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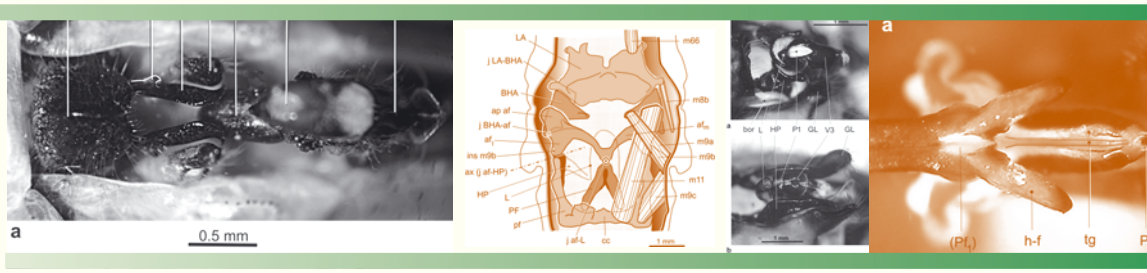

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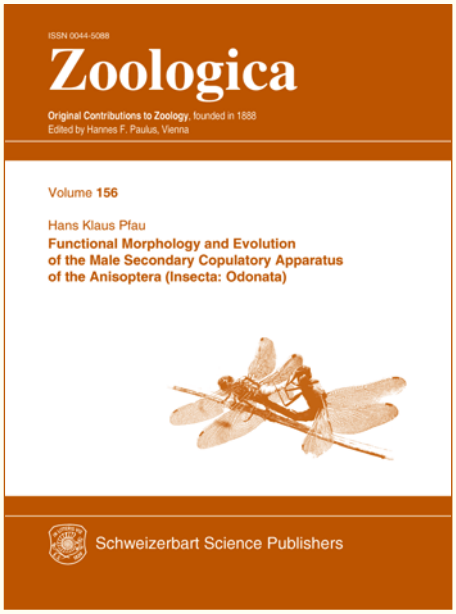

Hans Klaus Pfau

Functional Morphology and Evolution of the Male Secondary Copulatory Apparatus of the Anisoptera (Insecta: Odonata)

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In this study, the functions and mechanical interactions of different parts of the secondary copulatory apparatus of Anisoptera are reconstructed in detail and possible evolutionary pathways are described. Whereas in Zygoptera and Anisozygoptera the vesica spermalis of the third abdominal segment is a single segmented intermediate sperm-storage, this organ is subdivided into four segments in the Anisoptera. The evolutionary consequences of acquiring new functions as secondary (in reality tertiary) "penis" and sperm-syringe are one focus of this study.

The secondary copulatory apparatus of male dragonflies (Odonata), located at the second and third abdominal segment, consists of a number of sequentially arranged devices.

These serve (1) as support of the female ovipositor, (2) for carrying out preparatory actions for filling an intermediate sperm-storage, (3) for levering and inserting a secondary "penis" (in the primitive case the ligula) and (4) as transmitter of sperm to the female vagina. Each subtask affords a sequence of actions of the corresponding sclerites and muscles of this apparatus.

An impressive variety of different solutions to perform and secure the filling of the sperm-reservoir of the vesica spermalis in the Anisoptera is described. In the primitive case a laborious and time-consuming procedure – which probably depends on interrelated functions of the ligula and female ovipositor – is carried out. Reduction of the ovipositor in different lines of the Anisoptera apparently initiated evolutionary modifications, which finally led to more sophisticated modes of preparing filling and protection.

Another focus are the auxiliary devices and techniques in the Anisoptera for emptying the sperm-reservoir of the vesica spermalis. For instance, two different types of sperm-pumps are incorporated in its distal segment ("glans"). These pumps – which extend the function of a hydraulically working gland-structure, the erectile organ – show an opposite coordination of sperm-suction and -ejection in connection with compression and decompression movements. It was tried to reconstruct a transitional system to close a serious gap in the phylogenetic interpretation.

A comparative investigation of different 'glans' led to the discovery of different 'ways' of combining the emptying-mechanism of the sperm-reservoir with an intensification of the sperm-jet and a 'washing out' of sperm of the male predecessor (sperm displacement). The different stages of evolution of the glans, which reflect phylogenetic splittings, are outlined and discussed.

This study is of great interest to biologists interested in the functional morphology of the Odonata. It does not merely rely on painstaking comparisons of morphological details, but integrates functional points of view to use the heuristic power of hypothetical approach.

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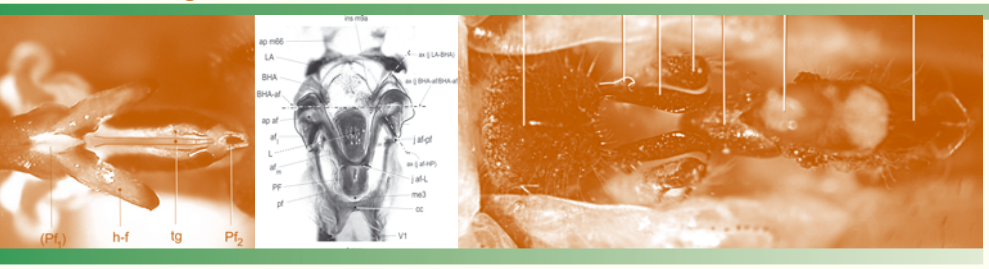
Johannesstr. 3a, 70176 Stuttgart, Germany., Tel. +49 (0)711 351456-0, Fax +49 (0)711 351456-99, order@schweizerbart.de, www.schweizerbart.de



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