

NEAR-GROUND VARIABILITY OF AIRBORNE FUNGAL SPORES IN A RESIDENTIAL GARDEN SITE: SHORT-TERM DYNAMICS

VARIABILITA HUBOVÝCH SPÓR V PRÍZEMNEJ VRSTVE ATMOSFÉRY V RÁMCI REZIDENČNEJ ZÁHRADY: KRÁTKODOBÁ DYNAMIKA

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Abstract

Airborne fungal spores are abundant and highly variable components of bioaerosols, yet their composition and dynamics near the ground surface in specific environments remain broadly unexplored. A short-term survey was conducted in a small residential garden site in northwestern Slovakia, where airborne fungal spores were collected using a personal volumetric air sampler over 2-hour afternoon sampling periods in July 2025. The aims were to characterise spore diversity and abundance in a heterogeneous residential garden and to evaluate the representation of spore types differing in trophic strategy and release mechanism. Total spore concentrations ranged from 3 572 to 11 499 spores/m³, and 59 spore types were recorded, including crop pathogens, saprotrophs, wood-decay fungi, and common aeroallergens. Dry-release spore types dominated all sampling periods, primarily due to the high abundance of *Cladosporium*, while wet-release types showed pronounced short-term peaks associated with *Coprinus* type and *Leptosphaeria* type. Despite temporal fluctuations in individual spore types, the overall assemblage remained broadly similar across sampling periods, indicating persistent local sources such as crop canopy, soil, surrounding vegetation, and nearby forest. Generalized linear mixed-effects models indicated that spore abundance was strongly structured by differences among fungal taxa, whereas trophic and release strategies did not significantly affect abundance. These findings demonstrate that even a small residential garden site may contribute substantially to local airborne spore levels and illustrate the value of near-ground aerobiological observations for understanding potential fine-scale fungal dynamics in urban-fringe environments.

Keywords: aeromycobiome; crop pathogens; allergenic fungi; near-ground sampling

Introduction

Fungal spores are ubiquitous components of outdoor bioaerosols and constitute a major fraction of airborne biological particles in most environments (Fröhlich-Nowoisky et al. 2009, Martínez-Bracero et al. 2022). Their atmospheric concentrations frequently exceed those of pollen grains and they may remain suspended in the air for extended periods (Ščevková et al. 2023). Many fungal taxa include species that are pathogenic to plants or allergenic to humans. Deposition of spores on susceptible host tissues may

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initiate plant disease, while inhalation by sensitised individuals can trigger allergic responses.

Routine aerobiological monitoring is generally conducted at elevated height on the rooftops of buildings following standardised methodology (Galán et al. 2014). These approaches provide an averaged representation of airborne bioparticles over areas spanning several kilometres around the sampler and offer a good approximation of spore concentrations at a regional scale. However, many fungal spores are deposited within approximately 100 m of their source, while only about 10% are dispersed over longer distances (Sesartic and Dallafior 2011). Larger or less aerodynamic spores are less likely to reach higher atmospheric layers and may therefore remain undetected in routine rooftop monitoring. Moreover, local microclimatic conditions and vegetation structure may influence fungal spore composition, even though fungal diversity is generally much more variable in soil than in the air (Abrego et al. 2020). Thus, near-ground monitoring in specific environments is important, because it covers smaller spatial scales, more detailed local patterns and potentially greater diversity than rooftop approaches. Previous studies have shown that even small differences in sampling height near the ground (e.g., 1.0 vs 1.5 m) may significantly influence the presence and abundance of airborne bioparticles (Ščevková et al. 2025). However, such approaches are more labour-intensive and require substantial time in the field. They also usually cover only short sampling periods and are not fully comparable with standard rooftop measurements. Consequently, relatively few studies have focused on near-ground aerobiological monitoring.

