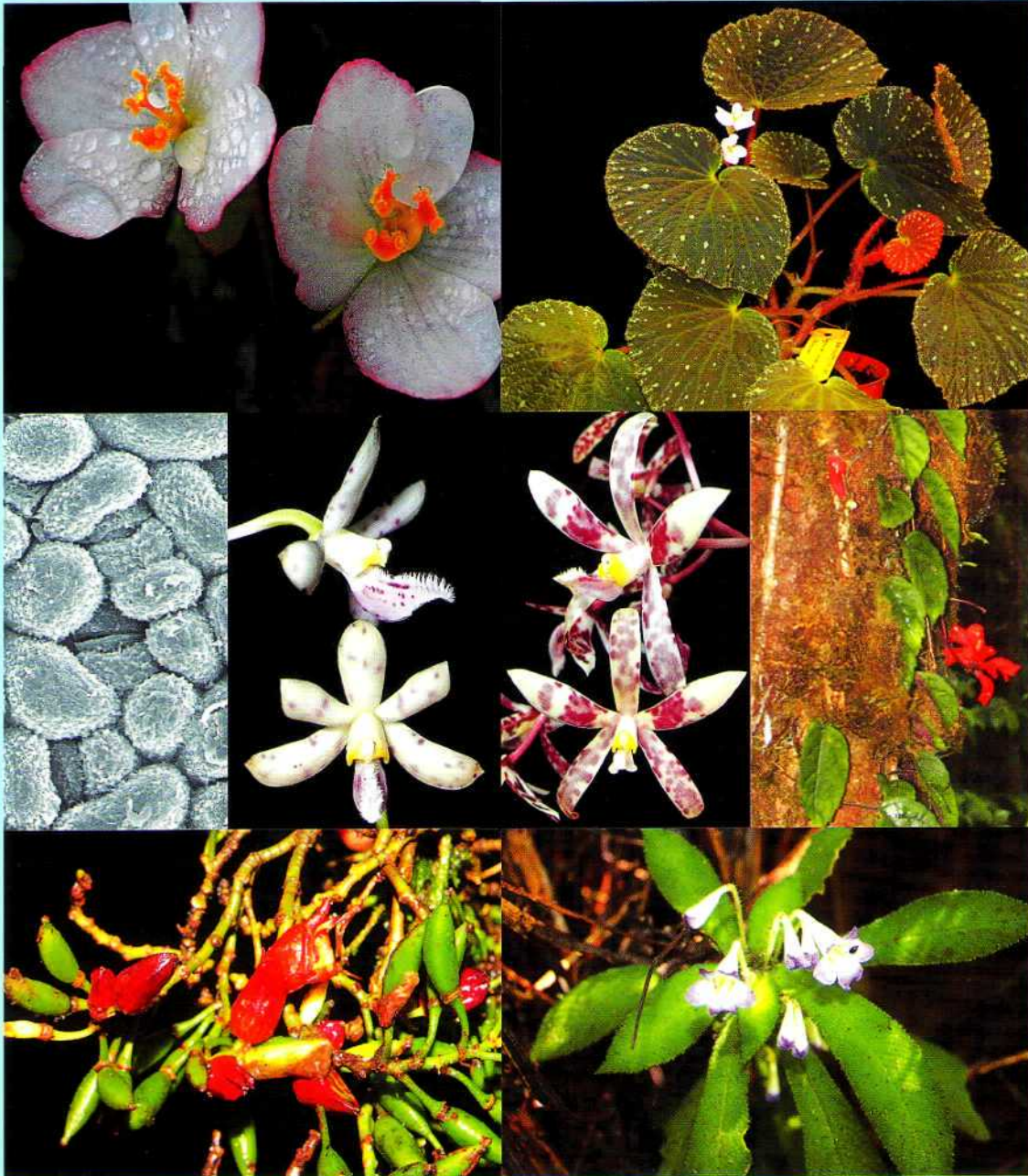




# REINWARDTIA

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1	1
2	3 3 4
4	4

Cover images: 1. *Begonia holosericeoides* (female flower and habit) (Begoniaceae; Ardi *et al.*); 2. Abaxial cuticles of *Alseodaphne rhododendropsis* (Lauraceae; Nishida & van der Werff); 3. *Dipodium puspitae*, *Dipodium purpureum* (Orchidaceae; O'Byrne); 4. *Agalmyla exannulata*, *Cyrtandra coccinea* var. *celebica*, *Codonoboea kjellbergii* (Gesneriaceae; Kartonegoro & Potter).

