Bioindication value of tar spot on maple trees in industrial areas: the case of Ostrava region, the Czech Republic

Kateřina Náplavová[1,2], Ján Gáper[1*,3]

[1]Department of Biology and Ecology, Faculty of Sciences, University of Ostrava, Chittusiho 10, 710 00 Ostrava, Czech Republic
[2]CEB-Centre of Biological Engineering, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
[3]Department of Biology and General Ecology, Faculty of Ecology and Environmental Sciences, Technical University in Zvolen, T. G. Masaryka 24, 960 53 Zvolen, Slovak Republic

Abstract

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Rhytisma acerinum is considered to be a bioindicator of air quality and therefore the occurrence of tar spot corresponding with the level of site pollution can be used as a tool for estimation of environmental pollution. The aim of this study was to assess the bioindication value of individual maple taxa. The research was established on fieldwork in the City of Ostrava (Czech Republic) and on the investigation of 1,247 trees. Four main habitat types were selected according to assumed (high or low) levels of air pollution and type of vegetation and land use. Different occurrence of symptoms of fungal pathogen in different categories of vegetation was found. Our analysis provides evidence that trees with lower diameter at breast height (DBH) suffered from higher infestation of tar spot. Airborne dust (PM_{10}) was identified as the air pollutant with the significant negative effect on stroma occurrence. Our results also reveal that infestation of maple leaves was significantly affected by cultivar. Therefore the most susceptible taxa to tar spot (*Acer pseudoplatanus*, *A. pseudoplatanus* 'Atropurpureum', *A. platanoides* 'Cleveland', *A. platanoides* 'Globosum') can be the best candidates for monitoring air pollution.

Key words

Acer, air pollution monitoring, *Rhytisma acerinum*, urban areas

Introduction

Tar spot occurring on the surface of maple leaves is caused by parasitic fungus – *Rhytisma acerinum* (Pers.) Fr. It is one of the most easily distinguishable fungal leaf diseases and it is distributed throughout temperate northern hemisphere. It belongs to Ascomycota and forms black flat macroscopic stromata on the leaf blades of maple trees (Weber and Webster, 2002). Detailed biology of this fungal pathogen has been previously described (Jones, 1925; Hudler et al., 1987; Weber and Webster, 2002). It overwinters on fallen leaves and then infects adaxial leaf surface in spring during the moist conditions. Leaf spots are first yellowish green but by mid to late summer a tar-like appearance occurs. Stromata are present mainly on leaves of *Acer pseudoplatanus* L. (Sycamore maple) and *Acer platanoides* L. (Norway maple) and less often in industrial and urbanized areas (Sutton, 1980; Farr et al., 1989; Weber and Webster, 2002; Mihál, 2004; Kosiba, 2007). Several studies were dedicated to examining effects of environmental pollution on tar spot distribution (Bevan and Greenhalgh, 1976; Vick and Bevan, 1976; Greenhalgh and Bevan, 1978; Gosling

*Corresponding author:
e-mail: jan.gaper@osu.cz

et al., 2016). Leith and Fowler (1987) and Gosling et al. (2016) also investigated other factors influencing its occurrence such as presence of overwintered leaf material or the exposure to wind. None of those studies was considering host specificity of tar spot among maple cultivars. So the hypothesis of the present study was that individual maple taxa have different bioindication value. It was based on monitoring of tar spot symptoms and its occurrence in the area of Northern Moravia, Czech Republic (especially in the surroundings of Ostrava City), evaluating its distribution through different categories of vegetation and examining if ontogeny of host trees plays any role in stroma quantity.

Currently one of the most pressing problems of the environment of Ostrava City, as an industrial agglomeration, is the bad air quality. The big industrial factories, engineering and metallurgical companies, automobile traffic and small emission sources have significant influence on air pollution (Zdravotní ústav, 2008).

Material and methods

The research was carried out during 2 years (2013 and 2014) in the area of Ostrava City districts (Fig. 1). Study areas have been selected according to the nature character and land use.

Fig. 1. A scheme of the Ostrava City districts area (www.ostrava.cz, 49°50’08”N, 18°17’33”E, area 214 km^2).