Many common airborne genera contain species that can act as saprotrophs, but also as crop pathogens or opportunistic human pathogens, including *Alternaria* and *Fusarium* (Lawrence et al. 2015, van Diepeningen and de Hoog 2016). Their release, dispersal, and atmospheric abundance are strongly influenced by meteorological conditions and the availability of local sources (Li and Kendrick 1995). Spore diversity and trophic structure reflect vegetation variability, phenology and the presence of decaying organic substrates, while concentrations are driven by temperature, relative humidity and precipitation (Tomassetti et al. 2009; Grinn-Gofroń et al. 2018). Warm and dry conditions generally favour passively liberated spores, characteristic of genera such as *Alternaria*, *Cladosporium* and *Drechslera* (Ianovici 2016; Grinn-Gofroń et al. 2018), while precipitation and high humidity promote the liberation of moisture-dependent or actively discharged spores, including *Leptosphaeria*, *Fusarium* and many Basidiomycota (Elbert et al. 2007; Antón et al. 2019).

Residential gardens represent a largely overlooked source environment for near-ground airborne fungal spores. Their heterogeneous vegetation structure, combination of managed and unmanaged surfaces, proximity to soil and decaying organic matter, and frequent human presence make them potentially important sites for local spore production and exposure. Despite their prevalence in urban and peri-urban landscapes, dedicated aerobiological studies in such environments remain scarce.

In this study, short-term variation in airborne fungal spore concentrations, taxonomic composition, and functional structure was examined using near-ground sampling in a small residential garden with heterogeneous vegetation and diverse management practices in northwestern Slovakia. Specifically, the study aimed to: (i) characterise the diversity and abundance of airborne fungal spore types; (ii) assess the representation of spore types differing in trophic strategy and release mechanism; and (iii) evaluate short-

term temporal dynamics in spore assemblage composition. The study contributes to understanding fine-scale fungal dynamics in residential environments and the relevance of near-ground observations for plant health and allergen exposure assessment.

Materials and Methods

Study area

The study was carried out in July 2025 in a small residential garden (49.22853°N, 18.78716°E; 345 m a.s.l.) located within the built-up area of Teplička nad Váhom in northwestern Slovakia (Figure 1A–B). The site is situated on flat terrain and consists of a crop field in the western part and a lawn with fruit trees in the eastern section. A lightly trafficked road was located approximately 5 m west of the crop field, whereas the lawn bordered neighbouring residential gardens. The mixed forest began approximately 60 m north of the site. During the sampling period, the crop field was managed under small-scale crop rotation and irrigated daily. Potatoes were the dominant crop, accompanied by garlic and other vegetables. No pesticide or fungicide treatments were applied before or during sampling, and the lawn was not mown throughout the study period.

The study area lies within the temperate continental climatic zone of Central Europe, characterised by warm summers and cold winters. Mean annual air temperature was 9.8 °C. August was the warmest month, with a mean temperature of 20.1 °C, whereas January was the coldest, averaging –1.3 °C. Mean annual precipitation was 728 mm, with the highest monthly total occurring in August (92.7 mm) and the lowest in March (32.7 mm). Climatic data were obtained from Meteomanz.com for the period 2015–2025 from the Žilina–Hričov meteorological station, located approximately 12.5 km west of the study site.

Air temperature during sampling periods was recorded in 30-min intervals using online data provided by the Slovak Hydrometeorological Institute (SHMÚ.sk) for the Žilina meteorological station. The mean temperatures during samplings were 20 °C on 18 July, 24.8 °C on 19 July, 29.1 °C on 21 July and 24.9 °C on 22 July.

Aerobiological sampling

Four two-hour sampling periods were conducted on 18, 19, 21 and 22 July 2025, between 16:00 and 18:00, to coincide with expected late-afternoon peaks in spore concentrations. Sampling was conducted only under dry conditions, without interruption by rainfall or garden maintenance activities. Airborne particles were collected using a personal volumetric air sampler (Burkard Manufacturing Co. Ltd; hereafter ‘sampler’) positioned within the eastern part of the crop field at 1.25 m above ground level (canopy height ~0.75 m) (Fig. 1D–E). Air was drawn at a flow rate of 10 L/min through a 2 × 14 mm orifice and impacted onto a microscope slide coated with an adhesive medium (petroleum jelly). After sampling, slides were mounted in glycerine–gelatine stained with basic fuchsin and examined at ×400 magnification using a light microscope (Motic B1-252SP). Fungal spores were identified to genus or spore type based on morphology using standard manuals and atlases (Grant Smith 2000; Lacey and West 2006; Li et al. 2023). Spore concentrations were expressed as the number of spores per cubic metre of air (spores/m³) for each 2-hour sampling interval.

