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# Differentiated reactions of fungi of the order Erysiphales in urban areas: monophagous and polyphagous species

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The aim of the study was to examine sensitivity of monophagous and polyphagous species of the Erysiphales to transport pollution. The infection degree of host plants was used as the assessment criterion. The test material consisted of fungi collected in 25 urban localities in the city of Olsztyn, established in places with high transport pollution concentrations, and 25 localities outside it, free from the influence of automotive exhaust gases, over a long-term period.

Individual species of fungi, regardless of the scope of parasitisation, showed different reactions to pollution: the infection index always decreased in the case of sensitive species in urban conditions. The reactions of monophagous species were clearly specific and orientated at resistance or sensitivity. Polyphagous species reacted less specifically: the same species showed a very high sensitivity on one host and resistance on another. These findings are indicative of a greater eco-physiological stability of the "host-pathogen" system with the participation of monophagous species than that with the participation of polyphagous species.

**Key words:** Erysiphales, monophagous species, polyphagous species, resistance, sensitivity, transport pollution

## INTRODUCTION

Phytopathological literature argues that numerous pathogenic fungi that are an integral part of the biosphere are not indifferent to the changes of biocoenotic factors, and their reactions to the disturbances occurring in the natural environment may vary greatly (Mułenko 1998). The present study is part of a research project investigating possible bioindicator potential and life strategies of the Erysiphales in the conditions of varied anthropopressure, especially urban areas. Most Polish studies on this exceptionally flexible group of obligate parasites focus on agricultural areas, and only few publications deal with their ecology (Majewski 1971;

Kućmierz 1976; Mułenko 1998). This is also supported by the epidemiological aspect connected with species resources of phytopathogens in natural reservoirs, more or less altered, where phytopathogens are exposed to often random environmental factors that trigger off various reactions and show pathogenecity features that may be used in prophylactics and protection planning of cultivated plants.

The aim of the study was to verify and evaluate sensitivity to transport pollution of monophagous and polyphagous species of Erysiphales using the infection degree of host plants (= disease coefficient) as the criterion. The results of long-term observations conducted by the present authors in natural (Dynowska, Fiedorowicz and Kubiak 1999) and anthropologically affected environments (Dynowska 1993, 1994, 1996) were used. The observations show that species within the *Erysiphales* react in different ways to urban pollution and suggest that monophagous species are the most sensitive to air pollution, while polyphagous species are characterised by great resistance (Dynowska and Sucharzewska 2001).

## MATERIAL AND METHODS

A total number of 8 fungal species was studied: 5 monophagous species (*Microsphaera alphitoides* Griff. et. Maubl* on *Quercus robur* L., *M. berberidis* (DC. ex Mérat) Lév.* on *Berberis thunbergii* DC., on *B. vulgaris* L. and *B. koreana* Blaze (L.), *M. palczewskii* Jacz* on *Caragana arborescens* Lam., *M. vanbruntiana* Gerard* on *Sambucus racemosa* L., *Erysiphe sordida* L. Junell* on *Plantago major* L. and *P. media* L.), and 3 polyphagous species (*Erysiphe cichoracearum* D.C. ex Mérat* on *Achillea millefolium* L., *Alchemilla vulgaris* L., *Aster dumosus* L., *Tanacetum vulgare* L. and *Taraxacum officinale* Web., *Erysiphe heraclei* D.C. ex st. – Am.* on *Heracleum sphondylium* L., *Pimpinella saxifraga* L., *Aegopodium podagraria* L., *Anthriscus sylvestris* (L.) Hoffm, *Torilis japonica* (Houtt.) DC., and *Erysiphe trifolii* Grev.* on *Lathyrus pratensis* L., *Lupinus polyphyllus* Lindl, *Melilotus alba* Medinear, *Trifolium medium* L. and *T. hybridum* L.).

The fungi were selected in such a way that species both resistant and sensitive to transport pollution, identified in a prior examination, were included in each group. They belong to common or very common species in the area of Olsztyn and its vicinity, where bioecological studies on the *Erysiphales* have been conducted since 1995. The infection degree of host plants in 25 urban localities, established in places where transport pollution concentrations are high, and 25 localities outside the city, free from automotive exhaust gases, was analysed annually three times every two weeks in the second half of the vegetative period.

The infestation degree was calculated using the McKinney formula:

$$R = \frac{\Sigma\,(a \times b) \times 100\%}{N \times 4}$$

R – disease coefficient in percent (index)

$\Sigma\,(a \times b) \times 100\%$ – sum of products obtained by multiplying the number of collected plant organs by the infection degree

N – total number of plants (or alternatively leaves, fruits) examined

4 – the highest grade in a 5-grade scale (0 – no infection; 1 – up to 10%; 2 – 11-25%; 3 – 26-50%; 4 – 51-100%)

Table 1
Infection degree (%) of host plants by monophagous species

| Fungal species | | *Microsphaera berberidis* | | | *Microsphaera alphitoides* | *Microsphaera palczewskii* | *Microsphaera vanbruntiana* | *Erysiphe sordida* | |
|---|---|---|---|---|---|---|---|---|---|
| Host plant | | *Berberis vulgaris* | *Berberis koreana* | *Berberis thunbergii* | *Quercus robur* | *Caragana arborescens* | *Sambucus racemosa* | *Plantago major* | *Plantago media* |
| Infection degree | Urban areas | 80% | 60% | 89% | 15% | 85% | 64% | 35% | 41,5% |
| | Suburban areas | 55% | 58,5% | 68,5% | 70% | 80% | 75% | 78,5% | 75% |

The fungi were determined according to Sałata (1985) and Braun (1987), while the host plants were determined on the basis of the study by Mirek et al. (1995).

