EVOLUTIONARY BIOLOGY

Thanks to a Parasite, Asexual Reproduction Catches On

Asexual reproduction is usually considered a way of life—an evolutionary choice a species makes when the drawbacks of sex outweigh its long-term benefits. Recent research, however, has shown that in some insects, parthenogenesis (in which females give rise only to daughters and no males are born) is more of a sickness than a strategy. And now, in the 22 March issue of the *Royal Society Proceedings: Biological Sciences*, two Dutch entomologists claim that parthenogenesis may literally be contagious.

The culprit is *Wolbachia*, a bacterium that infects perhaps 16% of all insect species and has come under intense scrutiny by biologists in recent years because it provides some bizarre examples of how a parasite can alter its host's sex life and reproduction for the parasite's benefit. "It's an exploding field," says Richard Stouthamer of Wageningen Agricultural University, who did the new study with colleague Menno Schilthuizen. Their work may offer practical benefits in pest control, as well as a whole new perspective on the evolution of reproductive strategies—a topic evolutionary geneticist Laurence Hurst of the University of Bath calls "one of the big problems in biology." The string of recent studies suggests, he says, that some instances of asexual reproduction may have evolved not for the organism's best interest but because of a parasite: "What [this] work shows is that it may not be adaptive to be asexual at all."

Wolbachia spends its life within the ovaries and testes of many arthropod species and is chiefly transmitted from mother insects to their offspring through the egg's cytoplasm. Because sperm are almost empty of cytoplasm, male insects—although they can be infected—are unable to pass on the organism. So *Wolbachia* prefers females, and it has developed ways of playing havoc with its hosts' sex lives and gender ratios. In wood lice, for example, the bacterium manages to transform infected males into functional females. And in a well-known phenomenon called cytoplasmic incompatibility, *Wolbachia* prevents some mating pairs from having viable offspring. In flies and mosquitoes, infected males are unable to fertilize uninfected eggs—a combination that wouldn't yield infected offspring and so wouldn't benefit *Wolbachia*.

In some wasp species, *Wolbachia* has eliminated males altogether, by somehow disrupting the first cell division in the wasp's egg. That makes the egg diploid, which in most wasps causes the egg to develop as a female. Researchers have found that in *Trichogramma*, a genus of minuscule wasps that parasitize moth and butterfly eggs, this condemns the insects to perpetual asexual multiplication. The wasps' asexual state can be "cured" only by treating them with antibiotics or bacteria-killing heat in the laboratory, explains Stouthamer.

But how does *Wolbachia* colonize *Trichogramma* species? The bacterium can jump from one species to another in mosquitoes and flies, a phenomenon called horizontal transmission. But in wasps the infection seemed to be inborn; it was impossible to transfer the bacterium from one wasp to another in the lab. This led researchers to speculate that in *Trichogramma*, the insect and its parasite might have cospeciated: Whenever a wasp lineage diverged into two species, a new *Wolbachia* strain would then develop in each isolated wasp species.

To test this hypothesis, Stouthamer and Schilthuizen collected 20 *Trichogramma* species that carried *Wolbachia* and sequenced specific DNA regions in each—about 800 base pairs in the microbe and some 420 base pairs of nuclear DNA from a diagnostic region in the wasp. Then, they drew up two evolutionary family trees, one for the insects and one for the microbe. If wasps and their parasites coevolved, the trees would be very much alike.

DAVID FERRO/FRAN HEYL

H. R. BRAIG AND S. L. O'NEILL/YALE UNIVERSITY

***Wolbachia* at work.** All these *Trichogramma* wasps are female *(top)* thanks to *Wolbachia*, seen as a cloudy area in a wasp egg *(above)*.

But they weren't. "It's a phylogenetic mess," says Stouthamer. "You find almost identical *Wolbachia* in wasp species that are far removed and vice versa." So cospeciation is highly unlikely. And although researchers couldn't re-create it in the lab, in nature *Wolbachia* must have leaped from one *Trichogramma* species to another many times, carrying the parthenogenetic lifestyle with it. "We knew parthenogenesis was curable; now we know it's contagious too," says Stouthamer. He suggests that the infection spreads in butterfly eggs, *Trichogramma*'s favorite place to breed. When infected and uninfected wasp species share an egg, the infection may jump between species.

All this may have practical use. "This is very important," says *Wolbachia* researcher Henk Braig of the Yale University School of Medicine, "because if there is horizontal transfer, there's hope we might be able in the future to make insects parthenogenetic at our will." Certain *Trichogramma* species are already used as effective parasitic weapons against pest insects, and all-female strains would be even better, because only the female wasps parasitize the pest by laying eggs. So Stouthamer says he will keep trying to carry the infection between wasp species.

Meanwhile, other researchers are trying to unravel the molecular mechanisms by which *Wolbachia* manipulates its host, with much of the work focusing on the details of cytoplasmic incompatibility. "If we can figure out the mechanism, it will tell us something brand-new and very fundamental about what happens when a sperm enters an egg. That would be a great step forward," says Timothy Karr of the University of Chicago.

Nor do researchers know whether *Wolbachia* really harms its hosts by making them asexual. The highly intimate relationship between the bacterium and its hosts suggests that *Wolbachia* is on the evolutionary road to becoming a cell organelle, just as mitochondria and chloroplasts have done, says Karr. But Hurst disagrees. "This relationship goes back an awfully long way," he says, perhaps for tens of millions of years. "If these things are going to evolve to be nice to the host, why haven't they done it already? On the whole, I think they are being quite nasty."

Another mystery is how widespread *Wolbachia* may be. Recently, it has shown up in crustaceans, mites, and even nematode worms, as well as insects. "We're years away from knowing its true distribution across animal and plant taxa," says Karr. "We could find out that humans have this, for all we know. Anything is possible."

Even catching a new kind of sex life.

–Martin Enserink

Martin Enserink is a science writer in Amsterdam, the Netherlands.