Effects of Habitat Characteristics and Climatic Factors on the Fungal Diseases of Reed Stands in Hungary

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Effects of habitat characteristics and climatic factors on the occurrence of reed pathogens were investigated in a four-year survey. While diseases caused by Puccinia magnusiana, Polythrinciopsis phragmitis and Stagonospora sp. started to increase as early as in August, the other species caused severe infection in September (Deightoniella arundinacea, Puccinia phragmitis) or even later in the vegetation period (Deightoniella roumeguerei). For the distribution of some fungal pathogens (Puccinia phragmitis, Deightoniella arundinacea, D. roumeguerei and Stagonospora sp.) weather conditions (especially precipitation) were profound, while the occurrence of others (Puccinia magnusiana and Polythrinciopsis phragmitis) depended more on the characteristics of reed stands.

Keywords: pathogenic fungi, common reed, habitat characteristics, climatic factors, Balaton.

Reeds have been exploited for a long time. The economic values of the common reed (Phragmites australis (Cav.) Trin. ex Steudel) mainly derive from thatching, grazing animals and producing several different products (paper, organic material, etc.). Reed stands also play important role in the purification of water, protection of the shore, etc.

Diseases of reeds caused by pathogenic fungi may considerably affect the above processes. Some of the pathogens can seriously damage the stem (Ustilago grandis Fries) or even kill the entire plant (Deightoniella arundinacea (Corda) Hughes) making industrial usage impossible (Ruttkay et al., 1964; Durska, 1970). Other fungal species cause leaf spot diseases (Deightoniella roumeguerei (Cav.) O. Const., Polythrinciopsis phragmitis Walker, Stagonospora sp.) or rupture the epidermis by rust pustules (Puccinia phragmitis (Schum.) Koernicke, Koernicke, P. magnusiana Koernicke) restraining the normal development of reed plants (Constantinescu, 1983; Fischl et al., 1996). However, the extent to which the causal agents of foliar diseases are associated with losses in reed stem quality is still unknown.

Reed decline is an important trait that should be considered in relation to the pathogens, since degradation of reed stands can be observed in many lakes and ponds in the world. There are several factors that may affect on and possibly included in the retreat of the stands (Ostendorp, 1989; Fischl et al., 1998), but the role of diseases in reed decline processes has not yet been thoroughly investigated.

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Not only reed plants can be affected by various pathogens but the influence of environmental factors on the distribution and intensity of diseases can also be profound. Thus, it has been previously shown that reed stands differing in terms of reed quality, water distance and management were attacked by their pathogens differently (Bán et al., 1996, 1998, 2000; Engloner et al., 2000). It is, therefore, important to determine the factors which contribute to the actual level of diseases thus influencing the extent of damage in reed stands. Most of these results, however, were based on short-term examinations, but only long-term surveys can result in the better understanding of the processes existing in reeds. In addition, beside the characteristics of a field (or a stand), the extent and the progress of many diseases are frequently dependent on climatic factors during the vegetation period and winter.

Therefore, the objectives of our investigations were: (1) to determine a general tendency for the temporal distribution of reed pathogens; (2) to compare disease intensities among different habitats in a four-year survey; (3) to compare disease records in relation to concurrent weather conditions; and (4) to see which of the factors either climatic or habitat will effect dominantly the occurrence of the pathogens examined.

**Materials and Methods**

Investigations were carried out in three and four reed stands (numbered as sites 1, 2, 3 and 4, 5, 6, 7) at Lake Balaton and Lake Velencei, respectively. These stands have different characteristics as shown in Table 1. Reed categories I to V (category I: the best quality, category V: the poorest one) are classifying reed stands mostly through visual observations, for example for homogeneity, density, vitality, height and the presence of accompanying species (Kovács et al., 1993). The examined reed stands at Lake Balaton equally belonged to category III, while reeds at Lake Velencei numbered as 4, 5, 6 and 7 belonged to categories II, III, IV and V, respectively. Stands 1, 6 and 7 were far from the

