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Preliminary data on low aerial plankton in a large city center, Paris

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ABSTRACT

Some organisms are able to disperse by air through passive or active flying and can colonize highly isolated habitat. We can hypothesis than aerial dispersions could be a process of biodiversity development even in isolated town habitats such as some building roofs.

The urban aerial plankton has been poorly studied and we analyzed here the arthropods and seeds trapping small species limited to 0.5–5 mm sizes and to a low part of the atmosphere (traps on roofs below 50 meters) in Paris, a center of a very large agglomeration. Using plates of wire meshes with fat, we observed that insects are dominant (Diptera and Hemiptera) when spiders and seeds appeared underrepresented.

At high heights of buildings (and not at low heights), the Landscape Greening Index seems to have a strong positive effect on abundances for spiders, insects and seeds stressing the role of sources and the effect of building barriers on aerial dispersion. These preliminary data encourage research on this process.

1. Introduction

In towns, the development and settlement of new nature areas (kitchen gardens, green roofs and walls, etc.) or of more natural management of parks with spontaneous species is well supported (Miller and Hobbs, 2002; Dallimer et al., 2011). These policies, that are now also promoted in dense urban areas, are motivated by the ecosystemic services which appear clearly important both to the well-being of citizens (pollution regulation, water management, social and sanitary benefits, etc.) and for economical topics (water and climate regulation, etc.) (Millennium Ecosystem Assessment, 2005). However, the durability of these new systems is linked to the presence of numerous species that can interact between them and, consequently, assure a "good" ecological functioning of the system (Croci et al., 2008; Heim and Lundholm, 2014). So the presence of numerous spontaneous plants and animals is desirable. Species translocation of animals in urban areas seems limited both economically and ecologically speaking. The process of species dispersion in cities between green spaces then seems important. The main objective of green frameworks, such as those developed in France, is to permit these dispersions. As in rural and suburban areas, corridors can match in dense urban areas (Ahern, 1995; Clergeau, 1997) but are less frequent.

Some organisms are able to disperse by air through passive or active flying like birds or invertebrates. Spiders are known to disperse by creating a silk balloon and move on the air over long distances (Bell et al., 2005). With this way of dispersal spiders are able to colonize highly isolated habitats. Progress in radar techniques also allowed researchers to detect frequent mass aerial migrations of arthropods such as carabids (Chapman et al., 2011). So, many small organisms are frequently present in the air and form the aerial plankton by analogy with the marine plankton (Chapman et al., 2004).

In urban landscapes, "natural" habitats are frequently distant from each other and separated by structures such as buildings that clearly limit the movement of many species, even those capable of aerial dispersal (Lizée et al., 2011; Peralta et al., 2011). Many authors have considered that those habitats are so isolated that they operate like habitat islands (Faeth and Kane, 1978; Balkenhol et al., 1991; Fernàndez-Juricic and Jokimaki, 2001; Clergeau et al., 2004). However those studies did not consider vegetated roofs. In an urban context, vegetated roofs are increasing and recent studies have shown their importance as habitats or as potential connectivity elements for arthropods (Madre et al., 2013) or spontaneous flora (Madre, 2014).

Generally, aerial dispersal in towns has been poorly studied (but see Balkenhol et al., 1991), but this knowledge has the potential to

