The European Journal of Plant Science and Biotechnology ©2011 Global Science Books

Powdery Mildews on Ornamental Trees and Shrubs in Norway

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ABSTRACT

This paper presents powdery mildew species recorded on woody ornamentals, with special emphasis on the latest arrivals; *Erysiphe flexuosa* on horse chestnut (*Aesculus hippocastanum*), *Erysiphe syringae-japonicae* on lilac (*Syringa vulgaris*) and *Podosphaera spiraeae* on white spirea (*Spiraea betulifolia*). The two former were found in 2006, while the latter was first detected in 2008. Chasmothecia (formerly named cleistothecia) were not found on white spirea until 2010. Several locations seemed to have optimal conditions for development of powdery mildew diseases in 2006. That year the long established *Sawadaea bicornis* on sycamore maple (*Acer pseudoplatanus*), was found for the first time on tatarian maple (*Acer tataricum* ssp. *ginnala*) and one cultivar from hedge maple (*Acer campestre* 'Red Shine'). Also several species and cultivars of *Rhododendron* had massive attacks of powdery mildew in 2006. In 2010, chasmothecia of *E. azaleae* were found on severely affected *R.* 'Magnifica' in western Norway. Most powdery mildew species are host specific, but especially *Phyllactinia guttata* has a wider host range, e.g. hazel (*Corylus* spp.) and common ash (*Fraxinus excelsior*).

Keywords: *Acer*, *Aesculus*, *Erysiphe*, *Phyllactinia*, *Podosphaera*, *Rhododendron*, *Sawadaea*, *Spiraea*, *Syringa*

INTRODUCTION

The aim of this paper was to publish an overview of powdery mildew species found on woody ornamental plants in Norway, based on material from the herbarium collection at our institute, including some new detections.

Powdery mildews are common diseases on woody ornamentals, and they often drastically reduce the aesthetical value of their host plants. More than 500 powdery mildew species on more than 7000 host plants have been recognized worldwide. The temperate region of North America may serve as an example of the situation on trees and shrubs, there at least 85 powdery mildew species representing 11 genera have been found on woody ornamentals (Sinclair and Lyon 2005).

Worldwide, Erysiphales is by far the largest powdery mildew order. During the last two decades, Erysiphales has been intensively studied by electron microscopy and molecular methods. Among the taxonomic consequences from these studies is an emendation of the genus *Erysiphe* to include the previous genus *Erysiphe* and the genera *Microsphaera*, *Uncinula* and some others. Two new genera, *Golovinomyces* and *Neoerysiphe*, have been established based on the remaining sections of the genus *Erysiphe.* The previous genus *Sphaerotheca* is now considered synonymous to *Podosphaera* (Cook *et al.* 1997; Takamatsu *et al.* 1998, 1999; Braun 1999; Braun and Takamatsu 2000).

In addition to *Erysiphe*, three more powdery mildew genera are represented on woody ornamentals in Norway; *Phyllactinia*, *Podosphaera*, and *Sawadaea.*

Host range and geographical distribution of Erysiphales in Norway have previously been treated by Jørstad (1925, 1945). In addition, the publication by Junell (1967) provides valuable information on powdery mildews of Norway. Preliminary results from some of the new powdery mildew discoveries in 2006, were published in Norwegian (Talgø *et al.* 2006a, 2006b, 2007). Also an overview of powdery mildew species on ornamental plants was previously published in Norwegian (Talgø *et al.* 2008). Some of the earlier detections were published by Jørstad (1925, 1945) and Gjærum (1991).

MATERIALS AND METHODS

Fresh plant material or samples from our herbarium were examined by light microscope. Holomorphic features of the pathogen structures, host range, and previous reports (Jørstad 1925; Jørstad 1945; Junell 1967; Gjærum 1991) on powdery mildew detections in Norway were used to produce this paper. To identify *Podosphaera* spp., conidia mounted in 3% KOH (potassium hydroxide > 85%, MERCK, Germany) solution were examined under light microscope to look for fibrosin bodies (crystals) (McGrath *et al.* 1996; Glawe 2008). Herbarium material was collected from all new host species. Taxonomy is in accordance with Index Fungorum (2010), except for *E. penicillata*, where the name *Microsphaera penicillata* still appears in the index. Furthermore, a powdery mildew on hydrangea (*Hydrangea opuloides* Koch.), currently named *M. polonica* in Index Fungorum, is mentioned as *E. polonica* in this paper since *Microsphaera* now belongs to the genus *Erysiphe.*

RESULTS AND DISCUSSION

Table 1 presents all powdery mildew species found on woody ornamentals in Norway, and in which county (**Fig. 1**) it was first detected during the period 1826-2010. They are further presented under their respective genera shown below.

