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Effects of pea aphid secondary endosymbionts on aphid resistance and development of the aphid parasitoid *Aphidius ervi*: a correlative study

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Abstract

In order to reduce parasite-induced mortality, hosts may be involved in mutualistic interactions in which the partner contributes to resistance against the parasite. The pea aphid, *Acyrthosiphon pisum* Harris (Hemiptera: Aphididae), harbours secondary bacterial endosymbionts, some of which have been reported to confer resistance against aphid parasitoids. Although this resistance often results in death of the developing parasitoid larvae, some parasitoid individuals succeed in developing into adults. Whether these individuals suffer from fitness reduction compared to parasitoids developing in pea aphid clones without symbionts has not been tested so far. Using 30 pea aphid clones that differed in their endosymbiont complement, we studied the effects of these endosymbionts on aphid resistance against the parasitoid *Aphidius ervi* Haliday (Hymenoptera: Braconidae: Aphidiinae), host–parasitoid physiological interactions, and fitness of emerging adult parasitoids. The number of symbiont species in an aphid clone was positively correlated with a number of resistance measurements but there were also clear symbiont-specific effects on the host–parasitoid interaction. As in previous studies, pea aphid clones infected with *Hamiltonella defensa* Moran et al. showed resistance against the parasitoid. In addition, pea aphid clones infected with *Regiella insecticola* Moran et al. and co-infections of *H. defensa–Spiroplasma*, *R. insecticola–Spiroplasma*, and *R. insecticola–H. defensa* showed reduced levels of parasitism and mummification. Parasitoids emerging from symbiont-infected aphid clones often had a longer developmental time and reduced mass. The number of teratocytes was generally lower when parasitoids oviposited in aphid clones with a symbiont complement. Interestingly, unparasitized aphids infected with *Serratia symbiotica* Moran et al. and *R. insecticola* had a higher fecundity than unparasitized aphids of uninfected pea aphid clones. We conclude that in addition to conferring resistance, pea aphid symbionts also negatively affect parasitoids that successfully hatch from aphid mummies. Because of the link between aphid resistance and the number of teratocytes, the mechanism underlying resistance by symbiont infection may involve interference with teratocyte development.

Introduction

Parasitoid existence depends on successful parasitism of their hosts. Given that parasitoids often kill their hosts as part of their life cycle, there is strong selection pressure on the host to evolve defences against parasitoid attack, and the parasitoid itself is selected to develop counter-resistance mechanisms against these host defences (Godfray, 1994; Kraaijeveld & Godfray, 2009). A suitable host allows all or nearly all immature parasitoids to develop into adults, whereas marginal hosts allow only a small proportion to develop, and unsuitable hosts allow no parasitoid

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