The olive fruit fly is never alone! Can its bacterial symbionts be useful in managing this olive pest?

The notion of individual has changed trough time, and truly, we are never alone as most organisms are entangled in symbioses. As first used in 1879 by Anton de Bary, symbiosis refers to close, long-term associations between different organisms living together. Although the exact definition might have been changing through times, its applied importance has been gaining recognition. The concept of symbiosis has becoming more relevant in the context of sustainable agriculture practices that can respond to modern challenges. Human population growth and climate change are amongst the most discussed challenges that global agriculture must face, and efficiency and resilience of crop production needs to be improved. Overall rising temperatures, changes in precipitation patterns, and water shortages will affect the fierceness and propagation of insect pests in largely unknown ways and that are particular of the pest species.

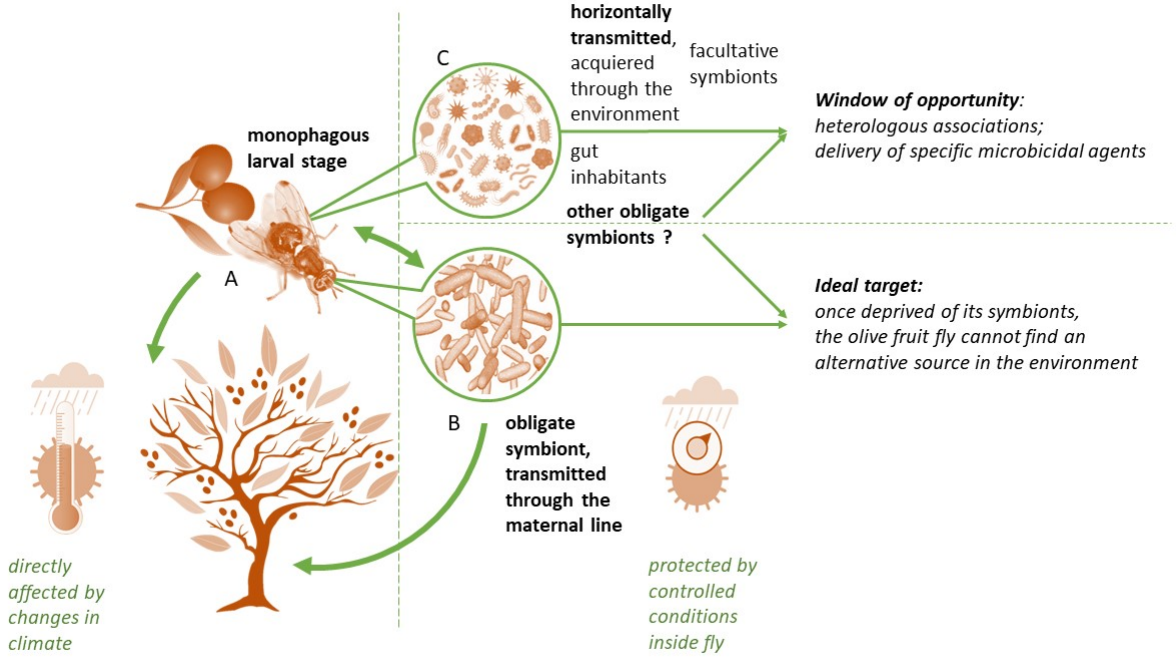

Fig. 1. Schematic representation of the putative relationships between olive fruit fly, its' symbiotic microorganisms and the olive tree/fruit. These evolved relationships are the 'Les Liasons Dangereuses' to explore as possible routes to pest management (adapted from https://doi.org/10.3390/microorganisms7080238)

Rates of climate change in the Mediterranean Basin are expected to exceed global trends for most

variables, and this change will certainly also affect olive production, one of the main crops of the region. The olive fruit fly, specialized to become monophagous during several life stages, remains the most important olive tree pest with high direct production losses, but also affecting the quality, composition and inherent properties of the olives, also reverting in indirect losses to the producers. The olive fruit fly is also never alone!, and to understand its evolution and behavior it is also better seen as a group of genetically different entities. These flies share diverse bacterial relationships with other fruit flies (Tephritidae, subfamilies Dacinae and Trypetinae), and traditional microbiological approaches have identified bacteria of the genera *Lactobacillus*, *Micrococcus*, *Pseudomonas*, *Streptococcus*, *Citrobacter*, *Proteus*, *Providencia*, *Enterobacter*, *Hafnia*, *Klebsiella*, *Serratia*, *Pantoea* and *Xanthomonas*. In particular, it has evolved to harbor a vertically transmitted and obligate bacterial symbiont —*Candidatus* Erwinia dacicola— that allows the insect to cope with abundant secondary metabolites, particularly the olive-plant-produced defensive compound oleuropein.

What if we could make use of these associations to manage olive fruit fly population numbers and prevent them to become pests? Eliminating the microorganisms required for sustained insect growth, reproduction and survival is a way forward. The most obvious target for this type of symbiosis-based approach to the olive fruit fly is *Ca.* Erwinia dacicola and the development of specific symbiocides because the treated insect host depends on this symbiont and cannot acquire it from the environment. Furthermore, several researchers are gathering the necessary knowledge on the host insect, its microorganisms and the types and characteristics of the microorganism's relationships. This in turn opens new potential routes of managing the host. Other classes of associated microorganisms are emerging, including species that have been repeatedly found in olive fruit fly populations (suggesting a somewhat obligate character of the interactions) but also transient microorganisms of the olive fruit fly (some acquired in food and water, which then become located in the gut lumen). What emerged clear from this literature review is that the diversity and specificity of olive fruit fly interactions with symbiotic bacteria invites the search for a thorough understanding of the system, with the promise that these naturally evolved connections are 'Les Liasons Dangereuses', that we can search for a sustainable targeted pest management.

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