Erysiphe

As seen from **Table 1**, a total of 17 species of *Erysiphe* have been found on 19 woody ornamental plant species in Norway.

Two *Erysiphe*-species were detected for the first time in the country during 2006; *E. flexuosa* (Peck) U. Braun & S. Takam. (syn. *Uncinula flexuosa* Peck) on horse chestnut (*Aesculus hippocastanum* L.) and *E. syringae-japonicae* (U. Braun) U. Braun & S. Takam. (syn. *Microsphaera syringae-japonicae* U. Braun) on lilac (*Syringa vulgaris* L.) (**Fig. 2**). Both were found relatively late in the growing season (end of August), and the damage was not very severe. By 2010, there were no indications that the situation had accelerated

Received: 15 October, 2010. Accepted: 27 January, 2011.

Original Research Paper

Table 1 Powdery mildew species on woody ornamentals in Norway. The pathogens are arranged in alphabetical order. Year, location (county), and reference for the first detection is given for each powdery mildew species and host (unpub. = unpublished data).

Powdery mildew	Host	Year	County	References
Erysiphe adunca	*Populus* sp.	1945	Oppland	Jørstad, unpub.
E. adunca	*Salix caprea* (**Fig. 4A**)	1898	Oslo	Schøyen WM, unpub.
E. aquilegiae var. *ran.*	*Clematis* sp. (**Fig. 4B**)	1980	Aust-Agder	Gjærum, unpub.
E. alphitoides	*Quercus* sp.	1911	Vest-Agder	Jørstad 1945
E. azaleae	*Rhododendron* (**Fig. 3**)	2010	Hordaland	Present publication
E. berberidis	*Berberis vulgaris* (**Fig. 5A, 5B**)	1947	Oslo	Gjærum, unpub.
E. berberidis	*Mahonia aquifolium* (**Fig. 5C, 5D**)	1990	Akershus	Gjærum, unpub.
E. divaricata	*Frangula alnus*	1948	Telemark	Jørstad, unpub.
E. flexuosa	*Aesculus hippocastanum* (**Fig. 2A-C**)	2006	Akershus	Talgø *et al.* 2006b
E. friesii	*Rhamnus catharticus* (**Fig. 4C**)	1961	Akershus	Jørstad, unpub.
E. hypophylla	*Quercus robur*	1972	Oslo	Roll-Hansen 1995
E. lonicerae	*Lonicera* sp. (**Fig. 4D**)	1883	Akershus	Jørstad 1945
E. ornata var. *europaea*	*Betula pubescens*	1879	Vestfold	Jørstad 1945
E. palczewskii	*Caragana arborescens* (**Fig. 4E**)	1990	Akershus	Gjærum 1991
E. penicillata	*Alnus incana*	1887	Hordaland	Jørstad 1945
E. polonica	*Hydrangea* sp.	1924	Akershus	Jørstad 1945
E. syringae-japonicae	*Syringa vulgaris* (**Fig. 2D-F**)	2006	Akershus	Talgø *et al.* 2006a
E. vanbruntiana	*Sambucus* sp. (**Fig. 4F**)	1985	Buskerud	Gjærum 1991
E. viburnicola	*Viburnum* sp.	1948	Rogaland	Ramsfjell, unpub.
Phyllactinia guttata	*Alnus incana*	1830	Oppland	Jørstad 1945
P. guttata	*Betula odorata*	1839	Oppland	Jørstad 1945
P. guttata	*Corylus avellana* (**Fig. 6C, 6D**)	1897	Akershus	Schøyen TH, unpub.
P. guttata	*Corylus maxima* 'Purpurea'	2006	Akershus	Talgø *et al.* 2008
P. guttata	*Corylus americana*	2006	Akershus	Talgø *et al.* 2008
P. guttata	*Fraxinus* sp. (**Fig. 6A, 6B**)	1826	Akershus	Jørstad 1945
P. guttata	*Fagus sylvatica*	1879	Vestfold	Jørstad 1945
P. guttata	*Sorbus aucuparia*	not r.	not reported	Jørstad 1945
Podosphaera aphanis	*Dasiphora fruticosa* (**Fig. 9A**)	1967	Akershus	Langnes, unpub.
P. clandestina var. *auc.*	*Sorbus* sp.	1947	Akershus	Ramsfjell, unpub.
P. clandestina var. *auc.*	*Fraxinus excelsior*	1826	Akershus	Jørstad 1945
P. clandestina var. *clan.*	*Amelanchier* sp. (**Fig. 9C, 9D**)	1989	Akershus	Gjærum, unpub.
P. clandestina var. *clan.*	*Crataegus* sp. (**Fig. 9B**)	1923	Oppland	Jørstad 1945
P. leucotricha	*Malus baccata*	1959	Sogn og Fj.	Ramsfjell, unpub.
P. mors-uvae	*Ribes* sp. (**Fig. 9E**)	1904	Telemark	Jørstad 1945
P. pannosa	*Rosa* sp. (**Fig. 9F**)	1870	Oslo	Jørstad 1945
P. spiraeae	*Spiraea betulifolia* (**Fig. 7**)	2010	Oslo	Present publication
Podosphaera sp.	*Spiraea japonica* (**Fig. 8**)	2010	Akershus	Present publication
Sawadaea bicornis	*Acer pseudoplatanus* (**Fig. 10B, 10C**)	1924	Hordaland	Jørstad 1945
S. bicornis	*A. campestre* 'Red Shine' (**Fig. 10E**)	2006	Akershus	Talgø *et al.* 2007
S. bicornis	*A. tataricum* ssp. *ginnala* (**Fig. 10D**)	2006	Akershus	Talgø *et al.* 2007
S. tulasnei	*A. platanoides* (**Fig. 10A**)	1840	Oslo	Jørstad 1945