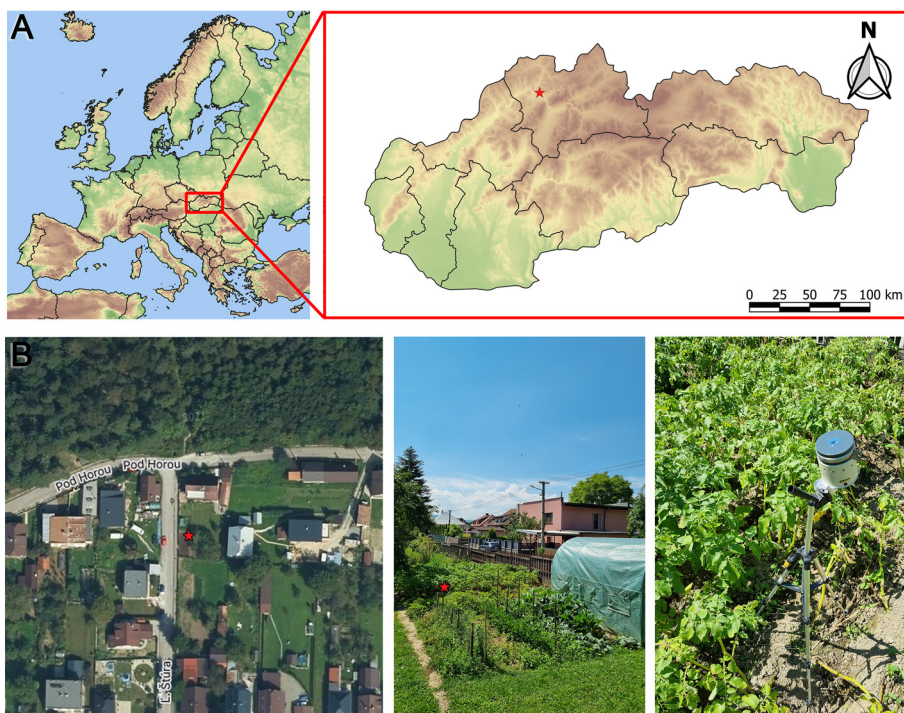


Fig. 1. Location of the sampling site and sampler (red stars) in Teplička nad Váhom, Slovakia: (A) position within Europe, and location within Slovakia on maps with terrain height; (B) overview of the garden and field with close-up of the sampler in the crop field.

Division of spore types by trophic strategy and release type

Fungal spore types were assigned to trophic strategies using the FungalTraits database (fungaltraits R package) with trait information extracted at the genus level and based primarily on FUNGuild classifications (Nguyen et al. 2016). Where multiple trophic strategies were reported for a genus, spore types were classified as having a mixed trophic strategy (MIX); spore types with a clearly prevailing strategy were assigned to pathotrophic, saprotrophic, or symbiotic trophic strategies. Spore types lacking sufficient ecological information were treated separately, together with other non-fungal groups (e.g., oomycetes).

Spore types were also grouped by predominant release conditions based on published aerobiological literature (Tomassetti et al. 2009; Ianovici 2016; Money 2016; Grinn-Gofroń et al. 2018). Spore types with a dry-release strategy were defined as those typically associated with passive release and higher abundance under warm, lower-humidity conditions, whereas spores with a wet-release strategy were defined as those commonly linked to elevated relative humidity and/or precipitation. Three spore types were classified as ‘both’ because they have been reported under both wet and dry conditions. This functional grouping was used to explore short-term variation in spore assemblages differing in trophic and release strategies. It should be noted that this classification reflects predominant behaviour reported in the literature and does not represent strict ecological categorisation, given that many fungal genera comprise species with diverse ecological strategies.

