

Does *Botrytis Cinerea* Influence Parasitization of *Myzus Persicae* by *Aphidius Colemanii*?

Review Article

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Abstract

The dynamics of the insect herbivore and its natural enemy appears to be influenced by the presence of the pathogen. More *M. persicae* and parasitoids *Aphidius colemani* were grown on lettuce plants free from *B. cinerea* infection. The size of *M. persicae* and its parasitoid, *A. colemani* was significantly larger when reared on uninfected plants. However, similar parasitoid sex ratio, 50:50 was found between parasitoids emerging from both infected and uninfected plants. The experiment provide further evidence that healthy plants free from *B. cinerea* infection provided better quality food resources for the aphid host which encourage fitness and results in larger sized offspring. Therefore the negative effect of *B. cinerea* on the interaction between aphid and its natural enemy parasitoid was determined in the present study may be very valuable in understanding interaction at higher trophic level and may also provide a clue for design of disease management strategies.

Keywords: *Aphidius colemani*; *Botrytis cinerea*; *Myzus persicae*; Lettuce plant

Introduction

Aphids are important agricultural pests, which causes direct and indirect damage to crops. The direct damage occur by aphids feeding on crops were they use their stylets for piercing into the phloem [1,2] while the in indirect damage occur when aphids act as vectors of viral diseases resulting in significant diseases to their host plants [3,4].

Aphids are attacked by a range of natural enemies including hymenopteran parasitoids (e.g. *Aphidius* species such as *Aphidius colemani*, *A. matricariae*, *A. ervi* and *A. abdominalis*), and a wide range of arthropod predators [5,3,6,7]. High aphid numbers on a plant serves as a resource for their natural enemies. Many studies have investigated the potential effects of natural enemies for keeping aphid population sizes below economic injury levels [8,9].

Previous researches by Yahaya and Fellowes showed that aphids indirectly interact with necrotrophic pathogens such as *B. cinerea* when sharing host plant [10]. Where aphid and *B. cinerea* encounter

one another on the same host plant both aphids and pathogens may induces the host plant to release various defensive chemicals [11], these chemicals in addition also serve as cues which attracted aphid natural enemies [9]. Although there have been fewer studies examining the effect of necrotrophic pathogens such as *B. cinerea* on the interaction between aphids and their natural enemies and its potential influence on successful biocontrol but Persson, Aquilino et al., Moreira and Mooney believed that the necrotrophic pathogens may provide a significant biotic factor which indirectly modulates the outcome of interspecific interactions at higher trophic levels [12-14].

The parasitoid *A. colemani* belongs to the sub-family Aphidiidae (Hymenoptera: Braconidae) which is a koinobiont [15-17]. Saljoqi reported that the rate of parasitism by natural enemies was related to the availability of the host, plant age, temperature, weather conditions and cultural practices [18]. Saljoqi and van Emden reported that *M. persicae* can attain very high densities on young plant tissues, causes water stress, wilting and reduced growth rate of the plant

[19]. However, natural enemies can be used to limit survival of the host. The female parasitoids choose hosts that provide the best resources for their offspring, were they select hosts, and control the sex of their offspring by influencing fertilization [20-24]. The female hymenopteran parasitoids regulate the release of sperm from the spermatheca while eggs pass through her genital tract; unfertilized eggs develop into males while fertilized eggs develop into females [23,25,17]. Because fitness and size are strongly correlated with size in female parasitoids, but not for males, female parasitoids can preferentially oviposit male eggs in poorer quality host when provided with a choice [26,22,27,17]. This research describes an experiment aimed at investigating whether the presence of the systemic pathogen, *B. cinerea*, on lettuce plant *Lactuca sativa* L. (Asteraceae: Compositae) influences the parasitization of an insect herbivore (the peach potato aphid *Myzus persicae*) by the parasitoid *A. colemani* which may provide a clue on the biocontrol of insect pest aphid *M. persicae*. We tested three hypotheses. First, that *Myzus persicae* reared on uninfected lettuce plants would be larger. Second, that *A. colemani* which emerges from an aphid host feeding on uninfected plants would in turn be larger. Third, that decision to oviposit or not would be influence by the presence or absence of *B. cinerea* infection.

Material and Methods

Experimental plants

Lettuce seeds (Tom Thumb), infected (obtained by inoculating lettuce plants at the flower stage) and uninfected by *B. cinerea*, were used for the experiment. Lettuce seeds were individually sown in 90 (45 infected, 45 uninfected) 15cm pots filled with a vermiculite growing medium in a controlled environment (18-20°C, L: D 12-12, ambient humidity).

