



Diagnostic and systematic significance of petiole anatomy in the identification of *Hopea* species (Dipterocarpaceae)



N. Talip^{a,*}, D.F. Cutler^b, A.S. Ahmad Puad^c, B.S. Ismail^a, A.R. Ruzi^a, A.A. Ahmad Juhari^a

^a School of Environmental and Natural Resource Sciences, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

^b Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, United Kingdom

^c Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

ARTICLE INFO

Article history:

Received 3 February 2016

Received in revised form 7 November 2016

Accepted 9 March 2017

Available online 22 March 2017

Edited by JS Boatwright

Keywords:

Leaf anatomy

Systematic anatomy

Micromorphology

Hopea

Shoreae

Dipterocarpaceae

ABSTRACT

A comprehensive study of the petiole anatomy of 33 species of the genus *Hopea* Roxb., belonging to the family Dipterocarpaceae, was carried out to examine variations in the petiole anatomy that might be useful in the identification and classification of the various species. The variations observed included the petiole outline, vascular bundle arrangement, trichome types, number of resin canals and presence of cell inclusions. Findings have shown that petiole anatomical characteristics are of taxonomic value for this genus and are valuable for species identification and classification. A combination of different petiole outlines and types of vascular bundle arrangement enable the division of this genus into five distinguishable groups. Variations in trichome types, distribution of sclerenchyma and resin canals provide useful diagnostic characters. In general, the petiole characteristics observed in the present study did show, to some extent, relationships in the context of existing phylogenies, but the findings cannot be used for the identification of *Hopea* species and more anatomical characteristics are needed for this purpose.

© 2017 SAAB. Published by Elsevier B.V. All rights reserved.

1. Introduction

The genus *Hopea* Roxb., is found in India, Sri Lanka, Myanmar, Southern China and throughout the Malesian region to the Philippines, Sulawesi and New Guinea (Ashton, 1982). It consists of 105 species and in the Malay Peninsula 32 species have been described by Ashton (1982). The bark pattern and the presence or absence of resin and stilt roots have been used to divide *Hopea* into four groups (Desch, 1941). This classification is rather arbitrary and more useful for the purpose of timber or field studies and is not a classification based on natural affinity. *Hopea* was originally divided into three sections, namely *Euhoepa* Symington, *Petalandra* Hassk. and *Dryobalanoides* Miq., by Brandis (1895), and this was the basic arrangement used by most subsequent taxonomists. The taxonomic ranks were later revised and *Hopea* was divided into four groups, namely *Euhoepa*, *Pierrea* F. Heim, *Dryobalanoides* and

Bracteata Symington (Symington, 2004). The genus was then further reclassified into two sections, *Dryobalanoides* and *Hopea*, based on the venation of the leaves (Ashton, 1982). The species in section *Dryobalanoides* are characterized by dryobalanoid or subdryobalanoid leaf venation, whereas scalariform venation is confined to the species in the section *Hopea* (Ashton, 1982). The section *Hopea* was further divided into two subsections, namely *Hopea* and *Pierrea*. The section *Dryobalanoides* was also divided into two subsections, namely *Dryobalanoides* (dryobalanoid venation) and *Sphaerocarpea* F. Heim (predominantly subdryobalanoid venation) (Noraini et al., 2014). Based on field characters, *Hopea* can be divided into four groups to which the following descriptive names have been given: the smooth-barked *Hopeas*; the flaky-barked *Hopeas*; the fissured-barked *Hopeas*; and the scaly-barked *Hopeas* (Symington, 2004) (Tables 1 & 3). Classification within Dipterocarpaceae has received much attention in the past years, with both taxonomic and phylogenetic studies motivating realignments (Tsumura et al., 1996; Kajita et al., 1998; Rath et al., 1998; Dayanandan et al., 1999; Kamiya et al., 2005; Yulita et al., 2005; Choong et al., 2008). The phylogeny of *Hopea* has been well-studied by Yulita et al. (2005) and Choong et al. (2008). The study by Yulita et al. (2005) was based on *trnL-trnF* and ITS sequences

* Corresponding author.

E-mail address: ntalip@ukm.edu.my (N. Talip).