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The fluctuations of airborne fungal components in western Romania

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Abstract: Outdoor regional concentrations of airborne fungal spores and fungal fragments were measured using the 7-day Lanzoni sampler. The daily and intradiurnal fluctuations recorded during the monitored period have been studied. The multiple regression analysis was performed in order to determine how much of the total variance in these concentrations could be explained by meteorological parameters. Daytime periodicity (statistically significant) was established only in a few cases. As the relative importance of the weather factors varied, they could not be ranked according to their effect.

Key words: Airborne fungal components, anamorphs, *Cladosporium,* Romania

1. Introduction

Over the past decades, attention to air pollution, occasioned not only by physical and chemical pollutants but also by fungal spores and pollen grains, has increased. Airborne fungal spores are considered an indicator of the level of atmospheric bio-pollution. Some spore types are of clinical importance due to the fact that they are considered allergenic (Ianovici, 2016a) A wide range of airborne fungi can inflict considerable agricultural losses worldwide as they act as plant pathogens (Rodriguez-Rajo et al., 2005).

In Romania, studies on airborne fungi are extremely scarce. These studies have been conducted only in a few cities such as Timisoara, Brasov, Bucharest, Craiova, and Cluj-Napoca (Ianovici et al., 2013). A limited number of investigations in order to determine the presence of allergenic fungi and to evaluate their seasonal variations have been carried out in Timisoara (Ianovici and Tudorică, 2009). As far as western Romania is concerned, it is well-known that the number of airborne fungal spores is maximal during summer. Many fungal spore types were recorded in Timisoara, with *Cladosporium* being the most prevalent fungal spore type during summer. Other major spore types were also quantified and classified: *Alternaria, Fusarium/Leptosphaeria* group, *Helminthosporium*, and airborne fungal fragments (Ianovici, 2017).

It is well-known that meteorological factors influence the day-to-day variability as well as the seasonal levels of airborne fungal spore concentrations and the composition of spores in the air. Meteorological parameters are known to influence their production, maturation, release, dispersal, and deposition (Grinn-Gofroń and Strzelczak, 2011). A few studies were based on the multiple regression model (Katial et al., 1997; Angulo-Romero et al., 1999; Mitakakis et al., 2001; Troutt and Levetin, 2001; Stennett and Beggs, 2004; Grinn-Gofroń, 2008; Dawidziuk et al., 2012; Kallawicha et al., 2017). The objective of the present study was to establish, by regression results, the most feasible predictor variables for fungal spore types commonly found in our urban area during the warm season (mid-summer, July). Another goal of my study was to determine the daily and intradiurnal fungal concentrations in the city of Timisoara.

2. Materials and methods

The volumetric spore trap was located on a rooftop of the West University building, in the centre of the city, about 20 m above the ground level. The surrounding vegetation is dense and consists mainly of ornamental plants, shrubs, and trees. The sampler was calibrated to aspirate an air flow of 10 l/min. The drum rotated past the orifice at a speed of 2 mm/h. The tape was removed on a weekly basis and dissected for microscopic examination. The fungal spores were counted with ×400 magnification. Estimated fungal spore values were transformed into the number of spores in each m^3 of air trapped per day. Daily mean concentrations reflect the number of spores found during the day. All spore concentrations were recorded in 2-h intervals in order to enhance the understanding of diurnal fluctuations. The value for each 2-h span was calculated by dividing the sum of the values of each 2-h span by the number of days when

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airspores were investigated (2-h running mean). Results were checked for normality using the Shapiro–Wilk test. The Kruskal–Wallis test or one-way ANOVA (when the data showed normal distribution) were applied in order to compare the spore concentrations between 2-h running means. Provided that the distributions were not normal, the nonparametric test was applied.

