

Faculty of Resource Science and Technology

Taxonomy, Phylogenetic Analyses and Pollination Biology of *Scaphochlamys* (Zingiberaceae) of Borneo

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Taxonomy, Phylogenetic Analyses and Pollination Biology of *Scaphochlamys* (Zingiberaceae) of Borneo

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DECLARATION

The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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ABSTRACT

Scaphochlamys Baker is a genus of 44 species in the family Zingiberaceae distributed from Southern Thailand through Peninsular Malaysia until Sumatera and Borneo. Previous taxonomic and phylogenetic studies concentrated on the species from Peninsular Malaysia. The interactions between the diverse Zingiberaceae flowers and their pollinators are important. However, there was no documentation on the floral biology and pollination mechanism of *Scaphochlamys*. Therefore, in this study, an integrated approach (including taxonomy, phylogeny, floral and pollination biology incorporated with SEM and floral volatile organic compounds (VOCs) analyses) was employed to study the Bornean *Scaphochlamys*. As a result, 12 taxonomic novelties were described (*Scaphochlamys durga* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys graveolens* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys hasta* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys lanjakensis* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys lucens* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys multifolia* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys nigra* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys penyamar* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys pseudoreticosa* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys scintillans* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov., *Scaphochlamys stenophylla* I. H. Ooi & S. Y. Wong, sp. nov., and *Scaphochlamys uniflora* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.). Several important morphologies were discussed. Six informal intrageneric taxonomic groups were proposed for Bornean *Scaphochlamys* species. A phylogeny of 26 *Scaphochlamys* species (36 accessions) with ITS and *trn*K-*mat*K sequence data was generated. Most of the

Scaphochlamys species on Borneo formed a clade together with *Myxochlamys* A. Takano & Nagam., except *S. limiana* and *S. polyphylla* were clustered among *Scaphochlamys* species from Peninsular Malaysia. A one-day diurnal flowering mechanism was observed for 19 species of *Scaphochlamys*. All investigated Bornean *Scaphochlamys* are entomophilous xenogamy. Two types of traplining bees (*Amegilla* bees and Halictid bees) were concluded as the pollinators for eight Bornean *Scaphochlamys* species. The pollen size of 21 investigated *Scaphochlamys* species is within the range of 72.53 – 96.52 μm long × 52.39 – 78.41 μm wide, spheroidal to elliptical, and more or less psilate. Three hundred and twenty one floral VOCs (mainly terpenes, terpenoids, aromatic compounds and fatty acid derivatives) were found in 17 species of *Scaphochlamys*. This study provides a comprehensive overview of the Bornean *Scaphochlamys* with the discovery of novel species, together with the phylogenetic relationship resolved, and interactions between plant-pollinator.

Keywords: Borneo, floral biology, morphology, phylogenetics, pollinator, *Scaphochlamys* (Zingiberaceae), taxonomy.

Taksonomi, Analisis Filogenetik dan Biologi Pendebungaan* Scaphochlamys *(Zingiberaceae) di Borneo

ABSTRAK

Scaphochlamys *Baker ialah salah satu genus dalam famili Zingiberaceae yang mengandungi 44 spesies tertabur dari Selatan Thailand ke Semenanjung Malaysia sehingga Sumatera dan Borneo. Kebanyakan penyelidikan taksonomi dan filogenetik sebelum ini hanya tertumpu kepada spesies-spesies di Semenanjung Malaysia. Interaksi antara pelbagai bunga Zingiberaceae dan agen pendebungaan adalah penting. Akan tetapi, masih belum ada laporan tentang biologi bunga dan pendebungaan untuk* Scaphochalmys. *Oleh yang demikian, untuk kajian ini, satu pendekatan secara integrasi (termasuk taksonomi, filogeni, biologi bunga dan pendebungaan, bersama-sama dengan SEM dan analisis sebatian organik meruap (VOCs) bunga) telah digunakan untuk mengkaji* Scaphochlamys *di Borneo. Sebagai keputusannya, 12 spesies baharu telah dilaporkan (*Scaphochlamys durga *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys graveolens *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys hasta *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys lanjakensis *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys lucens *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys multifolia *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys nigra *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys penyamar *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys pseudoreticosa *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys scintillans *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.,* Scaphochlamys stenophylla *I. H. Ooi & S. Y. Wong, sp. nov., dan* Scaphochlamys uniflora *I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov.). Ciri-ciri*

morfologi yang penting juga dibincangkan. Enam kumpulan taksonomi tidak formal dalam genus dicadangkan untuk spesies-spesies Scaphochlamys *di Borneo. Satu filogeni dengan data rangkaian ITS dan* trn*K*-mat*K yang meliputi 26 spesies* Scaphochlamys *(36 siri rujukan) telah dijanakan. Kebanyakan spesies-spesies* Scaphochlamys *di Borneo tergolong dalam satu kumpulan dengan* Myxochlamys *A. Takano & Nagam., kecuali* S. limiana *dan* S. polyphylla *tergolong dengan spesies-spesies* Scaphochlamys *dari Semenanjung Malaysia. Perkembangan bunga dalam sehari pada siang hari telah diteliti untuk 19 spesies* Scaphochlamys. *Semua* Scaphochlamys *di Borneo yang diteliti merupakan xenogami entomofili. Dua jenis lebah 'traplining' (lebah* Amegilla *dan lebah Halictid) telah dikenalpasti sebagai agen pendebungaan untuk lapan spesies* Scaphochlamys. *Saiz debunga untuk 21 spesies yang dikaji adalah dalam rangkuman 72.53 – 96.52 μm × selebar 52.39 – 78.41 μm, bulat atau bujur, dan lebih kurang licin. Tiga ratus dan dua puluh satu VOCs bunga (kumpulan terpene, terpenoid, sebatian aromatik dan terbitan asid lemak) telah ditemui di dalam 17 spesies* Scaphochlamys. *Kajian ini menghasilkan pengetahuan secara keseluruhan tentang* Scaphochlamys *di Borneo dengan penemuan spesies-spesies baru, bersama-sama dengan hubungan filogenetik secara resolusi, dan interaksi antara tumbuhan-agen pendebungaan.*

Kata kunci: *Borneo, biologi bunga, morfologi, filogenitik, agen pendebungaan,* Scaphochlamys *(Zingiberaceae), taksonomi.*

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CHAPTER 1

INTRODUCTION

1.1 Background

Zingiberaceae Martinov is well-known as the ginger family with many important culinary, medicinal and ornamental species. It is the largest family in order Zingiberales which consists of 56 genera with between 1,075-1,370 species (Stevens, 2001). Zingiberaceae is distributed throughout all the tropical regions globally but it is most diverse in South East Asia (Kress et al., 2002; Larsen, 2005) and contains four subfamilies (Siphonochiloideae W. J. Kress, Tamijioideae W. J. Kress, Alpinioideae Link and Zingiberoideae Hasskarl) with six tribes (Zingibereae, Globbeae, Alpinieae, Riedelieae, Tamijieae and Siphonochideae; *sensu* Kress et al., 2002).

