lév.)

Rosa sp.
Rosa damascena Mill.
(Ahmad 1978; Khan & Kamal 1968; Ghaffar & Kafi 1968)

Podosphaera xanthii (Castagne) U. Braun & Shishkoff

Ageratum conyzoides L.
Cucurbita pepo L.
(Khan & Kamal 1968; Malik & Virk 1968; Mukhtar & al. 2013b)

Host Index

- Ageratum conyzoides*: *Podosphaera xanthii*
Althaea rosea: *Leveillula contractirostris*
Astragalus coluteocarpus: *Erysiphe astragali* (≡ *Microsphaera astragali*)
Betula utilis: *Phyllactinia guttata*
Brassica napus: *Erysiphe cruciferarum*
Bunium persicum: *Erysiphe heraclei*
Celtis australis: *Pleochaeta shiraiana* (≡ *Uncinula polychaeta*)
Celtis eriocarpa: *Pleochaeta shiraiana* (≡ *Uncinula polychaeta*)
Celtis tetrandra: *Pleochaeta shiraiana* (≡ *Uncinula polychaeta*)
Centaurea calcitrapa: *Golovinomyces cichoracearum* (≡ *Erysiphe cichoracearum*)
Chenopodium ambrosioides: *Erysiphe betae*
Convolvulus arvensis: *Erysiphe convolvuli*
Cotoneaster bacillaris: *Phyllactinia mespili*
Cucumis melo: *Erysiphe communis*
Cucumis sativus: *Erysiphe communis*
Cucurbita moschata: *Golovinomyces* sp.
Cucurbita pepo: *Podosphaera xanthii*, *Erysiphe* sp.
Cynoglossum lanceolatum: *Golovinomyces asperifoliorum* (≡ *Erysiphe asperifoliorum*)
Dahlia variabilis: *Golovinomyces cichoracearum*
Dalbergia sissoo: *Phyllactinia dalbergiae*
Euphrasia rostkoviana: *Podosphaera fuliginea* (≡ *Sphaerotheca fuliginea*)
Galium aprine: *Neoerysiphe galii* (≡ *Erysiphe galii*)
Haloxylon recurvum: *Leveillula taurica*
Heteropogon contortus: *Leveillula taurica*
Jasminum humile: *Phyllactinia guttata*
Lagenaria vulgaris: *Erysiphe* sp., *Podosphaera fuliginea* (≡ *Sphaerotheca fuliginea*)
Lindelofia: *Golovinomyces asperifoliorum* (≡ *Erysiphe asperifoliorum*)
Lonicera quinquelocularis: *Phyllactinia guttata*
Medicago lupulina: *Erysiphe pisi*
Momordica charantia: *Erysiphe communis*
Morus alba: *Phyllactinia moricola*
Nepeta spicata: *Neoerysiphe galeopsidis* (≡ *Erysiphe galeopsidis*)
Oxytropis mollis: *Erysiphe astragali* (≡ *Microsphaera astragali*)
Peganum harmala: *Leveillula taurica*
Phlomis bracteosa: *Neoerysiphe galeopsidis* (≡ *Erysiphe galeopsidis*)
Phlomis stewartii: *Neoerysiphe galeopsidis* (≡ *Erysiphe galeopsidis*)
Pisum sativum: *Erysiphe pisi*
Plantago major: *Golovinomyces sordidus* (≡ *Erysiphe sordida*)
Poa pratensis: *Blumeria graminis* (≡ *Erysiphe graminis*)
Polygonum aviculare: *Erysiphe polygoni*
Polygonum amplexicaule: *Erysiphe polygoni*
Populus ciliata: *Erysiphe adunca* (≡ *Uncinula adunca*)

Prunus amygdalus: *Phyllactinia babayanii*
Pyrus malus: *Podosphaera leucotricha*
Quercus ilex: *Cystotheca lanestris* (≡ *Sphaerotheca lanestris*)
Q. dilatata: *Cystotheca lanestris* (≡ *Sphaerotheca lanestris*)
Rosa sp.: *Podosphaera pannosa* (≡ *Sphaerotheca pannosa*)
Rosa corymbifera: *Podosphaera macularis* (≡ *Sphaerotheca macularis*)
R. damascene: *Podosphaera pannosa* (*Sphaerotheca pannosa*)
Rumex nepalensis: *Erysiphe polygoni*
Rumex orientalis: *Erysiphe polygoni*
Salix sp.: *Erysiphe* sp. (as *Uncinula adunca*)
Salix tetrasperma: *Phyllactinia guttata*
Sambucus ebulus: *Erysiphe sambuci*
Scrophularia polyantha: *Podosphaera fuliginea* (≡ *Sphaerotheca fuliginea*)
Sorbus tianschanica: *Podosphaera curvispora*
Spiraea vestita: *Podosphaera ferruginea* (≡ *Sphaerotheca ferruginea*)
Stipa sibirica: *Blumeria graminis* (≡ *Erysiphe graminis*)
Thalictrum elegans: *Erysiphe aquilegiae* (= *Erysiphe ranunculi*)
Torilis leptophylla: *Erysiphe heraclei*
Tricholepis stewartii: *Leveillula lappae*
Triticum vulgare: *Blumeria graminis* (≡ *Erysiphe graminis*)
Urtica dioica: *Erysiphe urticae*
Vernonia elaeagnifolia: *Euoidium vernoniicola*
Viburnum grandiflorum: *Erysiphe viburni*
Vitis vinifera: *Erysiphe necator* (≡ *Uncinula necator*)
Ziziphus jujuba: *Erysiphe quercicola*

Acknowledgements

We are sincerely thankful to Prof. Dr. Susumu Takamatsu (Graduate School of Bioresources, Mie University, Tsu, Japan), Dr. Amy Y. Rossman (Oregon State University, Corvallis, USA) and Dr. Seyed Akbar Khodaparast (Department of Plant Protection, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran) for acting as presubmission reviewers and giving valuable suggestions.

