The genetics of life and death in an evolutionary arms-race

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Scientists at The University of Manchester have found evidence of the genetic basis of the evolutionary arms-race between parasitoids and their aphid hosts.

The researchers studied the reaction of aphids when a parasitic wasp with genetic variation laid eggs in them. They found that different genotypes of the wasp affected where the aphids went to die, including whether they left the plant host entirely. The team also found an example of the emergence of a shared phenotype that was partly wasp and partly aphid.

Dr Mouhammad Shadi Khudr, a visiting scientist at the Faculty of Life Sciences, led the research: "Natural selection on the aphid prey depends not only on aphid genes, but also on the genetics of the parasitic wasp. The indirect genetic effects underlying the relationship between natural enemies have been rarely shown, especially when they arise between species. Parasite-manipulation is endlessly fascinating, albeit with a somewhat ghoulish quality! This study sheds light on how genetic variation can influence that manipulation."

The researchers began the study by breeding 13 males with 3 females of the wasp *Aphidius ervi*, through which a quantitative genetic design was created. The resulting offspring of full and half siblings provided a basis of genetic variation in the parasitic wasp to test how different individuals of the latter are associated with variation in the aphids' behaviour when aphids are prone to the wasps' manipulation. One genotype of the pea

aphid *Acyrthosiphon pisum* was chosen. Since this species reproduces asexually by parthenogenesis, the resulting genetically identical individuals make up a specific type of colony known as 'clone'.

The team then introduced the wasps into 156 cages that contained a broad bean plant and an aphid colony. They then compared the behaviour of aphids in the presence and absence of the wasp by monitoring what the aphids did over the next ten days. Successful parasitism ends with the death of the aphid host which becomes a pale brownish remainder called a 'mummy'. Once the aphids had mummified, the location of each mummy was recorded according to its position on the plant and at other locations within the cage.

Dr Khudr says: "Our results confirm that parasitism by a parasitoid wasp can lead to behavioural modifications in an aphid host. The effect of the wasp fathers was significant on the distribution of the parasitised and non-parasitised aphids. There was also a notable effect of mothers indicating a maternal influence on the distribution of parasitised vs. non-parasitised aphids. This can reflect a fitness-difference between father families."

As well as monitoring their behaviour whilst they were alive, the positions of the aphids' bodies once the new wasp has hatched also varied both on and off the plants. This variation was dependent on the wasp genotype. It's this relationship between the wasp and its host which starts with parasitism and ends with predation that fascinates Dr Khudr.

"What we're witnessing on the broad bean plants is an evolutionary arms-race between two enemies where each one strives to cap each others' fitness. This can be observed through varying manipulative strategies applied by the parasitic wasps in order to subdue their hosts. The wasp has to ensure the aphid can be kept alive long enough to ensure it can mature. The parasitised aphid will on occasion commit suicide if it

realises it has the wasp growing within it and by doing so it can save the rest of the colony from a subsequent attack. What we've been able to do in this study is to open the window on how the genetics of one species influence the behaviour and manipulation of another host species."

The findings have been published in the Royal Society's *Biology Letters*. Discussing the findings Dr Khudr says he was surprised by what the team recorded: "We had expected some variation in the aphids' movement and behaviour but not to the extent that we witnessed. An organism's phenotype (behaviour) can be the product of the genes expressed in another organism"

The next step is to carry out further research to establish if specific genes in the wasps can be linked to particular behaviours in the aphids. Dr Khudr hopes this type of information could increase our understanding of the importance of genetic diversity in ecosystem services, and lead to the development of better biological controls for aphid populations.

More information: The paper title is "Parasitoid wasps influence where aphids die via an interspecific indirect genetic effect". It will be published in *Biology Letters* on April 10 2013. rsbl.royalsocietypublishing.or … .1098/rsbl.2012.1151

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