List of study areas

“Moravská Ostrava a Přívoz” city district
parks – Dr. Milada Horáková Park, Komenského sady Park, Bezručův sad Park, Husův sad Park; housing estates – cross roads of Českobratrská, Hornopolní, Varenská Streets, housing estate at Vítkovická Street close to Kaufland supermarket, area around Ostrčilova Sreet, area in front of Librex house near Černá louka exhibition ground, Jilemnice Square, area next to Aquapark Vodní svět situated close to Sokolská třída Street; parking lots – Soukenická Street, Varenská Street around Futurum shopping mall, area in front of Kaufland supermarket close to Vítkovická Street, area next to elementary school Ostrčilova; low traffic roads – Na jízdárně Street, Veleslavínova Street, Hus Square, Blahoslavova, Žerotínova, Gregorova, Budečská, Sadová Streets; high traffic roads – Českobratrská Street close to Janáček conservatory, Novinářská Street in front of Futurum shopping mall, 28. října Street between tram stops Dům energetiky and Krajský úřad, Nádražní Street, area around Černá louka exhibition ground;

“Slezská Ostrava” city district
part of Trojické Valley near to Ema heap, private gardens – Na Najmanské, Hýbnerova, Občanská, Keltičkova Streets; parking lot – close to Hladnovská Street in front of Penny hypermarket and Tylův sad Park;

“Mariánské hory a Hulváky” city district
part of Hulvácký Forest along U koupaliště Street; Smetanův sad Park; private garden at Boleslavova Street; housing estate near Rtm. Gucmana, Gen. Hrušky and Pflegrova Streets, between Vršovců and Václavská Streets; parking lot near Grmelova Street in front of Kaufland and Scontomarkets; along high traffic road – Přemyslovců Street;

“Ostrava - Jih” city district
part of Bělský Forest; park within Gen. Svoboda Park; private gardens – Chalupníkova, Klegova Streets; housing estates close to areas around Provaznická and Klegova Streets; parking lot between Horní and Jaromíra Matuška Streets; low traffic roads – Česká, Slezská, Klegova, Chalupníkova, Beskydská Streets; medium traffic road – u Haldy Street;

“Svinov” city district
greenery of parkland type between Stanislavského and Jandáskova Streets near Husův sbor Church, area around Dr. Braun Square, Sad míru Park; private garden at Polanecká Street; housing estate around Bílovecká Street; low traffic load along Kuršova Street; medium traffic load along Bílovecká Street;

“Poruba” city district
parks near Nálepka Square and Havlíček Square; greenery of parkland type – Španielova Street, area close to elementary school at Ukrajinská and Alžírská Streets; housing estate near to Mongolská Street; parking lots at Alšova, Kopeckého, Bulharská, Francouzská Streets; low traffic roads – Bohuslava Martinů, Čs. exilu, Budovatelská, Urxova, V závětří, Španielova Streets; medium traffic loads – Polská, Francouzská Streets, Nábřeží Svazu protifašistických bojovníků promenade; along high traffic roads – 17. listopadu, Porubská, Opavská Streets;

“Nová Ves” city district
area along 28. října road aprox. 400 m from tram stop Nová Ves vodárna direction to Svinov;

“Polanka nad Odrou” city district
part of Protected Landscape Area Poodří; greenery of parkland type next to Atlas house close to the bus stop Hraničky and Václav Nehýbl Park, couple of private gardens.

The only helpful source of information about occurrence of maple taxa in Ostrava City was a map portal (www.stromypodkontrolou.cz) which includes several parameters (species, diameter at breast height – DBH, tree height, health status and recommended treatment technology) about trees in the area of different city districts. Fieldwork included quantification of tar spot infection. This part of the research was conducted during the period of 14 days in 2013 (30 September–13 October) and 12 days in 2014 (3–14 October). Measurement of the DBH was carried out during the period of mid-October to early December. In addition, the estimation of total leaf number of each tree has been done. All gained data were supplemented by information about air pollution taken from official web pages of the Czech Hydrometeorological Institute (Chmi, 2014).