Scaphochlamys Baker is a genus of 44 described species in the Kaempferia Clade within tribe Zingibereae (Kress et al., 2002; Leong-Škorničková et al., 2011) and closely related to *Distichochlamys* M. F. Newman and *Myxochlamys* A. Takano & Nagam. (Takano & Nagamasu, 2007). Searle (2010) summarized a combination of morphological characters: leaf-sheath base pulvinate (Borneo only); bract arrangement spiral; flowering mode from base to apex; first bracteole keeled, arising opposite to bract; bracteole split to base; thecae with free basal spurs, to distinguish *Scaphochlamys* from other closely related genera. *Scaphochlamys* is distributed from Southern Thailand, through Peninsular Malaysia, to Northern Borneo and Sumatera but each single species is usually narrowly distributed with a high degree of endemism (Searle, 2010). In Borneo, there are 14

described species with five recently described novelties (Mas Izzaty et al., 2013; Ooi & Wong, 2014; Meekiong et al., 2015), of which all species are endemic.

Searle and Hedderson (2000) included five species (*S. biloba* (Ridl.) Holttum, *S. concinna* (Baker) Holttum, *S. kunstleri* (Baker) Holttum var. *rubra* Ridl., *S. obcordata* P. Sirirugsa & K. Larsen and *S. reticosa* (Ridl.) R.M. Sm., one Bornean species) in their phylogenetic investigation on tribe Hedychieae (*sensu* Burtt & Smith, 1972c) but only ITS region was employed. Two Peninsular Malaysia species, *S. kunstleri* and *S. lanceolata* (Ridl.) Holttum, were included in the phylogeny of tribe Zingibereae with ITS and *trn*L-*trn*F regions (Ngamriabsakul et al., 2004). For phylogenetic studies with ITS and *mat*K regions, previously, only two *Scaphochlamys* species from Peninsular Malaysia, *S. biloba* and *S. kunstleri*, were included (Kress et al., 2002; Takano & Nagamasu, 2007; Leong-Škorničková et al., 2011). Within Bornean *Scaphochlamys*, until very recently, only seven species were included in the phylogenetic analyses with both ITS and *mat*K regions (Sam et al., 2016).

Specht et al. (2012) stated that the ancestral pollination syndrome of Zingiberaceae is probably insect or bee pollination based on character mapping of developmental evolutionary floral and pollination biology datasets on Zingiberales phylogeny. In Borneo, Sakai et al. (1999; 2013) conducted a pollination study on the gingers (29 species in 11 genera) of Lambir Hills National Park, Sarawak, Malaysia and investigated the correlation of flower measurements and the pollinators. Three pollination guilds were reported, which are Halictid bee, *Amegilla* bee and Spiderhunter bird (Sakai et al., 1999; 2013). Aside from this, pollination by carpenter bee was reported for *Alpinia nieuwenhuizii* Val. in

Kinabatangan district, Sabah, Malaysia (Takano et al., 2005). More techniques were applied to inspect various aspects of Zingiberaceae species for better understanding about the plants and their ecological interactions, for examples, scanning electron microscopy (SEM) for pollen morphology (Theilade et al., 1993); pollen histology for investigating pollen nutrition and pollination systems correlation (Wang et al., 2004); and floral volatile organic compounds (VOCs) analysis for biochemical compounds in floral scent emission (Báez et al., 2011). So far, there is yet to be a single documentation on the pollination biology of *Scaphochlamys*.

1.2 Problem Statement

Although Zingiberaceae is a commonly known plant family, except those common domestic species, most of the highly endemic species are still understudied with very limited information available. For *Scaphochlamys*, Searle (2010) stated that owing to several reasons such as historical collections did not preserve well, ephemeral flowers and weakly written descriptions, the taxonomic revision was difficult and more novelties were expected from Borneo and Sumatera. The generic boundary is defined by a set of morphological characters in combination rather than any single key character (Searle, 2010). Thus, dealing with the taxonomic problem is crucial to provide a solid foundation for further scientific investigation to progress.

In Malaysia, Sam (2014) stated the confusion in the generic delimitation and relationship of *Scaphochlamys* and other close genera, which *Myxochlamys* is embedded within *Scaphochlamys* in phylogeny. For examples, the distichous bract arrangement in *Distichochlamys*, the 2-keeled first bracteoles and the grooved inner corolla tube in

Myxochlamys are present in *Scaphochlamys* as well. As the previous studies were concentrating in Peninsular Malaysia, the interspecific relationship among the species from Borneo is poorly known. So far, only half of the species were included in previous studies. Despites the fact that the species belonging to the order Zingiberales have high floral variability and complex pollination system (Kress & Specht, 2005), the pollination biology of most of the taxa including those from *Scaphochlamys* is still unknown.

With the sampling activities in this study, it was hypothesized that more novel species might be found because there were no intensive collecting carried out in Borneo previously. For phylogenetics, the intergeneric relationship of *Scaphochlamys* and other genera might not differ much from previous studies but the interspecific relationship of the species from Borneo would be better known. Furthermore, it was speculated that this floral biology study would provide the information on the pollination system of *Scaphochlamys* and some insight for the generic delimitation.

1.3 Objectives

This study aimed:-

(1) to study the morphology and taxonomy of the *Scaphochlamys* species on Borneo;

(2) to produce a phylogeny inferring the relationship of the Bornean *Scaphochlamys* species;

(3) to document the pollination strategies of the investigated taxa;

(4) to undertake floral scent analysis and link this into the pollination strategies of the investigated taxa.

CHAPTER 2

LITERATURE REVIEW

2.1 Zingiberaceae

Zingiberaceae comprises 56 genera with between 1,075-1,370 species which are divided into four subfamilies: Siphonochiloideae, Tamijioideae, Alpinioideae and Zingiberoideae (Stevens, 2001) with tribe Zingibereae, tribe Globbeae, and *Monolophus* (formerly *Caulokaempferia*; Mood et al., 2014) nested within Zingiberoideae, and tribe Alpinieae, tribe Riedelieae, and *Siliquamomum* nested within Alpinioideae. Tamijioideae are monospecific and Siphonochiloideae contain two genera (Kress et al., 2002). All subfamilies are well supported based on molecular and morphological data, but many speciose genera (e.g., *Alpinia* Roxb., *Amomum* Roxb., and *Curcuma* L.) have been shown to be paraphyletic and/or polyphyletic (*Amomum*: Harris et al., 2000; Xia et al., 2004 ; *Alpinia*: Rangsiruji et al., 2000; Zingibereae: Ngamriabsakul et al., 2004; *Etlingera* Giseke: Pedersen, 2004; *Globba* L.: Williams et al., 2004; Alpinioideae: Kress et al., 2005, 2007; *Curcuma*: Záveská et al., 2012; Leong-Škorničková et al., 2015).

