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Powdery mildew on *Rhododendron* caused by *Erysiphe azaleae* in Latvia

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In 2002 a fungus causing powdery mildew on *Rhododendron* in Latvia was discovered and identified as *Erysiphe azaleae*. The powdery mildew has since then been observed on leaves and seed pods of deciduous azaleas as well as evergreen rhododendrons, although the disease is more common on taxa of deciduous azaleas. Development of mature chasmothecia has been noticed at every location where the disease was detected. The distribution area of *E. azaleae* is expanding gradually from the south-west and central regions to the north and east parts of Latvia. It has been suggested, that climate change and large-scale plant import favour this process. To our knowledge, Latvia is so far the farthest north-easternmost site where *E. azaleae* has been detected.

Key words: *Erysiphe azaleae*, *Rhododendron*, Latvia.

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Článek pojednává o houbě *Erysiphe azaleae*, která v roce 2002 začala působit chorobu rododendronů v Lotyšsku. Jsou popsány symptomy napadení, hostitelé a šíření v Lotyšsku, které je nejseverovýchodnějším místem výskytu *E. azaleae*.

INTRODUCTION

Rhododendrons (*Rhododendron*) are popular woody ornamental plants nowadays. In Latvia rhododendron introduction began in the first part of the 19th century, but considerable introduction, breeding and propagation of species of this genus has been carried out since the 1950s (Kondratovičs 2005) and especially during the last twenty years rhododendrons have been widely used to decorate private and public gardens.

In Europe powdery mildew on rhododendrons has become one of the most serious diseases only during the last few decades, when the anamorphic state was detected in 1981 on outdoor rhododendrons for the first time in the United Kingdom (Boesewinkel 1981). However, the conidial form on rhododendrons was found in

Switzerland in 1944 (Bolay 2001). The teleomorph of the causal agent of the disease was detected in Germany only recently, in 1997 (Braun 1997). Since the first find of teleomorphic form, many reports have been published from different areas of Europe: England (Ing 2000), Italy (Garibaldi et al. 2002), Poland (Piątek 2003), Ukraine (Heluta 2004), the Czech Republic (Lebeda et al. 2006), Slovakia (Bacigálová & Marková 2006), and Norway (Talgø et al. 2011). In Latvia, symptoms of powdery mildew on rhododendrons were noticed for the first time in 2002. Of the countries bordering Latvia rhododendron mildew has so far been found in Lithuania (Grigaliūnaitė & Pribušauskaitė 2006), located more to the south.

The causal agent of powdery mildew in Europe has been identified mainly as the fungus *Erysiphe azaleae* (U. Braun) U. Braun & S. Takam. [formerly *Microsphaera azaleae* U. Braun (Braun 2000)], which most probably originated in North America (Braun 1982); however, in one case in Belgium a new species, *Erysiphe digitata* A.J. Inman & U. Braun, was described (Inman et al. 2000).

The expansion of the distribution area of *E. azaleae* on *Rhododendron* is one apt example of invasions of *Erysiphe* species, which are also known for *E. flexuosa* on *Aesculus* spp., *E. elevata* on *Catalpa bignonioides*, and *E. symphoricarpi* on *Symphoricarpos albus*, all observed in Europe for the first time during the last decades (Kiss 2005). Likewise, in Latvia powdery mildew on strawberries, caused by *Podosphaera* under field conditions, was detected for the first time in 2007 (Jarmoliča & Bankina 2009). It is presumed that the distribution area of various *Erysiphales* species has rapidly expanded in Europe (Glawe 2008).

The aim of the present study was to identify and characterise the causal agent of powdery mildew on rhododendrons and work out its distribution area in Latvia.

MATERIAL AND METHODS

Leaves of rhododendrons with visual symptoms of powdery mildew were collected in the Botanical Garden of the University of Latvia in Riga as well as in the Babīte Experimental and Breeding Nursery of Rhododendrons (University of Latvia) located near Riga on 20 Aug. 2009. The plant taxa examined were *Rhododendron luteum*, *R. japonicum*, *Rhododendron* hybrids cv. Madame Debene, cv. Pasaciņa, cv. Purple Splendour, cv. Bohumil Kavka and cv. Vizma. Morphological features (conidia, chasmothecium, etc.) of the causal agent of rhododendron mildew were investigated under a light microscope, observation and description were carried out according to the instructions written by Heffer (Heffer et al. 2006).