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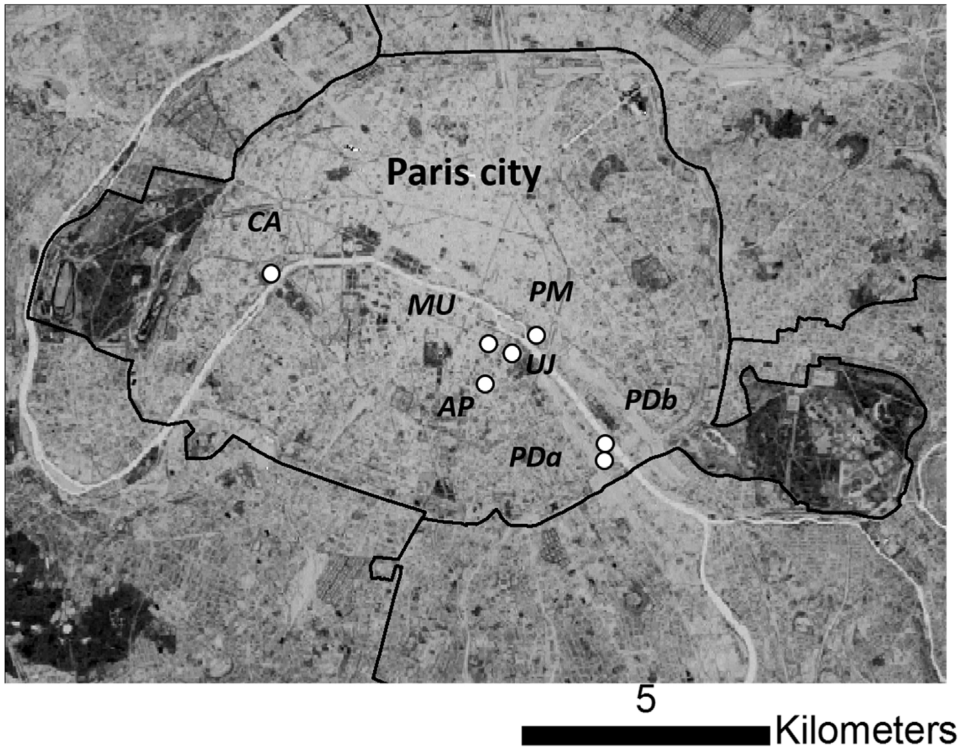

Fig. 1. Localization of the seven sampled sites and Normalized Difference Vegetation Index (NDVI) map. NDVI represents photosynthetic values and varied along an increasing grey scale color. Low values are represented by light grey and are mainly buildings and roads. High values are represented by dark grey and are vegetated areas such as urban parks.

help us understand both which and how small organisms can colonize new green areas such as vegetated roofs, and which species can invade or damage these areas. We present here a first study on the aerial plankton limited to 0.5–5 mm sizes and to a low part of the atmosphere (below 50 m) where we can expect a maximum number of individuals due to strong movement of air (vehicles, street canyons, etc.). We wanted to know what arthropods could be present and if aerial plankton included seeds that could factor in the dynamics of green roofs. We also test whether height of the roof and greening context could influence catch rates. We chose the city of Paris that can be defined more as a city center than as a city, with levels of soil sealing reaching 80% (Vergnes et al., 2014), and without real suburbs that surround greater Paris (especially allotments with small gardens). Here, we can test the responses of aerial plankton in a very large "city center".

2. Methods

2.1. Sampling design

Seven sites distributed in Paris have been sampled (Fig. 1; Tableau 1). We have used 20 × 40 cm plates of wire meshes with fat (see Appendix A for methodology design). In each site, a sample involving 2 or 3 plates was settled vertically on roofs or guard rails, in different directions, and always in a most clear possible environment, e.g. without wall at immediate proximity. We avoided putting our traps at street level (less than 10m) as short dispersions of seeds have already been studied here (von der Lippe et al., 2013).

Two trapping periods of 15–20 days each were conducted in autumn (October 2014) and spring (April 2015). We sampled 78 plates overall. To homogenize the trapping times and the numbers of plates, abundances are given per plate and per 100 days and then transformed into integers to be used as count data.

In each site, we measured the height and the landscape Greening Index (Table 1). The Landscape Greening Index is based on the NDVI (Normalized Difference Vegetation Index) taking account a 500 m radius around each site. NDVI was calculated on Landsat 8 images (30 m resolution, NASA Landsat Program 2014), it is based on the photosynthetic activity for a given pixel (Kerr and Ostrovsky 2003). The Landscape Greening Index reflects the potential source for aerial plankton around sites and is frequently using in urban landscape studies (Vergnes et al., 2012; Madre 2014). It has been calculated using ArcGis 10.1.

Plates of wire were collected from the roofs and analyzed at laboratory. Organisms were extracted and identified: seeds (to the family level) and Arthropods (classified in arachnids or insects at the order level).

2.2. Statistical analysis

We have analyzed the abundances of insects, arachnids and seeds. Data from autumn and spring did not show significant differences (Wilcoxon test, $p = 0.91$, 0.70 and 0.60 respectively) and were pooled.

We tested the effects of the interaction between height and NDVI using Generalized Linear Models (GLM) with a Poisson error distribution, particularly adapted for zero-rich data such as count data (Crawley, 2009). Then, we ran an Anova type 2 to assess the significance of parameters. To better interpret the interaction, the results were plotted using the package effects.

3. Results and discussion

In all, we collected and identified 10 211 arthropods (6447 in spring and 3764 in autumn) and 46 seeds (respectively 29 and 17) in our different sites and periods.