Infestation with *Myzus persicae*

Three weeks after germination all the plants were individually infested each with 10 nymphs *M. persicae*. *Myzus persicae* were placed on the reverse side of the leaves using a small moist brush. Plants were then covered with a transparent plastic dome for 48 h. Aphid colonies were covered at all times by a vented plastic container, preventing escape of aphids or parasitoids.

Parasitization rate

The source parasitoid *Aphidius colemani* is a commercially available biocontrol agent, and was obtained from Koppert UK. Female *A. colemani* oviposit a single egg into aphid nymphs. The larva develops inside the body of aphid host until it kills the host. The experimental *A. colemani* were fed with honey and maintained in vials at 5 °C in the laboratory. Prior to use parasitoids were allowed to acclimatize to room temperature for several hours. Immediately after the adult aphids were removed from the plants, the nymphs were exposed to attack by five female *A. colemani*. Thirty infected and uninfected plants were attacked with the aphid natural enemy while the aphids on the remaining fifteen infected and uninfected plants were allowed to serve as unattacked controls.

Rate of parasitoid attack

Emergence of mummies was determined by visual observation of the plastic doom. One week after parasitoid attack all the adult

aphids were counted and collected into 200ml Eppendorf tubes and placed on a laboratory bench for one week to allow the emergence of parasitoids.

Size of *M. persicae* and *A. colemani*

Ten adult *Myzus persicae* were randomly selected from each plant while all the resulting parasitoids from the mummies were collected for the determination of hind tibia length. Both *Myzus persicae* and *Aphidius colemani* were individually placed in a drop of 100% ethanol on a glass slide covered with a cover slip and hind tibia length measured using a micrometric eye piece attached to a Nikon Olympus microscope (New York Microscope Company) at 50 x magnifications.

Statistical analysis

All the experimental data were analysed using R [28]. Because the data met assumptions of normality hind tibia length data were not transformed prior to analysis. Attack rate and data counted from sex ratio were analysed using a generalised linear model using binomial errors [28].

Results

Size of *M. persicae*

Myzus persicae grown on plants uninfected by *B. cinerea* were larger than those reared on infected plants after parasitoid attack on both plants (Figure 1; $F_{1,38} = 260.02$, $P < 0.001$). In the control plants where aphids were not attacked by the parasitoids, aphids reared on uninfected plant were also larger than those reared on infected plants ($F_{1,38} = 22.40$, $P < 0.001$).

Aphidius colemani size

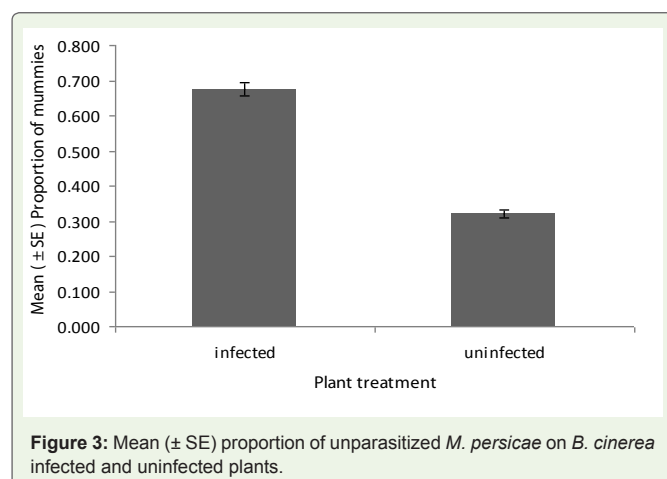
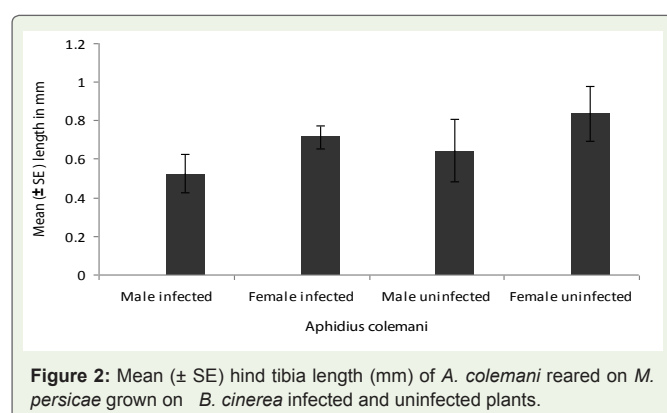
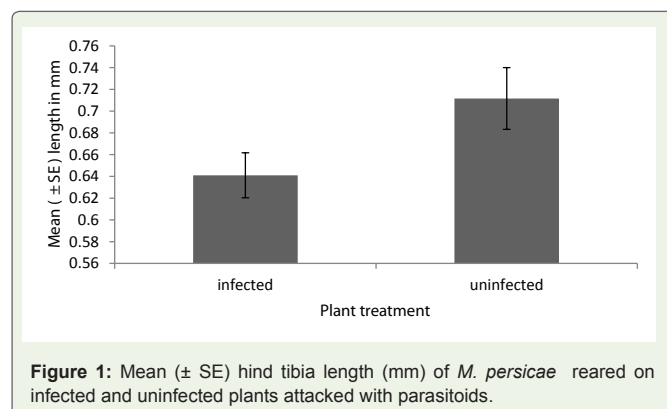
The hind tibia length of parasitoid that emerged from aphids reared on infected plants was significantly smaller than parasitoid grown on aphids feeding on uninfected plants ($F_{1,59} = 134.10$, $P < 0.001$). Female *Aphidius colemani* were significantly longer than male *Aphidius colemani* when reared on both infected (Figure 2; $F_{1,59} = 131.34$, $P < 0.001$) and uninfected plants.