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## CODONOBOEA (GESNERIACEAE) SECTIONS IN PENINSULAR MALAYSIA

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### ABSTRACT

LIM, C. L. & KIEW, R. 2014. *Codonoboea* (Gesneriaceae) Sections in Peninsular Malaysia. *Reinwardtia* 14(1): 13 – 17. — *Codonoboea* is the largest genus of Gesneriaceae in Peninsular Malaysia with 92 species. Nine sections, *Boeopsis*, *Codonoboea*, *Didymanthus*, *Glossadenia*, *Heteroboea*, *Pectinati*, *Reptantes*, *Salicini* and *Venusti*, have been erected based on morphological characters, such as habit, leaf arrangement and shape, type of inflorescence, number of flowers, corolla type and nectary type. Recent molecular phylogenetic study using ITS and *trnL-F* sequences show that only section *Heteroboea* is monophyletic. While the sections of *Codonoboea* can no longer be maintained as formal taxonomic taxa, as informal groupings they are useful in identification and in constructing keys.

**Key words:** *Codonoboea*, Gesneriaceae, Peninsular Malaysia, section.

### ABSTRAK

LIM, C. L. & KIEW, R. 2014. Seksi *Codonoboea* (Gesneriaceae) di Semenanjung Malaysia. *Reinwardtia* 14(1): 13 – 17. — *Codonoboea* merupakan marga terbesar dalam Gesneriaceae di Semenanjung Malaysia dengan 92 jenis. Sembilan seksinya yaitu *Boeopsis*, *Codonoboea*, *Didymanthus*, *Glossadenia*, *Heteroboea*, *Pectinati*, *Reptantes*, *Salicini* dan *Venusti* telah dibuat berdasarkan karakter morfologi, seperti habitus, bentuk dan susunan daun, tipe perbungaan, jumlah bunga, tipe daun mahkota dan tipe nektar. Penelitian filogenetik molekuler terkini dengan menggunakan sekuen ITS dan *trnL-F* menunjukkan bahwa hanya seksinya *Heteroboea* yang bersifat monofiletik. Sementara itu seksinya *Codonoboea* tidak bisa dipertahankan sebagai taksa taksonomi secara formal, pengelompokan informal seksinya ini dapat dimanfaatkan dalam membangun kunci dan dapat pula dimanfaatkan dalam proses identifikasi.

**Kata kunci:** *Codonoboea*, Gesneriaceae, Semenanjung Malaysia, seksinya.

### INTRODUCTION

Gesneriaceae Rich. & Juss. ex DC. (1816), the African violet family, is a diverse family with 140–150 genera and more than 3500 species worldwide (Weber, 2004) widely distributed in the subtropical and tropical regions in the Old and New World.

Peninsular Malaysia is the centre of diversity of *Codonoboea* Ridl. (Table 1) and in Peninsular Malaysia it is the largest and most diverse genus of the Gesneriaceae with 92 species (Kiew & Lim, 2011; Kiew, 2011; Kiew & Sam, 2012; Lim *et al.*, 2013) with still more awaiting new species description followed by *Paraboea* (24 species) and *Ridleyandra* (19 species).

In the past, the genus was confused with *Didymocarpus* Wall., *Didissandra* C. B. Clarke, *Paraboea* (C. B. Clarke) Ridl., *Loxocarpus* R. Br., *Henckelia* Spreng. and *Chirita* Buch.-Ham. ex D. Don. However, with evidence from the

molecular phylogenetic method, Weber *et al.* (2011) showed conclusively that *Codonoboea* is a monophyletic group distinct from the genera mentioned above.

Table 1. Distribution of *Codonoboea* species.

Area	No. species
Peninsular Thailand	4
Peninsular Malaysia	92
Sumatra	9
Borneo	27
Batam & Lingga Is.	2
Philippines	2
Sulawesi	2
Moluccas	1
New Guinea	1

In Peninsular Malaysia, its species are morphologically very diverse ranging in habit (creeping,



rosette or erect herbs), in leaf arrangement (alternate or opposite), branching of inflorescence (from much branched panicles to single-flowered cymes) and in flower size, colour and type (pollen or nectar flower). To facilitate the classification of this large and diverse genus, nine sections have been proposed based on one to several morphological characters (Table 2), but even with nine sections there are still a few odd species, such as *C. longipes* (C. B. Clarke) Kiew, that cannot be assigned to existing sections.