Tab. 1. Rhododendron collections inspected for the presence of powdery mildew in Latvia in the period from 2009 to 2011.

Region of Latvia	Inspected collections		
	name	**coordinates**	**date**
Central region	Several public parks and gardens in Riga (e.g. Botanical Garden of the University of Latvia, Opera Garden)	56°57'0" N, 24°3'32" E; 56°57'2" N, 24°6'47" E	20 Aug 2009; 15 Sep 2010; 10 Oct 2011
	Several public parks and gardens in Jūrmala (e.g. Bulduri Horticulture School garden, naturalized *Rhododendron* planting at Dubulti)	56°58'23" N, 23°51'0" E; 56°57'10" N, 23°46'10" E	25 Aug 2009
	Babīte Experimental and Breeding Nursery of Rhododendrons of the University of Latvia	56°57'47" N, 23°57'2" E	10 Aug 2009; 20 Aug 2010; 11 Oct 1011
	National Botanical Garden of Latvia at Salaspils	56°51'55" N, 24°21'33" E	26 Aug 2009; 12 Oct 2011
	Baltezers tree nursery	57°3'27" N, 24°18'35" E	25 Aug 2009
	Lāčupīte Dendrarium	57°3'6.80" N, 23°20'2.15" E	25 Aug 2009
Southern and western regions	Green area near Ventspils University College	57°23'3" N, 21°32'42" E	24 Sep 2010
	Rucava Arboretum	56°9'21" N, 21°9'11" E	23 Sep 2010; 17 Oct 2011
Eastern region	Kalsnava Arboretum	56°41'1" N, 25°56'47" E	14 Oct 2011
	Sakstagals tree nursery	56°32'50" N, 27°6'46" E	14 Oct 2011
Northern region	Lēdurga Dendrological Park	57°19'3" N, 24°45'27" E	01 Oct 2010; 11 Oct 2012
	Private collection near Vilķene	57°33'34" N, 24°35'27" E	01 Oct 2010; 11 Oct 2012

In period 2009–2011 several collections of rhododendrons were inspected for the presence of powdery mildew in different regions of Latvia (Tab. 1). Disease severity was evaluated on a 0–5 point scale, whereby 0 means that no powdery mildew was observed; 1 = 1–10 %, 2 = 11–25 %, 3 = 26–50 %, 4 = 51–75 %, and 5 = 76–100 % of the leaf surface and/or seed pods infected with powdery mildew. Four specimens (RIG 8713–8716) of infected leaves from deciduous and evergreen rhododendrons were deposited in the herbarium of the Faculty of Biology, University of Latvia.

RESULTS AND DISCUSSION

Erysiphe azaleae (U. Braun) U. Braun & S. Takam.

Description

Anamorph (Fig. 1). The fungus formed white epiphytic mycelium with abundant sporulation. Hyphae hyaline, mostly branching at right angles (Fig. 1A). Appressoria well developed, multilobed to moderately lobed, often paired (Fig. 1D).

Conidiophores cylindrical, unbranched, consisting of a kinked basal cell and one to three cylindrical cells (Fig. 1B). Conidia single, ellipsoid-cylindrical in shape, symmetric at both ends, 36 × 17 (26–49 × 12–21) µm (Fig. 1C).

Based on the anamorphic morphological features, the fungus was identified as a species of *Oidium* subg. *Pseudoidium*, most probably *Oidium ericinum* (Inman et al. 2000).

Teleomorph (Fig. 2). Chasmothecia dark brown, subglobose, 90–150 (on average 118) µm in diameter with more than 20 hyaline appendages. Appendages equatorially arranged and dichotomously branched, 76–159 (on average 115) µm in length (Figs. 2A, 4B). Chasmothecia contained several asci with short stalks (Fig. 2C), 52.6–67.3 × 33.3–41.9 (on average 58.7 × 37.4) µm. Ascospores (Fig. 2B) ellipsoid, 20.2–25.3 × 10.4–14.6 (on average 22.1 × 12.6) µm in diameter. The described features place the fungus into the genus *Erysiphe*.

