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Wolbachia-induced reproductive isolation

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Abstract

Infection with the bacterium *Wolbachia* is sufficient to establish a reproductive barrier between two otherwise compatible species of wasp, making *Wolbachia* a potential driving force in evolution.

Significance and context

Advances in molecular techniques allow us to study the effects of microbial infection throughout the animal kingdom. Many invertebrates harbor bacteria of the genus *Wolbachia*. These maternally inherited parasites are found in a quarter of all insects and can manipulate their host's reproduction in some unusual ways to achieve their goal - enhancing the mating prospects of infected females. At the simplest level, *Wolbachia* infection can increase the production of offspring. For certain wasp species in which unfertilized eggs normally develop into haploid males, *Wolbachia* can abort mitosis, generating unfertilized diploid eggs which then develop into infected females. Infected male embryos of some hosts die, or in others become feminized to reproduce as females. The best-studied reproductive effect of *Wolbachia* infection is cytoplasmic incompatibility (CI), which prevents infected males from fertilizing the eggs of uninfected females. Although the exact mechanisms behind this phenomenon remain unknown, CI somehow prevents normal decondensation of paternal chromosomes and they are eventually lost. Bidirectional CI can prevent parents from successfully mating unless they both carry the same strain of *Wolbachia*. One provocative theory is that *Wolbachia* might then be able to act as an agent of rapid 'infectious speciation' by reproductively isolating insect populations according to their individual infections. This study provides the first example of two sibling species which are reproductively isolated by *Wolbachia* but which can successfully interbreed when cured of infection.

Key results

Two closely related wasp species - *Nasonia giraulti* and *N. longicornis* - are found on the eastern and western sides of North America respectively. The authors collected samples of each from the wild and screened them by polymerase chain reaction (PCR) for *Wolbachia* infection. Both species were found to harbor multiple species-specific strains of *Wolbachia*. For untreated wasps, the resulting bidirectional CI prevented crossbreeding, but following antibiotic treatment hybrid offspring were generated with high levels of success. Other experiments were then needed to explore potential genetic incompatibilities in *N. giraulti*-*N. longicornis* hybrids. Crosses with uninfected females produced the same number of F1 progeny whether they mated with males of their own or the other species. Similarly, the number of female offspring remained constant, demonstrating that no fertilization incompatibilities exist between the two species. In the first generation, hybrid females were shown to have similar, if not better, fertility than controls. A previous study of another pair of wasp species had indicated genetic incompatibilities in hybrid males from the F2 generation. But for antibiotic-treated *N. longicornis* and *N. giraulti* no significant mortality differences were seen for F2 males, which were in turn capable of fertilizing females from either species. In fact, the only potential barrier to interbreeding of treated wasps appeared to be a degree of mate selection by *N. longicornis* females.

Links

More on this topic can be found at the Werren laboratory homepage.

Conclusions

These experiments show that, following antibiotic treatment to remove *Wolbachia*, *N. giraulti* and *N. longicornis* can interbreed to produce healthy offspring with no evidence of F1/F2 lethality, sterility or hybrid sickness. *Wolbachia*-induced cytoplasmic incompatibility thus appears to have preceded other isolating mechanisms. Although these experiments show a degree of partial pre-mating isolation in one direction, the contribution of *Wolbachia* seems to be the most significant biological barrier to crossbreeding.

Reporter's comments

Microbial isolation could potentially provide a rapid evolutionary force that overtakes the classical elements of mutation and genetic drift. By their very nature, however, evolutionary theories are almost impossible to prove, and as yet there is little evidence for infectious speciation in the wild. Instead, features such as geographic isolation are likely to play a major role. Other qualifying factors that act at the level of *Wolbachia* parasites themselves include natural variations in the penetrance and transmission of infection, both of which would allow a degree of gene flow between host populations. Horizontal transmission of *Wolbachia* between hosts would also act to reverse the effects of cytoplasmic incompatibility. But the findings of this study and the ubiquity of *Wolbachia* infection in nature indicate that CI might reinforce speciation rather than driving it directly. Ongoing studies have already identified other bacteria capable of inducing CI and the potential biological influences of such infections should soon become much clearer.

Table of links

Nature

Werren laboratory

References

1. Bordenstein SR, O'Hara FP, Werren JH: *Wolbachia*-induced incompatibility precedes other hybrid incompatibilities in *Nasonia*. Nature. 2001, 409: 707-710. 0028-0836