

HpQTL: a geometric morphometric platform to compute the genetic architecture of heterophylly

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Abstract

Heterophylly, i.e. morphological changes in leaves along the axis of an individual plant, is regarded as a strategy used by plants to cope with environmental change. However, little is known of the extent to which heterophylly is controlled by genes and how each underlying gene exerts its effect on heterophyllous variation. We described a geometric morphometric model that can quantify heterophylly in plants and further constructed an R-based computing platform by integrating this model into a genetic mapping and association setting. The platform, named HpQTL, allows specific quantitative trait loci mediating heterophyllous variation to be mapped throughout the genome. The statistical properties of HpQTL were examined and validated via computer simulation. Its biological relevance was demonstrated by results from a real data analysis of heterophylly in a wood plant, mei (*Prunus mume*). HpQTL provides a powerful tool to analyze heterophylly and its underlying genetic architecture in a quantitative manner. It also contributes a new approach for genome-wide association studies aimed to dissect the programmed regulation of plant development and evolution.

Key words: heterophylly; QTL; leaf shape; geometric morphometrics; shape mapping; woody plant

Introduction

The shoot of a plant grows by adding new metamers at its apex that form internodes, leaves and buds. These shoot components display gradual or disrupt transitions along the shoot, even in a constant environment, a phenomenon observed pervasively in most land plants [1–4]. Shape variation in leaves produced on

the same shoot, particularly called heterophylly, is a concept that has received a great deal of attention during the past centuries [5–10]. It has been widely accepted that heterophylly is of ecological and evolutionary significance because it is adaptive and functional under particular environmental conditions [8, 11, 12]. Heterophyllous characteristics have well been

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Submitted: 4 November 2016; Received (in revised form): 30 December 2016

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