Symptoms

According to the asexual and sexual morphology, the holomorph of the pathogen was identified as *Erysiphe azaleae* (U. Braun) U. Braun & S. Takam., a fungus recognized as the causal agent of powdery mildew on rhododendrons in a range of European countries (Inman et al. 2000, Bacigálová & Marková 2006, Talgø et al. 2011). In Latvia powdery mildew has been found on numerous species and cultivars of deciduous azaleas (Tab. 2). The first symptoms of the disease were usually noticed in the middle of June. The fungus affected both leaf surfaces as well as seed pods (Fig. 3). Symptoms of the disease and its severity differed depending on variety (Tab. 2). White mycelium developed on the upper and lower surface of leaves of *R. luteum* and cv. Madame Debene, while purple blotches, as the first symptoms of infection, and patches of mycelium expanded on the upper and lower surface of leaves of cv. Pasaciņa (Fig. 3B). On plants with a high disease severity, formation of abundant mycelium was often accompanied by production of a large number of chasmothecia.

In addition, the mycoparasite *Ampelomyces quisqualis* Ces. was identified on the leaves of *R. luteum* heavily infected by *E. azaleae* (collected in August 2009 in the Botanical Garden of the University of Latvia). However, this hyperparasite did not notably inhibit infestation by powdery mildew. The presence of *A. quisqualis* on the leaves of deciduous azaleas exhibiting symptoms of powdery mildew has been observed in the Czech Republic as well (Bacigálová & Marková 2006).

Tab. 2. Severity of powdery mildew on deciduous azaleas observed in several collections during October, 2011: Babīte Experimental and Breeding Nursery of Rhododendrons of the University of Latvia near Riga (Babīte), National Botanical Garden of Latvia at Salaspils (Salaspils); Rucava Arboretum (Rucava), Kalsnava Arboretum (Kalsnava). Disease severity was evaluated on a 0–5 point scale: 0 = no powdery mildew observed; 1 = 1–10 %, 2 = 11–25 %, 3 = 26–50 %, 4 = 51–75 %, and 5 = 76–100 % of the leaf area infected by powdery mildew. ▶

***Rhododendron* species/cultivars**	**Severity of powdery mildew**			
	Babīte	**Salaspils**	**Rucava**	**Kalsnava**
R. albrechtii	2	–*	–	1
R. arborescens	0	1	–	–
R. bakeri = *R. cimberlandense*	2	0	–	–
R. calendulaceum	–	0	2	2
R. calendulaceum var. *aurantiacum*	–	0	1	–
R. calendulaceum var. *aurantium*	2	–	–	–
R. calendulaceum var. *croceum*	3	–	–	–
R. canescens	–	0	–	–
R. canadense	1	–	–	0
R. canadense var. *album*	1	–	–	0
R. japonicum	4	4	4	4
R. luteum	5	5	3	5
R. nipponicum	–	–	1	–
R. occidentale	3	1	–	–
R. periclymenoides = *R. nudiflorum*	1	2	2	2
R. prinophyllum = *R. roseum*	1	2	–	2
R. schlippenbachii	0	–	–	–
R. speciosum = *R. flammeum*	–	0	–	–
R. vaseyi	1	0	2	–
R. viscosum	0	2	2	1
Ance**	0	0	–	–
Austra**	4	4	–	–
Babītes Anita**	2	1	–	–
Babītes Indra**	2	2	–	–
Babītes Inga**	3	2	–	–
Babītes Laura**	4	4	–	–
Francisa**	3	3	–	–
Gibraltar	4	–	–	–
Golden Sunset	5	–	–	–
Hotspur Red	3	–	–	–
Madame Debene**	5	4	–	–
Mazais Jefiņš**	0	0	–	–
Pasaciņa**	4	5	–	–
Polārzvaigzne**	3	3	–	–
Rīgas Rododendrs**	0	0	–	–
Rubīns**	4	4	–	–
Silver Slipper	5	–	–	5
Skaidrīte**	4	4	–	–
Spek's Brilliant	–	–	4	5
Uguns**	3	3	–	–

* no observations

** cultivars bred in Latvia by R. Kondratovičs

Tab. 3. Severity of powdery mildew on evergreen rhododendrons observed in Babīte Experimental and Breeding Nursery of Rhododendrons of the University of Latvia near Riga during 2009. Disease severity was evaluated on a 0–5 point scale: 0 = no powdery mildew observed; 1 = 1–10 %, 2 = 11–25 %, 3 = 26–50 %, 4 = 51–75 %, and 5 = 76–100 % of the surface of leaf area and/or seed pods infected by powdery mildew.