Zingiberaceae are an economically and ecologically important family of commelinid monocots with a centre of diversity in South-East Asia (Kress et al., 2002; Larsen, 2005). Zingiberaceae is easily separated from other Zingiberales families by possessing ligulate distichous leaves, flowers with a single dithecal stamen, and an often showy petaloid labellum formed from two or four staminodes (Simpson, 2010). The age of crown-group Zingiberaceae is more than 70 m.y. (Auvray et al. 2010).

2.2 *Scaphochlamys*

2.2.1 Background

Scaphochlamys is a small genus of 44 described species in the Kaempferia Clade (Kress et al., 2002; Leong-Škorničková et al., 2011). It forms a small clade of closely related taxa together with *Distichochlamys* and *Myxochlamys* (Takano & Nagamasu, 2007). Each of these genera is defined by a set of morphological characters in combination rather than any single key character (Searle, 2010). *Scaphochlamys* can be distinguished from the closely related genera by the following combination of characters: leaf-sheath base pulvinate (Borneo only); bract arrangement spiral; flowering mode from base to apex; first bracteole keeled, arising opposite to bract; bracteole split to base; thecae with free basal spurs (Searle, 2010). The described species are listed as follows:

1. *Scaphochlamys abdullahii* Y.Y.Sam & Saw
2. *Scaphochlamys anomala* (Hallier f.) R.J.Searle
3. *Scaphochlamys argentea* R.M.Sm.
4. *Scaphochlamys atroviridis* Holttum
5. *Scaphochlamys baukensis* Y. Y. Sam
6. *Scaphochlamys biloba* (Ridl.) Holttum
7. *Scaphochlamys biru* Meekiong
8. *Scaphochlamys breviscapa* Holttum
9. *Scaphochlamys burkillii* Holttum
10. *Scaphochlamys calcicola* A.D.Poulsen & R.J.Searle
11. *Scaphochlamys concinna* (Baker) Holttum
12. *Scaphochlamys cordata* Y.Y.Sam & Saw
13. *Scaphochlamys depressa* Mas Izzaty, Ampeng & Meekiong

14. *Scaphochlamys endauensis* Y. Y. Sam & H. Ibrahim

15. *Scaphochlamys erecta* Holttum

16. *Scaphochlamys gracilipes* (K.Schum.) S. Sakai & Nagam.

17. *Scaphochlamys grandis* Holttum

18. *Scaphochlamys iporii* Meekiong & Ampeng

19. *Scaphochlamys johorensis* Y. Y. Sam

20. *Scaphochlamys klossii* (Ridl.) Holttum

21. *Scaphochlamys krauensis* Y. Y. Sam

22. *Scaphochlamys kunstleri* (Baker) Holttum

23. *Scaphochlamys lanceolata* (Ridl.) Holttum

24. *Scaphochlamys laxa* Y. Y. Sam & Saw

25. *Scaphochlamys limiana* Meekiong & K. Yazid

26. *Scaphochlamys longifolia* Holttum

27. *Scaphochlamys malaccana* Baker

28. *Scaphochlamys minutiflora* Jenjitt. & K. Larsen

29. *Scaphochlamys obcordata* Sirirugsa & K. Larsen

30. *Scaphochlamys oculata* (Ridl.) Holttum

31. *Scaphochlamys pennipicta* Holttum

32. *Scaphochlamys perakensis* Holttum

33. *Scaphochlamys petiolata* (K. Schum.) R. M. Sm.

34. *Scaphochlamys polyphylla* (K. Schum.) B. L. Burtt & R. M. Sm.

35. *Scaphochlamys pusilla* Y. Y. Sam

36. *Scaphochlamys reticosa* (Ridl.) R. M. Sm.

37. *Scaphochlamys rubescens* Jenjitt. & K. Larsen

38. *Scaphochlamys rubromaculata* Holttum

39. *Scaphochlamys salahuddiniana* Meekiong, Ampeng & Ipor

40. *Scaphochlamys stenophylla* I. H. Ooi & S. Y. Wong

41. *Scaphochlamys subbiloba* (Burkill ex Ridl.) Holttum

42. *Scaphochlamys sylvestris* (Ridl.) Holttum

43. *Scaphochlamys tahanensis* Y. Y. Sam & Saw

44. *Scaphochlamys tenuis* Holttum

2.2.2 Taxonomic History

Scaphochlamys was established by Baker (1890) with a single species, *S. malaccana* Baker. At the same time two other species, now included in this genus, were published as *Kaempferia concinna* Baker and *Curcuma kunstleri* Baker. Early publications of species now in *Scaphochlamys* included *Curcuma sylvestris* Ridl. and *Gastrochilus biloba* Ridl. (Ridley, 1893) and *Kaempferia anomala* Hallier f. (Hallier, 1898). Ridley (1899) transferred *S. malaccana* to *Gastrochilus* Wall., thereby synonymising the genus, but gave it a new and thus illegitimate epithet, *Gastrochilus scaphochlamys* Ridl. He also combined some of the other *Scaphochlamys* species in this genus, such as *G. concinna* (Baker) Ridl., and described several new species such as *G. biloba* Ridl., *G. lancifolius* Ridl. and *G. oculata* Ridl. Over the next two decades, Ridley described several more *Scaphochlamys* species in the genus *Gastrochilus*. *Gastrochilus* Wall. is a later homonym of *Gastrochilus* D. Don so all these names are illegitimate. Ridley then decided that several of these species were more ‘Curcuma-like’ and placed them in a new genus *Hitcheniopsis* (Baker) Ridl., a name he decided to adapt from one of Baker’s sections of *Curcuma*: *Curcuma* section

Hitcheniopsis Baker. Thus *Hitcheniopsis kunstleri* (Baker) Ridl., *H. lanceolata* Ridl. and *H. sylvestris* Ridl. were published (Ridley, 1924).

In 1918, Valeton carried out detailed analyses of representatives of various genera of Zingiberaceae based on living materials from the Bogor Botanical Gardens in Java. Valeton defined a 'Scaphochlamys group' within *Gastrochilus* within a subgeneric classification based on both inflorescence and anther structures (Valeton, 1918). Valeton's use of fresh materials inspired Holttum, who in 1950 not only reinstated *Scaphochlamys* as a genus in its own right but also described nine new species from Peninsular Malaysia. In the 1970s and 1980s, extensive taxonomic work was carried out at the Royal Botanic Garden Edinburgh (e.g. Burtt & Smith, 1972a; 1972b; 1972c) and further species were transferred or were newly described from Sarawak (Smith, 1987). New species are continually being discovered throughout its range. As it grows in number of species and complexity, the genus is becoming better understood and the relationships with its sister genera are being clarified (Searle, 2010).

