7.4 *Orius laevigatus* Induces Plant Defenses in Sweet Pepper

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Pest management in protected sweet pepper crops primarily relies on biological control strategies. The release of the phytoseiid *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae) and the anthocorid *Orius laevigatus* Fieber (Hemiptera: Anthocoridae) provides effective control of the two key pests of this crop, the thrips *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae) and the whitefly *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) (Sanchez *et al.*, 2000; Calvo *et al.*, 2009; van der Blom *et al.*, 2009). A part of their direct effect on pest predation, zoophytophagous predators may induce defensive plant responses due to their plant feeding behaviour which involves the release of diverse volatiles through different pathways that are triggered by phytohormones (De Puysseleyr *et al.*, 2011; Naselli *et al.*, 2016; Pappas *et al.*, 2015, 2016; Pérez-Hedo *et al.*, 2015a,b). These responses may result in the repellence or attraction of pests and natural enemies. It is hence hypothesized that *O. laevigatus* would be able to induce plant responses in sweet pepper as has been demonstrated in other plant-zoophytophage systems. As a first step to better understand the interaction between *O. laevigatus* and sweet pepper, the behavior of *O. laevigatus* on the plants was studied and plant feeding behaviour quantified to compare general behaviors. *Orius laevigatus* spends the majority of its time (38%) feeding on apical meristems and apical fresh leaves, which were also preferred residence locations (Bouagga *et al.*, 2017) (Fig. 7.4.1).

 Proceedings of the 5th International Symposium on Biological Control of Arthropods (eds. P.G. Mason, D.R. Gillespie and C. Vincent)

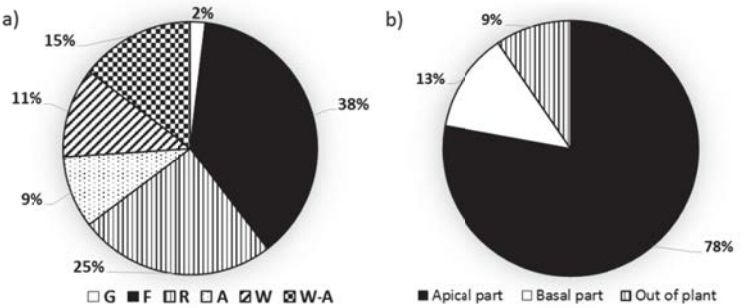

Fig. 7.4.1. a) Percentage of time spent exhibiting different behaviors (G: grooming; F: feeding; R: resting; A: antennating, W: walking; W-A: walking-antennating) by *Orius laevigatus* adults on sweet pepper plants; **b)** percentage of residence time of *O. laevigatus* adults on sweet pepper plants (adapted from Bouagga *et al.*, 2017).

A series of experiments were conducted to determine whether *O. laevigatus* feeding punctures on sweet pepper induce plant defence responses and whether these in turn lead to behavioural responses in pest and natural enemy species. Specifically, *O. laevigatus*-punctured sweet pepper plants induce repellency of the whitefly *B. tabaci* and the thrips *F. occidentalis*. In contrast, the whitefly parasitoid *Encarsia formosa* Gahan (Hymenoptera: Aphelinindae) was significantly attracted to *O. laevigatus*-punctured plants (Bouagga *et al.*, 2017). Our results also showed that the whitefly *B. tabaci* reduced its ovipositing and, more interestingly, its progeny when forced to oviposit on *O. laevigatus*-punctured plants (Fig. 7.4.2). This is a very interesting result that could explain the great success achieved by the IPM programs based on the release, establishment and conservation of *O. laevigatus* in sweet pepper crops.

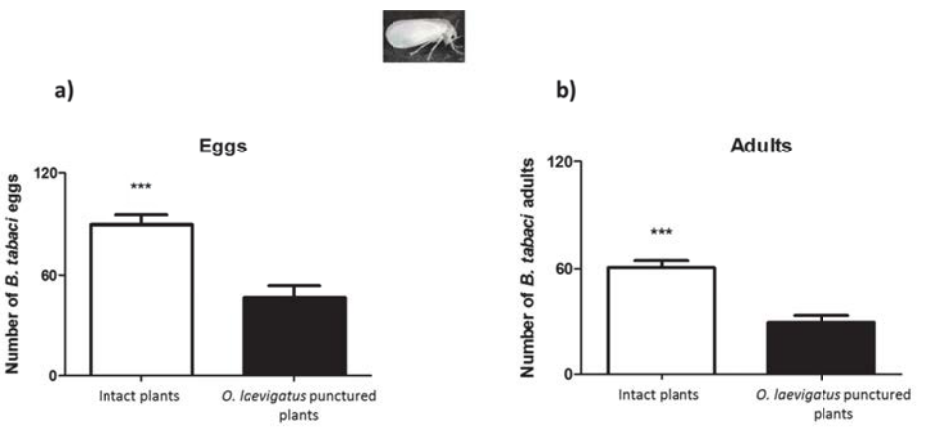

Fig. 7.4.2. Persistence of plant-mediated effect by *Orius laevigatus* on the performance of *Bemisia. tabaci* on *O. laevigatus*-punctured plants. **a)** Number of *B. tabaci* eggs per plant, **b)** Number of B. tabaci adults surviving from the hatched eggs, (mean number ± SE, n=5). Seven couples of B. tabaci were released per cage and left to lay eggs on the plants for 48 hours. (t-test; $P < 0.05$).

In parallel, targeted gene-expression analysis was used on plants previously exposed to *O. laevigatus* to ascertain which signaling pathways could be involved in plant defensive responses. Activation of the jasmonate acid and salicylic acid signalling pathways occurred in those sweet pepper plants previously punctured by *O. laevigatus* (Bouagga *et al.*, 2017).

Finally, the volatile compounds released as part of the plant response to *O. laevigatus* feeding punctures have been also characterized. Untargeted analysis of the volatiles emitted allowed the identification of ten compounds with significantly increased levels in punctured plants, while no compounds with decreased levels were identified. The emission of discriminant compounds increased in the range of 2 to 100-fold and corresponded to terpenoids (1 monoterpenoid, 4 sesquiterpenoids and 1 norisoprenoid), a set of two (Z)-3-hexenyl esters, methyl salicylate and another unknown compound (Bouagga *et al.*, 2017).

In summary, Bouagga *et al.* (2017) described, for the first time, the defensive response that *O. laevigatus* induces in sweet pepper plants due to its phytophagous behavior. This is of special interest since the predator *O. laevigatus* has been one of the most studied and successfully used augmentative biological control agents in sweet pepper. This indirect defense mechanism could add value to the current and future role played by this predator in sweet pepper crops. The practical application of predator-induced plant volatiles for insect pest control remains a goal that will require coordinated research by agricultural scientists and chemical ecologists.

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