***Rhododendron* species/cultivars**	**Severity of powdery mildew**	
	on leaves	**on seed pods**
R. brachycarpum	0	1
R. catawbiense	0	1
R. maximum	0	1
R. smirnowii	0	2
Academia Scientaria**	0	1
Babītes Sarkanais**	2	–*
Bohumil Kavka	2	–
Catawbiense Grandiflorum	0	1
Cunningham's White	0	1
Dace**	0	2
Egons**	1	–
Emeritus**	2	–
Emīls**	0	1
Henry's Red	1	–
Irina**	0	1
Kalinka	0	1
Kārlis**	0	1
Lita**	0	1
Nova Zembla	0	1
Purple Splendour	3	–
Sprīdītis**	0	1
Vizma**	2	–
Yellow May (seedlings)	0	2

* no observations
** cultivars bred by R. Kondratovičs (Latvia).

E. azaleae affected both leaves and seed pods of evergreen rhododendrons. Chasmothecia formation was detected on both organs (Tab. 3). It was noticed that the disease symptoms more often developed only on seed pods, sometimes only on remaining styles of seed pods of various evergreen rhododendron taxa. This observation is in agreement with the results obtained by Lebeda et al. (2007) in the Czech Republic. In this study as well as in the present one powdery mildew was found on seed pods of *R. catawbiense* and *R. smirnowii*. To date, powdery mildew (Fig. 4) was detected on leaves in Latvia only in the Babīte Experimental and Breeding Nursery of Rhododendrons (Tab. 3), where a rhododendron mono-

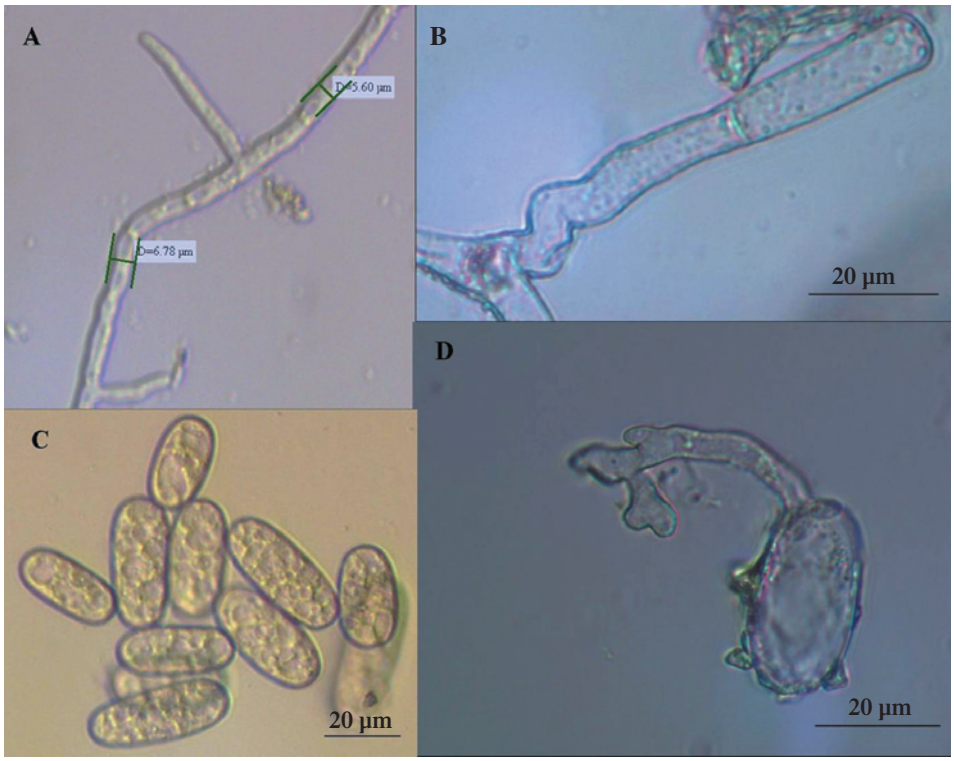

Fig. 1. Anamorphic stage of *Erysiphe azaleae* on *R. luteum* collected in the Botanical Garden of the University of Latvia: **A** – hyphae; **B** – conidiophore; **C** – conidia; **D** – germinated conidium with lobed appressoria. Photos by B. Bankina.

