The Legacy of an Incestuous Father

(September 19th, 2011) Recently, a British researcher found a unique lineage of insects, where females have managed to mostly wipe out males from their lives... is this the beginning of a new revolution? A world without males?

The end of males is probably not yet nigh just yet, at least not for most species. But for three rather extraordinary insect species of the genus Icerya, also known as scale insects, it is a very real possibility.

Scale insects, related to the better known stink bugs (but without any stink attached), are very tiny fellows, measuring between 1-5 mm. They look pretty strange; some, for example, are encased in a waxy shell and resemble a white mint candy with red swirls. Around 6,000 different species exist and they all feed on plant sap, some to the point of being a bit of a nuisance. Such is the case for the cottony cushion scale or Icerya purchasi, a major pest of citrus trees. But this scale insect and two other closely related species share a far more interesting secret, which Andy Gardner and Laura Ross from the University of Oxford, UK recently revealed.

They discovered the first instance of hermaphroditism in the multi-million species strong class, Insecta.

The Hermaphroditus legacy

Hermaphroditic organisms derive their name from Hermaphroditus, the son of Hermes and Aphrodite in Greek mythology, who, after being fused with the nymph Salmacis became an individual possessing both male and female traits.

Our more earthly hermaphrodites develop the organs needed to make both sperm and eggs, and they then take turns at being male or female. Hermaphrodites are not actually that rare; it all depends where you look. Most plants are hermaphrodites, as well as most pulmonated snails and some fish. But in all the millions and millions of insect species, only three tiny scale insect species went this way.

But simply being hermaphroditic wasn't enough for the cottony cushion scale. The little insect has an even greater surprise in store, as elegantly put by science blogger and writer Ed Yong: “scale insects can be father, mother, grandfather and grandmother to all of their grandchildren. Good luck drawing that family tree.”

How is that possible?

The cottony cushion scale females carry around a piece of tissue – it’s a generous gift from their father. This piece of tissue actually produces sperm. Yes, as weird as it sounds, a long time ago, a male scale father deposited a very special piece of tissue on his own daughter, which has since been “infecting” all following generations. The goal is to fertilise not only his “mate” (which is actually himself) but also his daughter. So, yes, he is indeed both father and grandfather to his own grandchildren.

Andy Gardner summarises, “The weird thing about this species is the same individual has tissues that produce eggs and sperm, so that it can mate with itself. Sometimes, Icerya are described as the only hermaphroditic insects. But, looking closer, it turns out that the egg-producing tissues have a different complement of genes from the sperm-producing tissues, so it may be better to see these individuals as regular females, who harbour ‘dwarf males’ inside their bodies”.

How did evolution come up with this?

Well, there was one hypothesis proposed back in 2009, by Benjamin Normark. He suggested that it all came down to the conflict between males and females. Once upon a time, there were males and females, and all was good. But then, somehow, by pure chance, males found a way to “infect” their daughters with this sperm-producing parasitic tissue. The advantages made this behaviour stick around because, in this way, the males were able to fertilise more eggs and pass on their genes, even beyond their own lifetime!
Andy Gardner and Laura Ross offer an alternative option to Normark’s idea, “Our explanation is essentially the same as Normark’s”, Gardner writes in an email to Lab Times, “but where we differ is in terms of figuring out what the female wants in the battle of the sexes. Normark described the infectious tissue as a parasite, and saw it as acting only in its own interests, and against those of the female, its host. But we pointed out that, because the female is genetically related to the infectious tissue that she carries (it is a clone of her father), then their interests can become aligned. What the female wants to do is to send copies of her genes into future generations, and she can do this by helping the infectious tissue to spread, since its genes are her genes. This helps to explain why the tissue has been so successful, and why it has virtually eliminated the need for regular males in this species.”

To add another twist to an already weird system, these insects also harbour certain bacteria species, located around the infectious tissue, which the authors believe may protect the tissue and may have helped in the demise of males. Why? Because the bacteria are passed down from mother to daughter… so if males mean extinction for them, then it is likely that they will do all in their power to help produce more females.

Is the end of males near?

Males are indeed rare in this species but are they really on their way to extinction or will they stay around? The answer to this question may come from within this system itself. One potential problem with mating with yourself, or with your father, is that you pretty much get the same genes over and over again. This is fine as long as those genes are fine. But when something goes wrong and you get a faulty copy of a gene, you won’t be able to get it out of your system. This can potentially lead to inbreeding depression and a reduction in fitness, due to the expression of so called recessive deleterious alleles, or in other words, bad genes. But Andy Gardner reassures, “The system does lead to strong inbreeding, but not necessarily inbreeding depression. Inbreeding is only bad for your health when recessive deleterious alleles occur frequently in the population but, in inbred populations, such alleles are frequently exposed to selection and weeded out, in a process called ‘purging’. So, inbreeding is okay, provided everyone else is doing it!”

And if that doesn’t work, there’s another option: the occasional, good old traditional mating with one of those rare normal males. Interestingly, it so happens that when the “infectious” tissue fails to fertilise the eggs for whatever reason, then the eggs become male. And thus, every now and then, males will “pop out” and preserve the gender!

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Photo: P. Hollinger, L. Ross