ZALF-PhD Project associated to BioMove, 2nd PhD student cohort

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Working place: ZALF, Müncheberg (Mark)
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Arthropods as mobile linkers for fungal spore dispersal - linking species behaviour and movement patterns with disease spread mechanisms

0. Brief expected profile of PhD student

The candidate should have a background in invertebrate taxonomy, landscape- and behavioral ecology, with an excellent MSc in Ecology or related discipline. Experience with capturing and species identifying of carabids and with applying advanced statistical methods is strongly preferred. Knowledge in microbiological and/or molecular-genetic methods is desirable.

1. Short Abstract

Mobile links connect different kinds of habitat patches, thereby affecting biodiversity. This project analyses how specific landscape characteristics such as availability and spatial distribution of habitats and resources affect the amount and frequency of mobile links between carabid occurrence and fungal spore dispersal.

2. Background and previous work

On agricultural fields, infected host plants are likely to interact with arthropods that may substantially impact the disease by influencing spread or condition of the shared host. *Fusarium* pathogens differ in spore production and impact on host volatile chemistry, which influences their suitability for arthropod dispersal. Conversely, arthropods also have traits driving interactions with *Fusarium* pathogens, such as post-harvest activity, different diet types, life cycles and habitat use. Arthropods may also interact with volatile chemicals from infected grains (Drakulic et al. 2017). In the case of arthropods, fungal spore dispersal can occur by transporting spores attached to the body (ecto-zoochory) or inside the gut of the animal (endo-zoochory) (Lilleskov & Bruns 2005). Transport of fungal spores by arthropods provides an effective means of dispersal and grants some advantage to pathogenic fungi, especially in dense crop stands (Oliviera et al. 2015). However, dispersal by insect vectors tends to be restricted to a local range, e.g., a few hundred kilometers.

Up to now, only few studies have investigated the interaction of arthropods with Fusarium Head Blight (FHB) disease epidemiology in small-grained cereals (Drakulic et al. 2017, Theron-De Bruin et al. 2017). Arthropods are known to move between semi-natural and agricultural habitats and provide numerous functional links this way, e.g. like pest control (Alignier et al., 2014). Here we are planning to investigate the spatial/temporal spread of disease vectors using the movement patterns of arthropods. Numerous arthropods are potential vectors of FHB disease pathogens, their effectiveness might vary between species and taxa depending on their traits. There is a need for an integrated approach, including arthropod behaviour, movement pattern and paths/mechanisms for crop infection as mediated by arthropod vectors.

The PhD project builds upon extensive previous work on carabid species occurrence and habitat use as well as on fungal disease occurrence and spatial spread, which until now have been analysed separately from each other.

3. Objectives/Aims

The key objectives of the PhD Project are (i) to quantify the functional interaction between agricultural fields and their neighbouring semi-natural habitats regarding carabid movement and FHB dispersal/control, (ii) identifying the drivers for the fungal diseases (species behaviour (arthropod traits); FHB vector behaviour (dispersal potential)), and (iii) to estimate the potential of carabids as process link (i.e. spreading fungal diseases).

4. Outline of work program

The work plan of the PhD is divided into three main parts: field surveys, feeding experiments and lab work.

Field work (year 1 and 2): species-specific carabid moving patterns between source habitats and crop fields will be quantified. Additionally, interfering arthropod occurrence in the crop phyllosphere will be measured during the most sensitive phase of fungal infection (flowering time of crop). Resource availability and variability will be quantified by monitoring crop specific growth and timing of management.

Feeding/exposition experiments (year 1-2): live-captured carabids with selected traits will be used to apply feeding/exposition experiments regarding the variation in spore/mycotoxin uptake between various arthropods species/taxa and their larvae (pre-selected species according their relevance for cereal fields).

Lab work (year 3): Estimation of infection rates of different fungal genera and of the *Fusarium* fungi in and on carabids as well as on wheat leaves and ears; occurrence and abundance of fungal vectors on the carabid body and in the carabid gut; variation in pathogen infection between particular carabid groups, analyses of mycotoxins as pathogenic factor in the arthropod-fungi interactions.

Using this data set, we will apply various analytical tools (e.g. network analysis) to analyse changes in the amount of process links and the frequency of their spatial connectivity (Jacoby & Freeman 2016).

5. Hypotheses, objectives and concepts

This project will analyse how the specific landscape configuration and human impacts in agricultural landscapes affect (i) the spatial and temporal scale of carabid movement paths and their behaviour as mobile linker for the spread of fungal spores and (ii) the scale, at which potential links may influence local plant diseases. We aim at a more mechanistic understanding of the processes (diseases vectoring), their main drivers (traits of carabids and kind of infection pathways).

Alignier, Audrey, et al. (2014) The effect of semi-natural habitats on aphids and their natural enemies across spatial and temporal scales." Biological control 77: 76-82.
Drakulic, J, T. J,. A. Bruce, and Rumiana V. Ray. (2017): Direct and host- mediated interactions between Fusarium pathogens and herbivorous arthropods in cereals." Plant Pathology 66.1 (2017): 3-13.
Jacoby MP & Freeman R (2016). Emerging Network-Based Tools in Movement Ecology. Trends in Ecology & Evolution 31: 301-314.
Jeltsch F. et al. (2013). Integrating movement ecology with biodiversity research-exploring new avenues to address spatiotemporal biodiversity dynamics. Movement Ecology 1:6.
Lilleskov, E.A., and Bruns, T.D. (2005). Spore dispersal of a resupinate ectomycorrhizal fungus, Tomentella sublilacina, via soil food webs. Mycologia 97, 762–769.
Oliveira, Anderson G., et al. (2015) Circadian control sheds light on fungal bioluminescence. Current Biology 25.7: 964-968.
Theron-De Bruin, N., et al. (2017) Birds mediate a fungus-mite mutualism. Microbial ecology: 1-12.