* Current nomenclature (Braun and Takamatsu 2000):

*Erysiphe alphitoides* Griff. et Maubl =*Microsphaera alphitoides* Griff. et Maubl

*Erysiphe berberidis* (DC. ex Mérat) Lév. =*Microsphaera berberidis* DC. ex Mérat

*Erysiphe palczewskii* Jacz. =*Microsphaera palczewskii* Jacz.

*Erysiphe vanbruntiana* Gerard =*Microsphaera vanbruntiana* Gerard

## RESULTS

The observations conducted corroborate the results of previous studies that demonstrated the existence of species belonging to the Erysiphales sensitive and resistant to transport pollution. The disease index in the city was a few times lower than that outside it in the case of sensitive species (Tabs 1, 2 a, b, c).

The reactions of monophagous species were unambiguous, exhibiting either resistance (*Microsphaera berberidis, M. palczewskii*, and *M. vanbruntiana*) or sensitivity (*M. alphitoides* and *Erysiphe sordida* (Tab. 1).

Polyphagous species reacted in a labile way (Tabs 2 a, b, c). The differences in the infection degree of individual hosts by the same fungal species in the same conditions were significant, which, as assumed, reflects the scope and nature of the reaction. *Erysiphe cichoracearum* shows great sensitivity to *Alchemilla vulgaris, Aster dumosus* and *Taraxacum offinicale, Erysiphe heraclei* to *Aegopodium podagraria* and *Heracleum sphondylium,* while *Erysiphe trifolii* to *Melilotus alba* and *Lathyrus pratensis*. These species on the other hosts reacted in a similar way both in the urban and suburban localities. The "host-pathogen" system with the participation of monophagous species reacts in a clear, specific and precise way.

Microhabitat conditions, produced by the host and dependent on its physiological condition, as well as macrohabitat conditions, determined by components of the ecosystem inhabited by the host, should be examined as part of bioecological analyses. Similarly, the biosphere, sociosphere and technosphere should

Table 2
Infection degree (%) of host plants by polyphagous species

a)

| Fungal species | | *Erysiphe cichoracearum* | | | | |
|---|---|---|---|---|---|---|
| Host plant | | *Taraxacum officinale* | *Achillea millefolium* | *Tanacetum vulgare* | *Alchemilla vulgaris* | *Aster dumosus* |
| Infection degree | Urban areas | 26,5% | 62,5% | 58% | 24% | 39,5% |
| | Suburban areas | 65% | 65,5% | 68,5% | 85,5% | 90% |

b)

| Fungal species | | *Erysiphe heraclei* | | | | |
|---|---|---|---|---|---|---|
| Host plant | | *Heracleum sphondylium* | *Aegopodium podagraria* | *Pimpinella saxifraga* | *Torilis japonica* | *Antriscus sylvestris* |
| Infection degree | Urban areas | 25% | 25,5% | 45% | 35,5% | 48,5% |
| | Suburban areas | 90% | 80% | 48,5% | 30% | 52,5% |

c)

| Fungal species | | *Erysiphe trifolii* | | | | |
|---|---|---|---|---|---|---|
| Host plant | | *Lupinus polyphyllus* | *Melilotus alba* | *Trifolium hybridum* | *Trifolium medium* | *Lathyrus pratensis* |
| Infection degree | Urban areas | 60,5% | 28% | 48,5% | 35% | 25,5% |
| | Suburban areas | 75% | 67,5% | 66% | 66,5% | 56% |

be studied if observations are conducted in urban areas, that is areas affected by anthropogenic activities, with a high accumulation of stressogenic factors, such as, undoubtedly, transport pollution. Suitable for quick calculation, the disease index proved to be a good criterion of the sensitivity of the fungi examined to this type of pollution. As their concentration increased, the disease index significantly decreased in sensitive species, the mycelium growth and development were accelerated, and cleistothecia developed and matured more quickly than in resistant species. Cleistothecia in the fungi examined serve as resting bodies that are most often developed in unfavourable environmental conditions or close the developmental cycle. It is a very characteristic defence reaction connected with the survival strategy, parallel to the reaction of many plants which reduce the vegetative period in strongly polluted environments, blossom and produce seeds faster. Additionally, the mycelium colonisation by fungi of the genera *Alternaria, Cladosporium* and *Tripospermum*, which significantly affected the development of ascomata of powdery mildews (numerous ascomata without asci and ascospores, with poorly developed appendages (Sucharzewska and Dynowska 2004)) was observed in the sensitive species.

