Hitching a ride on the feminine side

Some parasites can hitch-hike across generations by changing their hosts' sex. Alison Dunn explains.

Microsporidia infect all animal phyla, from protists to insects to humans, but they don't all hitch-hike across generations and change their hosts' sex. In humans microsporidian infections can kill Aids sufferers. Microsporidia are particularly interesting because they are eukaryotes—organisms that carry their genetic material on chromosomes within a cell nucleus. We know that feminisation and other reproductive manipulations are common in prokaryotic parasites (which don't have true cell nuclei), particularly the bacterium *Wolbachia*, but little is known about eukaryote feminisers. Screening other host species will help us discover how important these parasites are for ecology and evolution.

For some animals, their genes don't necessarily control their sex. *Gammarus duebeni,* for example, is a shrimp-like amphipod crustacean with unusual parasites. Those infected with *Nosema granulosis*, a single-celled microsporidian parasite, produce only daughters. The parasite lives in the ovary and infects the eggs, letting it hitch a lift to the next generation. This is the only known route for infection—healthy adults don't pick up this parasite. Sperm are too small to transmit *N. granulosis*, so by making sure only females are produced, the parasite can ensure its gets passed on.

Catching the crustacea.

In theory, feminising parasites can make host populations unstable, and even drive them to extinction. So we wanted to know whether *N. granulosis* is a biological rarity, or if microsporidian parasites often distort sex ratios.

We examined 17 species of European amphipods. To our surprise, they all suffered from microsporidian parasites that are transmitted across generations, and half of the parasites we tested could distort sex ratios. It also looks as though this ability has evolved several times, because the parasites came from all major branches of the microsporidian family tree.

To discover how parasites feminise their hosts, we compared the hormone function of normal and parasitised *G. duebeni*. In normal crustaceans, the androgenic gland produces a hormone that controls male development. But in the parasitised animals, this gland doesn't develop and the animals become females. Other researchers have found a similar system in woodlice (which are isopod crustaceans) and the feminising bacteria that infect them.

In theory, feminisers should spread rapidly. But when we looked at the real world, we found the numbers of infected animals stayed fairly constant at any one site. So we tested whether sexual behaviour had evolved to cope with the parasite. *G. duebeni* females infected with *N. granulosis* have fewer young as well as only producing daughters. When females heavily outnumber males in a population, parents that produce sons will eventually have more grandchildren than those that produce daughters, because the rarer sex will have more opportunities to mate. So to maximise their reproductive success, males should avoid mating with parasitised females. Male gammarids guard potential mates for several days before the female lays her eggs. We showed that males spend less time guarding infected than uninfected mates. And when males did mate with parasitised individuals, they donated fewer sperm. Females that were given too few sperm laid fewer eggs, and many of these didn't develop. So, by avoiding infected mates, males increase their breeding success and slow the parasite's spread.

Want to know more?
Alison and her colleagues are looking at how microsporidia and their hosts evolved together, and at how feminising parasites affect invasive species. You can find out more about Alison's research at www.biology.leeds.ac.uk/staff/ad/

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