Literature cited

- Afshan NS, Khanum S, Fiaz M, Khalid AN, Niazi AR. 2017. *Euoidium vernoniicola*, a new report for Pakistan. *Plant Pathology & Quarantine* 7(2): 142–144. <https://doi.org/10.5943/ppq/7/2/6>
- Ahmad S. 1956a. *Uredinales* of Pakistan. *Biologia* 2: 29–101.
- Ahmad S. 1956b. Fungi of West Pakistan. Biological Society of Pakistan, Lahore Monograph 1: 1–126.
- Ahmad S. 1960. Further contributions to the fungi of Pakistan. I. *Biologia* 6: 117–136.
- Ahmad S. 1969. Fungi of Pakistan. Biological Society of Pakistan, Lahore, Monograph.5, Suppl.
- Ahmad S. 1978. *Ascomycetes* of Pakistan. Biological Society of Pakistan, Monograph 7 & 8.
- Ahmad S, Arshad M. 1972. Contributions to the fungi of Pakistan. XII. *Biologia* 8: 7–17.
- Ahmad S, Iqbal SH, Khalid AN. 1997. Fungi of Pakistan. Sultan Ahmad Mycological Society of Pakistan, Lahore.
- Amano (Hirata) K. 1986. Host range and geographical distribution of the powdery mildew fungi. Japan Scientific Societies Press, Tokyo.
- Anwar A, Afshan NS, Ishaq A, Riaz M, Khalid AN, Sirajuddin. 2020a. First Pakistani report of *Erysiphe betae* on the invasive weed *Chenopodium ambrosioides*. *Mycotaxon* 135: 649–655. <https://doi.org/10.5248/135.649>

- Anwar A, Afshan NS, Ishaq A, Liaqat N, Sirajuddin. 2020b. First report of powdery mildew caused by *Podosphaera erigerontis-canadensis* on *Erigeron bonariensis* in Pakistan. *Plant Disease* 104(9): 2521. <https://doi.org/10.1094/PDIS-08-19-1788-PDN>
- Braun U, Cook RTA. 2012. Taxonomic manual of the *Erysiphales* (powdery mildews). CBS-KNAW Fungal Biodiversity Center. pp. 98–707.
- Burni T, Jamil F, Jabeen M. 2010. *Erysiphales* of Peshawar valley, Khyber Pakhtunkhwa, Pakistan. *Pakistan Journal of Plant Sciences* 16: 11–14.
- Ghaffar A, Kafi A. 1968. Fungi of Karachi. *Pak. J. Sc.* 20: 5–10.
- Haelewaters D, Dima B, Abdel-Hafiz AI, Abdel-Wahab MA, Abul-Ezz SR, Acar I, ... & Krisai-Greilhuber I. 2020. Fungal Systematics and Evolution: FUSE 6. *Sydowia* 72: 231–356.
- Ishaq A, Saleem S, Afshan NS, Khalid AN, Niazi AR. 2018. New reports of the plant pathogens *Aecidium viburni* and *Erysiphe viburni* on *Viburnum grandiflorum* from Pakistan. *Mycotaxon* 133: 551–557. <https://doi.org/10.5248/133.551>
- Kakishima M, Izumi O, Ono Y. 1993. Rust fungi (*Uredinales*) of Pakistan collected in 1991. *Cryptogamic Flora of Pakistan* 2: 169–179.
- Kaneko S. 1993. Parasitic fungi on woody plants from Pakistan. *Cryptogamic Flora of Pakistan*, Vol. 2 (Eds. T. Nakaïke and S. Malik), Nat. Sci. Mus., Tokyo, Japan. pp. 149–168.
- Khan SA, Kamal M. 1962. Some additional hosts to *Leveillula taurica* (Lev.) Arnaud from Pakistan. *Pak. J. Sci. Res.* 5: 41.
- Khan SA, Kamal M. 1968. The fungi of South West Pakistan. Part 1. *Pak. J. Sci. & Ind. Res.* 11: 61–80.
- Malik SA, Virk. 1968. Contribution to the knowledge of parasitic fungi of Quetta-Kalat Region. *Biologia* 14: 27–35.
- Mirza JH, Qureshi MSA. 1978. Fungi of Pakistan. University of Agriculture, Faisalabad, Pakistan.
- Mukhtar I, Khurram R, Hannan A, Hayat Z. 2012. First report of powdery mildew of pumpkin caused by *Golovinomyces cichoracearum* in Neelum Valley, Azad Kashmir. *Plant Disease* 96(6): 906. <https://doi.org/10.1094/PDIS-08-11-0642-PDN>
- Mukhtar I, Mushtaq S, Khokhar I. 2013a. First report of powdery mildew on dahlia (*Dahlia variabilis*) caused by *Golovinomyces cichoracearum* in Lahore, Pakistan. *Australasian Plant Disease Notes* 8: 1–3. <https://doi.org/10.1007/s13314-011-0025-7>
- Mukhtar I, Khokhar I, Mushtaq S. 2013b. New record of *Podosphaera xanthii* on *Ageratum conyzoides* L. in Pakistan. *Pakistan Journal of Weed Science Research* 19(4): 475.
- Riaz M, Afshan NS, Ishaq A, Niazi AR, Khalid AN. 2020. First report of powdery mildew caused by *Leveillula lappae* on *Tricholepis stewarti* in Pakistan, *Plant Disease* 104(2): 591. <https://doi.org/10.1094/PDIS-07-19-1387-PDN>