We divided number of infected leaves by total estimated number of leaves on each tree to allow comparison between different-sized trees. The relationship between the relative proportion of tar spot as response variable and the particular tree species, habitat type, DBH, concentration of PM_{10} (air pollutant) and year was examined using a generalized linear model with binomial error distribution and logit link function. Standard errors were corrected using quasi-likelihood function. Step-wise selection based on the lowest AIC was used to choose the best transformation function of the explanatory variable. We used an F-test to determine the significance of each variable because it is a robust test for overdispersed data. Data were analysed using R software (R Development Core Team, 2013).

Results

Out of 18 different maple taxa in total number of 1,247 tree individuals, 510 trees were characterized by presence of symptoms of tar spot, 737 were with no sign of infection in 2013. During 2014 there were 591 maples infected and 656 non-infected trees. The occurrence of symptoms was recorded on 9 taxa as well as 9 other taxa were asymptotic (Table 1). *Acer pseudoplatanus*, then *A. pseudoplatanus* ‘Atropurpureum’ and *A. platanoides* ‘Cleveland’ were taxa with the highest infestation (Fig. 2, Table 2). Significantly higher infection by tar spot was observed in 2014 (Fig. 3, Table 2).

Table 1. Overview of taxa frequency (with and without tar spot symptoms) recorded in Ostrava City during 2013 and 2014

		Occurrence			
		2013		2014	
Taxon	Total	yes	no	yes	no
Acer campestre L.	71	0	71	0	71
Acer campestre 'Elsrijk'	90	0	90	0	90
Acer negundo L.	114	0	114	0	114
Acer negundo 'Variegatum'	5	0	5	0	5
Acer palmatum Thunb.	45	0	45	0	45
Acer palmatum 'Dissectum'	3	0	3	0	3
Acer platanoides 'Cleveland'	74	30	44	55	19
Acer platanoides 'Columnare'	3	0	3	3	0
Acer platanoides 'Crimson King'	36	9	27	17	20
Acer platanoides 'Deborah'	43	21	22	34	9
Acer platanoides 'Drummondii'	19	0	19	0	19
Acer platanoides 'Globosum'	424	347	77	366	57
Acer platanoides 'Schwedleri'	25	3	22	7	18
Acer pseudoplatanus L.	78	65	13	70	8
Acer pseudoplatanus 'Atropurpureum'	40	31	9	35	5
Acer pseudoplatanus 'Leopoldii'	4	4	0	4	0
Acer saccharinum L.	90	0	90	0	90
Acer tataricum subsp. *ginnala* (Maxim.) Wesm.	83	0	83	0	83
Total	1,164	510	654	591	573

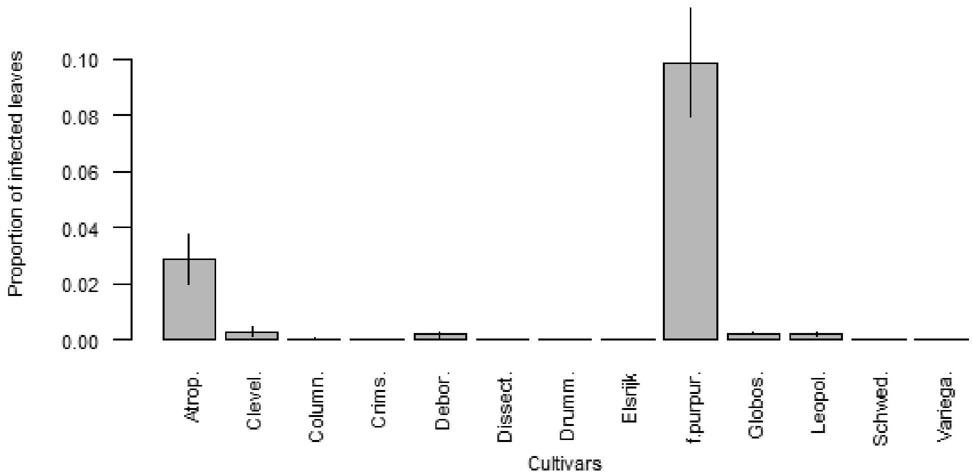

Fig. 2. Relative proportion of infected leaves by tar spot – *Rhytisma acerinum* according to individual taxa of *Acer* spp.; Atrop. – *A. pseudoplatanus* 'Atropurpureum', Clevel. – *A. platanoides* 'Cleveland', Column. – *A. platanoides* 'Columnare', Crims. – *A. platanoides* 'Crimson King', Debor. – *A. platanoides* 'Deborah', Dissect. – *A. palmatum* 'Dissectum', Drumm. – *A. platanoides* 'Drummondii', Elsrijk – *A. campestre* 'Elsrijk', f. purpur. – *A. pseudoplatanus*, Globos. – *A. platanoides* 'Globosum', Leopol. – *A. pseudoplatanus* 'Leopoldii', Schwed. – *A. platanoides* 'Schwedleri', Variega. – *A. negundo* 'Variegatum'.