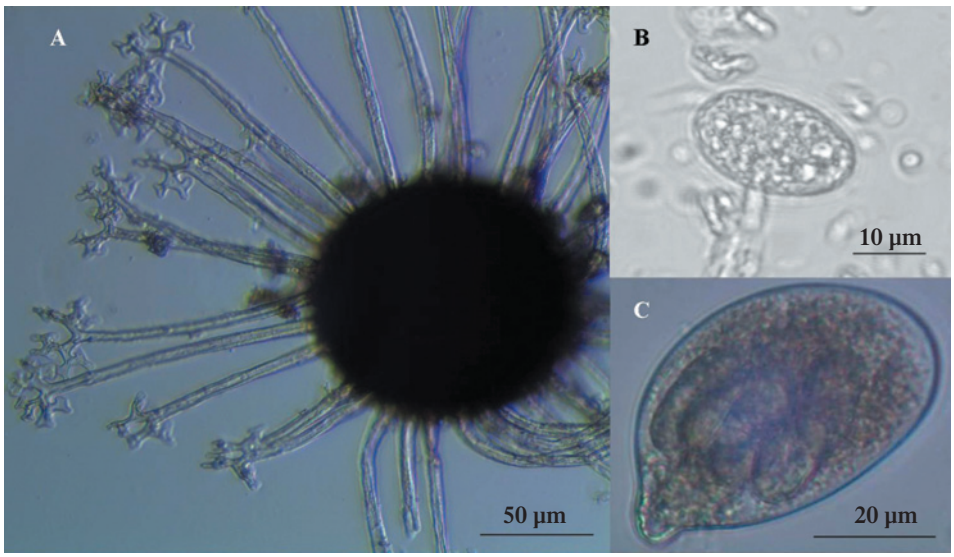

Fig. 2. Teleomorphic stage of *Erysiphe azaleae* on *R. japonicum* collected in the Botanical Garden of the University of Latvia: **A** – chasmothecium; **B** – ascospore; **C** – ascus. Photos by B. Bankina.

Fig. 3. Powdery mildew on deciduous azaleas observed in the Botanical Garden of the University of Latvia: **A** – contaminated shrub of *R. japonicum*; **B** – purple spots on leaves of cv. Pasaciņa with symptoms of powdery mildew; **C** – symptoms of powdery mildew on seed pods of a rhododendron hybrid. Photos by I. Apine.

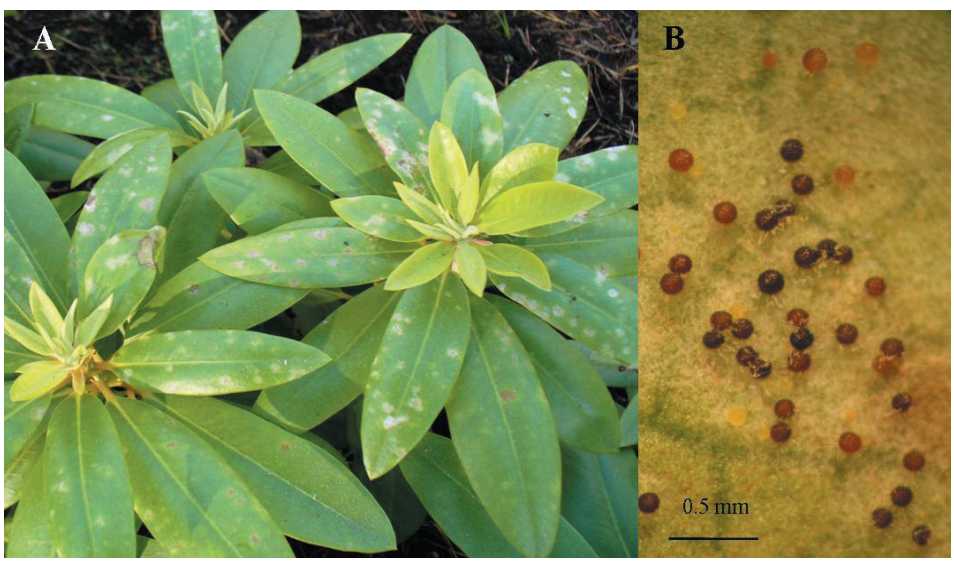

Fig. 4. Powdery mildew on evergreen rhododendron cv. Vizma found in the Babīte Experimental and Breeding Nursery of Rhododendrons of the University of Latvia: **A** – contaminated shrub; **B** – chasmothecia in different stages of development on lower side of leaf. Photos by I. Apine.

culture covers about 10 ha. Furthermore, the indications of the disease were not apparent every year. Powdery mildew symptoms on leaves usually developed later in the growing season, in August, and the severity of the disease was noticeably lower than for deciduous azaleas (Tab. 3).