Table 2 Morphological characteristics of four recently discovered teleomorph stages of powdery mildews on woody ornamentals in Norway; *Erysiphe azaleae* 2010, *E. flexuosa* 2006, *E. syringae-japonicae* 2006, and *Podosphaera spiraeae* (2010).

Pathogen	Host	Chasmothecia	Asci	Ascospores
Erysiphe azaleae	*Rhododendron* 'Magnifica'	Globose, 141 µm diameter (n=10), yellowish – becoming dark when mature, dichotomously branched appendages.	27.6-(31.9)-35.9×34.8-(50.8)-60.2 µm (n=10)	Hyaline, ellipsoidal, measuring 8.7-(10.3)-12.8 ×10.3-(15.0)-18.8 µm (n=25)
E. flexuosa	*Aesculus hippocastanum*	Globose, 166.5 µm diameter (n=10), yellowish – becoming dark when mature, two types of appendages (±50 per chasmothecia); relatively long and coiled or short and stiff.	25-(31)-35×50-(58)-60 µm (n=5)	Hyaline, ellipsoidal, measuring 7.5-(10.7)-12.5×15.0-(18.2)-20.0 µm (n=25)
E. syringae-japonicae	*Syringa vulgaris*	Globose, 112 µm diameter (n=10), yellowish – becoming dark when mature, 3-16 dichotomously branched appendages per chasmothecium.	50×55 µm (n=1, only 1 ascus intact on the stored slide)	Hyaline, ellipsoidal, measuring 6.8-(7.9)-10.0×15.0-(16.9)-20.0 µm (n=25)
Podosphaera spiraeae	*Spiraea betulifolia*	Globose, 93 µm diameter (n=10), dark brown, mycelioid appendages.	44-(47)-61×61-(71)-91 µm (n=10)	Hyaline, ellipsoidal, measuring 8.8-(11.0)-12.5×15.0-(17.3)-21.3µm (n=25)

on lilac, but attacks had clearly become more severe on horse chestnut, and many new locations for presence of *E. flexuosa* were recorded in south eastern Norway. Morphological descriptions of the teleomorph stages of the two fungi are given in **Table 2**. *E. flexuosa* originates from eastern North America. During the last decade it has spread epidemically throughout Europe, where it has been reported from a number of countries, including England in the West (Ing and Spooner 2002) and Hungary in the East (Kiss *et al.* 2003). In fact, the fungus was spread to Europe before it was reported from Western North America (Glawe and Dungan 2006). The specimens of *E. syringae-japonicae* examined in Norway had pigmented appendages towards the base (**Fig. 2F**) and between 6 and 8 ascospores per ascus. According to Braun (1987) these characteristics distinguish *E. syringae-japonica* from *E. syringae*. While *E. syringae-japonica* is common in Asia, *E. syringae* is considered to have originated in North America and later moved to Europe and Australia. In the last years, the separation of these two species has been questioned. Based on