Table 2. Result of testing of significancy of explanatory variables

	Df	Deviance	AIC	F-value	Pr (>F)
<none>		164365	168223		
cult	12	324480	328313	133.538	< 0.001***
year	1	337082	340937	1,728.582	< 0.001***
microloc	10	196408	196408	32.069	< 0.001***
loc	6	190082	193927	42.895	< 0.001***
bs(d)	3	187860	191712	78.381	< 0.001***
alike	3	175955	179806	38.664	< 0.001***
PM_{10}	1	166738	170593	23.747	< 0.001***

cult – maple taxa, year – year of tar spot symptoms observation, microloc – microlocality, loc – locality (different Ostrava City districts), bs(d) – trunk diameter, alike – generalized categorization of habitats, PM_{10} – airborne dust PM_{10}.

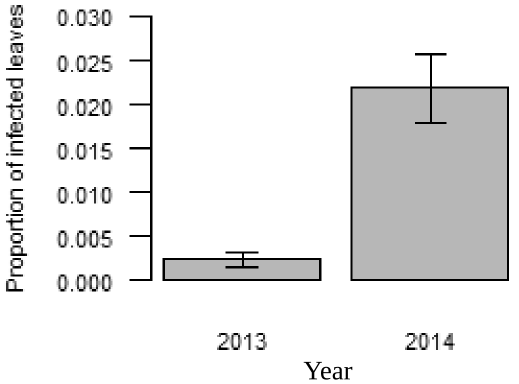

Fig. 3. Comparison of relative proportion of infected leaves by tar spot – *Rhytisma acerinum* during 2013 and 2014.

The highest infection rate was observed in Protected Lanscape Area (Fig. 4). For better comparison of natural and urbanized sites all the studied habitat microlocalities were divided into 4 categories (Fig. 5) according to similarities and character of the landscape: "forest" (contains forest-like habitat type – suburban forest, Protected Landscape Area), "ornamental" (includes parks, greenery of parkland type, private gardens), "traffic" (summarizes areas along weakly, moderately and highly frequented roads) and "urban" (contains microlocalities of housing estates and parking lots). Microlocality containing 4 individuals of *Acer pseudoplatanus* (with red-violet underside) growing along the agricultural area was not incorporated into any category. Generalized linear model revealed that habitat type significantly affected tar spot infestation among different maple taxa (Table 2).

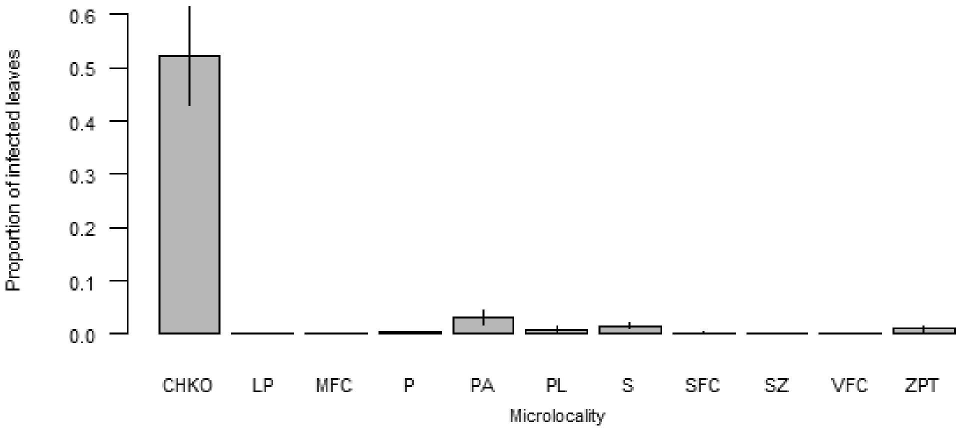

Fig. 4. Relative proportion of infected leaves by tar spot – *Rhytisma acerinum* according to the habitat type (microlocality); CHKO – Protected Landscape Area, LP – recreational forest, MFC – along medium traffic road, P – parking lot, PA – park, PL – suburban forest, S – housing estate, SFC – along low traffic road, SZ – private property (garden), VFC – along high traffic road, ZPT – greenery of parkland type.