2.2.3 Morphology of *Scaphochlamys*

The main growth structure is called the rhizome. It tends to grow horizontally either over the ground surface, through the leaf litter, or through the soil, and terminates by growing vertically upwards to form first the peduncle and then the rachis of the inflorescence. The rhizome is a modified 'stem' from which both the roots and leaves develop. Two main types of rooting systems are shown by species in this genus: either they produce a thick mat of fine roots or they produce long 'string-like' prop roots that appear to act as an

anchoring mechanism, helping to keep a surface-growing plant upright and stable (though they are finer than those usually called stilt-roots; Searle, 2010).

Vegetative growth consists of the development of a series of successive shoots or ‘elements’ (Holttum, 1950) by the continued growth of the rhizome from a bud either at the base of a leaf or at the base of a scale leaf further back on the rhizome. Each element forms an individual shoot that comprises one to several leaves in a clump. The leaf develops straight from the rhizome and is subdivided into clearly defined structures that develop in a set order: sheath, ligule, petiole and lamina. At the very base of the leaf is the leaf-sheath. Recent studies in Borneo have shown the existence of a swelling, or pulvinus, just above the point of emergence of the leaf-sheath from the rhizome (Shafreena, 2006). More obvious in fresh than dried materials, it may be a crucial identification character for sterile materials in the field. The leaf-sheath is crescent-shaped in cross-section with two fine, membranous edges. The leaf-sheath terminates in the ligule, which is paired, membranous and delicate and can be several centimetres long (it can also decay very quickly). Above the ligule the petiole is much thinner, without the thin membranous edging, and terminates in the lamina (Figure 2.1A). The lamina is characterised by the midrib running its length, with parallel secondary venation leading off the midrib towards the margins. There is a distinct abaxial and adaxial surface. A highly reduced version of the leaf is called a leafless- sheath where only the sheath develops (Searle, 2010).

The inflorescence is attached to the rhizome by the leafless peduncle which terminates at the first bract, after which the main axis is called a rachis (Larsen et al., 1999). The bracts are arranged in a spiral pattern up the rachis and each one subtends a structure



Figure 2.1: General morphology of a 'typical' *Scaphochlamys* plant— A: the leaf with i. a single leafless-sheath at its base, ii. leaf-sheath, iii. paired ligules, iv. petiole, v. lamina; B: inflorescence with overlapping bracts (e.g. an immature S. erecta), i. peduncle, ii. rachis, iii. Bract; C: stylised image of a dissected cincinnus within a single bract, i. bract, ii. first bracteole (facing 180 °to bract), iii. first flower (fully opened), iv. second bracteole encasing a flower bud; D: a typical flower consisting of i. the dorsal petal, ii. 2 lateral petals, iii. 2 lateral staminodes, iv. bilobed labellum, v. downward-bending stamen (not to scale) – adopted from Searle (2010).

called a cincinnus of bracteoles and flowers (Figure 2.1B). In 1950, Holttum used the terms ‘bracteoles’ and ‘secondary bracts’ interchangeably in his species descriptions. The terminology was clarified in a later paper, however, where a detailed analysis of the morphology of the family was carried out (Holttum, 1974). These days, ‘bracteole’ is the more generally accepted term. The first bracteole arises opposite the bract with a single flower in its axis (Figure 2.1C). Successive bracteoles arise within and at 180 ° to the preceding one, again each with its own flower. The inflorescence can build up to consist of many bracts each containing many bracteoles and flowers. On the other hand reduction to one or a few bracts can occur, as well as reduction to one bracteole and flower per bract. In the case of extreme reduction it can be hard to interpret what is bract and what is bracteole (Searle, 2010).

The floral structures comprise a short tubular calyx and a corolla tube that splits distally into three petals or lobes. The petals tend to be small and hidden. The showy part of the flower is derived from the androecium and is comprised of two lateral staminodes and a labellum (Figure 2.1D). Each lateral staminode is derived from a sterile stamen and the bilobed labellum is derived from two fused sterile stamens (Kirchoff, 1988; 1991). In the centre is a single fertile stamen that is subdivided into the filament, which is attached to the corolla tube, the two thecae and at the apex a small extension to the back of the anther called the crest. The gynoecium comprises an inferior ovary surmounted by a pair of epigynous glands (or nectaries). The long thin style is held in place between the two thecae and terminates in a small cup-like stigma with a ring of cilia around the rim (Kirchoff, 1988).

2.2.4 Taxonomic Description

Scaphochlamys Baker in Hooker, Fl. Brit. India 6: 252. 1892; Holttum, Gard. Bull. Singapore 13: 82. 1950; Smith, Notes Roy. Bot. Gard. Edinburgh 44: 207. 1987; Larsen et al. in Kubitzki, Fam. Gen. Vasc. Pl. 4: 485. 1998. – Type species: *Scaphochlamys malaccana* Baker.

Ground-dwelling, perennial, rhizomatous herbs. Rhizome normally horizontally creeping, sometimes obliquely ascending or upright; generally thin and woody, never fleshy or tuberous. Successive shoots either crowded together or widely spaced, composed of 1 to many leaves normally encased by leafless-sheaths, glabrous to densely hairy, often scarious and decaying with age. Leaf-sheath with broad membranous margin, hairy or glabrous. In Bornean species pulvinus base present (see morphology section above). Ligule bilobed, membranous and delicate, generally triangular in shape, occurring anywhere from the base of the leaf hidden among leafless-sheaths up to just below the base of the lamina depending on the species. Petiole thin, canaliculate and occasionally terete, hairy or glabrous. Lamina obovate to oval, ovate, lanceolate or linear, commonly elliptic, symmetric or, more often, slightly asymmetric; base nearly always decurrent, usually attenuate, rounded or cordate; apex acute to acuminate, sometimes mucronulate, or broadly pointed. Upper surface dark green, occasionally with white markings. Lower surface either pale green or flushed with purple, usually hairy or pilose along the midrib. Venation parallel, branching from primary mid-vein (reticulate in Scaphochlamys reticosa). Inflorescence composed of spirally arranged bracts (occasionally distichous) with base to apex (indeterminate) flowering; compact and ovoid or ellipsoid, or lax with rachis visible between the bracts; often elongating with age. Bract broad and pouched to ovate, boat-

shaped, spathulate and linear, firm to thin, glabrous to densely hairy, green, red-brown, red, or flushed with purple, not connate laterally, base amplexicaul. First bracteole at 180 ° to bract, generally boat-shaped to linear, 2-keeled, margins overlapping but never fused, apex acute to trilobed, sometimes tufted, usually just shorter than the bract, glabrous to finely hairy; successive bracteoles decreasing in size. Ovary inferior, trilocular to unilocular, small, creamy- white, glabrous to finely hairy. Epigynous glands 2, fine, needle-like, surmounting ovary; creamy yellow. Calyx tubular, split down one side, apex usually dentate, shorter than first bracteole. Corolla tube slender at base, widening towards apex, sometimes finely hairy; corolla lobes linear, usually white, glabrous, dorsal corolla lobe normally stiff with an acute, hooded apex; the 2 lateral corolla lobes linear with rounded apices; corolla usually white, sometimes pale yellow to yellow or pale green. Lateral staminodes oblong to obovate, with rounded apex, spreading obliquely. Labellum obovate to clawed, flat, usually bilobed (sometimes entire), the lobes often overlapping, white with a yellow median band, this band often flanked on either side by variously coloured markings, for example pink, purple or red, sometimes with strongly coloured blotches near the base, slightly grooved in the middle towards the base, this groove more or less hairy. Fertile stamen bent forward over labellum, facing down; filament broad, pollen sacs 2, linear, with longitudinal dehiscence, each theca terminating in a short spur at the base, apex of anther terminated by a short reflexed rounded to trilobed crest; all androecial members (i.e. staminodes, labellum and back of the anther) sometimes covered with tiny glandular hairs. Style very fine, sometimes held in a groove inside the corolla tube. Stigma held just above apices of thecae, backed by the crest; rounded cup-shaped, the ostiole edged by a single row of cilia of varying lengths and thicknesses. Fruit ellipsoid, thin-