Meteorological data were obtained from the National Meteorological Administration. A total of 11 weather factors were selected for this study: precipitation quantities in L m^{-2}; near-surface soil temperature expressed in °C; daily mean temperature expressed in °C; minimum temperature (°C); maximum temperature (°C); relative humidity in %; mean wind speed expressed in m s^{-1}; daily maximum wind speed expressed in m s^{-1}, atmospheric pressure in millibars; nebulosity in tenths; sunshine hours in h.

Representative of the summer season, July is the warmest month of the year as the air temperature is higher than in June, while the degree of instability lower. According to the data recorded between 1961 and 2018 at the weather stations within the National Meteorological Administration network, the multiannual monthly average temperature exceeds 22 °C. In popular tradition, July is regarded as the month of "oven". In the west of the country, the nights last between 10 PM and 6 AM (approximately 8 h 20 min–8 h 45 min).

Multiple linear regression is a commonly used method in environmental sciences. The aim was to provide information about the types of meteorological parameters that might be controlling the dispersion of each spore type. Weather conditions (independent variables) influence airborne fungal spore concentrations (dependent variables). Multiple linear regression was performed in order to identify the variables likely to influence the dynamics of the airborne spore and fungal fragments on the same day (SD) and the day prior (previous day-PD) to the spore sampling. Values were computed by the programs SPSS, PAST, and the Excel application of the Microsoft Office 2003 package.

3. Results

3.1. Daily concentrations of airborne fungal components

Five basidiospore types, 1 oospores type, and 35 ascospore types were recorded in the outdoor air. Other fungal spore types that were observed in air samples included the anamorphs (44 genera). Besides fungal spores, other bioparticles (pollen grains, fragments of insects, plant parts) were also recorded (Ianovici et al., 2015). Spores were mostly identified on a generic level. We use the term "type" to include different taxa whose spores are, morphologically speaking, very similar when using an optic microscope (Ianovici, 2016b). For example, *Drechslera* and *Exserohilum* were considered as belonging to the *Drechslera* type. Another example is the *Fusarium/Leptosphaeria* type who included spores of *Melanomma* and *Phaeosphaeria.* Xylariaceae were recorded as 1 pooled type. It is impossible for airborne fungal fragments (broken hyphae and conidiophores) to be taxonomically identified. The spores in *Aspergillus* and *Penicillium* genera are very similar morphologically and are, therefore, grouped together as they cannot be distinguished (Ianovici and Tudorică, 2009). This type was not included in the total concentration of fungi.

During the research period, the 25 airborne fungal components (major and minor spore types, airborne fungal fragments) and daily total fungal components were subjected to analyses (Figure 1). Asexual structures are called anamorphs, while sexual structures are commonly known as teleomorphs. The anamorph (or conidial fungi) concentration obtained during the research process was 47360.3 AFS/m^3 (Figure 1). Teleomorphs fungi were more infrequently identified (1395.7 AFS/m^3). *Cladosporium* constitutes 88.057% of the airborne anamorph load (Table 1).

3.2. Intradiurnal concentrations of airborne fungal components

Concentrations of the fungal spores changed in the atmosphere over the course of 24 h. Daytime periodicity (statistically significant) could be established only in 7 cases (Figure 2). Solely the airborne spore release observed in 3 types (airborne fungal fragments, *Paraphaeosphaeria*, and *Pleospora*) was concentrated in a definite period. In the case of *Polythrincium* spores, the curve was bimodal. The rest of curves (*Capronia, Fusarium/Leptosphaeria* type, Xylariaceae type) were almost multimodal, i.e. they had many peaks. The presence of fungal components in the atmosphere during 24 h can be described as follows: in the morning 13.87%, at noon 18.17%, in the afternoon 19.52%, in the evening 16.91%, in the first half of the night 16.6%, in the second half of the night 14.91%. The maximum concentration observed between 2 PM and 4

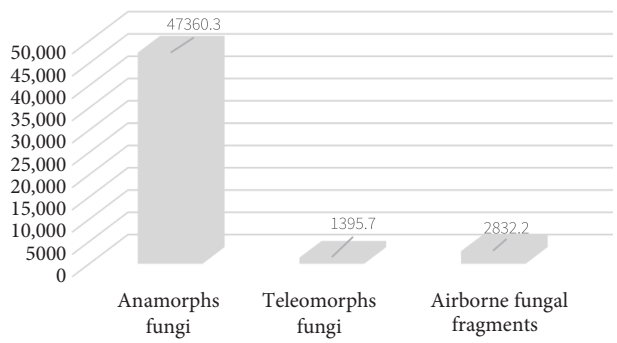

Figure 1. Total airborne fungal components.