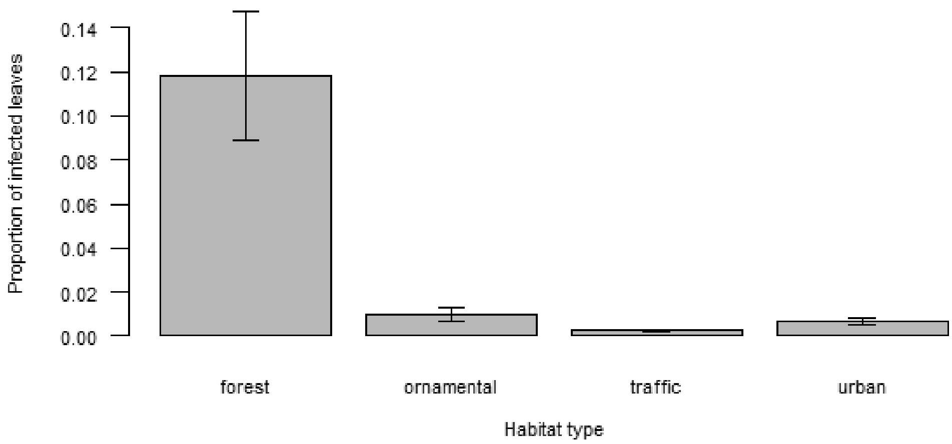

Fig. 5. Relative proportion of infected leaves by tar spot – *Rhytisma acerinum* according to generalized categorization of habitats.

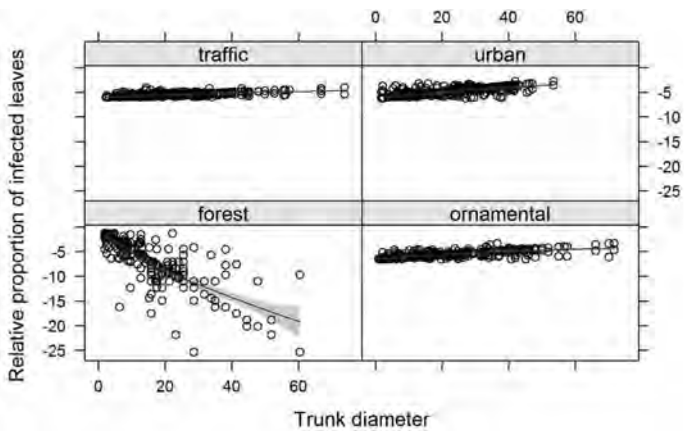

Fig. 6. Relative proportion of infected leaves by tar spot – *Rhytisma acerinum* according to the trunk diameter (DBH) and generalized categorization of habitats

Next we evaluated dependence of symptoms of tar spot on ontogeny of host trees by measuring tree girth. The result showed (Fig. 6, Table 2) that bigger trunk diameter correlates with lower quantity of stromata (non-linear dependence), especially in areas closer to the nature.

