

Evolutionary patterns and colonization of new environments: understanding the evolution and functional morphology of freshwater chelicerates

Chelicerates are one of the major extant arthropod groups, with only the hexapods (insects and their close relatives) surpassing them in the number of described species. While chelicerates such as the aquatic horseshoe crabs and eurypterids are not as well-known as spiders and their arachnid relatives, they exhibit exceptional diversity in the fossil record. Horseshoe crabs are famous today for being the so-called 'living fossils', seemingly unchanged for hundreds of millions of years, and extinct eurypterids are considered effective marine predators, rivaling early vertebrates in ancient seas. However, both groups have complex evolutionary histories that encompass very disparate morphologies (forms and structures) and ecologies (life habits). Some of the most bizarre taxa are thought to represent lineages adapted to wholly freshwater conditions, as in Triassic austrolimulids bearing extremely long spines or Carboniferous belinurids known for miniscule eyes. However, these hypotheses have never been tested, and it is difficult to distinguish between freshwater, brackish (slightly saline, as in estuaries) and marine deposits in the geological record. It is also uncertain how many independent shifts to freshwater habitat in chelicerates were there and what factors influenced these evolutionary transitions.

This project aims to examine how shifts in habitats from marine to freshwater environments have affected diversity and morphology of chelicerates through a novel combination of modern phylogenetic, imaging and modelling methods, reanalysis of sedimentological data for accurate paleoenvironment reconstructions, and with new Polish material promising to shed more light on the chelicerate history in freshwater habitats.

To uncover the diversity of freshwater chelicerates we will describe new fossil material from Poland and compare it with known specimens in Poland and abroad. We will also conduct fieldwork to find new specimens in known as well promising new localities in the same stratigraphic units and to uncover the true environments in which these extinct animals were living. Based on the collected data we will conduct a major phylogenetic analysis of horseshoe crabs, eurypterids and their close relatives using different phylogenetic methods, to pinpoint when and where the proposed shifts to freshwater habitat occurred, to constrain how many of them occurred, and to disentangle how they influenced the evolution of these arthropods. Finally, we will use advanced computational techniques and 3D models based on computer tomography scans to model how well were various representatives of those groups adapted to different aquatic environments and compare them with modern analogues.

Employing different approaches, methods, and data sets, in conjunction with new fossil material from Poland, will allow us to greatly improve the understanding of how chelicerates colonized and diversified in freshwater environments. We will also expand the knowledge on past freshwater ecosystems and evolutionary patterns associated with major habitat shifts. In addition, by studying the drivers of change in arthropods we will be able to better understand the apparent stasis of the so-called 'living fossils'. Our project will also provide more information on the phylogeny of chelicerates, utilization of different phylogenetic methods and the influence of mass extinction events on arthropod evolution.