Statistical analyses

Spore abundance was summarised using descriptive statistics and temporal and compositional patterns across fungal taxa and functional groups were assessed by visual inspection of concentration profiles and relative abundance plots. To formally test the effects of trophic and release strategies on spore abundance, generalized linear mixed-effects models (GLMMs) were fitted using the *glmmTMB* package in R (Brooks et al. 2017). A negative binomial error distribution with a log-link function was applied to account for overdispersion in the count data. Trophic and release strategies were included as fixed effects. To account for non-independence among observations, taxon identity and sampling date were included as random intercept effects. Model selection was performed by comparing nested models using likelihood ratio tests and Akaike Information Criterion (AIC). Statistical significance of fixed effects was assessed using Wald z-tests.

Results

Total airborne fungal spore concentrations ranged from 3 572 to 11 499 spores m^{-3} across the four sampling periods (Tab. 1). Approximately 42% of recorded spore types occurred in all samples, whereas 22% were observed only once. *Cladosporium* dominated the assemblage throughout the study. *Coprinus* type was the second most abundant spore type during 18–21 July, whereas *Leptosphaeria* type was the second most abundant during the 22 July sampling period (Fig. 2, Tab. 1).

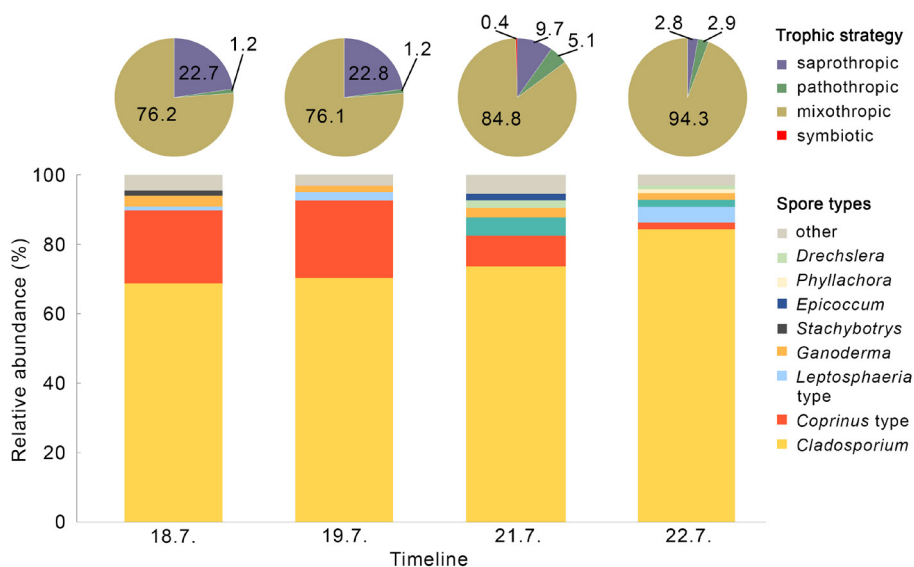


Fig. 2. Relative abundances of fungal spore types (columns) and spores in trophic strategies (pie charts) across the sampling periods expressed as % from total.

Tab. 1 All spore types recorded at the study site (expressed as spores/m³), with the total concentration and total number of recorded spore types, during four 2-h sampling periods in July 2025. Each type has an assigned trophic and release strategy.