Occurrence on rhododendrons

Powdery mildew has been detected on evergreen rhododendrons and deciduous azaleas in Germany (Inman et al. 2000), Switzerland (Bolay 2001), and Norway (Talgø et al. 2011), while reports from Italy (Garibaldi et al. 2002), Ukraine (Heluta et al. 2004), Slovakia (Bacigálová & Marková 2006), Lithuania (Grigaliūnaitė & Pribušauskaitė 2006), and Poland (Piątek 2003, Werner & Karolewski 2010) only make notice of mildew on deciduous azaleas. Thus, the results of the present and these previous studies indicate that deciduous azaleas are more susceptible to *E. azaleae* than evergreen rhododendrons.

In Latvia symptoms of powdery mildew have hitherto not been observed on so-called evergreen azaleas (e.g. *R. kiusianum*, *R. kaempferi*, *R. obtusum*, *R. poukhanense*, and their hybrids), which are also mentioned as susceptible to *E. azaleae* (Inman et al. 2000, Bertetti et al. 2005). The need to examine native plant species such as *R. tomentosum* (formerly known as *Ledum palustre*) in Ukraine has been suggested earlier (Heluta et al. 2004), since *E. azaleae* is found on *R. neoglandulosum* (former *Ledum glandulosum*) in North America (Farr et al. 1989). This may be an important observation, as *R. tomentosum* is a species native to Latvia. However, the pathogen has not been observed on this plant yet, even in places where numerous *Rhododendron* species, infected by *E. azaleae*, are growing with *R. tomentosum*.

Distribution in Latvia

A gradual increase in distribution of *E. azaleae* can be observed in Latvia today. In 2002 the symptoms of powdery mildew on rhododendrons were observed for the first time in the Babīte Experimental and Breeding Nursery of Rhododendrons (University of Latvia), located near Riga (Tab. 1). Since 2006 the symptoms of this disease have been observed on numerous varieties of deciduous azaleas in the area around Riga, in the central region of the country – in places with the largest concentration of already existing rhododendron plantings and recently imported rhododendrons. Until 2010, *E. azaleae* had been observed in the southern, western and central parts of the country (Tab. 1), where the climate is milder than in the northern and eastern areas. In the last few years (2011–2012) the pathogen was detected for the first time in the northern (Lēdurga Dendrological Park) and eastern part (Kalsnava Arboretum) of Latvia as well. However, in a private rhodo-

dendron collection near Viļķene (northern part) and in the Sakstagals tree nursery (eastern part) *E. azaleae* has not been observed yet (Tab. 1). This could indicate that the climate conditions are gradually becoming more favourable for the pathogen in those cooler regions. In every location where powdery mildew was identified, development of mature chasmothecia was observed, which could promote successful survival and further distribution of the fungus. To our knowledge, Latvia is so far the north-easternmost site where *E. azaleae* has been detected.

Gravity of *E. azaleae*

Kiss (2005) noticed that *E. azaleae*, similar to other causal agents of powdery mildews such as *E. kusanoi* and *E. symphoricarpi*, have not spread very rapidly and have not induced any severe epidemics in Europe. However, in Latvia and the nearby regions powdery mildew is the first serious disease detected on *Rhododendron*, especially for deciduous azaleas. The pathogen not only remarkably diminishes the ornamental value of the plants, but also often reduces the vigour of the host plants resulting in important economic loss for growers. We have found that numerous introduced *Rhododendron* taxa and locally bred cultivars (Tab. 2, 3) both tend to show similar susceptibility to powdery mildew. This means that local breeders are challenged to get resistant cultivars in the future.

Expansion of the distribution area of *E. azaleae* and other *Erysiphales* may be supported not only by global climate change (Glawe 2008, Roos et al. 2011), but also by large-scale import of plant material (Talgø et al. 2011). Both of these factors could be relevant in Latvia judging from the expansion pattern of *E. azaleae*. Global climate changes and extensive plant trade may contribute to further dissemination of pathogens to the North as well as adaptation of fungi to new host plants.

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