Diversity and evolution of animal genitalia have intrigued systematic and evolutionary biologists for a long time. Particularly in arthropods, male genitalia often provide the only reliable diagnostic characters available for distinguishing species suggesting that they evolve much more rapidly than other morphological characters.

The ligula or secondary penis of the male damselfly (Odonata: Zygoptera) is a multifunctional structure primarily designed for sperm transfer and supposedly - in many species - for sperm removal (Cordero-Rivera, 2010). Since Waage (1979), for the first time, had provided evidence for the occurrence of sperm competition in calopterygid damselflies, several further cases and mechanisms of sperm competition in Odonata have become known. However, the diversity and variation of these functional morphological traits is largely unknown for many groups of Zygoptera, and the underlying mechanisms are poorly understood.

In the course of phylogenetic-taxonomic projects on damselflies, scanning electron microscopic (SEM) studies of the male secondary copulatory apparatus in the damselfly families Coenagrionidae, Platycnemididae, Platycestididae and Argiolestidae and others were performed, providing new insights with regard to the amazing structural diversity of the zygopteran ligula.

In many groups of damselflies, the ligula provides diagnostic and taxonomic characters that may be used to recognize and distinguish between different species. Often the species of those groups are rather similar with regard to secondary sexual characters such as the male posterior appendages, or to coloration. In contrast, species that have uniform ligulae usually are more diverse in other character complexes, suggesting that different selective forces are in effect among zygopteran genera and families, or that there is selection pressure on different character complexes. Different ligula types within a group of closely related species have also been referred to different mating systems (Robinson & Novak, 1997). The evolution of different mechanisms of sperm competition even within allopatric populations of the same species may be an important factor triggering speciation (Cordero-Rivera et al., 2010). The ligula also provides phylogenetically informative characters. In platystictid damselflies, the morphological and presumably functional diversity is high, but the ligula may be fairly constant at species-group level. In Platycnemididae, the inner flagellum of the ligula head is a particular structure characterizing a large clade of Papuan representatives of this family. The lack of spines on the ligula shaft is an autapomorphy of Platycnemidiae (Gassmann, 2005).

References


Diagnosis characters in Idiocnemis

Sperm competition may be considered widespread in the Zygoptera. Sperm removal potential can be derived from several kinds of morphological structures, the most ‘obvious’ of them being the comb-like arrangements of micro-spines found on different parts of the ligula (Gassmann, 2007). Bulbous, hollowed flagellae, spoon-shaped lobes and other structures may be suitable for males to remove the sperm of competitors from the female spermathecae. Sexual conflict, i.e. the battle between the sexes over the control of fertilization, is largely held responsible for divergence in genital structures. Several candidate structures were identified in damselflies. Males of diverse groups in the superfamily Megapodagrionidae have the ligula armed with fields or arrays of seemingly robust spines. Some Coenagrionidae possess knife-shaped structures that may be considered harmful for the female genital tract and therefore suitable for preventing other males from successfully inseminating the female after the first copulation.

Morphological evidence for sexual conflict

Structural diversity and functional morphology of the damselfly ligula: implications for taxonomy, systematics and evolutionary biology

Diversity and evolution of animal genitalia have intrigued systematic and evolutionary biologists for a long time. Particularly in arthropods, male genitalia often provide the only reliable diagnostic characters available for distinguishing species suggesting that they evolve much more rapidly than other morphological characters.

The ligula or secondary penis of the male damselfly (Odonata: Zygoptera) is a multifunctional structure primarily designed for sperm transfer and supposedly - in many species - for sperm removal (Cordero-Rivera, 2010). Since Waage (1979), for the first time, had provided evidence for the occurrence of sperm competition in calopterygid damselflies, several further cases and mechanisms of sperm competition in Odonata have become known. However, the diversity and variation of these functional morphological traits is largely unknown for many groups of Zygoptera, and the underlying mechanisms are poorly understood.

In the course of phylogenetic-taxonomic projects on damselflies, scanning electron microscopic (SEM) studies of the male secondary copulatory apparatus in the damselfly families Coenagrionidae, Platycnemididae, Platycestididae and Argiolestidae and others were performed, providing new insights with regard to the amazing structural diversity of the zygopteran ligula.