spore type/ date	18.7.2025	19.7.2025	21.7.2025	22.7.2025	trophic strategy	release strategy
<i>Agaricus</i> type	5	1	5	2	SAP	WET
<i>Agrocybe</i>	7	12	1	1	SAP	WET
<i>Albugo</i>	2	7	5	3	PAT	WET
<i>Alternaria</i>	16	66	187	236	MIX	DRY
<i>Arthrinium</i>	0	0	2	0	MIX	DRY
<i>Ascobolus</i>	0	0	0	1	SAP	WET
<i>Ascochyta</i>	1	0	0	0	PAT	WET
<i>Asterosporium</i>	0	0	0	1	SYM	DRY
<i>Bipolaris</i>	2	0	2	10	MIX	DRY
Boletaceae	2	0	7	19	PAT	WET
<i>Botrytis</i>	1	0	0	0	PAT	WET
<i>Bovista</i>	3	0	0	1	SAP	DRY
<i>Caloplaca</i>	0	0	13	0	SYM	DRY
<i>Cercospora</i>	0	0	0	1	PAT	DRY
<i>Cerebella</i>	0	6	5	0	PAT	WET
<i>Cladosporium</i>	2 772	5 920	2 631	9 685	MIX	DRY
<i>Comatricha</i>	0	0	4	30	MIX	WET
<i>Coprinus</i>	3	4	1	5	SAP	WET
<i>Coprinus</i> type	845	1 877	316	227	SAP	WET
<i>Dictyodesmium</i>	1	0	0	0	MIX	DRY
<i>Drechslera</i>	10	31	76	122	PAT	DRY
<i>Epicoccum</i>	36	42	69	55	MIX	DRY
<i>Fusarium</i>	2	0	0	4	MIX	BOTH
<i>Fusicladium</i>	1	1	2	0	MIX	DRY
<i>Ganoderma</i>	128	164	99	218	MIX	BOTH
Helicomycetes	0	2	2	5	SAP	DRY
<i>Chaetomium</i>	0	0	2	0	MIX	BOTH
<i>Leptosphaeria</i> type	44	201	12	513	MIX	WET
<i>Leptosphaerulina</i>	0	8	0	6	MIX	DRY
<i>Lophiostoma</i>	4	0	1	4	MIX	WET
<i>Metasphaeria</i>	1	0	0	0	SAP	WET
Myxomycetes	2	3	5	5	SAP	WET
<i>Nigrospora</i>	1	1	1	2	SAP	DRY
<i>Oidium</i> type	2	5	5	6	PAT	WET
<i>Panaeolina</i>	25	6	3	12	SAP	DRY
<i>Panaeolus</i>	0	2	1	7	SAP	DRY
<i>Paraphaeosphaeria</i>	15	2	2	13	SAP	WET
<i>Periconia</i>	0	0	8	0	MIX	DRY
<i>Peronospora</i>	1	1	1	4	PAT	WET
<i>Phyllachora</i>	4	4	24	135	PAT	WET

spore type/ date	18.7.2025	19.7.2025	21.7.2025	22.7.2025	trophic strategy	release strategy
<i>Phytophthora</i>	0	1	2	0	PAT	WET
<i>Pithomyces</i>	4	10	12	6	PAT	DRY
<i>Pleospora</i>	0	0	3	1	MIX	WET
<i>Polythrincium</i>	3	0	1	0	PAT	DRY
<i>Puccinia</i>	1	0	0	0	PAT	WET
<i>Sclerotinia</i>	5	12	1	0	MIX	WET
<i>Sordaria</i>	0	0	0	1	MIX	WET
<i>Splanchnonema</i>	1	0	0	0	MIX	WET
<i>Sporidesmium</i>	0	1	1	0	PAT	DRY
<i>Sporormiella</i>	0	2	0	1	SAP	WET
<i>Stachybotrys</i>	58	3	4	39	MIX	DRY
<i>Stemphylium</i>	1	2	2	35	MIX	DRY
<i>Stropharia</i>	1	0	0	0	SAP	WET
<i>Thyronectria</i>	0	0	0	1	MIX	WET
<i>Torula</i>	4	1	10	10	SAP	DRY
uredinospores	2	5	6	14	PAT	WET
<i>Ustilago</i>	13	26	37	26	PAT	WET
<i>Venturia</i>	1	0	0	0	PAT	WET
Xylariaceae	2	2	1	32	SAP	WET
SUM	4 032	8 431	3 572	11 499		
COUNT	41	34	42	41		