Table 1. Percentage (%) of the captured airborne fungal spore types from Timisoara.

Anamorphs fungi		Teleomorphs fungi	
Alternaria	2.713665	*Ascobolus*	4.628502
Bipolaris	0.050253	*Caloplaca*	4.019488
Cladosporium	88.05772	*Capronia*	14.25091
Diplodia	0.100506	*Diatrype*	1.461632
Drechslera	0.104096	*Paraphaeosphaeria*	11.08404
Epicoccum	0.466636	*Pleospora*	8.038977
Fusarium/Leptosphaeria type	4.616103	*Peronospora*	15.71255
Helminthosporium	2.699307	*Tilletia*	5.724726
Nigrospora	0.168707	Xylariaceae type	27.52741
Pithomyces	0.07538	Other sporadic fungi	7.551766
Polythrincium	0.089738		
Pseudocercospora	0.139991		
Sporidesmium	0.043074		
Stemphylium	0.161528		
Torula	0.229728		
Other sporadic fungi	0.283571		

PM is directly associated with the concentration of airborne spores of *Cladosporium.*

3.3. Multiple linear regression analysis of airborne concentrations of fungal components according to meteorological factors

In Table 2, the multiple linear regression analysis for atmospheric fungal components can be depicted. The most important factors statistically and significantly different from 0 varied according to each type. Unstandardized coefficients indicate how much the concentrations of airborne fungal spores (dependent variable) vary with an independent variable when the remaining independent variables are held constant. Differences in the dependences between fungal spore levels and meteorological parameters can be observed for both days (the same day and the day before the sampling).

The impact of relative humidity on airborne spore concentrations may be simultaneously positive (Xylariaceae) and negative (airborne fungal fragments). Precipitation quantities were strongly associated with *Pleospora* and *Pseudocercospora*. The occurrence of spores of *Polythrincium, Fusarium/Leptosphaeria* type and *Sporidesmium* was significantly associated with the lowest near-surface soil temperature values. Other statistically significant variables could be mentioned during the same day: average wind speed (for airborne fungal fragments, *Parapheospheria* and *Ascobolus),* minimum temperature (for *Pithomyces)*, and sunshine (for *Polythrincium).*

Multiple regression analyses consisting of average temperature + maximum temperature during the same day explained the variability in *Cladosporium* spore concentrations. With every additional degree to the average temperature, an increase in the spore concentrations with 1165 AFS m^{-3} occurs. On the other hand, with every additional degree to the maximum temperature, a decrease in *Cladosporium* spore concentrations with 507 AFS m^{-3} occurs on the same day. Sporulation conditions for spores, particularly for *Cladosporium,* seem to be optimized by temperatures exceeding 30 °C when combined with an adequate level of relative humidity (between 60%–65%). These factors proved to influence to a certain extent the daily total spore dispersion on the same day.

