The fossil record of Coccinellidae and its significance for reconstruction of evolution of the ladybird beetles

Continuous development of biological and computational sciences, enables in recent times, reconstruction of evolution of living organisms based on analysis of molecular and morphological data, coming from modern as well as fossil organisms.

The ladybird beetles are one of the best recognizable group of insects for general public. Moreover, they serve as a model group in biological, ecological and genetic studies. They are predominantly predators feeding on aphids and scales (but diversity of their diet is much broader), and numerous species are used as biological control agents in agriculture. Despite their significance, their phylogeny remains a mystery, regardless numerous recent molecular studies on evolution of that group. Through the XX and XXI centuries several hypotheses about their evolution were proposed based on morphological and molecular data. Traditional investigation of the evolutionary processes in the family Coccinellidae were constructed predominantly on personal conviction of the researchers and their experience frequently based on local or available fauna. On the other hand, more recent molecular studies, regardless of the kind and quantity of analyzed markers do not provide a clear image of phylogenetic relationships at tribal level which could be translated onto a modern and reliable classification system of that group.

Most of the molecular studies place the origin of this group of beetles in the early Cretaceous. Even though ladybirds evolved quite a long time ago, their fossils record is surprisingly poor. The oldest known representatives of the Coccinellidae come from early-Eocene amber from Oise, France. Nonetheless, Baltic amber is the richest source of information about the fossil record and evolution of ladybirds. Recent studies revealed occurrence of 10 species representing four tribes (from around 40) from two subfamilies (out of 3 known). The image of coccinellid fauna during Eocene which emerged from these preliminary research on Baltic amber partially contradicts the results of the most recent molecular analyses, which place tribes such as Coccinellini (traditionally treated as a crown group) or Epilachnini as one of the first branches on ladybirds phylogenetic tree, while Coccidulini (traditionally one of the most “primitive” groups) as the most evolutionary advanced. Bearing in mind a very selective preservation of the diversity of fauna in fossil resins, the image of ladybird diversity in modern ecosystems differs from the one emerging from the fossil record.

Electrolotis hoffeinsorum Szawaryn & Tomaszewska 2020 (Coccinellidae: Sticholotidini) from Baltic amber.

The main goal of the proposed project is to analyze diversity of the family Coccinellidae in fossil record based on examination of diverse amber sources such as Baltic, Dominican and amber from Zhangpu. Analysis of a broad range of fossils coming from several geographic localities as well as geological periods enable more precise investigation of the evolution of that group of beetles. Because very frequently the state of preservation of fossil specimens is far from ideal we plan to use modern microtomography techniques to reconstruct morphology of fossil taxa. We also plan to combine these new paleontological data with previous results coming from recent project of our group (genetic and morphological data of extant fauna), which will allow us to use modern computational approaches integrating such diverse information about evolution of ladybird beetles. Such integrative approach which utilizes information coming from present and past diversity, and modern analytical methods will enable to propose hypothesis about evolution of Coccinellidae, which reflect evolutionary processes of that group of beetles, as accurately as possible, and facilitate construction of natural classification system of ladybird beetles.