

# LIMITS TO INSECT MINIATURIZATION BY THE EXAMPLE OF THE SMALLEST COLEOPTERA

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External and internal structure of the smallest free-living insects, members of the family Ptiliidae (Coleoptera), and larger beetles related to them (Staphylinidae) was studied with light and electron microscopes. For the studied beetles, three-dimensional computer reconstructions were made and relative volumes of organs were analysed.

More than 40 structural properties related to miniaturization are revealed in Ptiliidae. The most important of these are the following: reduction of many sclerites of the exoskeleton, reduction of two malpighian tubules, absence of heart, reduction of circulatory system and its replacement with the fat body, adaptation of mouthparts to feeding on semiliquid substances, feather-like wing of the adult, strong oligomerization and concentration of the nervous system of the adult, reduction of the size and number of nerve cells, reduction of one of the two testes and one of the two ovaries.

Changes of body size are accompanied by changes in relative volume of inner organs. Excretory and digestive systems change isometrically, and the other systems change allometrically. Relative volume of muscles is strongly reduced when body size decreases. The most interesting changes occur in the exoskeleton, the reproductive and the nervous systems; their relative volume increases when body size decreases.

The quantitative and qualitative data obtained give evidence that the fundamental factors limiting the diminution of body size in insects are the size of the nervous system, restricted by the number and size of nerve cells, and the size of the egg, and thus, of the reproductive system, as well as the mass of the exoskeleton.