The meteorological parameters affect spore concentrations differently. Only one meteorological variable had a statistically significant impact on the total variance of the occurrence of *Epicoccum, Capronia*, and *Nigrospora* spores on the day prior to the sampling process. The coefficients of determination with meteorological factors fall sharply when considering the previous day in which airborne spores were recorded (except for Xylariaceae*, Epicoccum, Torula, Nigrospora, Tilletia, Stemphylium)*. Multiple linear regression analysis indicated that (in Table 3) the wind speed recorded 1-day prior was a more important variable than the wind speed on the same day for *Fusarium/Leptosphaeria* type, *Capronia, Parapheospheria*, and *Pleospora*. In these cases, maximum wind speed favoured increased levels of airborne spores. Wind upholds spore release in different ways. Maximum wind speeds proved to be more important than the average

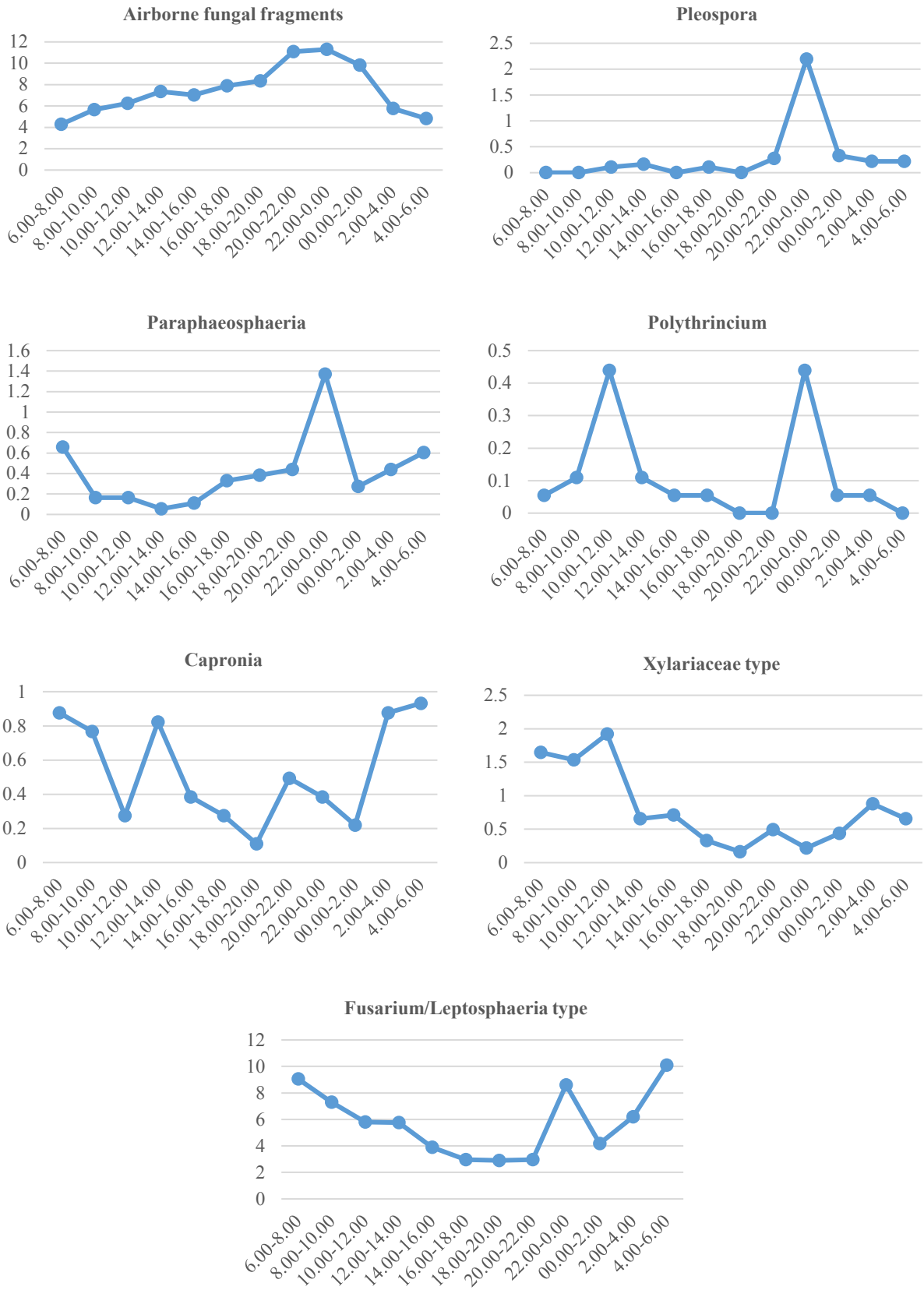

Figure 2. Intradiurnal patterns with significantly different time intervals.

