Cross-talk between aphid facultative symbiosis and plant nitrogen fixation symbiosis in the *Acyrthosiphon pisum - Medicago truncatula* interaction

Symbiosis, insect-symbionts-plant interaction, biological nitrogen fixation, pea aphid, plant defense

The field of microbial symbiosis has achieved astonishing advances demonstrating that symbionts play a crucial role in shaping the host phenotype and drive its adaptation to the environment. In this context, the cross-talk between different interacting species and their respective symbionts adds a level of complexity that still remains to be considered. The project will explore this new field focusing on the interaction between a leguminous plant and a leguminous-dependant aphid species.

Legumes live a well-described symbiosis with bacteria that increases the availability of nitrogen. *Medicago truncatula*, a small self-fertile annual plant, is one legume model organism. It is attacked by the pea aphid *Acyrthosiphon pisum* (the aphid model) that feeds on several legumes (e.g. pea, alfalfa, broad bean), and is thus a major agronomic pest. Aphids have evolved as sap-feeding insects thanks to their trophic association with an obligatory bacterium, and the pea aphid also hosts eight different facultative symbionts that strongly influence its phenotype (e.g. pathogen resistance, immune components). Interestingly, this species is structured into host races adapted to different legume plants, and particular facultative symbionts are strongly associated with aphids feeding on certain plants (Peccoud and Simon 2012). Finally, there has been recent evidence in sap-feeding insects of symbiont circulation in sap and plant-mediated symbiont transfer (Caspi-Fluger, 2012; Gonella et al., 2015).

The PhD project will question whether and how the presence of different facultative symbionts in the pea aphid and the nitrogen fixing symbiosis (NFS) modulate the legume-aphid interaction and vice-versa. Using aphid lines of the same genetic background harboring different symbionts, we will i) evaluate the influence of the NFS on aphid and symbionts traits and of each facultative symbiont on the NFS efficiency (plant growth, primary metabolism) *i*i) identify Medicago defense pathways to aphids and the possible variation in relation with different aphid facultative symbionts. Having evaluated the importance of aphid and plant microbial partners in the outcome of the interaction, we will focus on identification of their cellular and molecular bases (effector molecules and signalling pathways) in the different partners. *NB: This second aspect will be treated in collaboration, focusing on the way the nitrogen fixing symbiosis influences the observed effects of facultative symbionts.*

Functional aspects of symbiosis are generally considered at the species level. Here, we will evaluate the multitrophic, direct and indirect effects of the species association with various bacterial symbionts. Identifying biotic factors that may interfere in the field with NFS efficiency will also be highly relevant for sustainable agronomy.

Available tools: Aphid lines of identical genetic background with different facultative symbionts (collab. JC Simon, Rennes). Genomes available (*Medicago*, pea aphid, symbionts). Genetic transformation tools (Medicago), RNAi (aphid).
Main approaches: Plant genetics, transcriptomics, metabolomics, cell biology, microbiology.

- Puppo A, Pauly N, Boscari A, Mandon K, Brouquisse R. (2013) Hydrogen peroxide and nitric oxide: key regulators of the legume – Rhizobium and mycorrhizal symbioses. Antioxidant and Redox Signaling. 18(16):2202-2219.

- Schmitz A, Anselme C, Ravallec M, Rebuf C, Simon J-C, Gatti J-L, Poirié M (2012) The cellular immune response of the pea aphid to foreign intrusion and symbiotic challenge. PLoS One 7(7): e42114.

- Foyer CH, Verral SR, Hancock RD (2015) Systematic analysis of phloem-feeding-insect-induced transcriptional reprogramming in Arabidopsis highlights common features and reveals distinct responses to specialist and generalist insects. J. Exp. Bot 66(2): 495-512.