walled, enclosed by persistent bracts. Seeds ellipsoid, dark brown to black with a white aril, lacerate to the base. (taken *in toto* from Searle, 2010)

2.3 Bornean *Scaphochlamys*

Valeton (1918) and Holttum (1950) investigations on the genus were made based on living materials. Valeton (1918) made his careful observations based on the inflorescence and floral structures, while Holttum (1950) reinstated *Scaphochlamys* with description of nine new species from Peninsular Malaysia (Searle, 2010). However, Holttum (1950) work was confined to species in Peninsular Malaysia and thus the transfer of the Bornean *Scaphoclamys* was only made in 1972 with *S. polyphylla* (K. Schum.) B. L. Burtt & R. M. Sm. (Burtt & Smith, 1972b), and followed by three latter species, *S. petiolata* (K. Schum.) R. M. Sm. (Smith, 1987), *S. gracilipes* (K. Schum.) S. Sakai & Nagam. (Sakai & Nagamasu, 2006), and *S. anomala* (Hallier f.) R. J. Searle (Searle, 2010). So far, 14 species were described from Borneo with six recently described novelties (Meekiong et al., 2011; Ooi & Wong, 2014; Meekiong et al., 2015). All 14 species are endemic to Borneo.

2.4 Phylogeny

2.4.1 Gene Regions

2.4.1.1 *trn*K-*mat*K

The *mat*K is a protein coding region that codes the tRNA for the lysine (*trn*K) and consists of the 5' terminal of an intron, the *mat*K gene itself and the 3' portion of the intron. The gene consisting of ≈ 1500 base pairs (bp). A homology search indicates that the 102 amino acid positions at the carboxyl terminus are structurally related to portions of matura-like polypeptide (maturase K), an enzyme involved in splicing of Group II introns (Sugita et al.,

1985; Neuhaus & Link, 1987; Mohr et al., 1993; Ems et al., 1995; Hilu & Liang, 1997; Hilu et al., 2003). Furthermore, it has been suggested as the most rapidly evolving coding region found so far in the chloroplast genome (Neuhaus & Link, 1987; Olmstead & Palmer, 1994).

The *mat*K generally presents more polymorphisms than other protein-coding genes (Hilu & Liang, 1997) and the mutation rate is three times higher than in *rbc*L (Soltis et al., 1996). Hence, it may be useful for phylogenetic studies on different levels, from infrageneric (Gravendeel et al., 2001; Grob et al., 2002) to ordinal level (Hilu et al., 2003). Past research works has shown that *mat*K coding region has been used to assess phylogenetic relationships at the inter- and intrafamiliar level in angiosperms such as within Polemoniaceae Juss. (Steele & Vilgalys, 1994), Crassulaceae J.St.-Hil. (Mort et al., 2001), Caryophyllales Juss ex. Bercht & J.Presl (Cuénoud et al., 2002); and infratribal level such as Orchidaceae Juss. (Jarrell & Clegg, 1995; Hidayat et al., 2005; Van Den Berg et al., 2005).

2.4.1.2 Internal Transcribed Spacer (ITS)

Inside rDNA, each repeat unit consists of a transcribed region (having genes for 18S, 5.8S and 26S rRNAs and the external transcribed spacers, ETS1 and ETS2) and a non-transcribed spacer (NTS) region (Starr et al., 2003). The internal transcribed spacers (ITS) are found on either side of the highly conserved 5.8S rRNA gene and are described as ITS1 and ITS2 (Wheeler & Honeycutt, 1988). The length and sequences of ITS regions are believed to be fast evolving and therefore varying from 500-700 bp in angiosperms (Baldwin et al., 1995) to 1500-3700 bp in gymnosperms (Álvarez & Wendel, 2003). The

advantages of the fast evolving ITS region: i) biparental inheritance, ii) having high number of copies, up to ~30, 000 per cell of rDNA repeats (Dubouzet & Shinoda, 1999; Calonje et al., 2008); iii) intragenomic uniformity and intergenomic variability, merit their utility for phylogenetic reconstructions and other applications (Baldwin et al., 1995).

The ITS regions generally evolve more rapidly than coding plastid region and have shown to be equally informative, being able to differentiate between close related species (Baldwin, 1992; Baldwin et al., 1995; Alvarez & Wendel, 2003; Mitsui et al., 2008; Feliner & Rosselló, 2007). This also makes the ITS region an interesting subject for evolutionary/phylogenetic investigations (Baldwin et al., 1995; Hershkovitz & Zimmer, 1996) as well as biogeographic investigations (Baldwin, 1993; Suh et al., 1993; Hsiao et al., 1994; Dubouzet & Shinoda, 1999; Motley et al., 2005; Mitsui et al., 2008). Moreover, ITS 2 is slightly more conserved than ITS 1 and can allow for alignments in ranks above the genus level (Hershkovitz & Lewis, 1996) and infrageneric level (Gauthier et al., 2008; Ng'uni et al., 2010).

2.4.2 Phylogeny of *Scaphochlamys*

A *Kaempferia* clade, including *Haniffia*, *Zingiber*, *Kaempferia*, *Distichochlamys*, *Scaphochlamys*, *Boesenbergia*, *Curcumorpha* and *Cornukaempferia* was weakly supported in the study by Kress et al. (2002). However, Kress et al. (2002) did not include *Haplochorema* and *Parakaempferia* into their study. This clade has also been recognized by other studies (Newman, 1995; Searle & Hedderson, 2000; Wood et al., 2000). The *Kaempferia* clade is defined by the lack of distinctive pseudostem (except for *Zingiber* and *Haniffia*) found in other members of the subfamily Zingibereae (Kress et al., 2002).

However, the resolution among the genera of the *Kaempferia* clade is generally low (Kress et al., 2002).

The close relationship between *Distichochlamys* and *Scaphochlamys* as well as their generic boundaries has been recognized in Newman (1995) and Kress et al. (2002) proved this close relationship. *Distichochlamys* differs from *Scaphochlamys* by the distichously arranged bracts, absence of spurs and chromosome number 2n=26 (Newman, 1995).