<table>
<thead>
<tr>
<th>Location</th>
<th>Site code</th>
<th>Reed quality</th>
<th>Distance from the lake</th>
<th>Reed stand management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Balaton</td>
<td>1</td>
<td>III</td>
<td>far (2 km)</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>III</td>
<td>near (5 m)</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>III</td>
<td>near (20 m)</td>
<td>burnt</td>
</tr>
<tr>
<td>Lake Velencei</td>
<td>4</td>
<td>II</td>
<td>near (5 m)</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>III</td>
<td>near (10 m)</td>
<td>cut</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>IV</td>
<td>far (50 m)</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>V</td>
<td>far (100 m)</td>
<td>none</td>
</tr>
</tbody>
</table>

*Acta Phytopathologica et Entomologica Hungarica* 37, 2002
lakes (0.1–2 km apart), while the others were situated onshore. Only reed stands 3 and 5 were regularly managed (burnt/cut) during the examination period.

Fungal pathogens previously found to attack reed stands in Hungary were: *Puccinia phragmitis* (Schum.) Koern., *Puccinia magnusiana* Koern., *Deightoniella arundinacea* (Corda) Hughes, *Deightoniella roumeguerei* (Cav.) O. Const., *Polythrinciopsis phragmitis* Walker and *Stagonospora* sp. (Fischl et al., 1996; Bán et al., 1998). Disease assessment was performed on ten marked shoots (ramets) of each of the seven locations at monthly intervals from June to October in 1996–97, and on 50 ramets at two sampling sites (site 3: Balatonberény and site 2: Fenékpuszta, at Lake Balaton) in September in the years 1998 and 2000 based on a five-scaled assessment key (Bán et al., 2000). For *Puccinia magnusiana*, reed ramets were assessed until September because symptoms caused by this fungus were difficult to detect as late as by the end of the vegetation period (October). Similarly, since the vegetation period finished earlier in 1997, disease assessment was performed until September for all fungi. The disease assessment records of single leaf blades were the subject of calculating disease indices for the plants examined by using the formula described earlier (Bán et al., 2000). The sampling conditions during the four-year examination period are summarized in Table 2.

<table>
<thead>
<tr>
<th>Examination period</th>
<th>Number of ramets (Number of sampling)</th>
<th>Sampling sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>June–October 1996</td>
<td>10 (monthly)</td>
<td>sites 1–7</td>
</tr>
<tr>
<td>June–September 1997</td>
<td>10 (monthly)</td>
<td>sites 1–7</td>
</tr>
<tr>
<td>September 1998</td>
<td>50 (once)</td>
<td>sites 2, 3</td>
</tr>
<tr>
<td>September 2000</td>
<td>50 (once)</td>
<td>sites 2, 3</td>
</tr>
</tbody>
</table>

Meteorological data (mean monthly temperature and monthly precipitation) recorded at Siófok (Lake Balaton) which is the closest town to the sampling sites were provided by the National Meteorological Service.

Experimental data were evaluated by one-way analysis of variance (ANOVA) and by canonical variates analysis (CVA) using the MINITAB 10.2 and SYN-TAX computer program packages (Podani, 1994, 1997).

**Results**

*Temporal distribution of reed pathogens*

Since the temporal distribution of reed pathogens showed similar tendency from year to year (i.e. the distribution of each pathogen showed a characteristic disease curve during the vegetation period), only disease records at site 4 (Lake Velencei in 1996) as a
representative are presented here (Fig. 1). While diseases caused by *Puccinia magnusiana*, *Polythrinciopsis phragmitis* and *Stagonospora* sp. started to increase as early as in August, the other species caused severe infection in September (*Deightoniella arundinacea*, *Puccinia phragmitis*) or even later in the vegetation period (*Deightoniella roumeguerei*).

Distribution of pathogens at different sampling sites

Although each disease has a characteristic progress during the vegetation period, it can be highly affected by the habitat conditions where it occurs. The occurrence of fungal diseases in each of the seven sampling sites in September 1996 and 1997 is presented in Figs 2, 3, respectively. In general, the most common fungal pathogens to occur were the rust fungi (*Puccinia phragmitis* and *P. magnusiana*) and *Stagonospora* sp., as far as both disease incidence (occurrence or frequency by sampling sites) and disease severity (measured by disease index) were concerned. Furthermore, the majority of the pathogens were common in nearly all sampling sites, whereas *Polythrinciopsis phragmitis* occurred in a few areas (sampling sites 2, 6 and 7) only.

