Genomic Shifts, Phenotypic Clines, and Fitness Costs Associated With Cold Tolerance in the Asian Tiger Mosquito

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Abstract

Climatic variation is a key driver of genetic differentiation and phenotypic traits evolution, and local adaptation to temperature is expected in widespread species. We investigated phenotypic and genomic changes in the native range of the Asian tiger mosquito, *Aedes albopictus*. We first refine the phylogeographic structure based on genome-wide regions (1,901 double-digest restriction-site associated DNA single nucleotide polymophisms [ddRAD SNPs]) from 41 populations. We then explore the patterns of cold adaptation using phenotypic traits measured in common garden (wing size and cold tolerance) and genotype–temperature associations at targeted candidate regions (51,706 exon-capture SNPs) from nine populations. We confirm the existence of three evolutionary lineages including clades A (Malaysia, Thailand, Cambodia, and Laos), B (China and Okinawa), and C (South Korea and Japan). We identified temperature-associated differentiation in 15 out of 221 candidate regions but none in ddRAD regions, supporting the role of directional selection in detected genes. These include genes involved in lipid metabolism and a circadian clock gene. Most outlier SNPs are differently fixed between clades A and C, whereas clade B has an intermediate pattern. Females are larger at higher latitude yet produce no more eggs, which might favor the storage of energetic reserves in colder climate. Nondiapausing eggs from temperate populations survive better to cold exposure than those from tropical populations, suggesting they are protected from freezing damages but this cold tolerance has a fitness cost in terms of egg viability. Altogether, our results provide strong evidence for the thermal adaptation of *A. albopictus* across its wide temperature range.

***Key words:* *Aedes albopictus*, thermal adaptation, next-generation sequencing, common garden, fitness, cold tolerance, diapause, wing size.**

Introduction

Temperature is one of the main determinants of species distribution as it impacts physiological functions and ultimately population growth (Pörtner et al. 2006). The tropical regions show low seasonal variation and high ambient temperatures compared with higher latitudes marked by strong seasonality, daily thermal fluctuations, and cool temperatures. These climatic characteristics impact the thermal tolerance of ectotherms (Sunday et al. 2011) and species having a latitudinal distribution are expected to present fitness shifts due to local thermal adaptations between climatic regions (i.e., ecotypes), or more gradual changes along the climatic gradient (i.e., phenotypic clines). The main fitness-related traits associated with climatic gradients reported in insects include body size (temperature–size response) (Forster et al. 2012; Horne et al. 2018) and survival at low temperature: diapause and