

Identification of the most common predatory hoverflies of Mediterranean vegetable crops and their parasitism using multiplex PCR

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Abstract The larvae of many hoverflies (Diptera: Syrphidae) are important polyphagous predators used in integrated pest management programs. Because the accurate identification of preimaginal stages by morphological characters is difficult, we have developed a multiplex PCR to identify the immature and/or adult stages of the most common syrphid species in Mediterranean vegetable crops: *Episyrphus balteatus*, *Scaeva pyrastris*, *Eupeodes corollae*, *Meliscaeva auricollis*, *Sphaerophoria scripta*, and *Sphaerophoria rueppellii*. The latter two species were amplified by the same primer pair due to the high similarity of their cytochrome oxidase subunit I sequences. Additionally, the assay included a primer pair targeting *Diplazon laetatorius*, a common koinobiont ichneumonid endoparasitoid of predatory syrphid larvae. The multiplex PCR assay proved to be highly specific and sensitive, and it was

used to study the assemblage of hoverfly species in larval stage in two Mediterranean lettuce crops in two consecutive years. The molecular analysis revealed that *Eu. corollae*, *Ep. balteatus*, and *Sph. scripta/Sph. rueppellii* were the species present in the investigated fields. Species composition differed depending on sampling date and whether the larvae were collected on the plants or on the ground. The parasitoid *D. laetatorius* was not detected in any of the analyzed hoverfly larvae, suggesting low-parasitism pressure in the studied syrphid populations. The wide distribution of most of these syrphid species makes this multiplex PCR assay an ideal tool to deepen our knowledge on the ecology of these polyphagous hoverfly species in preimaginal stages and to improve the use of hoverflies to control insect pests.

Keywords Syrphidae · COI · *Diplazon laetatorius* · Molecular species identification · Lettuce crops · Diagnostic PCR

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Introduction

Hoverflies (Diptera: Syrphidae) are an abundant group of insects present in natural and agriculture related ecosystems. With about 750 species recorded in Europe (Speight 2011), at least 355 species are recorded from Spain (Marcos-García et al. 2002). Their adults provide crucial ecosystem services as important pollinators, obtaining their energy requirements by feeding on nectar and pollen (Haslett 1983; Branquart and Hemptinne 2000; Jauker et al. 2012). The larvae of about 35 % of the species of the family of syrphids are polyphagous predators of a broad range of soft-bodied arthropods, including coleopteran and lepidopteran larvae, mites, thrips, and hemipterans (e.g.,