SUM - total spore concentration in m³ of air; **COUNT** - total number of spore types; **SAP** - saprotroph; **PAT** - pathotroph; **SYM** - symbiotroph; **MIX** - mixotroph; **WET** - wet-released spores; **DRY** - dry-released spores; **BOTH** - wet- and dry-released spores

Other frequently recorded spore types included *Ganoderma*, *Alternaria* and *Epicoecum*. Concentrations of *Ganoderma* and *Epicoecum* varied relatively little among sampling periods, whereas *Alternaria* exhibited greater variation (16–236 spores/m³). Several spore types exhibited temporary peaks, including *Phyllachora* and *Stemphylium*, which increased markedly during the 22 July sampling period (Tab. 1).

In total, 59 spore types were recorded, with between-day differences of up to eight spore types. Of these, 17 spore types were predominantly saprotrophic, 18 pathotrophic and 22 showed mixed trophic strategies. Two symbiotic spore types were detected only during the third sampling period and contributed only 0.4% of total spore concentrations (Fig. 2). The most frequent trophic strategy was mixotrophic, followed by saprotrophic and pathotrophic, which had comparable relative abundances during the 22 July sampling. Regarding release strategy, 24 spore types were classified as predominantly dry-released, 32 as wet-released, and three as exhibiting both release strategies. Spores with a dry-release strategy dominated all sampling periods, primarily due to the high abundance of *Cladosporium*. Spores with a wet-release strategy peaked on 19 July, driven mainly by *Coprinus* type, and on 22 July, driven mainly by *Leptosphaeria* type (Fig. 3).

Compared with 18 July, total spore concentrations and mean air temperature were higher on 19 July. However, despite mean temperatures approaching 30 °C on 21 July,

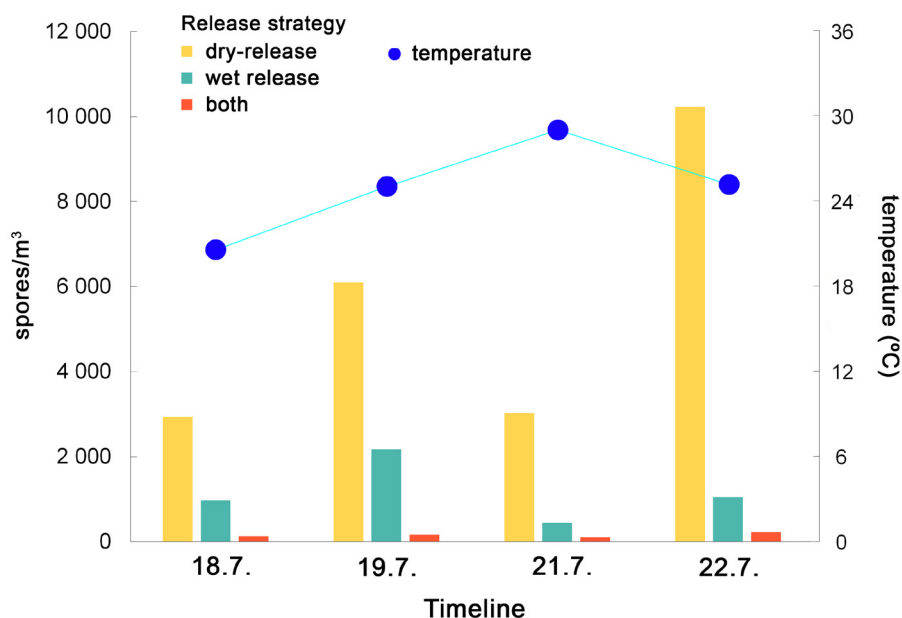


Fig. 3 Airborne spore concentrations (expressed as spores/m³) divided into groups by release type strategy. Average temperature during samplings is indicated in blue dots.

spore concentrations decreased by more than half relative to 19 July. On 22 July, lower temperatures coincided with a threefold increase in total spore concentrations relative to 21 July.