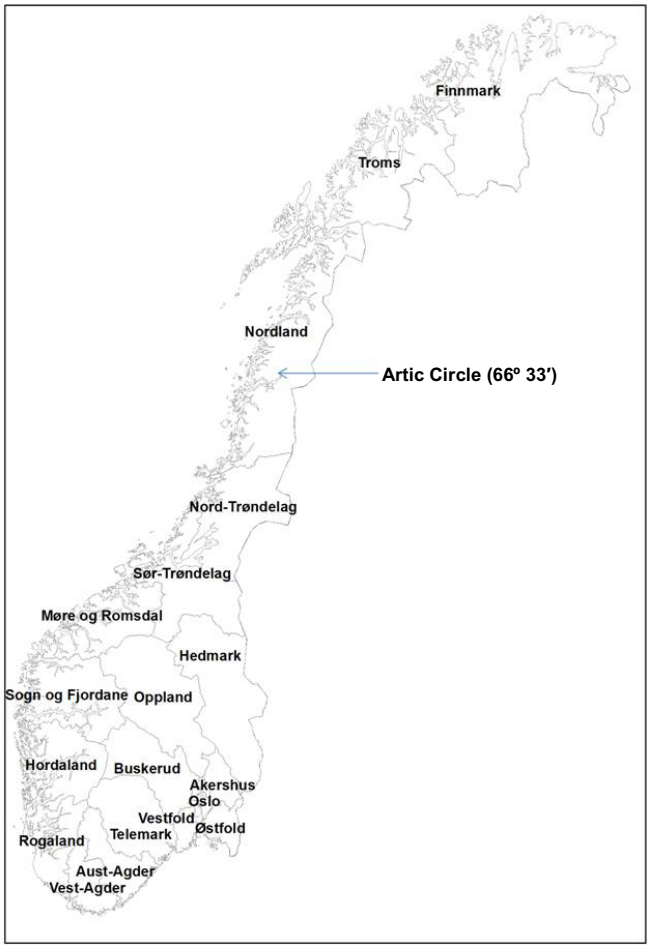

Fig. 1 County map of Norway. The latitude of Norway ranges from approximately 57 to 72° north. The Artic Circle goes through Nordland County at approximately 66° (indicated on the map). The furthest north detection of powdery mildew so far is *Erysiphe lonicerae* on honeysuckle (*Lonicera* sp.) at 69º 40′ latitude.

Fig. 2 *Erysiphe flexuosa* on horse chestnut (*Aesculus hippocastanum*) (A, B, C) and *Erysiphe syringae-japonicae* on lilac (*Syringa vulgaris*) (D, E, F). Image **A** and **D** shows typical white to greyish discoloration of the foliage of the two hosts due to powdery mildew infection. The yellow/brown lesions on the horse chestnut leaves were caused by *Guignardia aesculi*, also a new addition to our fungal flora (Talgø and Stensvand 2008). **B** and **E** are close up images of mycelium and fruiting bodies (chasmothecia) on the upper leaf surface (see sizes of chasmothecia in **Table 2**), and **C** and **F** are microscope images of chasmothecia with asci and ascospores. Akershus County, August 2006. Photos: Venche Talgø.

molecular methods, two groups of powdery mildew have been described on lilac, the S and the K-type. These two

Fig. 3 *Erysiphe azaleae* on rhododendron (*Rhododendron* 'Magnifica') (A) and *Rhododendron* (*Azalea*) *molle* × *sinense* (B, C). Bergen (Hordaland County) 2006. In 2010, chasmothecia (**B**) were found on the plant in **A**. Photos: Venche Talgø.

groups could not be assigned to the two previously described species. The K-type seems to have been introduced in Europe from East Asia in the 1900s (Seko *et al.* 2008). The ITS sequence of the ribosomal DNA (rDNA) of the Norwegian specimens were not determined, but they produced abundant chasmothecia, typical for the K-type.

In September 2010, chasmothecia from *E. azaleae* (U. Braun) U. Braun & S. Takam. (syn. *M. azaleae* U. Braun) were found for the first time in Norway on the lower side of rhododendron leaves (*Rhododendron* 'Magnifica') in Bergen, Hordaland County (**Fig. 3**). Powdery mildew has become an increasing problem on rhododendron in Norway after it was first found on the cultivar 'Scarlet Wonder' in Bergen in 1993 (recorded as *Oidium* sp.). A limited survey in 2006 (Talgø *et al.* 2008), revealed powdery mildew on *R.* 'Rosata', *R.* 'Radiant', *R.* 'Irene Koster', *R.* 'Azaleoides', *R.* 'Fragrans', *R.* 'Glory Litleworth', *R.* 'Govenianum', *R.* 'Valley Sunrise', and *R. mekongense* 'Doshong La' in Bergen, and on *R. smirnowii*, *R.* 'Koster's Brilliant Red', *R.* 'Koster's Brilliant Laks', *R.* 'Hellikki', and *R. luteum* in Ås (Akershus county). Powdery mildew on rhododendrons has been widely reported, and the teleomorph stage (chasmothecia) has been found in many countries, including USA (Byter *et al.* 2000; Jones and Benson 2001).

