Twisted Parasites From "Outer Space" Perplex Biologists

A bizarre group of parasitic insects challenges the biological rule book

The odd group of insects called twisted-wing parasites, or more formally Strepsiptera, is easily overlooked. Spending most of their lives hidden inside other insects, the majority of the 596 known species have been identified only from adult males caught during their brief mate-seeking flight. "These are really, truly enigmatic insects," says David Grimaldi, entomology curator at the American Museum of Natural History in New York City. "They break all the rules."

The differences between males and females of the same strepsipteran species are extreme. Adult males are small, flylike creatures, whereas most adult females resemble grubs and remain inside their host, merely protruding their fused heads and thoraces when ready to receive a male's sperm. In one strepsipteran family, males and females actually parasitize different kinds of insects. "Everything you find about them is like they came from outer space," says population geneticist J. Spencer Johnston of Texas A&M University in College Station.

Unlocking the secrets of how these strange parasites originated and how they maintain their bizarre lifestyle promises to deliver new insights in evolutionary and developmental biology, says Jeyaraney Kathirithamby, an insect evolutionary taxonomist at Oxford University in the United Kingdom. She and Johnston have recently turned up oddities in the strepsipteran genome and begun to tease out how the parasites survive within their hosts. Kathirithamby and researchers in Papua New Guinea have even enlisted Strepsiptera in the battle against important insect pests.

Quirky physical characteristics and lifestyle have made Strepsiptera tough to place in the insect family tree, notes Grimaldi. Some systematists group them with the beetles, others with flies. Grimaldi, however, has recently analyzed a primitive strepsipteran found in Cretaceous amber and says it doesn't resemble either flies or beetles. Meanwhile, he adds, molecular analyses of strepsipteran phylogeny have been "at best controversial."

The sequencing of a strepsipteran genome could resolve its phylogeny, but no organization has stepped forward so far to fund such an effort. Last month, however, a team led by Kathirithamby and Johnston reported online in *Insect Molecular Biology* that the strepsipteran *Caenocholax fenyesi* has the smallest documented genome of any insect. In still-unpublished work with graduate student Joseph Gillespie of Texas A&M, they also discovered that the ribosomal DNA of this species has a unique structure. "They're just so different from everything else," says Johnston.

Strepsipterans parasitize 34 families across 7 of the 32 orders of insects, most commonly wasps, bees, and Hemiptera (true bugs). The discovery last year that the larvae of one species, *Stichotrema dallatorreanum*, wrap themselves in a bag created from their katydid host's epidermis, thereby eluding an immune response, may explain how strepsipterans are able to parasitize such a wide range of hosts. But Kathirithamby and Johnston think it's possible that this strategy only evolved in the family Myrmecolacidae to which *S. dallatorreanum* belongs.

For most parasites, males and females prey upon the same host. Myrmecolacids are an exception: They are the only group of parasitic insects in which male and female larvae enter completely different hosts, notes Kathirithamby. The males parasitize ants, whereas females take up residence in crickets or grasshoppers. An intriguing question, says Kathirithamby, is whether myrmecolacid larvae start life sexless and only become male or female once they enter an ant or cricket. "To date, there is no organism that determines its sex by its host, but it makes sense to me," says Johnston. It's possible that a signal from the host sets off a cascade of sex-determining genes, he adds.

Studying sex determination in myrmecolacids is no easy task. The differences between the sexes have made it difficult to find the females and match them to males of the same species. Kathirithamby and Johnston scored a first last year when they used DNA analyses to match male and female specimens of *C. fenyesi* from Mexico.

At the same time, they discovered that there are significant differences between the DNA sequences of two genes in *C. fenyesi* males from Texas (which parasitize red imported fire ants) and identical-looking males from Mexico (which parasitize other ants). That suggests that these insects are actually separate species, or are on the verge of becoming so, because they have different hosts. "What is puzzling us is how this speciation is going on," says Kathirithamby.

Strange pair. Strepsipteran males (left) and females (right) look very different and, in one family, parasitize completely different hosts.

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Understanding the basic biology of strepsipterans may prove useful in controlling insect pests, such as those ravaging coffee, rice, and oil palm crops. *S. dallatorreanum* is already a hit with oil palm growers in the Papua New Guinean island of West New Britain; since its introduction in 2000, it seems to have reduced katydid numbers and lessened oil palm damage.

Whether strepsipterans could also control U.S. red imported fire ants remains an open question. Jerry Cook, an entomologist at Sam Houston State University in Huntsville, Texas, has estimated that *C. fenyesi* is unlikely to be effective because it parasitizes only 1% to 2% of ants. Kathirithamby and Johnston think that this is an underestimate; in large fire ants, parasitism rates run as high as 55%, they say.

Still, Johnston acknowledges that the "funny biology" of strepsipterans may create a hitch. Fire ants naturally eat any insect in sight, including crickets, the most probable hosts of *C. fenyesi* females.

–Fiona Proffitt