## DISCUSSION

Studies on the influence of environmental pollution on selected phytopahogens were conducted in Poland between 1978 and 1988 by Burgieł (1993) who observed the development of *E. graminis* and *Puccinia triticina* on wheat leaves in the zone of emission of the Skawina Aluminium Smelting and Power Plant. He also analysed the health of roses in the Voivodeship Culture and Relaxation Park, directly influenced by transport pollution, in the town of Chorzów, where he evaluated the occurrence of *Sphaerotheca pannosa* and *Diplocarpon rosae*. The results were unambiguous in the latter case: pathogens occurred more quickly, the disease developed more rapidly; the infection degree, however, was lower in places where contamination levels accumulated.

Reactions to changes in habitat conditions in numerous pathogenic fungi may differ significantly, as exemplified by the order *Erysiphales*, for instance *E. graminis*, and *Uredinales*, mostly the genera *Puccinia, Melampsoridium, Melampsora* and *Cronartium*. It has been observed that species of the genera *Ascochyta*, *Coniothyrium* or *Sclerotinia* are resistant to $SO_2$ while *Phytophtora* spp. and *Venturia inaequalis* were defined as exceptionally sensitive (Burgieł 1993). As the latter reacts to pollution, its life processes are disturbed, cultures on artificial substrates age quickly, sporulation is disturbed, and germination and hyphal development are weakened.

Klama, Mułenko and Żarnowiec (1966) suggest that phytopathogens are a more sensitive indicator of habitat changes than vascular plants that constitute the living environment for fungi. Changes are difficult to notice in the "host-pathogen" system as adaptation processes of the host, pathogen, their features, transmitability of, and the ability to strengthen (or weaken) resistance features over time should be considered (Dynowska and Sucharzewska, 1996; 2001). Therefore, the diversity of reactions of the phytopathogens examined depends not only on the degree of anthropopressure but first of all on the phytogenetically fixed eco-physiological features of the pathogen and the host (Falińska 2004). This has been corroborated in our study: reactions of individual species to the same environmental factor varied significantly. It seems understandable that polyphagous species reacted less precisely because of the wide range of hosts, and, consequently, physiological systems and ecological combinations generated in this way. The strict dependence between the parasite and the host, developed in the process of co-evolution, influences defined types of individual reactions. It also determines the nature of the relationship between the pathogen and the host plant constituting a specific system (Thompson and Burdon 1992). In the case of monophagous species, this system seems more lasting and therefore the reactions of both components may be similar, which results in a precise and clearly orientated specific reaction of the pathogen. It is a feature of a potential bioindicator.

Host expansion and, consequently, the dissolution of the dividing line between monophagous and polyphagous species may be observed in powdery mildews, similarly to other pathogenic fungi (Sałata 1985; Braun 1987). This would be indicative of the fact that monophagous species, more sensitive to habitat changes, not only look for a new nutritive basis but first of all for new ecological systems in which they may improve adaptation processes and acquire immunity. The process may seem highly favourable ecologically as the presence of strong phytopathogens may trigger off plant defence reactions that may be strengthened and fixed in favourable habitat conditions. Infected plants are often characterised by a greater viability and ability to compete and to colonise new areas (Mułenko 1998).

Contemporary ecology has gradually begun to include complicated, lower levels of nature organisation in which parasites are given a key role (Mułenko 1998). The factors reducing pathogen frequency and prevalence automatically eliminate natural components of the environment upon which the preservation of the homeostasis at the level of the biocoenosis, and sometimes of the entire ecosystem, depends. Therefore, the study of phytopathogen reactions may provide a substantial deal of information on the changes occurring in the environment and, more importantly, may help predict the future development of these changes and their consequences for man.

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## Zróżnicowane reakcje grzybów z rzędu Erysiphales w urbicenozach – gatunki monofagiczne i polifagiczne

### Streszczenie

Celem pracy było sprawdzenie wrażliwości monofagicznych i polifagicznych gatunków Erysiphales na zanieczyszczenia komunikacyjne, stosując jako kryterium stopień porażenia roślin żywicielskich. Materiał badawczy stanowiły grzyby zebrane w ciągu kilku lat na 25 stanowiskach miejskich w Olsztynie, wyznaczonych w miejscach o wysokiej koncentracji zanieczyszczeń komunikacyjnych i 25 stanowiskach poza miastem, pozbawionych wpływu spalin samochodowych.

Poszczególne gatunki grzybów reagowały różnie na wielkość zanieczyszczeń miejskich. Reakcje monofagów były wyraźnie sprecyzowane i ukierunkowane na odporność lub wrażliwość. Polifagi reagowały mniej precyzyjnie – ten sam gatunek wykazywał bardzo wysoką wrażliwość na jednym żywicielu, a odporność na innym. Sugeruje to większą stabilność ekofizjologiczną układu „patogen-żywiciel" z udziałem gatunków monofagicznych niż polifagicznych oraz większą jego przydatność jako potencjalnego bioindykatora.