Takano and Nagamasu (2007) described a new genus, *Myxochlamys* from Central Kalimantan, Borneo. *Myxochlamys* is sister to *Scaphochlamys* although only two Peninsular Malaysia species were included, *S. kunstleri* and *S. biloba* (Takano & Nagamasu, 2007). *Myxochlamys* is characterized by indistinct congested inflorescence with pseudostems; spirally arranged bracts; copious, highly viscous, axillary-pooled mucus secreted from glands on imbricate bracts; and flowers with a concave labellum, versatile anthers, and a groove formed by the inner surface of the corolla tube to envelope and hold the style. *Myxochlamys* is distinct from *Scaphochlamys* in that it has a groove within the corolla tube, concave labellum and versatile anthers (Takano & Nagamasu, 2007).

Sam (2014) studied the morphology, phylogeny and conservation status of *Scaphochlamys* and reported that *Distichochlamys* is the sister clade of *Scaphochlamys* but *Myxochlamys* is placed within *Scaphochlamys* between Malayan clade (including *S. polyphylla*) and Bornean clade. The phylogeny included 25 species from Peninsular Malaysia and six species from Borneo (*S. calcicola*, *S. petiolata*, *S. polyphylla*, *S. reticosa*

and two unidentified species) but based solely on ITS region. Few additional characteristics useful for species identification were concluded, including petiole shape in cross section, the length of bracteole, shape and structure of stigma and anther crest. Sam (2014) stated that the generic delimitation of *Distichochlamys-Myxochlamys-Scaphochlamys* becomes obscure because the taxonomic characteristics of *Myxochlamys* (2-keeled first bracteoles, grooved inner corolla tube) and *Distichochlamys* (distichously arranged bracts) are also found in *Scaphochlamys*.

As the current study is in its final stage of writing, Sam et al. (2016) published a new genus for Bornean species, *Borneocola* Y. Y. Sam. *Borneocola* comprising eight species from Borneo previously classified as members of the *Scaphochlamys*. *Borneocola argenteus* (R. M. Sm.) Y. Y. Sam, *B. biru* (Meekiong) Y. Y. Sam, *B. calcicola* (A. D. Poulsen & R. J. Searle) Y.Y.Sam, *B. iporii* (Meekiong & A. Ampeng) Y.Y.Sam, *B. petiolatus* (K. Schum.) Y. Y. Sam, *B. reticosus* (Ridl.) Y. Y. Sam, and *B. stenophyllus* (I. H. Ooi & S. Y. Wong) Y. Y. Sam were formally transferred with *S. anomala* placed as unknown species (Sam et al., 2016). *Scaphochlamys polyphylla* remains in the genus based on the molecular findings. The genus is distributed in northwest Borneo and all species are very rare and highly endemic (Sam et al., 2016). *Borneocola* is characterised by several thin, translucent and marcescent floral bracts, absence of coloured streaks on the labellum and capitate stigma with two dorsal knobs. However, not all species from Borneo has the thin, translucent and marcescent floral bracts (e.g. *S. calcicola* and *S. graveolens*). The coloured streaks on the labellum and the stigma shape are not consistent in the remaining *Scaphochlamys* species as well.

Our opinion is that the separation of Bornean species ascribed to *Scaphochlamys* into a discrete genus is premature with patently inadequate sampling (including representation of only three out of six groups proposed here), not least because Sam et al. (2016) failed to address with the position of *Myxochlamys* in a convincing manner and furthermore removal of selected species of Bornean *Scaphochlamys* from the corpus of the genus renders the residual species nearly impossible to define with morphological characteristics (i.e. taxa closely related to *S. kunstleri* and *S. malaccana* despite the fact that this pair of species is morphologically as at least as distinct from *Scaphochlamys* as is *Borneocola*). For these reasons, we retain all Bornean species under *Scaphochlamys* awaiting more comprehensive sampling and analyzing.

2.5 Floral Biology of Zingiberaceae

2.5.1 Floral Morphology and Development

The bilateral flowers of Zingiberaceae are generally showy, with three petals, only one fertile stamen and an often conspicuous petaloid structure called the labellum. Developmentally, the two androecial whorls, are reduced in the Zingiberaceae (Ley & Harris, 2014). In the outer whorl one organ is entirely absent and the other two are only visible as two small remnant lobes which are referred to as staminodes. In the inner whorl there is only a single fertile stamen and the other two organs are fused to form the conspicuous labellum (Kress, 1990; Bartlett & Specht, 2010). This ‘labellum’ is shared with the sister family Costaceae Nakai and often used in taxonomic determinations in that family due to its interspecies variability (Specht et al., 2001). The labellum has an important function in floral display for pollination (Specht et al., 2001).

The structure of the gynoecium is variable in the Zingiberaceae. Smith (1981) summarizes the morphology of the ovary by tribe. The Hedychieae have a trilocular ovary with axile placentation, or a unilocular ovary with basal or free columnar placentation. The ovaries of the Globbeae are unilocular with parietal placentation. Those of the Zingibereae are trilocular with axile placentation, and in the Alpineae the ovary is trilocular with axile placentation (sometimes imperfectly trilocular) or, rarely, unilocular with parietal placentation (Kirchoff, 1998).

All of the families of the Zingiberales, except the Lowiaceae (Kirchoff & Kunze, 1995), possess some type of nectary (Pai & Tilak, 1965). In most cases, these are gynopleural nectaries (Smets & Cresens, 1988). Gynopleural nectaries are nectaries that occur either in the septa of the locules, or in contiguous regions of the ovary. In the Zingiberales, gynopleural nectaries occur both in the septa (Strelitziaceae Hutch., Cannaceae Juss., Marantaceae R. Br.) and in regions contiguous with the septa but above (Musaceae Juss.) or below (Heliconiaceae (Endl.) Nakai) the locules. It is highly probable that the epigynous nectaries of the Zingiberaceae are derived from gynopleural nectaries (Kirchoff, 1998). Brown (1938) first proposed this hypothesis, which was supported by the work of Rao et al. (1954), Rao and Pai (1959; 1960), and Rao and Gupte (1961) and is discussed in more detail by Rao (1963) and Newman and Kirchoff (1992). The developmental description presented in Kirchoff (1998) confirms the placement of the nectaries of the Zingiberaceae in an anterolateral position, approximately above the septa which supports the hypothesis that the epigynous nectaries are derived from gynopleural nectaries. Kirchoff (1998) also confirms Holttum's (1950) statement that the nectaries arise relatively late in flower development.

In *S. kunstleri*, the ovary is basally trilocular and apically unilocular. This is perhaps due to growth and fusion of the three gynoecial primordia in only the basal parts of the ovary (Kirchoff, 1998). These developmental similarities support the interpretation of the ovary of *S. kunstleri* as trilocular. The paper further indicated that the uni-/trilocular condition found in *S. kunstleri* evolved from a strictly trilocular condition (Kirchoff, 1998).