Fig. 4 shows signs and symptoms caused by six other commonly appearing *Erysiphe* spp.; *E. adunca* var. *adunca* (Wallr.) Fr. (syn. *U. adunca* (Wallr.) Lév.), *E. aquilegiae* var. *ranunculi* (Grev.) R.Y. Zheng & G.Q. Chen (syn. *Erysiphe ranunculi* Grev.), *E. friesii* (Lév.) U. Braun & S. Takam. (syn. *M. friesii* Lév.), *E. lonicerae* DC. (syn. *M. lonicera* (DC.) G. Winter), *E. palczewskii* (Jacz.) U. Braun & S. Takam. (syn. *M. palczewskii* Jacz.), and *E. vanbruntiana* var. *sambuci-racemosae* (U. Braun) U. Braun & S. Takam. (syn. *M. vanbruntiana* var. *sambuci-racemosae* U. Braun.). The present situation and recorded history of these six *Erysiphe* species are as follows;

E. adunca var. *adunca* infects several species of poplar (*Populus* spp.) and willow (*Salix* spp.) in Norway, but was first identified on *S. caprea* L. in 1898 in Oslo. It is now widely distributed north to Sør-Trøndelag County. A dense, white mat of mycelium and conidia covers both sides of the leaves.

E. aquilegiae var. *ranunculi* was first recorded in Aust-Agder County in 1980 on clematis (*Clematis* × *jackmanii*), and has since been collected in the counties of Oslo, Akershus and Sogn og Fjordane. Both leaves and petals become infected, which reduces the ornamental value dramatically. On species in the genera *Aconitum* L. (aconitums), *Delphinium* L. (larkspur) and *Ranunculus* L. (buttercups and others) the pathogen has been recorded for more than 60

Fig. 4 *Erysiphe* spp. on several ornamental shrubs and trees. *E. adunca* var. *adunca* on willow (*Salix caprea*) (**A**), *E. aquilegiae* var. *ranunculi* on clematis (*Clematis* sp.) (**B**), *E. friesii* on buckthorn (*Rhamnus catharticus*) (**C**), *E. lonicerae* on honeysuckle (*Lonicera* sp.) (**D**), *E. palczewskii* on Siberian pea shrub (*Caragana arborescens*) (**E**), and *E. vanbruntiana* var. *sambuci-racemosae* on elderberry (*Sambucus racemosa*) (**F**). Akershus County 2006. Photos: Venche Talgø

Fig. 5 *Erysiphe berberidis* on barberry (*Berberis vulgaris*) (A, B) and on hollyleaved barberry (*Mahonia aquifolium*) (C, D). Akershus County 2006. Photos: Venche Talgø

years, thus, it appears to be common in Norway. Cunnington *et al.* (2004) failed to separate *E. aquilegiae* var. *aquilegiae* from *E. aquilegiae* var. *ranunculi* based on ITS sequence variation in the rDNA region, but they identified a third host specialized taxon on larkspur.

E. friesii is common on buckthorn (*Rhamnus catharticus* L.), but the plant species is not widely distributed and grows naturally only in south eastern Norway. Since 1941, it has been prohibited to plant buckthorn, because it is host for crown rust (*Puccinia coronata* Corda) on oat (*Avena sativa* L.) (Jørstad 1945).

E. lonicerae has been known in Norway since 1883, and collected on honeysuckle species (*Lonicera* L.) north to Tromsø in Troms County. The mycelium is present on both leaf surfaces, but generally rather thin layered and easily overlooked.

E. palczewskii, reported by Gjærum (1991) on Siberian pea shrub (*Caragana arborescens* Lam.), is especially problematic. It is an introduced Asian (Eastern Siberia) powdery mildew. In Europe, it was first found in Oslo, Norway (Gjærum 1991), but during the last 20 years it has been recorded in several European countries (Gelyuta 1998). Siberian pea shrub was commonly used both as a solitary plant and in hedgerows in Norway, but due to heavy attacks every year by *E. palczewskii*, it is no longer recommended as an ornamental plant.

E. vanbruntiana var. s*ambuci-racemosae* was first detected on elderberry (*Sambucus* L.) in Buskerud County in 1985, and has since been collected as far north as Nord-Trøndelag County.