In a large and unwieldy genus, sections can serve several functions for example in (a) grouping similar species together can facilitate identification and the construction of keys by dividing a large number of species into smaller units of similar taxa, (b) making it easier to discern phyto-geographic patterns, and (c) it may reflect evolutionary trends. However, the problem with similar morphology is that it may also reflect parallel or convergent evolution in adaptation, for example, similar habitat, pollinator or dispersal mechanism. To assess whether the *Codonoboea* sections are monophyletic, the molecular phylogenetic method was used on a sample of species from Peninsular Malaysia.

## MATERIALS

Twenty seven taxa of *Codonoboea* were included in the study with representatives from five of the nine sections from Peninsular Malaysia

(Table 3). Another four species from Borneo, the Philippines and Sumatra have not been assigned to a section (Middleton *et al.*, 2013). Species from *Microchirita* (C. B. Clarke) Y. Z. Wang [*M. caliginosa* (C. B. Clarke) Y. Z. Wang, *M. involucrata* (Craib) Y. Z. Wang, *M. ruthiae* Rafidah and *M. viola* (Ridl.) A. Weber & Rafidah] and *Boea* [*Boea hygrometrica* (Bunge) R. Br. and *B. philippensis* C. B. Clarke] were selected as out-group taxa.

Using molecular phylogenetic technique, two regions, *i.e.* *trnL-F* intron-spacer region, and the nuclear ITS1-5.8S-ITS2 region were analysed (Lim, 2014). Mapping of sections character-state transitions was carried out in MacClade 4.08 (Maddison & Maddison, 2003).

## RESULTS AND DISCUSSION

Mapping of sections onto a molecular phylogenetic tree is shown in Fig. 1. From the tree, only section *Heteroboea* is monophyletic. Section *Heteroboea* is well-supported with all species sampled forming a clade together with the undescribed *Codonoboea sp. nov.* 2. Species of this section are caulescent with spirally arranged leaves and large, solitary, trumpet-shaped flowers with a large annular nectary. Phylograms of ITS1-5.8S-ITS2 region, *trnL-F* intron-spacer region as well as the combined results of the two regions show that the species in the clade do not differ

Table 2. Sections in *Codonoboea*.

Section	Publication	Salient characters
<i>Boeopsis</i>	Ridley (1907) J. Roy. As. Soc. Str. Br. 49: 22; Kiew (1992) Gard. Bull. Sing. 44: 39.	Rosette plants, small campanulate corolla
<i>Codonoboea</i>	Kiew (1990) Blumea 35: 167.	Epiphyllous flowers
<i>Didymanthus</i>	Clarke (1883) Monogr. Phan. 5 (1): 87, tab. 10.	Erect stem, opposite and well-spaced petiolate leaves
<i>Glossadenia</i>	Weber & Burt (1998) Beitr. Biol. Pflanzen 70: 335.	Tongue-like nectary
<i>Heteroboea</i>	Bentham (1876) Genera Plantarum 2: 1022.	Spirally arranged leaves, winged petiole
<i>Pectinati</i>	Ridley (1923) Flora of Malay Peninsula 2: 508.	Serrate to deeply toothed lamina
<i>Reptantes</i>	Ridley (1905) J. Roy. As. Soc. Str. Br. 44: 29.	Creeping stem, opposite and well-spaced leaves
<i>Salicini</i>	Ridley (1896) J. Linn. Soc. Bot. 32: 514; Kiew (1992) Gard. Bull. Sing. 44: 41.	Small campanulate corolla, narrow lamina
<i>Venusti</i>	Kiew (1995) Malay. Nat. J. 48: 203.	Foliaceous, conspicuous bracts

Table 3. *Codonoboea* species according to the section.