Sex ratio and parasitization rate by *Aphidius colemani*

The attack rate suffered by *M. persicae* was higher in uninfected plants and also more *A. colemani* was recorded than on infected plants (Figure 3; $F_{1,39} = 4.20$, $P = 0.01$). However, there was no significant effect of plant infection status on the sex ratio of emerging *A. colemani*, which has same proportion.

Discussion

The systemic pathogen appears to influence the dynamics of the insect herbivore and its natural enemy. More *M. persicae* and parasitoids *Aphidius colemani* were grown on lettuce plants free from infection by *B. cinerea*. The aphids and emerging parasitoids were significantly larger when reared on uninfected plants. Similar parasitoid sex ratio, 50:50 was found between parasitoids emerging from both infected and uninfected plants. The study found that size of the aphid is a measure of host quality, where host quality is a linear function of size and determines the ability of the developing parasitoid to obtain the required nutritional resources from the host



this was similarly, reported by Sequeira and Mackauer [29] and Ode et al. [22]. The results showed that female *A. colemani* oviposit more in hosts reared on uninfected plants, probably because their offspring have a higher probability of survival this was similarly reported by Roitberg et al. and Ode et al. 2005 [30,22]. Larger hosts have more food and provide a better resource for the growth and development of offspring, which in turn influences the survival and fecundity of the adult parasitoid.

The study showed that a high number of parasitoid mummies

were recorded in aphids reared on *B. cinerea* free plants, which is an indication that presence of *B. cinerea* exert a negative influence on the interactions between *M. persicae* and their natural enemy *A. colemani*. Previous studies showed that this negative interaction occur because *Botrytis cinerea* can lowered the fitness of the aphids making it a poor-quality hosts resulting in a high mortality rate of the parasitoid [31]. This occurs when the *B. cinerea* induce the plant to synthesize secondary metabolites which may have toxic effects on the aphids. Therefore, the foraging parasitoid discriminate between feeding on aphid reared on infected and uninfected plants whether to feed, oviposit or to ignore, because host choice correlates with offspring performance which has a direct impact on the parasitoid host choice [32,31,27]. However, in the present study, parasitoids were not allowed a choice between infected and uninfected hosts, and as a result it is not possible to state categorically if host preference is likely to have influence the differences in attack rate.

In agreement with the present experiment the work of Jarosik et al. [33], Harri et al. [34]; Rehman and Powell [24] have shown that *A. colemani* emerging from small aphids, showed a significant male biased offspring sex ratio. The shift in emergence sex ratio may be the results of a significantly higher mortality of female progeny in smaller hosts. Female *A. colemani* often have a more strict nutritional requirements compared to males and may therefore reach a larger size than males even in a hosts of equal size, where the female have extended period of larval development on growing hosts which enables them to consume more resources than the males [29,35,15,36,37]. In the present study more aphids and parasitoids with larger size were recorded from uninfected plants. As reported by Charnov et al. [20] and Paul et al. [38], higher female mortality in small aphids although not measured in the present study normally occurs due to a shortage of resources during the early stages of female development. The sex ratio determined by female choice at oviposition may as a result be altered by differential mortality of the sexes. Therefore a biased sex ratio may result either from the female's control of fertilization at oviposition, or may result from the differential mortality of male and female offspring during early stages of development [20,38].

