Linking air and leaves: disentangling the main drivers of microbial assembly and exchange in the urban phyllosphere

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Urban vegetation is known to support diverse microbial communities that play key roles in ecosystem functioning. However, the mechanisms governing their assembly and connectivity with the atmosphere remain incompletely understood. The present study investigates the relative contributions of different ecological drivers in shaping bacterial and fungal communities of the phyllosphere and their linkage with airborne microbiomes across an urban gradient in Milan (Italy). Leaves from four common plant species and particulate matter were sampled on a seasonal basis over one year, and microbial communities were characterised through 16S rRNA and ITS1 amplicon sequencing.

Multivariate analyses revealed that plant species, season, and sampling area (and their combinatory effects) are important drivers in shaping the microbial communities. Network-based indicator species analysis demonstrated substantial connectivity between air and phyllosphere microbiomes, with numerous taxa shared across habitats and plant species, suggesting active microbial exchange. This connectivity was particularly evident during transitional seasons, when overlap between airborne and leaf-associated communities changed actively.

Seasonal transition analyses further demonstrated dynamic shifts in microbial distribution, with alternating patterns of homogenization and diversification between habitats. Notably, bacterial communities exhibited stronger dispersal from shared to phyllosphere-specific assemblages, whereas fungal communities displayed different temporal dynamics.

The findings demonstrate that the composition of urban phyllosphere microbiomes is influenced by a complex interplay of deterministic host filtering and stochastic airborne dispersal. These have significant implications for our understanding of microbial contributions to ecosystem services in urban environments, thereby influencing the decisions of policy-makers and local authorities in the development of greener cities.