Study resolves the position of fleas on the tree of life

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A living flea. Credit: NIGPAS

A study of more than 1,400 protein-coding genes of fleas has resolved one of the longest standing mysteries in the evolution of insects, reordering their placement in the tree of life and pinpointing who their

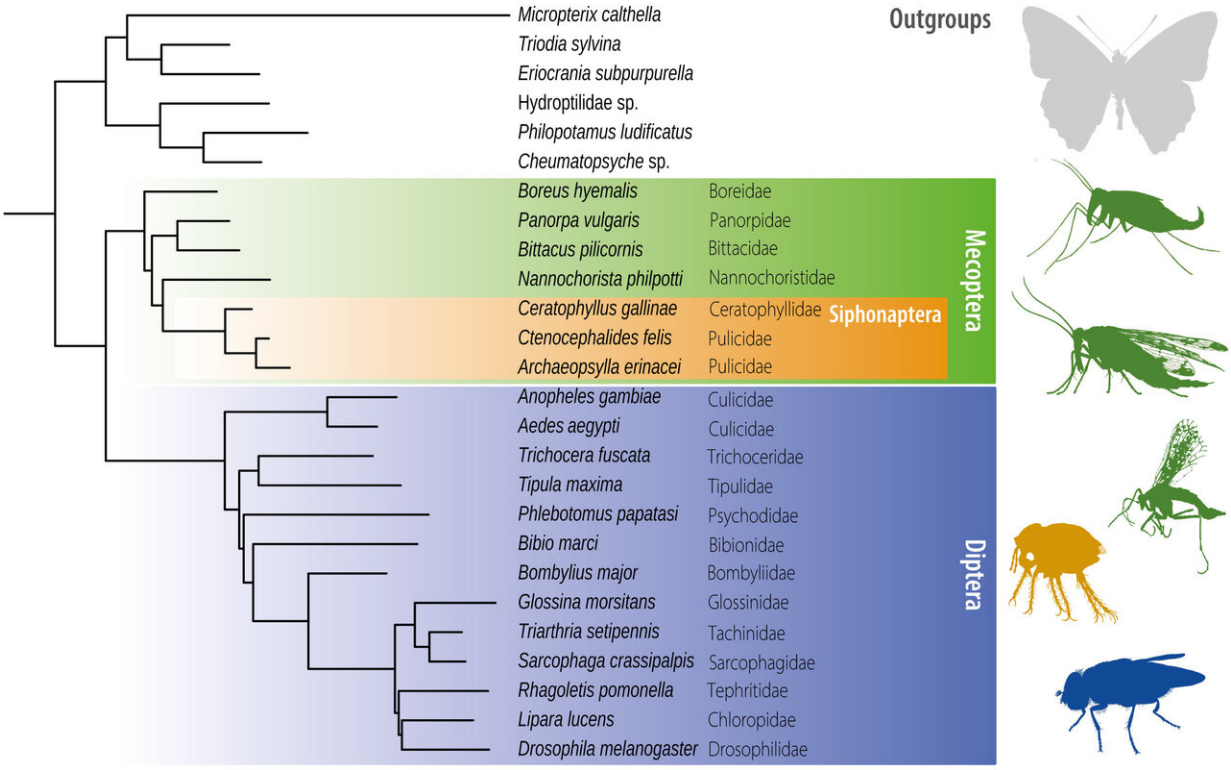
closest relatives are.

The University of Bristol study, published in the journal *Palaeoentomology*, drew on the largest insect molecular dataset available. The dataset was analysed using new statistical methods, including more sophisticated algorithms, to test all historically proposed hypotheses about the placement of fleas on the insect tree of life and search for new potential relationships.

The findings overturn previously held theories about fleas, the unusual anatomy of which has meant that they eluded classification in evolutionary terms. According to the authors of the study, contrary to popular belief, fleas are technically scorpionflies, which evolved when they started feeding on the blood of vertebrates sometime between the Permian and Jurassic, between 290 and 165 million years ago.

The closest living relatives of fleas are the members of the scorpionfly family Nannochoristidae, a rare group with only seven species native to the southern hemisphere. Unlike the blood-thirsty fleas, adult nannochoristid scorpionflies lead a peaceful existence feeding on nectar.

"Of all the parasites in the animal kingdom, fleas hold a pre-eminent position. The Black Death, caused by a flea-transmitted bacterium, was the deadliest pandemic in the recorded history of mankind; it claimed the lives of possibly up to 200 million people in the 14th century," says lead author and undergraduate student Erik Tihelka from the School of Earth Sciences.



The results have fundamental implications for our understanding of the origin of parasitism in insects and the early evolution of the group. Credit: NIGPAS

"Yet despite their medical significance, the placement of fleas on the tree of life represents one of the most persistent enigmas in the evolution of insects."

It used to be thought that all blood-feeding parasitic insects began life as either predators or by living alongside vertebrate hosts in their nests. In actual fact, blood feeding can evolve in groups that originally fed on nectar and other plant secretions.

"It seems that the elongate mouthparts that are specialized for nectar feeding from flowers can become co-opted during the course evolution

to enable sucking blood," says Mattia Giacomelli, a Ph.D. student at the University of Bristol who participated in the study.

Previous studies had suggested a connection between fleas and anatomically unusual groups of scorpionflies, but their exact relationships remained unresolved. The mystery was prolonged by the fact that flea genomes underwent rapid evolution, which makes reconstructing ancient evolutionary relationships challenging. Moreover, the nannochoristids are a quite rare and little-studied group that only occurs in New Zealand, southeastern Australia, Tasmania, and Chile, so they are easy to overlook.

"The new results suggest that we may need to revise our entomology textbooks. Fleas no longer deserve the status of a separate insect order, but should actually be classified within the scorpionflies," says Chenyang Cai, associate professor at the Nanjing Institute of Geology and Palaeontology (NIGP) and a research fellow at the University of Bristol specialising on Mesozoic insects.

"We have exceptionally preserved fossil fleas from the Jurassic and Cretaceous. In particular, some Jurassic fleas from China, about 165 million years old, are truly giant and measure up to two centimetres. They may have fed on dinosaurs, but that is exceedingly difficult to tell. What is more interesting is that these ancient fleas share important characters with modern scorpionflies."

More information: ERIK TIHELKA et al,

Fleas are parasitic scorpionflies

, *Palaeoentomology* (2020). DOI: 10.11646/palaeoentomology.3.6.16 , dx.doi.org/10.11646/palaeoentomology.3.6.16

Provided by University of Bristol

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