*Acta Phytopathologica et Entomologica Hungarica* 37, 2002
Fig. 2. Occurrence of *Puccinia phragmitis*, *P. magnusiana* and *Polythrinciopsis phragmitis* by sampling sites in September 1996 and 1997

(I means standard deviation)
Fig. 3. Occurrence of *Deightoniella arundinacea*, *D. roumeguerei* and *Stagonospora* sp. by sampling sites in September 1996 and 1997 (I means standard deviation)
Infection data obtained from different sampling sites in 1996 and 1997 were com-
paired by variance analysis to reveal correlations between habitat characteristics and the
occurrence of each fungal species. Based on ANOVA our results corroborated with those
previously found by Bán et al. (1998): *Puccinia phragmitis, Deightoniella arundinacea*
and *Deightoniella roumeguerei* were all predominant in good and medium quality reeds
(categories II and III) situated near the lakes, but *Puccinia magnusiana* inhabited poor
(category IV) or good quality stands either far from or near the lakes (Table 3). In contrast,
*Polythrinciopsis phragmitis* mainly infected reed stands that were of poor quality and
situated far from the water. Furthermore, with the exception of *Deightoniella* species, the
pathogens mentioned above caused more severe infections in those areas where reeds had
not been treated in the last few years. Reed management (burning, cutting or harvesting),
therefore, appeared to be a significant factor in decreasing the disease occurrence in reed
stands. Interestingly, the occurrence of *Stagonospora* sp. was found to be independent
from any of the factor in the 1996–1997 examination period.

**Table 3**
Habitat characteristics preferred by the reed pathogens examined

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Reed quality</th>
<th>Distance from the lake</th>
<th>Reed stand management</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Puccinia phragmitis</em></td>
<td>II, III</td>
<td>near</td>
<td>none</td>
</tr>
<tr>
<td><em>Puccinia magnusiana</em></td>
<td>II, IV</td>
<td>far/near</td>
<td>none</td>
</tr>
<tr>
<td><em>Deightoniella arundinacea</em></td>
<td>II, III</td>
<td>near</td>
<td>treated</td>
</tr>
<tr>
<td><em>Deightoniella roumeguerei</em></td>
<td>III</td>
<td>near</td>
<td>treated</td>
</tr>
<tr>
<td><em>Polythrinciopsis phragmitis</em></td>
<td>IV</td>
<td>far</td>
<td>none</td>
</tr>
<tr>
<td><em>Stagonospora</em> sp.</td>
<td>II, V</td>
<td>far/near</td>
<td>treated/none</td>
</tr>
</tbody>
</table>

In 1998, relatively high infection rates were recorded for *Puccinia phragmitis* at
sites 2 and 3, and for *Stagonospora* sp. at site 2 as compared to other pathogens (Fig. 4).
The greater amount of sampling (50 ramets per sampling sites) in the years 1998 and 2000
allowed us to perform canonical variates analysis (CVA) in order to see whether or not
sampling sites 2 and 3 differed in the occurrence of fungal diseases. The result of CVA is
presented in Fig. 5. Variables (fungal species) are shown as vectors and objects (sampling
sites) are presented by isodensity circles around centroids. These two reed stands were
more different in 1998 than in 2000 as far as infections by *Puccinia phragmitis* and
*Stagonospora* sp. were concerned. In 2000 reeds were similar based on their diseases as
the overlapping circles show (Fig. 5). The other fungi (*Puccinia magnusiana* and the
*Deightoniella* species) represented by shorter vectors seemed not to contribute to the diffe-
rences between the two stands.
Fig. 4. Occurrence of reed pathogens at Lake Balaton (sites 2 and 3) in September 1998 and 2000 (I means standard deviation)
Differences in the distribution of reed pathogens in the investigated years

Disease indices of the examined pathogens varied not only by sampling sites, but also between years. Except for *Polythrinciopsis phragmitis* and *Puccinia magnusiana*, both disease incidence and severity of the reed pathogens markedly decreased in 1997 as compared to 1996 (Figs 2, 3). A similar tendency was recorded in the years 1998 and 2000 in two sampling sites (2 and 3) at Lake Balaton, where disease indices, in general, decreased by 2000, but infections caused by *Puccinia magnusiana* were similar in the sampling areas during this period (Fig. 4).