Table 2. Intradiurnal patterns of airborne fungal components. Expressions in bold indicate statistically significant differences: *P ≤ 0.05-statistically significant differences; **P ≤ 0.01- statistically more significant differences; ***P ≤ 0.001- statistically high significant differences; ****P ≤ 0.0001- statistically very high significant differences; ns- without significant differences.

Anamorphs fungi	Day time								Night time				H – one-way ANOVA	Chi 2 - ruskal–Wallis test
	6.00–8.00	8.00–10.00	10.00–12.00	12.00–14.00	14.00–16.00	16.00–18.00	18.00–20.00	20.00–22.00	22.00–0.00	00.00–2.00	2.00–4.00	4.00–6.00		
Alternaria	1.8645	2.5225	2.19354	3.0709	4.7709	4.3322	3.7290	3.6741	4.1677	3.9483	4.0032	2.7967	1.468 ns	
Cladosporium	84.9451	88.3451	97.06451	146.4194	145.4323	120.8645	104.5226	121.7968	106.1129	99.6967	97.887	90.1	1.29 ns	
Fusarium/ Leptosphaeria type	9.0483	7.2935	5.8129	5.7580	3.8935	2.9612	2.9064	2.9612	8.6096	4.1677	6.1967	10.0903	**2.392*****	
Helminthosporium	1.8645	3.3451	4.1129	3.0161	3.6193	3.6193	4.5516	2.9612	4.3870	2.7967	2.7967	2.3580	1.071 ns	
Bipolaris	0.2741	0	0	0.0548	0.0548	0.0548	0	0.1096	0.0548	0.0548	0	0.1096	no variance	0.9725 ns
Diplodia	0.54838	0.0548	0.16451	0.1645	0.1096	0.0548	0.1645	0.0548	0	0	0	0.2193	no variance	0.8702 ns
Drechslera	0	0.1096	0.10967	0.3290	0.1096	0	0.2193	0.1096	0.2193	0.0548	0.2193	0.1096	no variance	2.791 ns
Epicoccum	0.2193	0.3838	0.38387	0.8225	0.7677	0.7677	0.8225	0.3290	0.4935	0.3290	0.9870	0.4935	1.209 ns	
Nigrospora	0.2741	0.1645	0.21935	0.2193	0.3290	0.3838	0.1645	0	0	0.2193	0.1645	0.4387	no variance	5.058 ns
Pithomyces	0.0548	0.1645	0.10967	0.0548	0.0548	0.0548	0	0.3290	0.0548	0.0548	0.1645	0.0548	no variance	0.881 ns
Polythrincium	0.0548	0.1096	0.43871	0.1096	0.0548	0.0548	0	0	0.4387	0.0548	0.0548	0	no variance	**8.628******
Pseudocercospora	0.2193	0.1645	0.10967	0.1096	0.1096	0.0548	0.0548	0.1096	0.1096	0.4387	0.2741	0.3838	0.8657 ns	
Sporidesmium	0	0.0548	0.1096	0.0548	0.1096	0	0.05483	0.0548	0	0.1096	0.1096	0	no variance	0.6645 ns
Stemphylium	0.1645	0.2741	0.1645	0.2741	0.1096	0.1645	0.1645	0.1645	0.10967	0.1645	0.3838	0.2741	0.62 ns	
Torula	0.1096	0.1645	0.1096	0.1096	0.1096	0.1645	0.8225	0.7677	0.60322	0.0548	0.0548	0.3838	1.138 ns	
Teleomorphs fungi														
Xylariaceae type	1.6451	1.5354	1.9193	0.6580	0.7129	0.3290	0.1645	0.4935	0.21935	0.4387	0.8774	0.6580	**4.726******	
Ascobolus	0.0548	0.1645	0.0548	0.1096	0.2193	0.4387	0.2193	0.0548	0.49354	0.1645	0.0548	0.0548	0.9067 ns	
Caloplaca	0.1096	0.1645	0.1645	0	0.2193	0.0548	0	0.1645	0.43871	0.1096	0	0.3838	no variance	1.436 ns
Capronia	0.8774	0.7677	0.2741	0.8225	0.3838	0.2741	0.1096	0.4935	0.38387	0.2193	0.8774	0.9322	**2.106***	
Diatrype	0.0548	0	0.0548	0.0548	0.4935	0	0	0	0	0	0	0	no variance	0.4761 ns
Paraphaeosphaeria	0.6580	0.1645	0.1645	0.0548	0.1096	0.3290	0.3838	0.4387	1.37096	0.2741	0.4387	0.6032	**1.887***	
Pleospora	0	0	0.1096	0.1645	0	0.1096	0	0.2741	2.19354	0.3290	0.2193	0.2193	no variance	**4.549***
Tilletia	0.2741	0	0.2741	0.2741	0.2193	0.1645	0.2741	0.3838	0.38387	0.1645	0.1096	0.0548	no variance	3.39 ns
Peronospora	0.8225	1.1516	0.1645	0.5483	0.4387	0.4935	0.3290	0.6032	0.60322	0.3838	0.6580	0.4935	0.9841 ns	
Airborne fungal fragments	4.2774	5.6483	6.2516	7.3483	7.0193	7.8967	8.3354	11.0774	11.29677	9.8161	5.7580	4.8258	**1.849***	
Total fungal components	109.6774	114.5581	121.9613	171.8097	170.6581	144.9387	129.6387	143.7871	143.5129	124.9774	123.2774	117.7935	1.267 ns	