In many families of the Zingiberales, there is an extension of the ovary that lengthens the closure of the locules. In some families (Strelitziaceae, Lowiaceae Ridl.), this prolongation may function in protection of the ovary from pollinator damage (Kirchoff & Kunze, 1995). This type of protection is important in species where the pollinators are vigorous in their search for nectar and could potentially damage the flowers (Frost & Frost, 1981; Kress & Stone, 1993; Kress et al., 1994). In the Zingiberaceae, at least part of this protective function may be assumed by the nectaries and floral tube. The epigynous nectaries are borne on top of the ovary tightly wrapped in the floral tube (Holttum, 1950; Rao, 1963). Pollinators probing for nectar would encounter the nectaries and the sides of the floral tube before contacting the ovary. This arrangement could restrict damage to non-essential parts of the flower while protecting the ovules (Kirchoff, 1998).

Box and Rudall (2006) presented comparative morphological and ontogenetic data on flowers and bulbils of *Globba* to clarify their homologies. Kong et al. (2007) worked on the inflorescence and floral development of *Globba barthei*.

Flexistyly, a unique floral mechanism in plants that appears to promote outcrossing in the populations where it is found (Li et al., 2001; Renner, 2001; Barrett, 2002), was first described in *Amomum* and *Alpinia*, two polyphyletic genera (Kress et al., 2005). Flexistyly has been documented in 24 species of the Zingiberaceae (Cui et al., 1996; Li et al., 2001, 2002; Zhang et al., 2003; Kress et al., 2005).

2.5.2 Pollination Biology

The order Zingiberales is renowned for its high floral variability and great diversity of pollination systems (Kress & Specht, 2005). However, pollination biology is poorly known in Zingiberaceae (Ippolito & Armstrong, 1993; Endress, 1994).

Sakai et al. (1999; 2013) completed a detailed study of floral morphology and pollination in 29 ginger species representing 11 genera. Among the 29 species studied, eight were pollinated by spiderhunters (Nectariniidae), 11 by medium-sized *Amegilla* bees (Anthophoridae, *Amegilla* Friese), and ten by small halictid bees. Most species in the three guilds were separated on the plot by the first and second canonical variables. Spiderhunter-pollinated flowers had longer floral tubes, while *Amegilla*-pollinated flowers had wider lips than the others, which function as a platform for the pollinators. Pistils and stamens of halictid-pollinated flowers were smaller than the others. The fact that gingers with diverse morphologies in a forest with high species diversity were grouped into only three pollination guilds and that the pollinators themselves showed low species diversity suggests that many species of rare understory plants have evolved without segregating pollinators in each pollination guild (Sakai et al., 1999).

Ley and Harris (2014) investigated at floral morphology in African *Aframomum* K. Schum. where most species had purple, trumpet-shaped flowers that were postulated to be pollinated by bees. The analyses showed the importance of allopatry and phylogenetic incompatibility as isolation mechanisms in maintaining species boundaries in *Aframomum*.

Flexistyly in *Alpinia* and *Amomum* (see Section 2.5.1; Li et al., 2001; 2002), have two specific floral phenotypes in a population: cataflexistylous individuals possess flowers with stigmas that are held erect at anthesis and turn downward in the late morning after anther dehiscence is complete, whereas stigmas of anaflexistylous individuals that are turned downward and receptive at flower opening become reflexed backwards out of the way of the dehiscing anther of the same flower in the late morning. This mechanism promotes pollen movement between individuals of the two floral types in the population and has apparently evolved to ensure outcrossing. Species of *Alpinia* and *Amomum* are pollinated by large bees (*e.g.*, *Xylocopa* Latreille) (Kress & Specht, 2005). Moreover, Takano et al. (2005) reported the carpenter bee pollination for *Alpinia nieuwenhuizii* in Kinabatangan district, Sabah, Malaysia (Takano et al., 2005).

Ippolito and Armstrong (1993) gave a detailed floral biology and pollination study of *Hornstedtia scottiana* (F. Muell.) K. Schum. in Queensland, Australia. Three species of honeyeaters (Melphagidae) were observed to be the only floral visitors capable of effecting pollination. *Hornstedtia scottiana* produced sucrose-rich nectar. Flowering was diurnal with anthesis beginning at dawn. Floral visits were most frequent during mid-mornings. By early afternoon, if flowers were not visitor-pollinated, elongation of the corolla tube effected self-pollination. Pollination manipulations determined that outcrossed flowers set

significantly more fruit, with significantly heavier seeds, than self-pollinated flowers, suggesting an inbreeding depression. Mean seed mass data from open-pollinated controls suggested that the fruits produced were from a combination of self (65%) and outcrossed (35%) pollinations (Ippolito & Armstrong, 1993).

Zhang et al. (2011) investigated the floral biology, breeding system and pollination ecology of *Roscoea cautleoides* Gagnep. and *R. humeana* Balf. F. & W. W. Sm., from Hengduan Mountains, southwest China. Pollination experiments showed that the two species were self-compatible and depended on insects for fruit production. The principal pollinators observed were pollen-collecting generalist bees, with low visitation frequencies. Fan and Li (2012) reported a new type of autonomous self-pollination in *R. debilis* Gagnep. which occurred after the flowers wilted and noted that visitations by effective pollinators were rare.

2.5.3 Palynology

Pollen morphology is important to understand the taxonomy and phylogeny of the order Zingiberales (Kress & Stone, 1983; Dahlgren et al., 1985). For some time, it was thought that the pollen grains of Zingiberaceae were exineless (Stone et al., 1979; Zavada, 1983; Dahlgren et al., 1985), possesing a structurally complex intine (Hesse & Waha, 1982). However, in the majority of the Zingiberales, an exinous layer does exist, although it is poorly developed in many taxa (Hesse & Waha, 1982; Kress & Stone, 1982; Skvarla & Rowley, 1988; Chen, 1989). The pollen of Zingiberaceae is usually classfied as inaperturate (Theilade et al., 1993).

Pollen morphology of 89 species and 3 varieties belonging to 18 genera (out of 150 species in 20 genera) of Zingiberaceae in China was studied in Liang (1988) under both light microscope and scanning electron microscope. Pollen grains of Zingiberaceae are spherical, subspherical, ovoid and prolate, 36-225 μm in size, nonaperturate or aperturate (spiraperturate, porate). The wall is composed of a very thin exine and a thick intine. The exine is psilate, spinate, cerebelloid-areolate, striate, verrucate and foveolate. According to the presence or the absence of aperture and differential ornamentations, two types and six subtypes are recognized. The Kaempferia Clade belongs to the type Nonaperturate under the subtype Psilate, in which, the exine is nearly smooth (Liang, 1988).

2.5.4 Seed Morphology

Seeds of Zingiberales have been studied for more than a century (Tschirch, 1891; Humphrey, 1896; Netolitzky, 1926; Mauritzon, 1936; Takhtajan, 1985). Zingiberaceae seeds are morphologically and anatomically diverse and possess a large number of systematically significant characters. No single seed character was found to distinguish each subfamily, but combinations of characters were found to differentiate between the subfamilies. Recognition of the tribes based on seeds was possible for Globbeae, but not for Alpinieae, Riedelieae, or Zingibereae, due to considerable variation (Benedict et al., 2015).