Generalized linear mixed-effects models with a negative binomial error structure showed that spore abundance was strongly structured by differences among fungal taxa (taxon variance = 4.13), while variability among sampling dates was low (variance = 0.08). However, neither the trophic strategy nor the release strategy significantly affected abundance (all p-values > 0.4), and adding the release strategy to the reduced model did not significantly improve model fit ($\chi^2 = 1.13$, $p = 0.57$).

Discussion

The recorded spore spectrum comprised a diverse aeromycobiota including spore types associated with crop disease, saprotrophy, wood decay and allergenic exposure, consistent with multiple local sources within and around the field, including crop canopy, soil, surrounding vegetation and nearby forest. Several detected spore types include important plant pathogens and/or aeroallergens, including *Alternaria*, *Cladosporium* and *Fusarium* (Arie 2019; Abel-Fernández et al. 2023; Schmey et al. 2024), while several other detected genera are also associated with plant disease (*Bipolaris*, *Cercospora*, *Sclerotinia*, *Stemphylium*) or allergenic exposure (*Epicoccum*, *Leptosphaeria* type, *Stachybotrys*). Several spore types reached concentrations exceeding 100 spores/m³,

a threshold suggested to be capable of triggering allergic responses (Katotomichelakis et al. 2016), although concentrations reported to promote plant infection in laboratory bioassays ($\sim 10^5$ spores/m³) were not reached (Amsellem et al. 1990). However, it should be noted that infection thresholds vary considerably among pathogens and environmental conditions, and the values cited here should be interpreted with caution.

The assignment of spores to trophic strategies indicated dominance of mixotrophic spore types, reflecting the fact that several abundant genera, including *Alternaria*, *Cladosporium*, *Ganoderma*, and *Leptosphaeria* type, comprise numerous species with diverse trophic and ecological strategies (Li et al. 2023). This limits the ecological interpretability of the trophic classification at the genus level and highlights the need for further taxonomic resolution in future studies.

Among release strategies, dry-release spores were dominant, as expected under the warm and dry summer conditions. However, their concentrations decreased during periods of peak temperatures (approximately 30 °C), consistent with previous studies reporting reduced sporulation above specific temperature thresholds (Damialis et al. 2015; Martínez-Bracero et al. 2020). The occurrence of wet-dispersed spores may have been promoted by daily crop irrigation, which could locally elevate moisture and relative humidity conditions, thereby enhancing fungal growth and spore aerosolization. This interpretation is consistent with the known moisture dependence of wet-release spore types such as *Coprinus* type and *Leptosphaeria* type (Ščevková and Kováč 2019), though direct measurements of local humidity were not available to formally test this hypothesis. The observed temporal differences in spore assemblage composition were not supported by statistically significant effects in the applied models, which should be interpreted in the context of the short sampling period and limited number of sampling occasions. The strong taxon-level variance detected in GLMMs (variance = 4.13) substantially exceeded variability among sampling dates (variance = 0.08), suggesting that differences among fungal taxa outweighed the effects of trophic or release strategy classifications. This indicates that species- or genus-specific ecological traits may play a greater role in shaping near-ground airborne assemblages than broad functional categories, a finding that underscores the limitations of coarse functional groupings in aeromycological studies.

The overall taxonomic pattern was broadly comparable to reports from higher sampling heights, although concentrations and the relative representation of individual spore types differed between near-ground and rooftop sampling (Žilka et al. 2024). As in many European surveys, *Cladosporium*, *Coprinus* type and *Leptosphaeria* type were among the dominant components of the airborne fungal assemblages (Oliveira et al. 2010; Grinn-Gofroń et al. 2018; Antón et al. 2019; Ščevková and Kováč 2019; Reznik et al. 2023; Symon et al. 2025). However, detailed data from near-ground observations remain comparatively limited despite documented vertical variation in spore composition and abundance (Charalampopoulos et al. 2022, Ščevková et al. 2025). Recent work has highlighted that near-ground concentrations can also diverge substantially from rooftop measurements, including higher near-ground peaks in agricultural contexts (Sobieraj et al. 2026). Near-ground sampling, therefore, provides important complementary information to rooftop monitoring by better capturing local emission sources and short-range dispersal processes, particularly in heterogeneous environments such as residential gardens where multiple spore sources coexist in close proximity.