Table 3. Multiple regression variable result.

Airborne fungal components	Environmental factors on the same day (SD)		Environmental factors on the previous day (PD)	
	Regression variable result - proportion of variance explained	The significant explanatory variables (unstandardized coefficients B)	Regression variable result - proportion of variance explained	The significant explanatory variables (unstandardized coefficients B)
Fusarium/Leptosphaeria type	69.3%	near-surface soil temperature (–14.923)	53%	daily average wind speed (–76.688) daily max. wind speed (55.616)
Xylariaceae type	57.1%	daily mean temperature (7.591) daily average relative humidity (1.037)	67%	daily mean temperature (7.460) maximum temperature (–3.431) daily average relative humidity (1.198)
Pleospora	54.3%	quantities of precipitations (1.649)	41%	daily average wind speed (–3.518) daily max. wind speed (10.341)
Parapheospheria	54.8%	daily average wind speed (–9.446)	52.6%	daily average wind speed (–8.639) daily max. wind speed (6.924)
airborne fungal fragments	65.1%	daily average relative humidity (–5.851) daily average wind speed (83.132)	39.9%	-
Polythrincium	64.6%	sunshine hours (0.435) near-surface soil temperature (–0.611)	40.1%	-
Pseudocercospora	64.5%	quantities of precipitations (0.779)	48.7%	-
daily total spores	56.9%	daily mean temperature (1192.03) maximum temperature (–504.992)	41.3%	-
Cladosporium	56.3%	daily mean temperature (1165.03) maximum temperature (–507.280)	40.6%	-
Pithomyces	56.2%	minimum temperature (0.742)	31.5%	-
Ascobolus	51%	daily average wind speed (6.891)	45.5%	-
Sporidesmium	46.1%	near-surface soil temperature (–0.508)	26.5%	-
Capronia	64.9 %	-	62.8%	daily max. wind speed (6.032)
Nigrospora	39.6%	-	51.3%	quantities of precipitations (0.485)
Epicoccum	33.8%	-	35.5%	daily average relative humidity (0.605)
Tilletia	24.9%	-	47.1%	daily mean temperature (–3.005) sunshine hours (0.910)
Alternaria	39.3%	-	27.7%	-
Helminthosporium	43%	-	27.4%	-
Peronospora	42.3%	-	22.9%	-
Torula	23.4%	-	41.9%	-
Oidium	37.9%	-	27.4%	-
Stemphylium	22%	-	25.7%	-
Caloplaca	33.3%	-	26%	-
Drechslera	34.5%	-	23.6%	-
Diplodia	24.3%	-	21.9%	-
Bipolaris	26.6%	-	18.1%	-
Diatrype	26.3%	-	24.1%	-

