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Water striders illustrate evolutionary processes

How do new species arise and diversify in nature? Natural selection offers an explanation, but the genetic and environmental conditions behind this mechanism are still poorly understood. A team led by Abderrahman Khila—CNRS Senior Researcher at the Institute of Functional Genomics of Lyon (CNRS / ENS de Lyon / Claude Bernard Lyon 1 University), or IGFL—has just figured out how water striders (family *Veliidae*) of the genus *Rhagovelia* developed fan-like structures at the tips of their legs. These structures allow them to move upstream against the current, a feat beyond the abilities of other water striders that don't have fans. The researchers identified two genes, hitherto unknown, that are responsible for the formation of *Rhagovelia* leg fans. Their findings are reported in *Science* (October 20, 2017).

Rhagovelia belong to a group of insects (Gerromorpha) that stand out for their ability to walk on water. Water-repellent hairs covering their legs make this possible. Unlike other Gerromorpha, *Rhagovelia* are specialized for locomotion on streams with strong currents using fan-like extensions on their second pair of legs that act as swimming fins. As *Rhagovelia* alone possess these fans, they offer an ideal model for studying how new structures, or morphological innovations, form during the evolutionary process.

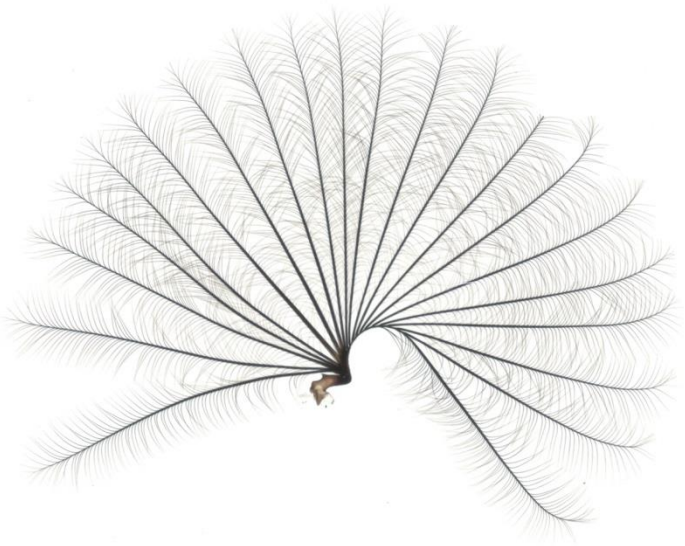
The scientists first wanted to know what genetic information programmed the development of the fans. They discovered two previously unknown genes in *Rhagovelia* that must be expressed for fully formed fans to appear. When these genes are silenced, *Rhagovelia* form normal legs, but they lack fans. Deeper investigation revealed that one of the two genes is actually of early origin, having been inherited from an ancestral insect. The other gene is new, however: it is only found in *Rhagovelia*.

The striking similarity between the two genes suggests that a genetic mutation may have given rise to the *Rhagovelia*-specific gene by duplication of the ancestral one. The researchers also noted that the genes are only expressed in cells at the tips of the middle legs. This means that the evolution of fans involved at least two major genetic events: a duplication of a gene to yield two copies in *Rhagovelia*; and the expression of these genes in the cells that give rise to the fans. As these feathery extensions are reminiscent of the fans of Japanese geisha, the newer gene has been dubbed *geisha*; and the ancestral gene, *mother-of-geisha*.

Khila's team then had to figure out the purpose of these fans and their importance for these particular water striders. Surprisingly, *Rhagovelia* move rapidly over still water with or without fans. On moving bodies of water, however, normal *Rhagovelia* (i.e., with fans) quickly and effortlessly run upstream, while fanless *Rhagovelia* are no match for the current. What's more? *Rhagovelia* with rudimentary fans do a halfway decent job—better than fanless *Rhagovelia*, but worse than individuals with fully developed fans.

These findings reveal that some genetic modifications can lead to the emergence of new structures that directly affect organisms' lifestyles and give them access to ecological niches formerly out of their reach.

Rhagovelia *walking on water © Abderrahman Khila, IGFL (CNRS / ENS de Lyon / Claude Bernard Lyon 1 University)*



Fan removed from middle leg of Rhagovelia *© Abderrahman Khila, IGFL (CNRS / ENS de Lyon / Claude Bernard Lyon 1 University)*

Videos available upon request from Alexiane Agullo (alexiane.agullo@cnrs-dir.fr)

Bibliography

Taxon-restricted genes at the origin of a novel trait allowing access to a new environment. Santos ME, Le Bouquin A, Crumière AJJ, Khila A.. *Science*. 2017 Oct 20.

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