Fig. 5 presents symptoms of *E. berberidis* Y.S. Paul & J.N. Kapoor. It has commonly been found in south eastern Norway on barberry (*Berberis vulgaris*) and on hollyleaved barberry (*Mahonia aquifolium* Nutt.). In general, the pathogen produces a thin mycelium with scattered chasmothecia on both leaf surfaces on barberry. On hollyleaved barberry the mycelial mat is denser, and the leaves become discoloured.

No images are included here from the remaining six *Erysiphe*-species that have been found on woody ornamentals in Norway, but they are all presented in alphabetic order in the text below.

E. alphitoides (Griffon & Maubl.) U. Braun & S. Takam. (syn. *M. alphitoides* Griffon & Maubl.) was first recorded on pedunculate oak (*Quercus robur* L.) in Norway in 1911 in Vest-Agder County (Jørstad 1945). The pathogen is common throughout the area of natural distribution of oak, that is in the coastal areas from Østfold County to Møre og Romsdal County. In 1972, *E. hypophylla* (Nevod.) U. Braun & Cunningt. (syn. *M. hypophylla* Nevod.), a second powdery mildew on oak (*Q. robur* and *Q. petraea*) was detected in Oslo (Roll-Hansen 1995). This new species had spread rapidly in Europe (Junell 1967). The chasmothecia of *E. hypophylla* are similar to those of *E. alphitoides*, but the two species can be distinguished by their symptoms, as well as the shape and size of the conidia. While the conidia of *E. hypophylla* are cylindrical and more than 2.5 times as long as they are broad, the conidia of *E. alphitoides* are ellipsoidal and only about 1.5 times as longer than broad (Junell 1967). Takamatsu *et al.* (2006) identified a powdery mildew on a peony species (*Paeonia* L.) as *E. hypophylla* based on morphological observations. By determination of ITS sequences of the rDNA region from the powdery mildew specimens from peony and *E. hypophylla* from oak, the authors confirmed the identity of the peony fungus, but the sequences were also identical to sequences from *E. alphitoides* on oak. Later, Takamatsu *et al.* (2007) confirmed that chasmothecia of *E. hypophylla* and *E. alphitoides* are morphologically very similar.

E. divaricata (Wallr.) Schltdl. is common in areas in Norway where the host alder buckthorn (*Frangula alnus* Mill.) grows and has been commonly found since 1950. Young shoots are sometimes deformed by the fungus.

E. ornata var. *europaea* (U. Braun) U. Braun & S. Takam. (syn. *M. betulae* Magnus) on birch species (*Betula* L.) was first collected in Larvik, Vestfold County in 1879 (Jørstad 1945).

E. penicillata (Wallr.) Link (syn. *M. penicillata* (Wallr.) Lév.) was first reported on mountain alder (*Alnus incana* L.) by Jørstad (1945). The mycelium develops mainly on lower leaf surfaces.

E. polonica Siemaszko (syn. *M. polonica* Siemaszko, *Oidium hortensiae* Jørst.) was first found on hydrangea (*Hydrangea opuloides* Lam.) in Akershus County during

Fig. 6 *Phyllactinia guttata* on common ash (*Fraxinus excelsior* 'Uppsala') (A, B) and hazel (*Corylus avellana*) (C, D). *P. guttata* produces fruting bodies (chasmothecia) on the abaxial surface of the leaves (hypophyllous). Akershus County 2006. Photos: Venche Talgø

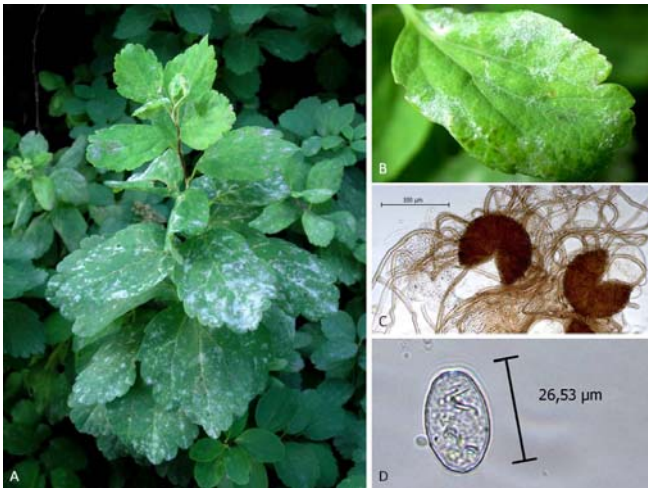

Fig. 7 *Podosphaera spiraeae* on white spirea (*Spiraea betulifolia*) (A, B), its chasmothecia (C) and a conidium (D). Oslo 2010. Photos: Ole Billing Hansen (**A**), Venche Talgø (**B, C**), and Aruppillai Suthaparan (**D**)

1924 (Jørstad 1945). This powdery mildew species is common on greenhouse grown hydrangea and occurs occasionally on garden grown hydrangea.