Section	Species
<i>Boeopsis</i>	<i>C. anthonyi</i> , <i>C. codonion</i> , <i>C. floribunda</i> , <i>C. heterophylla</i> , <i>C. leiophylla</i> , <i>C. oreophila</i> , <i>C. pumila</i> , <i>C. puncticulata</i> , <i>C. rubiginosa</i>
<i>Didymanthus</i>	<i>C. albomarginata</i> , <i>C. glabrata</i> , <i>C. malayana</i> , <i>Codonoboea</i> sp. nov. 1
<i>Heteroboea</i>	<i>C. bombycina</i> , <i>C. crinita</i> , <i>C. curtisii</i> , <i>C. platypus</i> , <i>C. fasciata</i> , <i>Codonoboea</i> sp. nov. 2
<i>Salicini</i>	<i>C. salicina</i> , <i>C. salicinoides</i> , <i>C. tiumanica</i>
<i>Venusti</i>	<i>C. calcarea</i>
Not assigned	Borneo: <i>C. bakoensis</i> , <i>C. crenata</i> Philippines: <i>C. corrugata</i> Sumatra: <i>C. racemosa</i> Peninsular Malaysia: <i>C. longipes</i> , <i>Codonoboea</i> sp. nov. 3, <i>Codonoboea</i> sp. nov. 4, <i>Codonoboea</i> sp. nov. 5

