1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan, all in English)

Project title:

Changes in vegetation and soil properties in maritime sand dunes habitats due to invasion of *Rosa rugosa* Thunb.

1.1. Project goals

The project deals with the problem of plant-soil interactions in the context of *Rosa rugosa* invasion. The aim of this project is to: (1) Compare parameters of vegetation (plant species number, cover, community composition, functional groups, life forms and strategies, the presence of other alien species and endangered species), soil physicochemical properties (moisture, water-holding capacity, pH, elemental composition) and soil microbiome (bacteria, archaea and fungi) characteristics (abundance, richness and phylogenetic composition), soil respiration, nitrogen (N) mineralization rate, enzymatic activity between stands of invasive *R. rugosa* and native plant communities in relation to the quantity and chemical quality (concentrations of elements and phenolic compounds) of plant biomass under field conditions. (2) Relate parameters of vegetation with physicochemical and microbiome variables. (3) Characterize the biomass and chemical quality of different *R. rugosa* parts, namely leaves, stems and rhizomes/roots in relation to biomass and chemical quality of aboveground and belowground parts of native species. (4) Compare soil physicochemical and microbiome properties between monocultures and mixtures of *R. rugosa* and native species in pot experiment under controlled conditions.

1.2. Outline

Rosa rugosa invade natural habitats, such as dry coastal ecosystems in Northwestern Europe and Northeastern North America. So far, only the influence of *R. rugosa* invasion on the diversity and species composition of plant dune communities has been studied, showing adverse changes in their structure and a significant decrease in species number (Isermann 2008, Hill et al. 2010). The strong reduction of native plant species diversity is partly explained by the effect of shading by *R. rugosa* (Isermann 2008, Hill et al. 2010). Importantly, the allelopathic impact of its secondary metabolites on native species found in dunes has

not been studied so far. It may be expected that *R. rugosa* would have a profound effect on the soil environment of seashore habitats as it belongs to distinct functional group than native grasses dominating the dunes, differing considerably from these grasses in traits such as size, productivity, organic matter supply and its quality. Large amounts of litter reaching the soil beneath *R. rugosa* are anticipated to increase soil element pools and support the activity and biomass of decomposer microbiome communities. On the other hand, *R. rugosa* contains a number of secondary metabolites, mainly phenolics, in both belowground and aerial parts (Hashidoko et al. 2002, Lanta et al. 2015). These compounds may negatively influence the performance of native plants and microbiome communities when released to the soil from litter or as root exudates. The preliminary study showed that *R. rugosa* increased concentrations of some macroelements in soil and reduced total microbiome, total bacterial and G+ bacterial biomass, and increased arbuscular mycorrhizal fungi (AMF) biomass markers in mineral soil (Stefanowicz et al. 2019). As this was a pilot study, we included only some structural aspects of microbiome communities, i.e., biomass and structure based on analysis of phospholipid (PLFA) and neutral fatty acids (NLFA). Moreover, analyses were restricted mainly to mineral soil, and we assessed only a limited number of parameters in organic matter. Also plant tissues were characterized only in terms of total phenolic concentration. To our knowledge, no information is yet available on taxonomic composition of bacterial and fungal communities and only little information can be found on soil biological processes and microbiome activity under *R. rugosa* (Lanta et al. 2015, Helsen et al. 2019). In order to gain deeper insight into changes caused by *R. rugosa* invasion in soil, we plan to employ a set of novel approaches in the project. In particular, we will (1) analyze the composition of whole soil bacterial and fungal communities in two soil horizons (organic and mineral) under *R. rugosa* and native vegetation, (2) integrate soil physicochemical and microbiome parameters with data on vegetation properties, plant biomass, element and phenolic concentrations in the biomass at the time of senescence.

1.3. Work plan

Stage 1 – field study

Aim: Linking soil physicochemical and microbiome properties under invasive R. rugosa and native communities to the quantity and quality of plant biomass

This part of the study will be conducted at the coast of the Baltic Sea. Twenty five sites consisting of near monoculture *R. rugosa* stands and neighboring patches of native plant communities (controls) have already been selected along the Hel Peninsula. Vegetation will be characterized in terms of species richness, cover and composition. At each site, in the patches of both the invasive plant and native communities, soil samples (organic and mineral horizon) will be collected. Aboveground and belowground plant biomass will be harvested, dried and weighted. Senescing plant biomass will be characterized in terms of element and phenolic concentrations. Physicochemical soil properties (water holding capacity, moisture, element concentrations, pH) and soil microbiome characteristics (abundance, richness and phylogenetic composition), soil respiration, nitrogen mineralization rate, enzymatic activity will be assessed.