E. viburnicola U. Braun & S. Takam. (syn. *U. viburni* Y. Nomura, Tanda & U. Braun) on a viburnum species (*Viburnum* L.) was first detected in Rogaland County in 1948, and has later been found in most counties in southern Norway north to Sogn og Fjordane. This powdery mildew is easily overlooked as it sporulates on the lower surface of leaves. Infected leaves turn red and drop off early.

Phyllactinia

Phyllactinia guttata (Wallr.) Lév. has been found on eight host species in Norway (**Table 1**). Two of them are represented in **Fig. 6**; common ash (*Fraxinus excelsior* L.) and hazel (*Corylus avellana* L.). The fungus was also found on the cultivars *C. avellana* 'Contorta' and *C. avellana* 'Aurea' in Akershus county in 2006 (Talgø *et al.* 2008). Since the hypha and fruiting bodies of *P. guttata* are concentrated on the lower surface of the leaves, it does not give as obvious symptoms as many other powdery mildews. The distribution of *P. guttata* in Norway is north to Korgen in Nordland County (Jørstad 1945).

Podosphaera

Totally seven *Podosphaera* spp. have been found on 10 woody plant species in Norway (**Table 1**).

Recently, *P. spiraeae* (Sawada) U. Braun & S. Takam. (syn. *Sphaerotheca spiraeae* Sawada) was identified on white spirea (*Spiraea betulifolia* Pall.) (**Fig. 7**). It was first discovered at a location in Oslo in 2008, but chasmothecia (**Table 2**) were not found until 2010, on samples from the same location. The disease has so far not been recorded in any other locations in Norway. Fibrosin bodies were detected in conidia treated with KOH (**Fig. 7D)**. This is a typical characteristic for the tribe Cystotheceae, which include three genera; *Podosphaera*, *Sawadaea* and *Cystotheca*. The two latter genera are represented on trees, but not on shrubs.

Also on Japanese spirea (*S. japonica* L.), a powdery mildew has been observed in Norway during the last two decades (**Fig. 8**). In our herbarium, we have a specimen from 1991 of Japanese spirea with powdery mildew, recorded as *Oidium* sp. In 2003, an *Oidium* sp. was also found on Japanese spirea in Italy (Garibaldi *et al.* 2004). No chasmothecia has so far been detected on Japanese spirea in Norway, but as seen from **Fig. 8D**, fibrosin bodies were present in the conidia, thus, indicating it may belong to *Podosphaera* sp.

Fig. 9 shows *P. aphanis* (Wallr.) U. Braun & S. Takam. on potentilla (*Dasiphora fruticosa* L.), *P. clandestina* var. *clandestina* (Wallr.) Lév. on hawthorn (*Crataegus laevigata* (Poir.) DC. and on a serviceberry species (*Amelanchier* Medik.), *P. mors-uvae* (Schwein.) U. Braun & S. Takam. on flowering currant (*Ribes sanguineum* Pursh), and *P. pannosa* (Wallr.) de Bary on roses (*Rosa* L.). Furthermore, not presented by images, *P. clandestina* var. *aucupariae* (Erikss.) U. Braun (syn. *Podosphaera aucupariae* Erikss.) and *P. leucotricha* (Ellis & Everh.) E.S. Salmon were found on *Sorbus aucuparia* L. and *Malus baccata* L., respectively. Of these powdery mildews, *P. pannosa* on roses is most problematic, especially in greenhouse production. Leaves, sepals, fruits and stems become infected, and the mycelium forms a dense, white or greyish felt. The rose powdery mildew was first described in 1819, but the disease was present long before (Horst 1989). In Norway, *P. pannosa* has been known since 1881 (Jørstad 1945). It is common on roses and has been collected as far north as Troms County. Powdery mildew has become increasingly problematic on serviceberry. During the last few years hedgerows from serviceberries rarely appear healthy towards the autumn. The American gooseberry mildew *P. mors-uvae* was probably brought to Europe from North-America late in the 19th century. Following the first identification in 1900 of the pathogen in Ireland, the dispersal in Europe was rapid. It

