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Ecological Trade-offs between Migration and Reproduction Are Mediated by the Nutrition-Sensitive Insulin-Signaling Pathway

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Abstarc :

Crowding and changes in food availability are two critical environmental conditions that impact an animal's trajectory toward either migration or reproduction. Many insects facing this challenge have evolved wing polyphenisms. When conditions favor reproduction, wing polyphenic species produce adults that either have no wings or short, non-functional wings. Facultative wing growth reflects a physiological and evolutionary trade-off between migration and reproduction, triggered by environmental conditions. How environmental cues are transduced to produce these alternative forms, and their associated ecological shift from migration to reproduction, remains an important unsolved problem in evolutionary ecology. The brown planthopper, a wing polymorphic insect exhibiting strong trade-offs in investment between migration and reproduction, is one of the most serious rice pests in Asia. In this study, we investigated the function of four genes in the insulin-signaling pathway known to couple nutrition with growth, PI3 Kinase (PI3K), PDK1, Akt (Protein Kinase B), and the forkhead gene FOXO. Using a combination of RNA interference and pharmacological inhibitor treatment, we show that all four genes contribute to tissue level regulation of wing polymorphic development in this insect. As predicted, silencing of the NlPI3K, NlAkt and NlPDK1 through dsRNA and with the pharmacological inhibitor Perifosine resulted in short-winged brown planthoppers, whereas knockdown of NlFOXO resulted in long-winged planthoppers. Morphometric analyses confirm that phenotypes from our manipulations mimic what would be found in nature, i.e., major parameters such as bristle number, wing area and body weight are not significantly different from non-experimental animals. Taken together, these data implicate the insulin-signaling pathway in the transduction of environmental factors into condition-dependent patterns of wing growth in insects.

Key Word :
Brown planthopper, wing, polyphenism, evolutionary tradeoff, insulin signaling pathway, PI3K, Akt, FOXO

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