Overall the result of the present study has confirmed the influence of *B. cinerea* on the parasitization *M. persicae* by parasitoids *A. colemani*. The observations of the experiment provide further evidence that healthy plants free from *B. cinerea* infection provide better quality food resources for the aphid host which encourage fitness and results in larger sized offspring. The study found that infected plants which were infested with aphids showed reduced aphid and parasitoid population counts which indicated the negative effect of *B. cinerea* on the population dynamics of both herbivore and its natural enemy. Therefore the negative effect of *B. cinerea* on the interaction between aphid and its natural enemy parasitoid determined in the present study may be very valuable in understanding interaction at higher trophic level and may also provide a clue for design of disease management strategies.

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References

- Blackman RL, Eastop VF (2000) Aphids on the world's Herbaceous Plants and Shrubs, Wiley, Chichester, England.
- Eisen J (2010) Genome sequence of the pea aphid *Acyrthosiphon pisum*. Plos Biol 8: e 1000313.
- Pell JK, Pluke R, Clark SJ, Kenward MG, Anderson PG (1997) Interactions between two aphid natural enemies, the entomopathogenic fungus *Erynia neoaphidis Remaudiere* and Hennebert (Zygomycete: Entomophthorales) and the predatory beetle *Coccinella septempunctata*. L. (Coleoptera: Coccinellidae). Invertebr Pathol 69: 261-268.
- Mouttet R, Bearez P, Thomas C, Desneux N (2011) Phytophagous arthropods and a pathogen sharing a host plant: Evidence for Indirect Plant-Mediated Interactions. Plos One 6: e18840.
- Hatcher PE, Paul ND, Ayres PG, Whittaker JB (1995) Interactions between *Rumex* spp. herbivores and a rust fungus: the effects of *Uromyces rumicis* infection on leaf nutritional quality. Functional Ecology 9: 97-105.
- Gwynn DM, Callaghan A, Gorham J, Walters KFA, Fellowes MDE (2005) Resistance is costly: trade-offs between immunity, fecundity and survival in the pea aphid. Proc Biol Sci 272: 1803-1808.
- Hazell SP, Fellowes MDE (2009) Intra-specific variation affects the structure of the natural enemy assemblage attacking pea aphid colonies. Ecological Entomology 34: 34-42.
- Trumble JT (1982) Within plant distribution and sampling of aphids (Homoptera: Aphididae). On Broccoli in southern California. Journal of Economic Entomology 75: 587-592.
- Fellowes MDE, Van Alphen JJM, Jervis M (2005) Foraging behaviour. In Mark AJ (ed.) Insects as Natural Enemies: A Practical Perspective. Pp 1-71. Springer, Dordrecht, the Netherlands.
- Yahaya SM, Fellowes MDE (2013) Host plant infection by *Botrytis cinerea* affects the interaction between aphids and their parasitoids. Journal of Biological Science and Bioconservation 5: 111-123.
- Hatano E, Kunert G, Michaud JP, Wolfgang W, Weisser W (2008) Chemical cues mediating aphid location by natural enemies. Eur J Entomol 105: 797-806.
- Persson L (1999) Trophic cascades: abiding heterogeneity and the trophic level concept at the end of the road. Oikos 85: 385-397.
- Aquilino KM, Cardinale BJ, Ives AR (2005) Reciprocal effects of host plant and natural enemy diversity on herbivore suppression: an empirical study of a model tritrophic system. Oikos 108: 275-282.
- Moreira X, Mooney KA (2013) Influence of plant genetic diversity on interactions between higher trophic levels. Biol Lett 9: 20130133.
- Godfray HCJ (1994) Parasitoids: Behavioral and Evolutionary Ecology. Princeton University Press, Chichester, UK.
- Colinet H, Salin C, Boivin G, Hance TH (2005) Host age and fitness-related traits in a koinobiont aphid parasitoid. Ecological Entomology 30: 473-479.