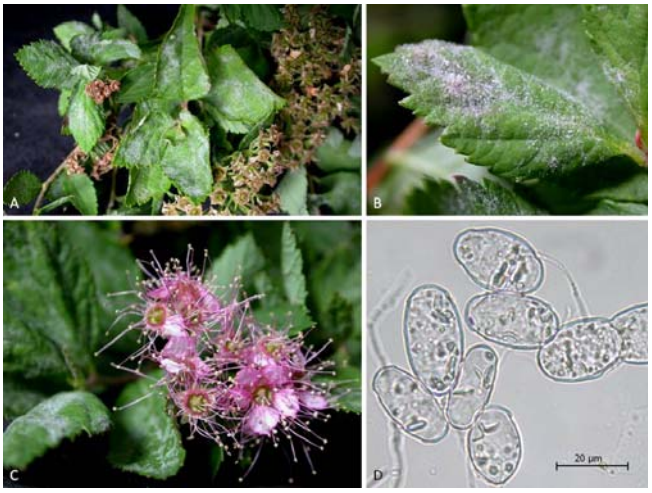

Fig. 8 *Podosphaera* sp. on Japanease spirea (*Spiraea japonica*) (A, B, C) and its conidia (D). Akershus County 2010. Photos: Venche Talgø (**A, B, C**) and Aruppillai Suthaparan (**D**).

Fig. 9 *Podosphaera* spp. on ornamental bushes. *P. aphanis* on potentilla (*Dasi-phora fruticosa*) (**A**), *P. clandestina* on hawthorn (*Crataegus laevigata*) (**B**) and *Amelanchier* sp. (**C, D**), *P. mors-uvae* on flowering currant (*Ribes sanguineum*) (**E**), and *P. pannosa* on rose (*Rosa* sp.) (**F**). Akershus County 2006 (**A, B, E, F**) and 2010 (**C, D**). Photos: Venche Talgø

Fig. 10 *Sawadaea* spp. on maples. *S. tulasnei* on Norway maple (*Acer platanoides*) (**A**) and *S. bicornis* on sycamore maple (*A. pseudoplatanus*) (**B,C**), tatarian maple (*Acer tataricum* ssp. *ginnala*) (**D**), and hedge maple (*Acer campestre* 'Red Shine') (**E**). Akershus County 2006. Photos: Venche Talgø

was observed in Sweden in 1901 (Junell 1967). In Norway, it was first detected in 1904 in Telemark County on gooseberries (*R. uva-crispa* L.), and later on blackcurrant (*R. nigrum* L.) (Nord-Trøndelag County 1908), redcurrant (*R. cultorum* L.) (Vestfold County 1909), Alpine currant (*R. alpinum* L.) (Buskerud County 1922), and stink currant (*R. bracteosum* Dougl. ex Hook.) (Rogaland County 1925) (Jørstad 1945). Young shoots, leaves, flowers and fruits get infected and distorted by the pathogen.

Sawadaea

Two *Sawadaea*-species have been found in Norway on four maple species (**Table 1**, **Fig. 10**).

S. tulasnei (Fuckel) Homma (syn. *Uncinula tulasnei* Fuckel) was first found on Norway maple (*Acer platanoides* L.) in Oslo in 1840, and *S. bicornis* (Fuckel) Homma (syn. *Uncinula bicornis* (Wallr.) Lév.) was first detected on sycamore maple (*A. pseudoplatanus* L.) in Kristiansand in Vest-Agder County in 1920 (Jørstad 1945). White spots coalesce into mats of white, dense mycelium, which makes the leaves appear more or less white during the growing season. In 2006, *S. bicornis* was found on two new maple hosts in Akershus County; tatarian maple (*A. tataricum* L. ssp. *ginnala* (Maxim.) Wesmael) and hedge maple (*A. campestre* L. 'Red Shine') (**Table 1**). Other cultivars of hedge maple, standing adjacent to the diseased ones, had no symptoms; *A. c.* 'Uppsala', *A. c.* 'Elsrijk', and *A. c.* 'Queen Elizabeth'. Tatarian maple has showed severe symptoms every year since 2006, and they appear early in the growing season. The susceptibility to powdery mildew makes tatarian maple no longer attractive for use in landscape plantings.

CONCLUDING REMARKS

In Norway, there is an extensive import of woody ornamentals. The new powdery mildews on horse chestnut, lilac and white spirea have most likely entered the country on imported plant material. With a continuous free movement of planting material across borders, in addition to predicted climate changes, we expect several more introductions of powdery mildews into the country, and they will follow their hosts to higher altitudes and further north.

ACKNOWLEDGEMENTS

This work was partly financed through the project "Planter for norsk klima" [Plants for Norwegian climate]. We want to acknowledge the arboretum in Bergen for the collaboration on powdery mildew on rhododendrons. Furthermore, we want to acknowledge Prof. Ole Billing Hansen for providing samples and photo of powdery mildew on white spirea, and Mr. Jafar Razzaghian at Bioforsk for valuable technical assistance.

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