The ´elongate chelicera-problem‘: a virtual approach in an extinct pterygotid sea scorpion from a 3D kinematic point of view

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Abstract

Chelicerae, the distinctive feeding appendages in chelicerates such as spiders, scorpions, or horseshoe crabs, can be classified based on their orientation relative to the longitudinal body axis as either orthognathous (parallel) or labidognathous (inclined), exhibiting considerable diversity across various taxa. Among extinct chelicerates, sea scorpions belonging to the group Pterygotidae represent the exclusive chelicerates possessing markedly elongated chelicerae. Despite various hypotheses regarding the potential ecological functions and feeding movements of these tripartite structures, no comprehensive 3D kinematic investigation has been conducted yet to test these ideas. In this study, we generated a comprehensive 3D model of the pterygotid eurypterid Acutiramus, making the elongated right chelicera movable by equipping it with virtual joint axes for conducting Range of Motion analyses. Due to the absence in the fossil record indicating whether the chelicerae were of a orthognathous or a labidognathous orientation, and their potential lateral or ventral movements (vertical or horizontal insertion of joint axis 1), we explored the Range of Motion analyses under four distinct kinematic settings. The most compelling and plausible kinematic setting involved orthognathous chelicerae that could be folded ventrally over a horizontal joint axis. This configuration positioned the tips of each chelicera closest to the oral opening. Concerning the maximum excursion angle, our analysis revealed that the chela could open up to 70°, while it could be retracted against the basal element to a maximum of 145°. The maximum excursion in the proximal joint varied between 55°-116° based on the insertion and orientation. Our findings underscore the utility of applying 3D kinematics to fossilized arthropods for addressing inquiries on functional ecology such as prey capture and handling, enabling insights into their behavioral patterns. Pterygotid sea scorpions likely captured and processed their prey using the chelicerae, subsequently transporting it to the oral opening with the assistance of other prosomal appendages.

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