wind speeds on the previous day. The other statistically significant variables impacted spore composition differently in the day before sampling: relative humidity explained a part of the total variance in the occurrence of Xylariaceae and *Epicoccum,* average temperature for Xylariaceae and *Tilletia,* precipitations for *Nigrospora,* sunshine hours for *Tilletia*, and maximum temperature for Xylariaceae.

4. Discussions

During the research process, the following airborne fungal components were analysed: 15 anamorphs, 9 teleomorphs and airborne fungal fragments. Anamorphic fungi dominate the spectrum of airborne fungal spores.

A substantial number of analyses of the occurrence of mycoflora in outdoor environment in different regions of the world clearly indicate the *Cladosporium* dominance in comparison with other fungal spores (Akgül et al, 2016; Damialis et al., 2015). In western Romania, the highest concentrations were usually recorded in July, when temperatures were high and rainfall was optimum for fungal growth and sporulation (Ianovici, 2016). This relationship is clearly visible in this study. Data analysis revealed the fact that daily mean temperature was the most important meteorological parameter positively affecting *Cladosporium* spore concentrations in the air (Kasprzyk et al., 2016). A decrease in spore concentration was related to increasing maximum temperature. *Cladosporium* concentrations were significantly higher between 12 PM and 4 PM. In other studies, variable diurnal trends have been observed for *Cladosporium* spore concentrations, but such variability may be explained by the existent differences in the climate and biogeographical characteristics of the areas under scrutiny. However, these spores are recognized as being dry. The dynamics of *Cladosporium* spore concentration determines the dynamics of the total fungal components on a 24-h span.

Polythrincium illustrated a distinct intradiurnal pattern, in which hourly spore concentrations had been changing gradually, achieving a greater representation during the central hours of the day and at night (10 PM–12 AM). As observed, the largest amount of the total variance in the *Polythrincium* spore was explained by the sunshine hours. Negative impact of the near-surface soil temperature was observed in the daily data set for *Polythrincium* spores.

Our analyses showed that fungal spore concentrations had varied during day and night. The total fungal components in the atmosphere for 24 h are similarly distributed. Diurnal fluctuations in spore concentrations are less likely to be explained by meteorological parameters compared to the overall daily sum of spores in the air (Grinn-Gofroń et al., 2018).

Multiple regression analysis was subsequently performed in order to determine how much of the total variance in these daily concentrations of atmospheric fungal spores could be explained by meteorological parameters. The aim was to give information about the types of factors that might be controlling the dispersion of airborne spore concentrations. High concentrations of spores of *Fusarium/Leptosphaeria* type were influenced by many factors: the near-surface soil temperature recorded on the same day, the average wind speed and maximum wind speed on the day prior to the appearance of fungal spores. The ascospores of the Xylariaceae type were influenced by the average temperature and relative humidity recorded on the same day, the average temperature, maximum temperature, and relative humidity in the day prior to the appearance of fungal spores. The major explanatory variables for *Pleospora* concentrations were precipitations on the same day and wind speed on the day before sampling. Other airborne spores, such as *Alternaria*, *Helminthosporium, Peronospora*, *Torula*, *Oidium*, *Stemphylium*, *Caloplaca, Drechslera*, *Diplodia*, *Pithomyces*, *Bipolaris*, and *Diatrype*, did not have any statistically significant relationships with environmental factors. However, the percentage of explained variance is fair.

