Determination of Developmental Modules and Conservatism in the Outer Wings of Two Species of Cockroaches using Landmark-based Geometric Morphometrics

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Abstract: The wings of cockroaches are highly compartmentalized as shown by the major and minor veins separating the different compartments or modules which are believed to correspond to units of "gene regulation" and are genetically conserved. To evaluate whether there is a number and pattern of developmental modules in cockroach wings and determine whether there exists genetic conservatism based on intra- and inter-modular variations in the wings, *a priori* models applying the tools of landmark-based geometric morphometrics (GM) were constructed. To do this, a total of 199 landmark points were used to summarize the major parts of the wings. These were then statistically tested for the goodness of fit test (GoF) statistic by comparing the observed and expected covariance matrices. Jackknife support values for each variational model were also computed using γ^* as the GoF statistic. Modularity and integration was determined from six *a priori* models generated using the MINT (Modularity and Integration Tool, version 1.5) software. Different hypotheses were formulated and tested as to the possible spatial boundaries based on major wing venations. Results showed that the wings of the 2 species of cockroaches are comprised of three distinct modules: the first is bounded by the anterior margin of the wing and radius; the second bounded by the radius and post cubitus vein; the third bounded by the post cubitus vein and the posterior margin of the wing. Results showed fair consistency in the observed number and patterns of hypothesized developmental modules implying that the wings of these species of cockroaches are highly conserved. It is concluded that there is genetic conservatism in the morphological spaces in the wings of the two species. This study also shows the importance of landmark-based geometric morphometrics as a tool in understanding quantitatively the biological phenomena of wing compartmentalization in the 2 species of cockroach.

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