This field study will allow for comparisons between (1) vegetation and soil properties in the *R. rugosa* sites and in native vegetation in relation to the quantity and chemical quality of senesced plant biomass, (2) chemical quality of different *R. rugosa* organs – leaves, stems and rhizomes/roots with

aboveground and belowground parts of native species.

Stage 2 – Pot experiment

Aim: Assessment of the effect of R. rugosa on soil physicochemical and microbiome properties and on the condition of native plant species

On the basis of the preliminary research, two native plant species affected by *R. rugosa* invasion have been tentatively selected for the experiment: a forb *Artemisia campestris* subsp. *sericea* and a grass *Corynephorus canescens*. These two species commonly inhabiting coastal dunes are also easy to cultivating. Dune soil from the Hel Peninsula, not affected by *R. rugosa* invasion, will be placed in experimental pots and local plants will be planted in several combinations: (i) *R. rugosa* (ii) native forb (iii) native grass (iv) native forb + native grass (v) *R. rugosa* + native forb (vi) *R. rugosa* + native grass (vii) *R. rugosa* + native forb + native grass (viii) bare soil. Physicochemical soil properties (WHC, moisture, element concentrations, pH), soil microbiome characteristics (abundance, richness and phylogenetic composition), soil respiration, N mineralization rate, enzymatic activity and the condition of native species (leaf area, photosynthesis parameters, biomass; number and height of blades, tillers, stolons, rhizomes and roots; cover) will be measured after two years of plant growth. This experiment will allow assessment of the influence of *R. rugosa* on native dune species and soil physicochemical and microbiome properties.

1.4. Literature

1. Hashidoko Y., Itoh E., Yokota K., Yoshida T., Tahara S. 2002. Characterization of five phyllosphere bacteria isolated from Rosa rugosa leaves, and their phenotypic and metabolic properties. Biosci. Biotechnol. Biochem. 66: 2474–2478.

2. Helsen K., Bassi L., Van Cleemput E., Somers B., Honnay O. 2019. Using both a function trait and spectranomics based approach to understand *Rosa rugosa* invasion impacts on community litter decomposition. 019 IAVS 62nd ANNUAL SYMPOSIUM Vegetation Science and Biodiversity Research, Bremen, GermanyAt: Bremen, Germany.

3. Hill N., Beveridge L, Flynn A., Garbary D.J. 2010. Rosa rugosa as an invader of coastal sand dunes of Cape Breton Island and Mainland of Nova Scotia. Canadian Field-Naturalist 124: 151–158.

4. Isermann M. 2008. Effects of Rosa rugosa invasion in different coastal dune vegetation types. In: Tokarska-Guzik B., Brock J. H., Brundu G., Child L., Daehler C. C., Pyšek P. (Eds.), Plant Invasions: Human Perception, Ecological Impacts and Management. Backhuys Publishers, Leiden, pp. 289–306.

5. Lanta V., Hyvönen T., Norrdahl K. 2015. Leaf litter decomposition of nonnative shrub species in nonnative and native shrub environments: a fieldexperiment with three Rosaceae shrubs. Invasive Plant Sci. Manag. 504: 81–89.

6. Stefanowicz A. M., Zubek Z., Stanek M., Grześ I. M., Rożej-Pabijan E., Błaszkowski J., Woch M. W. 2019. Invasion of Rosa rugosa induced changes in soil elements and microbial communities of coastal sand dunes. Science of the Total Environment 677: 340–349.

1.5. Required initial knowledge and skills of the PhD candidate

Knowledge of biology and ecology, MSc (mgr or mgr inż.) in biology/environmental protection/environmental engineering/chemistry/agriculture forestry.

1.6. Expected development of the PhD candidate's knowledge and skills

The doctoral student will receive practical knowledge of modern interdisciplinary scientific research in the environmental sciences from the investigations planning stage, through their implementation, analysis and interpretation of results, to their presentation at conferences and leading international journals. The PhD candidate's knowledge will be large extended, especially in biology, ecology and chemistry.