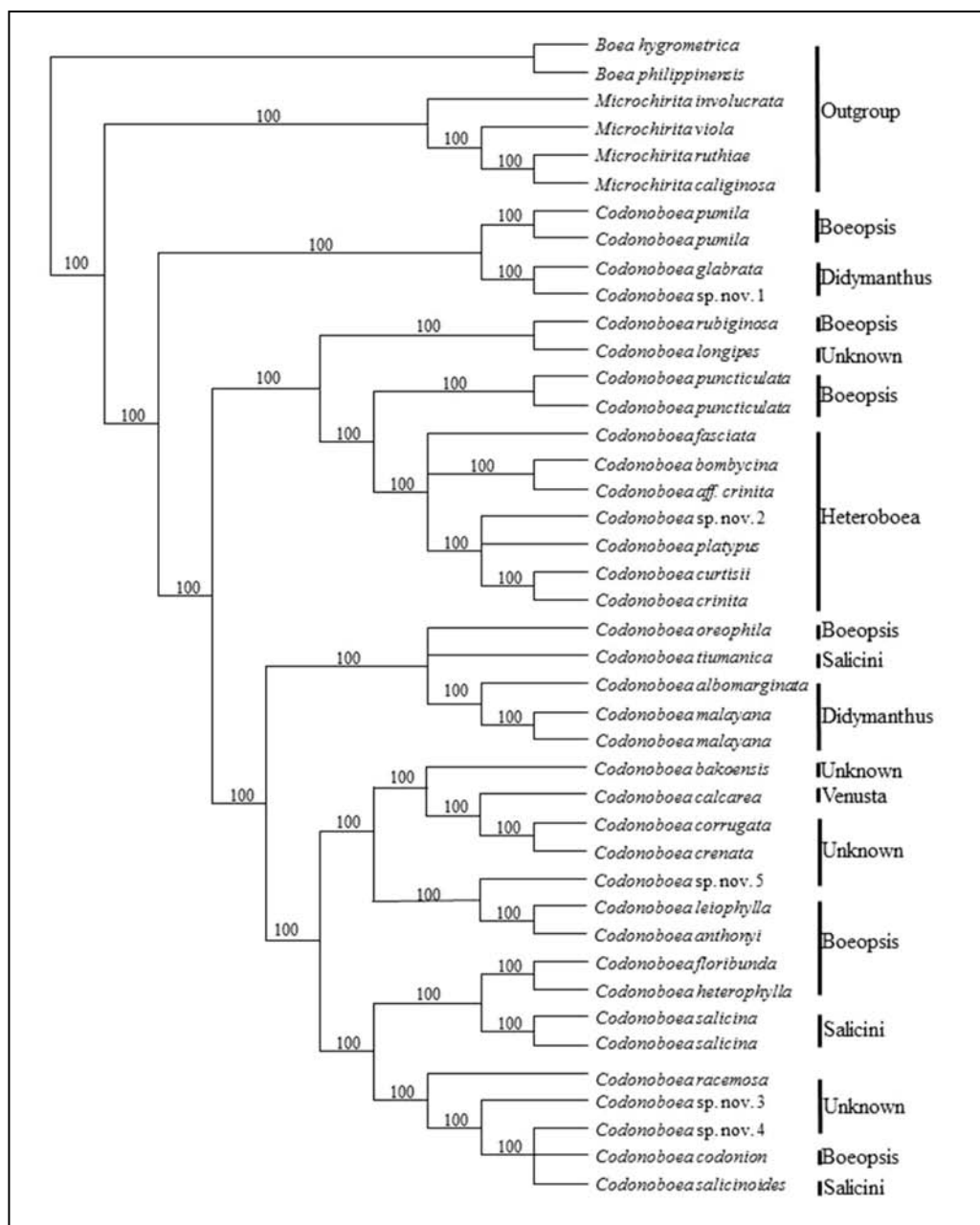


Fig 1. Mapping of *Codonoboea* sections on maximum parsimony majority-rule consensus tree based on combined ITS and *trnL-F* sequences. Number above branches are majority-rule frequencies.

much genetically (Lim, 2013). In fact, it is possible that the species concept in this section is too narrow because several species groups, such as the *C. crinita* (Jack) C. L. Lim, *C. platypus* (C. B. Clarke) C. L. Lim and *C. bombycina* (Ridl.) C. L. Lim complex, are difficult to identify, because while the extreme forms are distinct there are many specimens showing intermediate character states.

In contrast, section *Boeopsis*, *Didymanthus* and *Salicini* are not monophyletic in the tree. Their morphological similarity is likely therefore to be the result of convergent evolution due to adaption to pollinator or environmental factors.

For example, the salient characters of section *Salicini* are (a) narrow lamina that can be explained as adaptive to their rheophytic habitat and (b) small campanulate corolla as adaptation to the same pollinator (which is as yet unknown). Similarly, the rosette habit of section *Boeopsis* is an adaptation to their growing on vertical earth banks or rock faces and the trend from the nectar flowers (large trumpet-shaped corolla and large annular nectar) to the flat-faced pollen flower with a minute or no nectary is a trend that appears to have occurred more than once in *Codonoboea*.

## CONCLUSIONS

The results from the molecular study call into question the taxonomic value of the sections and indeed Kiew & Lim (2011) did not assign species to section for precisely this reason. Although, section *Heteroboaea* is monophyletic, it is firmly nested within the other *Codonoboea* species sampled, so it makes no sense to maintain giving it formal taxonomic status. *Codonoboea* is very diverse morphologically and informal subgeneric groups are still useful for a speciose genus in formulating user-friendly keys for identification. Indeed, the only key for all species in Peninsular Malaysia is that of Ridley (1923) and the ease of using it (always relative in the case of Ridley's keys) is because it is based on these groups that enable rapid identification. Therefore, it is advocated here that while informal groups are useful that they not be given formal taxonomic status and that the nine sections should therefore lapse into synonym.

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MUHAMMAD EFFENDI, TATIK CHIKMAWATI & DEDY DARNAEDI. New cytotypes of <i>Pteris ensiformis</i> var. <i>victoria</i> from Indonesia.....	133
SUZANA SABRAN, REUBEN NILUS, JOAN T. PEREIRA & JOHN BAPTIST SUGAU. Contribution of the heart of Borneo (HoB) initiative towards botanical exploration in Sabah, Malaysia.....	137
WENNI SETYO LESTARI, BAYU ADJIE, TASSANAI JARUWATANAPHAN, YASUYUKI WATANO & MADE PHARMAWATI. Molecular phylogeny of maidenhair fern genus <i>Adiantum</i> (Pteridaceae) from Lesser Sunda Islands, Indonesia based on <i>Rbcl</i> and <i>Trnl-f</i> .....	143
ELIZABETH A. WIDJAJA & DANIEL POTTER. Floristic study of Mekongga Protected Forest: towards establishment of the Mekongga National Park.....	157
YESSI SANTIKA, EKA FATMAWATI TIHURUA & TEGUH TRIONO. Comparative leaves anatomy of <i>Pandanus</i> , <i>Freycinetia</i> and <i>Sararanga</i> (Pandanaceae) and their diagnostic value.....	163
SUHARDJONO PRAWIROATMODJO & KUSWATA KARTAWINATA. Floristic diversity and structural characteristics of mangrove forest of Raj a Ampat, West Papua, Indonesia.....	171
IAN M. TURNER. A new combination in <i>Orophea</i> (Annonaceae) for <i>Uvaria nitida</i> Roxb. ex G. Don.....	181
IVAN S AVINOV. Taxonomic revision of Asian genus <i>Glyptopetalum</i> Thwaites (Celastraceae R. Br.).....	183
YUSI ROSALINA, NISYAWATL ERWIN NURDIN, JATNA SUPRIATNA & KUSWATA KARTAWINATA. Floristic composition and structure of a peat swamp forest in the conservation area of the PT National Sago Prima, Selat Panjang, Riau, Indonesia.....	193
IMAN HID AY AT & JAMJAN MEEBOON. <i>Cercospora brunfelsiicola</i> (Fungi, Mycosphaerellaceae), a new tropical Cercosporoid fungus on <i>Brunfelsia uniflora</i> .....	211
MAX VAN BALGOOY & ELIZABETH A. WIDJAJA. Flora of Bali: a provisional checklist.....	219
EKA FATMAWATI TIHURUA & INA ERLINAWATI. Leaf anatomy of <i>Pandanus</i> spp. (Pandanaceae) from Sebangau and Bukit Baka-Bukit Raya National Park, Kalimantan, Indonesia.....	223
JULIA SANG & RUTH KIEW. Diversity of <i>Begonia</i> (Begoniaceae) in Borneo - How many species are there?.....	23 3
DIAN LATIFAH, ROBERT A. CONGDON & JOSEPH A. HOLTUM. A Physiological approach to conservation of four palm species: <i>Arenga australasica</i> , <i>Calamus australis</i> , <i>Hydriastele wendlandiana</i> sa <i>Alicuala ramsayi</i> .....	237