Conclusions

This study demonstrates that even small residential gardens with heterogeneous vegetation and diverse management practices may contribute substantially to local airborne fungal assemblages, with spore composition reflecting inputs from multiple co-occurring sources, including crops, soil, managed vegetation, and nearby forest edges. Detected spores included important crop pathogens, saprotrophs, wood-decay fungi and common aeroallergens, several of which reached concentrations exceeding thresholds associated with allergic responses.

Airborne spore dynamics were strongly influenced by differences among fungal taxa, as indicated by the strong taxon-level variance in generalized linear mixed-effects models, while neither trophic strategy nor release strategy significantly affected spore abundance. This highlights the ecological complexity of near-ground fungal assemblages and suggests that genus- or species-specific traits play a greater role in shaping airborne spore composition than broad functional classifications.

Near-ground aerobiological sampling in residential environments, where people are exposed to airborne spores in close proximity to vegetation, soil, and managed green spaces, provides information of considerable relevance for both human and plant health. Such environments remain underrepresented in the aerobiological literature despite their prevalence in urban and peri-urban landscapes and their potential importance as local spore sources. Further characterization of near-ground spore dynamics through continuous sampling and inclusion of additional environmental variables such as local humidity and wind speed, and application of molecular identification methods would improve understanding of fungal assemblage variability in residential environments and allow more robust assessment of exposure-related risks.

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Abstrakt

Hubové spóry predstavujú početnú a variabilnú zložku bioaerosólov s významným vplyvom na okolité prostredie; ich zloženie a variabilita v blízkosti zemského povrchu v špecifických prostrediach však zostávajú stále pomerne málo preskúmané. Krátkodobý výskum bol realizovaný v malej rezidenčnej záhrade na severozápadnom Slovensku, v rámci ktorého boli hubové spóry zachytávané pomocou prenosného volumetrického lapača počas 2-hodinových intervalov v popoludňajších hodinách počas štyroch dní v júli 2025. Cieľom výskumu bolo preskúmať produkciu spór vzhľadom na heterogénne využitie plôch v záhrade a jej okolí. Analýza sa zamerala na diverzitu, abundanciu a zastúpenie trofických typov a stratégií uvoľňovania spór (uvoľňované za suchého alebo vlhkého počasia, prípadne oboch). Celkové koncentrácie spór sa pohybovali od 3 572 do 11 499 spór/m³ a zahŕňali spolu 59 typov spór, medzi ktorými boli zastúpené fytopatogény, saprotrofné a drevokazné huby, pričom niektoré patrili aj medzi významné aeroalergény. Celkovo dominovali spóry so stratégiou uvoľňovania za suchého počasia, zatiaľ čo spóry uvoľňované za vlhkého počasia tvorili menšiu skupinu spolu s tromi typmi spór uvoľňujúcich sa počas oboch typov počasia. Napriek krátkodobým výkonom zostávalo celkové zloženie spór medzi jednotlivými odbermi pomerne podobné, čo naznačuje pretrvávajúci vplyv lokálnych zdrojov, ako sú porasty plodín, pôda, okolitá vegetácia a les v blízkosti odberov. Táto štúdia naznačuje, že aj malé rezidenčné záhrady môžu významne prispievať k lokálnym koncentráciám hubových spór a zároveň poukazuje na význam krátkodobých aerobiologických pozorovaní v prízemnej vrstve atmosféry, pre lepšie pochopenie ekologických vzťahov a potenciálnych zdravotných rizík.

Kľúčové slová: aeromykobióm; fytopatogény; alergénne hubové spóry; prízemný zber