- Kant R, Minor MA, Trecwick SA (2012) Fitness gain in a koinobiont parasitoid *Diaretiella Rapae* (Hymenoptera: Braconidae) by parasitizing hosts of different ages. Journal of Asia-Pacific Entomology 15: 83-87.
- Saljoqi AR (2009) Population dynamics of *Myzus persicae* (Sulzer) and its associated Natural enemies in spring potato crop, Peshawar Pakistan. Sarhad Journal of Agriculture 25: 564-571.
- Saljoqi AUR, Van Emden HF (2003) Selective toxicity of different granular insecticides to the peach-potato aphid, *M. persicae* (Sulzer) (Homoptera: Aphididae) and its parasitoid, *A. matricariae* Haliday (Hymenoptera: Aphidiidae) in two differentially resistant potato cultivars. Journal of Biological Sciences 3: 215-227.
- Charnov EL, Los-den Hartogh RL, Jones WT, Van den Assem J (1981) Sex ratio evolution in a variable environment. Nature 289: 27-33.
- King BH, Seidl SE (1993) Sex ratio response of the parasitoid wasp *Muscidifurax raptor* to other females. Oecologia 94: 428-433.
- Ode PJ, Hopper KR, Coll M (2005) Oviposition vs offspring fitness in *Aphidius colemani* parasitizing different aphid species. Entomologia Experimentalis et Applicata 115: 303-310.
- He XZ, Wang Q (2006) Host age preference in *Aphidius ervi* (Hymenoptera: Aphidiidae). Journal of New Zealand Plant Protection Society 59: 195-201.
- Rehman A, Powell G (2010) Host selection behaviour of aphid parasitoids (Aphidiidae: Hymenoptera). Journal of Plant Breeding and Crop Science 2: 299-311.
- Rabelling C, Lino-Neto J, Cappellari SC, Dos-Santos IA, Mueller UB, et al. (2009) Thelytokous parthenogenesis in fungus-gardening Ant Mycocepurus smithii (Hymenoptera: Formicidae) Plos One 4: e6781.
- Morris R, Fellowes M (2002) Learning and natal host influence host preference, handling time and sex allocation behaviour in a pupal parasitoid. Behavioural Ecology and Sociobiology 51: 386-393.
- Bilu E, Hopper KR, Coll M (2006) Host choice by *Aphidius colemani*: effects of plants, plant-aphid combinations and the presence of intra-guild predators. Ecological Entomology 31: 331-336.
- Crawley MJ (2005) An Introduction Using R. Wiley. United Kingdom.
- Sequeira R, Mackauer M (1992b) Covariance of adult size and development time in the parasitoid wasp *Aphidius ervi* in relation to the size of its host *Acyrthosiphon pisum*. Evolutionary Ecology 6: 34-44.
- Roittberg BD, Boivin G, Vet LEM (2001) Fitness, parasitoids and biological control: an opinion. Can Entomol 133: 429-438.
- Kruess A (2002) Indirect interaction between a fungal plant pathogen and a herbivorous beetle of the weed *Cirsium arvense*. Oecologia 130: 563-569.
- Guevara R, Rayner ADM, Reynolds SE (2000) Orientation of specialist and generalist fungivorous ciid beetles to host and non-host odours. Physiological Entomology 25: 288-295.
- Jarosik V, Holy I, Lapchin L, Havelka J (2003) Sex ratio in the aphid parasitoid *Aphidius colemani* (Hymenoptera: Braconidae) in relation to host size. Bull Entomol Res 93: 255-258.
- Harri SA, Kraus J, Muller CB (2008) Fungal endosymbionts of plants reduce lifespan of an aphid secondary parasitoid and influence host selection. Proc Biol Sci 275: 2627-2632.
- Sequeira R, Mackauer M (1993a) Nutritional ecology of an insect host-parasitoid association: the pea-aphid *Aphidius ervi* system. Ecologist 73: 183-189.
- Mackauer M (1996) Sexual size dimorphism in solitary parasitoid wasps: influence of host quality. Oikos 76: 265-272.
- Lykouressis D, Garantonakis N, Perdakis D, Fantinou A, Mauromoustakos A (2009) Effect of female size on host selection by a koinobiont insect parasitoid (Hymenoptera: Braconidae: Aphidiinae). Eur J Entomol 106: 363-367.
- Ode P, Berenbaum MR, Zangeri AR, Hardy ICW (2004). Host plant, host plant chemistry and the polembryonic parasitoid *Copidosoma sosares*: indirect effects in a tritrophic interaction. Oikos 104: 388-400.