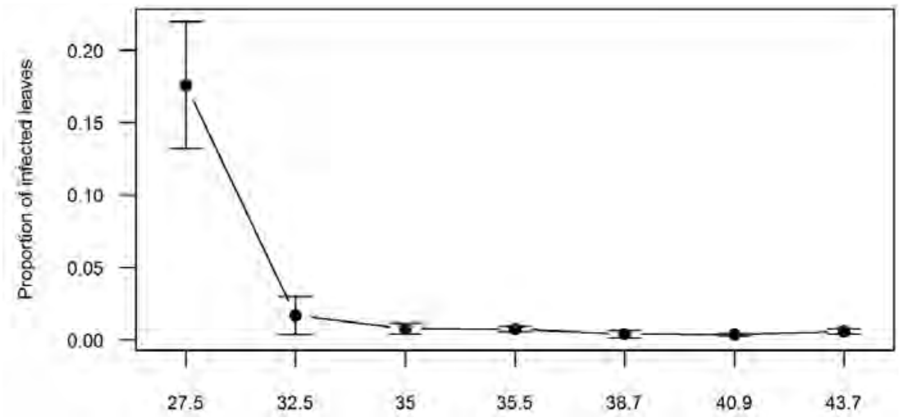

Fig. 7. Relative proportion of infected leaves by tar spot – *Rhytisma acerinum* according to the average annual concentration of PM_{10} (µg m^{-3}).

In addition, we studied the annual average concentration of airborne dust (PM_{10}) in the City of Ostrava and its surroundings. We found that lower concentrations of PM_{10} correlate with higher degree of infestation (Fig. 7, Table 2).

Discussion

Habitat type

Our survey found different distribution of tar spot dependent on microlocalities. Rate of infestation was the highest in the Protected Landscape Area (CHKO). This result is consistent with fact that infection occurs mainly in natural areas (Weber and Webster, 2002). This microlocality is also close to the Odra River, where moisture and shade play a positive role in infection (Hudler et al., 1987; Leith and Fowler, 1987; Kosiba, 2007).

Generally, less infected leaves were found in areas of urban type. This may be influenced by density of tree growth. Lower incidence of stromata is expected in solitary individuals or alleys when individuals are exposed to the high insolation, wind and generally low air humidity compared to individuals located in dense forest communities in wet and shaded areas (Kosiba, 2007). It could be caused by the maintenance of urban greenery when removal of fallen leaves is regularly practiced in fall because lack of fallen leaves reduces potential of infection by tar spot (Healy, 2007; Gillman, 2011). The infection was higher in Protected Landscape Area than in areas located in the city center, where parks, gardens and other greenery are periodically maintained.

We observed significantly higher infection in 2014. This is probably due to different amount of precipitation. There was higher rainfall two months before actual observation of stroma quantity in 2014 (Table 3).

Table 3. The average monthly precipitation in 2013 and 2014 in Ostrava City (mm)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12
2013	65.70	37.75	51.50	24.20	113.75	133.50	15.15	44.80	90.10	21.50	27.80	14.05
2014	25.60	20.80	19.75	35.70	106.95	59.05	73.30	131.10	91.15	48.60	34.65	22.85

Warm and wet winters cause decay of sclerotia and failure of germination in spring (Leith and Fowler, 1987). On the other hand humidity and rainy weather are favorable conditions (Heald, 1926; Manion, 1981). But although rain and humidity are the key factors to the outbreak, they must be present in small amounts and in regular intervals (Kosiba, 2007). Other factors influencing infection of maple leaves by tar spot such as moisture on the leaf surface, wind speed, temperature are described by Bevan and Greenhalgh (1976).

Also it is known that drying of the tree extends from the top to the bottom, so leaves located closer to the surface should have a higher probability of germination of ascospores than leaves located on the upper parts of the tree (Leith and Fowler, 1987). This fact was not taken into account but on the basis of observation during the fieldwork we can assume that this is so.

The external stimulus is needed for ascospore release from the wet mature stromata, such as shaking of the leaf or falling drops of water onto the stromatal surface (Leith and Fowler, 1987). This fact may explain fewer infections in areas protected from wind and rain or, on the contrary, the greater rate in sites with higher human activity, in housing estates or in parks.

Maple species

In our study there were tar spot attacks during both years at the species level only on *Acer pseudoplatanus* with reddish underside. *Rhytisma acerinum* parasitizes *Acer platanoides* L. (Norway maple), *A. pseudoplatanus* L. (sycamore), *A. saccharum* Marshall (sugar maple), *A. macrophyllum* Pursh (big-leaf maple), *A. rubrum* L. (red maple) and on *A. saccharinum* L. (silver maple), (Edmonds et al., 2000). However, recent studies reveal that a new species of leaf-spotting fungus occurring in America – *Rhytisma americanum* Hudler & Banik was found on red maple and silver maple (Hudler et al., 1998; Hsiang and Tian, 2007), (in accordance with result – 90 individuals of silver maple with no spots). Box elder (*Acer negundo* L.) was reported to host *R. americanum* (Healy, 2007). On the other hand, there are reports that on box elder *Rhytisma punctatum* (Pers.) Fr. parasitizes (Edmonds et al., 2000).