Effects of weather conditions and habitat characteristics on the occurrence of fungi

During the examination period the mean monthly temperature was similar, while precipitation showed prominent differences (Fig. 6). In the years 1996 and 1998 the weather was relatively rainy in August and in September, but it was especially dry from August to October in 1997 and 2000.
Since the weather in August–September 1996 and 1998 were considerably rainy and *Puccinia phragmitis*, *Deightoniella arundinacea*, *D. roumeguerei* and *Stagonospora* sp. caused equally severe infections during this period, it seems that rainy periods are more favourable for the occurrence of these species. Although characteristics of the habitat (reed quality, distance from water and management), found to contribute to disease occurrence and to species diversity together with summer mean temperatures, were constant during the examination period (1996–2000), it was the precipitation that fluctuated with years significantly influencing the distribution of these fungi.

In contrast, there were no differences found in the diseases caused by *Puccinia magnusiana* and *Polythrinciopsis phragmitis* between rainy and dry years and these species frequently infected reeds growing far from the lake. In addition, *Puccinia magnusiana* was often observed and mostly being the only fungus on reed plants along railway embankments and roads. It seems, therefore, that habitat characteristics play a more significant role in the occurrence of the latter fungal species than do climatic factors.

**Discussion**

Effects of habitat characteristics and climatic factors on the occurrence of reed pathogens were investigated in this study in a four-year survey. Diseases caused by *Puccinia magnusiana*, *Polythrinciopsis phragmitis* and *Stagonospora* sp. started to increase as early
as in August, while the other species caused severe infection in September (Deightoniella arundinacea, Puccinia phragmitis) or even later in the vegetation period (Deightoniella roumeguerei).

According to the occurrence of fungi under different climatic and habitat conditions, the investigated reed pathogens can be divided into two groups. On one hand, Puccinia phragmitis, Deightoniella arundinacea, D. roumeguerei and Stagonospora sp. caused severe infections in rainy years (in 1996 and 1998) as well as in rainy periods, e.g. at the end of the vegetation period (September–October). On the other hand, Puccinia magnusiana and Polythrinciopsis phragmitis infected reed plants even in mid-summer, i.e. in the drier seasons and fluctuation in the weather conditions had no effect on their distribution: the level of infection caused by these fungi was similar either in rainy or in dry periods. Furthermore, these two pathogens were the most characteristic elements of reeds growing either far from the lakes or bordering railway embankments and roads, indicating that habitat characteristics play a more significant role in the occurrence of these species than do climatic factors. Differences in the ecological requirements of the two rust fungi (Puccinia magnusiana and P. phragmitis), belonging to the same fungal genus, are remarkable.

While some of the investigated factors (reed quality, distance from water) exist independently from human activity, reed management is the only one through which health condition of reeds can be effected. Since infection level caused by the majority of the pathogens was significantly lower in reeds where management (burning or cutting) was performed (Table 3), human activity with a proper reed management program can highly improve the health condition of reed stands. Beside the investigated factors, however, other effects such as water quality, water depth, etc. also have to be considered (Engloner, 2001).

In conclusion, a wide variety of factors may effect on the diseases in reeds. The distribution of some pathogens (Puccinia phragmitis, Deightoniella arundinacea, D. roumeguerei and Stagonospora sp.) is primarily weather-dependent (especially precipitation), while others (Puccinia magnusiana and Polythrinciopsis phragmitis) are mainly associated with the investigated characteristics of the reed habitat. The background of these differences is not yet known and would require further investigations.

**Acknowledgement**

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**Literature**


*Acta Phytopathologica et Entomologica Hungarica* 37, 2002