REINWARDTIA  
Vol. 14. No. 1.2014  
CONTENTS  
Page

ABDULROKHMAN KARTONEGORO & DANIEL POTTER. The Gesneriaceae of Sulawesi VI: the species from Mekongga Mts. with a new species of <i>Cyrtandra</i> described.....	1
LIM CHUNG LU & RUTH KIEW. <i>Codonoboea</i> (Gesneriaceae) sections in Peninsular Malaysia.....	13
WISNU H. ARDI, YAYAN W. C. KUSUMA, CARL E. LEWIS, ROSNIATI A. RISNA, HARRY WIRIADINATA, MELISSA E. ABDO & DANIEL C. THOMAS. Studies on <i>Begonia</i> (Begoniaceae) of the Molucca Islands I: Two new species from Halmahera, Indonesia, and an updated description of <i>Begonia holosericea</i> .....	19
YUZAMMI, JOKO R. WITONO & WILBERT L. A. HETTERSCHIED. Conservation status of <i>Amorphophallus discophorus</i> Backer & Alderw. (Araceae) in Java, Indonesia.....	27
MOHAMMAD F. ROYYANI & JOENI S. RAHAJOE. Behind the sacred tree: local people and their natural resources sustainability.....	35
FIFI GUS DWIYANTI, KOICHI KAMIYA & KO HARADA. Phylogeographic structure of the commercially important tropical tree species, <i>Dryobalanops aromatica</i> Gaertn. F. (Dipterocarpaceae) revealed by microsatellite markers.....	43
SACHIKO NISHIDA & HENK VAN DER WERFF. Do cuticle characters support the recognition of <i>Alseodaphne</i> , <i>Nothaphoebe</i> and <i>Dehaasia</i> as distinct genera?.....	53
NURUL AMAL LATIFF, RAHAYU SUKMARIA SUKRI & FAIZAH METALI. <i>Nepenthes</i> diversity and abundance in five habitats in Brunei Damssalam.....	67
NURUL HAZLINA ZATNI & RAHAYU SUKMARIA SUKRI. The diversity and abundance of ground herbs in lowland mixed Dipterocarp forest and heath forest in Brunei Darussalam.....	73
MUHAMMAD AMIRUL AIMAN AHMAD JUHARI, NORATNI TALIP, CHE NURUL ATNI CHE AMRI & MOHAMAD RUZI ABDUL RAHMAN. Trichomes morphology of petals in some species of Acanthaceae.....	79
DIAN ROSLEINE, EIZI SUZUKI, ATIH SUNDAWIATI, WARDI SEPTIANA & DESY EKAWATI. The effect of land use history on natural forest rehabilitation at corridor area of Gunung Halimun Salak National Park, West Java, Indonesia.....	85
JULIUS KULIP. The Ethnobotany of the Dusun people in Tikolod village, Tambunan district, Sabah, Malaysia.....	101
PETER O'BYRNE. On the evolution of <i>Dipodium R. Br.</i> .....	123

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