In our investigation symptoms were not observed on *Acer campestre* L. (field maple), however, it can also be a host of tar spot (Hsiang and Tian, 2007). According to Fungal Databases (Farr and Rossman, 2014) symptoms were registered in Denmark, Germany, Greece, Iran, Ukraine and United Kingdom. The Fungal Records Database of Britain and Ireland – hereafter FRDBI (Kirk and Cooper, 2014) also contains records about occurrence of symptoms. Out of total 71 individuals none of them was infected. This could be explained by a series of environmental interactions – altitude, temperature, precipitation, etc. On *Acer tataricum* subsp. *ginnala* (Maxim.) Wesm. (Amur maple) there were no stromata but Gilman and Watson (1993a) and Gillman (2011) reported that black spots and other leaf blisters on this maple species occurred. Fungal Databases (Farr and Rossman, 2014) confirmed its presence in Canada and China. On the other hand, FRDBI does not contain any information about organisms associated with this maple species.

Maple cultivars

Proportion of infected leaves by tar spot according to the individual taxa of *Acer* spp. was the highest on *Acer pseudoplatanus* (formerly known as *Acer pseudoplatanus* f. *purpureum*). *Acer pseudoplatanus* f. *purpureum* has been a form of sycamore which differs in leaf color of the reverse side (red-violet color) and it is located mainly in microlocalities of forest type. High infection rate was also found on *Acer pseudoplatanus* 'Atropurpureum' cultivar, probably due to interaction with the environment. These two maple taxa can be considered as the best indicators of air pollution (along with Norway and sycamore maples). The infection rate of the disease is influenced by microclimate and stress from the external environment as well as by tree genetic factors (Douglas, 2009).

Almost all cultivars of Norway maple are infected regularly by tar spot and by a variety of other leaf spots (Gilman and Watson, 1993b-k). In this research stromata were found on all the Norway maple cultivars except for *Acer platanoides* 'Drummondii'. Only 5 specimens of cultivar *Acer negundo* 'Variegatum' were investigated. We can assume that if there is no infection on the species *A. negundo,* then probably symptoms will not occur on its cultivar *A. negundo* 'Variegatum' either. However, the literature indicates (Gilman and Watson, 1993l), that the black spots on box elder were documented. Also Fungal Databases (Farr and Rossman, 2014) contain records of tar spot on box elder, but only from Canada. On the other hand, FRDBI (Kirk and Cooper, 2014) does not include any data about box elder infection. Regarding *A. negundo* 'Variegatum' similar cultivar – *A. negundo* 'Elegans' was observed with tar spot (Gilman and Watson, 1993m).

Acer palmatum 'Dissectum' was present in a number of only 3 specimens. Again, we can assume that if tar spot symptoms appear on none of *A. palmatum* individuals (Japanese maple), symptoms will not occur on its cultivar either. This is also cultivar primarily bred for high ornamental value, so it would be undesirable to obtain lower aesthetic quality due to black spots on leaves – nevertheless the occurrence it is not excluded – according to data in Fungal Databases (Farr and Rossman, 2014) symptoms were observed in Japan and Korea and according to FRDBI (Kirk and Cooper, 2014) 9 records of tar spot symptoms on Japanese maples exist. On the other hand, with proper care and maintenance, as it is a custom of most of gardeners, this condition is often avoided (Douglas, 2009).

Diameter at breast height (DBH)

Tar spot disease itself is not health threatening but sometimes the occurrence of numerous stromata makes the tree unsightly (Flynn, 1996, 1998; Gillman, 2011) and in some cases it can lead to the premature leaf drop (Healy, 2007). If premature defoliation happens several years in a row, it can lead to the stress and subsequently cause susceptibility to other problems. Infection has little or no effect on the growth of sycamore maples (Leith and Fowler, 1987). According to the most recent available study, the outbreak of the disease causes decline in Norway maple saplings and tree growth

(Lapointe and Brisson, 2011). In all studies previously mentioned the influence of infection on host growth was tested, but the host age influence on the occurrence of symptoms of fungal pathogen was not studied. The result of this work shows the correlation between trunk diameter and quantity of stromata. This was reflected in habitats close to the nature, where spontaneous spread of seeds happens. In urban areas, young individuals are deliberately planting and thanks to the urban greenery care there is not uncontrolled spread of seeds. This outcome could be influenced by the occurrence of older specimens in more polluted areas.