In the present work, no significant associations were found between nebulosity and the fungal spore concentrations. However, cloudy weather with high relative humidity may cause clumping of vegetative cells and consequently increasing their survival in the air (Zhu et al., 2003).

In some studies, the percentage of explained variance increases considerably when the concentration of spores from the previous day is included in the model. It may be considered that this variable reflects the conditions on which the concentration of spores in the air depends, both for their formation, release, and transport (Ceter and Pinar, 2009; Farah et al., 2017). A multiple regression between atmospheric fungal spore concentrations and independent variables (meteorological parameters from the previous day and the same day) was made relying on the data obtained during July. The values for the coefficient of determination indicate a significant level of prediction. The effects of meteorological factors varied throughout the days when analyses were performed employing the multiple linear regression method. We believe that it is important not to exclusively consider the meteorological variables recorded on the sampling day.

Various environmental factors have been shown to favour sporulation, including temperatures, wind, sunshine, relative humidity and rainfall with a day prior to spore dissemination. In our analysis, the values of the near-surface soil temperature were significantly

higher than those of the maximum, mean and minimum temperature recorded during the same day. The strongest association was generally found with the temperatures of the same day. The optimal conditions for some airborne spore concentrations were wind strongly associated with mean temperatures on the previous day, favouring the maturing and release of these spore types.

The concentration of fungal spores in the air strongly depends on the abundance of their formation during the studied period. This in turn relates to geobotanical region, degree of urbanization, climatic conditions, season, current weather, wind force and direction, local microclimate, and many other factors. It is documented that the season of occurrence of airborne fungal spores is related to the phenology of vegetation (Ianovici, 2017). Nutrient resources may shoe seasonal variation, since they are linked to plant growth cycles. Soil surface temperature has critical influence on climate, agricultural and hydrological activities since it serves as a good indicator of the energy budget of the earth's surface (Gow et al., 2010). Soil and near-ground air temperatures are powerful "bio-controllers". In temperate climates, the transition from the nongrowing to the growing season occurs when temperature rises above a threshold or "base temperature". Temperature drives chemical and biological processes, leading to the Q10. Biological "clock" which determines the developmental stages of a plant or a fungus are run not by time alone but by time multiplied by temperature (Gliński et al., 2011). Temperature and humidity profiles can vary markedly both seasonally and over short timescales. For example, on a day with nebulosity, temperatures near the surface can be highly dynamic (Gow et al., 2010).

Our results are comparable to those obtained in other monitoring locations located in central and eastern Europe (Croatia, Ukraine, Poland) (Kasprzyk et al., 2015; Peternel et al., 2004; Grinn-Gofron, 2019). However, across temporal and spatial dimensions, microclimate has a stronger influence and is an important indicator of spore concentration rather than vegetation type (Ianovici et al., 2013; Grinn-Gofroń et al., 2019).

Most of the spores do not travel very long distances. We assume that our data represent the "escaped fraction" (10% of all released fungal spores that are transported farther than 100 m) (Sesartic and Dallafior, 2011). On the other hand, rooftop sampling has been shown to underestimate the concentration of some fungal spores. As the volumetric method reflects only a portion of airborne fungi, the concentrations in Timisoara's air might be richer than those illustrated by our results.

5. Conclusions

This study has made an important contribution to the measurement of the levels and types of airborne fungal spores in Romania. This paper shows the results obtained for western Romania. The multiple regression method was employed in order to understand the impact of meteorological variables on atmospheric fungal components. The concentrations of airborne fungal spores occasionally depend on the weather conditions of both the sampling day and the day before. The intradiurnal concentrations found in Timisoara have not been studied until now. The diurnal patterns of airborne fungal spores in each region must be known in order to take better health actions for people that are sensitive to them.

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