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PRESS RELEASE

Untangling the Spider Tree of Life

Genomic evidence sheds new light on our understanding of spider evolution

After a burst of work in the 1980s, it was believed that science had a sound understanding of the evolution of spiders. However, in a new study employing cutting edge bioinformatics and next generation sequencing techniques, scientists have reconstructed the spider 'tree of life' to come to intriguing new conclusions about the evolution of the web, something which has important implications for the overall story of spider evolution.

The arachnid order to which spiders belong, Araneae, is an incredibly ancient and diverse group comprising over 45,000 described species with nearly three times as many awaiting discovery; by all counts they are the largest known animal group that is exclusively predatory. In addition to remarkable diversity, ecology, and abundance, spiders are known for some extraordinary biomolecules , such as venoms and silks. Although few spider venoms are dangerous to humans, they hold enormous medical promise as insecticides and therapeutics. And, no other animal can claim a more varied and elegant use of silk – a super strong material being used to create biometic material such as artificial nerve constructs, implant coatings, and drug delivery systems.

Despite their amazing diversity, and important biomolecules, our understanding of spider evolution has long been an open question. The orb web, the spiral wheel shaped web made by many spider species, once considered "the crowning achievement of aerial spiders" has captured the imagination of evolutionary biologists for over a century as a consequence of its intricate beauty. Initially thought to have evolved independently at least twice across the group's evolutionary history, complex associated morphologies and behaviors studied extensively in the 1980s suggested otherwise, sparking a shift in thinking that ultimately concluded that the orb web and the taxa that spin it all shared a common ancestor. Subsequent evolutionary changes in thread chemistry along with a vertically oriented orb web were thought to have sparked a tremendous bout of species diversification.

Now, however, a team of US scientists led by researchers at Auburn University, writing in the peer-reviewed journal PeerJ, have produced the largest-ever phylogenetic study of spiders that calls into question what the scientific world has long inferred about spider evolution. Using next generation sequencing technologies, the scientific team generated a genomic data set composed of nearly 3,400 genes based on nearly 700,000 amino acid residues. Working together, the team of biologists that included spider taxonomists, evolutionary biologists and bioinformaticians from institutions in Alabama, Washington DC, California, and Vermont, scoured museum collections, existing databases, and local forests to gather 70 spider taxa that represented a wide breadth of the order's diversity. The resulting phylogenetic tree – a branching diagram that maps the evolutionary diversity of the group – confirms earlier suspicions that all orb weaving spiders are, in fact, not closely related to one another. Although these data could be interpreted to mean that the orb web evolved more than once the team finds this hypothesis highly unlikely.

"Our results are relatively clear that while orb weaving taxa are not as closely related as previously thought, our data do support the notion that the orb web itself has evolved only once. What we are calling the "ancient origin hypothesis" for the web, simply means that the largest branch on the spider tree of life had an ancestor that constructed an orb web but most of its descendants abandoned it for other more seemingly more lucrative prey hunting strategies." said Jason Bond, an Auburn University Professor and senior author on the study.

Using sophisticated approaches to evaluating rates of species diversification (i.e. the "speed" at which new spider species multiplied through time) seems to suggest that losing the aerial orb web in favor of hunting on the ground coincided with a tremendous burst of speciation in spiders. "Based on molecular clock calibrations the timing of these accelerated rates, not surprisingly, appears to have happened about the same time that we see a concomitant increase in ground dwelling insects during the Cretaceous Tertiary Revolution – this is really exciting because it upends much of what we previously thought about why spiders were so diverse." said Nicole Garrison the lead author on the study and PhD student at Auburn University. These exciting results are also consistent with a number of new fossil findings by paleontologist Paul Selden, from the University of Kansas, and colleagues.

Despite the importance of these data the team concludes that their work is far from over. “While this paper is clearly at the cutting edge of spider phylogenomics, we still have a long way to go before the case is closed on the origin of the orb web,” Bond said. The team has plans to expand the study to over 800 spider species using a much more efficient targeted set of genes that are distributed across the spider genome. Bond and colleagues said that recent advances in molecular technologies have really made sequencing lots of genes for many spider species incredibly cost effective.

“In addition to upsetting our existing paradigms regarding orb web evolution there are other interesting take home messages from these data. It appears that a number of elements of spider classification may be wrong and our understanding of how spider mating structures have evolved may also be up for debate,” said Juanita Rodriguez a postdoctoral research associate and bioinformatician at Auburn University, “this is a really exciting time to be studying spider evolution.”

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Media: **Zip file** of the high resolution images, and a PDF of this press release:
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Typical adhesive orb web. Intricate pattern of radii and adhesive spiral threads shows why this web type has long been considered the crowning achievement of spider web evolution. Photo Credit – Ingi Agnarsson and Matjaz Kuntner


A huntsman spider (family Sparassidae) from Namibia. Like many members of the incredibly diverse RTA clade, Sparassids are cursorial hunters who no longer use aerial webs for prey capture. Photo Credit – Jason E. Bond


Trapdoor spider species Aptostichus stephencolberti found along the California coast. Trapdoor spiders do not build webs but instead use their silk to line an underground burrow from which they hunt at night below the cover of a heavily camouflaged trapdoor. Photo Credit – Jason E. Bond

Common orb web weaver, Leucauge species. Photo Credit – Ingi Agnarsson and Matjaz Kuntner

Typical Thermion adhesive cob web. Like other araneoid spiders, members of this family construct webs with “gluey" adhesive threads but no longer construct an orb web. Photo Credit – Ingi Agnarsson and Matjaz Kuntner

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