Air pollution

This research was conducted within an urbanized area and its neighborhood. The area of the city is characterized by its microclimate, the air is more heated up and drier because of the buildings and paved surfaces, it contains dust and microorganisms and also air pollutants due to the traffic (Tello at al., 2005; Juhásová et al., 2008; Gáperová, 2009; Wong and Chen, 2010). All these elements could affect occurrence of stromata. To compare results with urban and non urban areas the Protected Landscape Area was also included in the research.

Polluted air inhibits occurrence of tar spot (Vick and Bevan, 1976). Distribution of symptoms of *Rhytisma acerinum* is associated with amount of sulphur dioxide in the air, which is produced by burning fossil fuels (Vick and Bevan, 1976) as well as with amount of nitrogen dioxide in the air (Gosling et al., 2016). Tar spot is less frequent in urban and industrial areas (Weber and Webster, 2002). Tolerance limit of this fungus is approximately 90 μg m^{-3} SO_2 (Bevan and Greenhalgh, 1976) and about 20 μg m^{-3} NO_2 respectively (Gosling et al., 2016). Leith and Fowler (1987) found that the average annual concentration of 50 μg m^{-3} did not have any impact on occurrence of symptoms. Currently, the limit value for sulphur dioxide (to protect ecosystems and vegetation) is 20 μg m^{-3} (Chmi, 2014). In 2012 the air quality limits for SO_2 for 1 hour concentration and for 24-hour concentration were not exceeded at any measuring station (Chmi, 2014). Due to the lack of information about concentrations of SO_2 in various localities in Ostrava City and its surroundings, this factor could not be statistically evaluated. The highest average annual concentration recorded in 2012 was 9.3 μg m^{-3} – in the city district Ostrava-Jih (Chmi, 2014). Therefore, we can assume that the occurrence of fungal disease is influenced by other factors, not only by the amount of SO_2.

Another problem related to the air quality in Ostrava City is high dust level (Gacka, 2014). The result of analysis regarding the effect of PM_{10} implies that its presence reduces occurrence of black spots on maple leaves. Solid emissions (such as PM_{10}) have a negative effect on plants (Rai and Kulshreshtha, 2006). It may cause clogging of stomata, reduction of photosynthesis, respiration and transpiration. So we can conclude that there may be blockage of stomata preventing penetration of ascospores into epidermal cells of the leaf, thereby halting the initial infection. Inhibition of transpiration and thus a reduction of moisture on the leaf blade may also cause lower chances of infection.

Another factor influencing amount of tar spot in such a characteristic urban environment could be a soil contamination. High content of nitrogen and sulfur (SO_x and NO_x) and heavy metals affect its occurrence. In areas with a low content of these elements in the soil, the high infestation of black spots was recorded (Kosiba, 2007).

Conclusions

By studying over 1,200 individuals of *Acer* spp. it was found that there are significant differences in occurrence of symptoms of tar spot in its number dependent on both, site and host species. Out of 18 different taxa the symptoms were recorded on a half of them. The most susceptible taxa to tar spot (*Acer pseudoplatanus*, *A. pseudoplatanus* 'Atropurpureum', *A. platanoides* 'Cleveland', *A. platanoides* 'Globosum') can be the best candidates for monitoring air pollution (especially in urban areas). The highest frequency of stromata was observed in the Protected Landscape Area and generally in non-urban areas (typically less polluted). Thus we can state that *Rhytisma acerinum* prefers areas with a lower degree of air pollution. Moreover, our analysis provides evidence that trees with lower diameter of trunk suffered from higher infestation of tar spot. Further research focused on alternative environmental factors in urban area (such as soil contamination by chemicals, etc.) affecting occurrence of tar spot should be conducted. It would be appropriate to make further observations and analysis of the impact of hosts ontogeny on the occurrence of symptoms.

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