Worm-like creature with legs and spikes finds its place in the evolutionary tree of life

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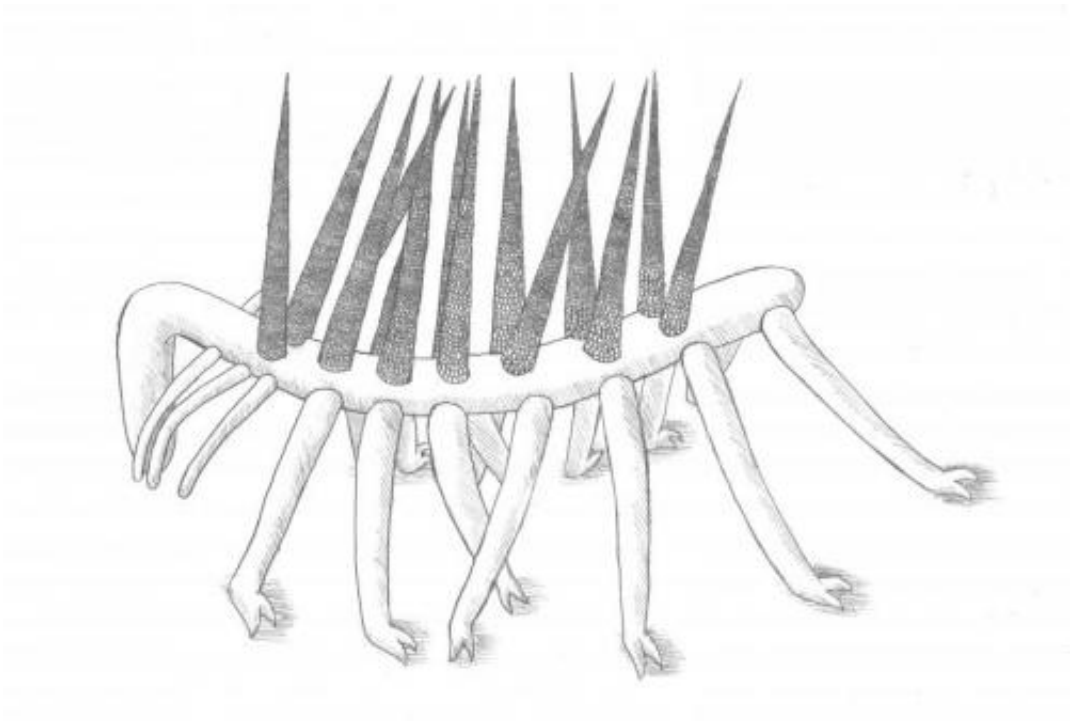

A reconstruction of the Burgess Shale animal *Hallucigenia sparsa*. Credit: Elyssa Rider

One of the most bizarre-looking fossils ever found - a worm-like creature with legs, spikes and a head difficult to distinguish from its tail – has found its place in the evolutionary Tree of Life, definitively linking it with a group of modern animals for the first time.

The animal, known as *Hallucigenia* due to its otherworldly appearance, had been considered an 'evolutionary misfit' as it was not clear how it related to modern animal groups. Researchers from the University of Cambridge have discovered an important link with modern velvet worms, also known as onychophorans, a relatively small group of worm-like animals that live in tropical forests. The results are published in the advance online edition of the journal *Nature*.

The affinity of *Hallucigenia* and other contemporary 'legged worms', collectively known as lobopodians, has been very controversial, as a lack of clear characteristics linking them to each other or to modern animals has made it difficult to determine their evolutionary home.

What is more, early interpretations of *Hallucigenia*, which was first identified in the 1970s, placed it both backwards and upside-down. The spines along the creature's back were originally thought to be legs, its legs were thought to be tentacles along its back, and its head was mistaken for its tail.

Hallucigenia lived approximately 505 million years ago during the Cambrian Explosion, a period of rapid evolution when most major animal groups first appear in the fossil record. These particular fossils come from the Burgess Shale in Canada's Rocky Mountains, one of the richest Cambrian fossil deposits in the world.

Looking like something from science fiction, *Hallucigenia* had a row of rigid spines along its back, and seven or eight pairs of legs ending in claws. The animals were between five and 35 millimetres in length, and lived on the floor of the Cambrian oceans.

A new study of the creature's claws revealed an organisation very close to those of modern velvet worms, where layers of cuticle (a hard substance similar to fingernails) are stacked one inside the other, like

Russian nesting dolls. The same nesting structure can also be seen in the jaws of velvet worms, which are no more than legs modified for chewing.

"It's often thought that modern animal groups arose fully formed during the Cambrian Explosion," said Dr Martin Smith of the University's Department of Earth Sciences, the paper's lead author. "But evolution is a gradual process: today's complex anatomies emerged step by step, one feature at a time. By deciphering 'in-between' fossils like *Hallucigenia*, we can determine how different animal groups built up their modern body plans."

While *Hallucigenia* had been suspected to be an ancestor of velvet worms, definitive characteristics linking them together had been hard to come by, and their claws had never been studied in detail. Through analysing both the prehistoric and living creatures, the researchers found that claws were the connection joining them together. Cambrian fossils continue to produce new information on origins of complex animals, and the use of high-end imaging techniques and data on living organisms further allows researchers to untangle the enigmatic evolution of earliest creatures.

"An exciting outcome of this study is that it turns our current understanding of the evolutionary tree of arthropods – the group including spiders, insects and crustaceans – upside down," said Dr Javier Ortega-Hernandez, the paper's co-author. "Most gene-based studies suggest that arthropods and velvet worms are closely related to each other; however, our results indicate that arthropods are actually closer to water bears, or tardigrades, a group of hardy microscopic animals best known for being able to survive the vacuum of space and sub-zero temperatures – leaving velvet worms as distant cousins."

"The peculiar claws of *Hallucigenia* are a smoking gun that solve a long

and heated debate in evolutionary biology, and may even help to decipher other problematic Cambrian critters," said Dr Smith.

More information: Hallucigenia's onychophoran-like claws and the case for Tactopoda, *Nature*, DOI: 10.1038/nature13576

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