2.6 Floral Scent

Floral scent predominantly acts as the attractant for the pollinators (Dudareva & Pichersky, 2006; Knudsen et al., 2006). It signals (Pellmyr & Thien, 1986), attracts or guides pollinators to approach, land, seek reward (occasionally mating and reproducing) and cross

pollinate the pollen (Raguso, 2001). This signalling cue is potentially more important than visual and tactile cues, and is a subject for co-evolution between plant-pollinator (Kite et al., 1998).

The headspace volatile compounds of the flowers of *Hedychium coronarium* J. Koenig were analyzed by solid phase micro-extraction coupled with capillary gas chromatography/mass spectrometry (SPME). A total of 39 compounds were identified, representing 98% of the entire amount. The volatile fraction was characterized by monoterpene hydrocarbons (34.9%), oxygenated monoterpenes (34.4%) and sesquiterpene hydrocarbons (13.2%). The major components were (E)-β-ocimene (28.7%), linalool (19.3%) and 1,8-cineole (14.5%), and they were found to make a major contribution to the typical scent of this flower (Báez et al., 2011). Yue et al. (2014) isolated two novel terpene synthase (TPS) genes (HcTPS7 and HcTPS8) to study the biosynthesis of monoterpenes in *H. coronarium*. *In vitro* characterization showed that the recombinant HcTPS7 was capable of generating sabinene as its main product, in addition to nine sub-products from geranyl diphosphate (GPP). Recombinant HcTPS8 almost specifically catalyzed the formation of linalool from GPP, while it converted farnesyl diphosphate (FPP) to a-bergamotene, cis-a-bi- sabolene, b-farnesene and other ten sesquiterpenes.

CHAPTER 3

MORPHOLOGY AND TAXONOMY

3.1 Introduction

Scaphochlamys is a small genus of 44 described species in the Kaempferia Clade (Kress et al., 2002, Leong-Škorničková et al., 2011), distributed from Southern Thailand, through Peninsular Malaysia, to Northern Borneo and Sumatra. *Scaphochlamys* forms a small clade of closely related taxa together with *Distichochlamys* and *Myxochlamys* based on DNA phylogenetic analyses (Takano & Nagamasu, 2007). Each of these genera is defined by a set of morphological characters in combination rather than any single key character. Each of these character traits on its own can be shared by more than one genus, so one has to consider the presence or absence of all these characters together before trying to allocate a species to a genus (Searle, 2010).

Scaphochlamys can be distinguished from the closely related genera by the following combination of characters: leaf-sheath base pulvinate (Borneo only); bract arrangement spiral; flowering mode from base to apex; first bracteole keeled, arising opposite to bract; bracteole split to base; thecae with free basal spurs (Searle, 2010). Searle (2010) stated that owing to several reasons such as historical collections are depauperate, flowers are ephemeral and do not preserve well, and much of the literature comprises weakly written descriptions, the taxonomic revision on the genus was difficult.

Valeton (1918) and Holttum (1950) investigations on the genus were made based on living materials. Valeton (1918) made his careful observations based on the

inflorescence and floral structures, while Holttum (1950) reinstated *Scaphochlamys* with description of nine new species from Peninsular Malaysia (Searle, 2010). However, Holttum (1950) work was confined to species in the Peninsular Malaysia and thus the transfer of the Bornean *Scaphoclamys* was only made in 1972 with *S. polyphylla* (Burtt & Smith, 1972), and followed by three latter species, *S. petiolata* (Smith, 1987), *S. gracilipes* (Sakai & Nagamasu, 2006), and *S. anomala* (Searle, 2010). So far, 14 species were described from Borneo with five recently described novelties (Mas Izzaty et al., 2013; Ooi & Wong, 2014; Meekiong et al., 2015). All sixteen species are endemic to Borneo.

As part of the investigation into the floral biology of the Bornean *Scaphochlamys* species, the morphological characters of the Bornean *Scaphochlamys* were examined in detail. In the process of doing so, several novelties were discovered and here, eleven new taxa are described. The Bornean *Scaphochlamys* are revised in this study. Based on the morphological characters, the Bornean *Scaphochlamys* are divided into six informal groups: Anomala Group, Calcicola Group, Graveolens Group, Limiana Group, Petiolata Group, and Polyphylla Group. The groupings recognized here are supported by the phylogeny based on ITS and *mat*K gene regions (Chapter 4).

3.2 Materials and Methods

Fieldwork was undertaken throughout the state of Sarawak, Malaysian Borneo since November 2013, during which all recognized taxa of *Scaphochlamys* were studied and collected (except *S. anomala*, and *S. gracilipes*, *S. iporii* and *S. salahuddiniana*). Living collections were maintained at the Botanical Research Centre, Semenggoh, Kuching, Sarawak in order to examine more fertile materials. Vouchers (dried specimens and spirit

materials) were deposited at Sarawak Forestry Herbarium (SAR). Fieldwork was extended to Peninsular Malaysia to check on the type of the genus, *S. malaccana*, and to make comparison with *S. kunstleri* and *S. biloba*. Vegetative characters were examined in the field while reproductive characters were examined by a hand lens or a stereo microscope. Several significant morphological characters were discussed.

3.3 Results and Discussion

3.3.1 Morphology

The following is an overview of the taxonomically important features observed in mainly Bornean *Scaphochlamys*, and based on observations from plants in its natural habitat or living collection established in a green house.

3.3.1.1 Element

All studied species were observed to possess different elements during juvenile and adult forms. Generally, all of these species are polyphyllous in juvenile form (Figure 3.1A) which may be easily mistaken as a *Boesenbergia* species. Most species in Sarawak eventually reduced to be monophyllous form but few species remain in polyphyllous form (Polyphylla Group and *S. multifolia* I. H. Ooi, K. Meekiong & S. Y. Wong). For non-Bornean species, only juvenile of *S. malaccana* was observed and confirmed to possess a polyphyllous element. The rest are yet to be observed.

3.3.1.2 Pulvinus

Shafreena (2006) showed the existence of a swelling, or pulvinus (Figure 3.1B), just above the point of emergence of the leaf-sheath from the rhizome. All observed species of



Figure 3.1: Morphological characters— A: plant in polyphyllous juvenile form; B: pulvinate petiole base; C: imbricated inflorescence; D: slightly lax inflorescence; E: tightly congested inflorescence; F: morphologically indistinctive bract and bracteoles; G: bract and bracteoles with distinctive morphological differences; H: anther spurs at middle with taper end and curved outward; I: anther spurs at middle with taper end but do not curved; J: spurless anther; K: anther spurs on one side with blunt end and slightly curved outward; L: anther spurs on one side with blunt end but do not curved; M:anther spurs on one side with blunt end and curved outward; N: fruit with colliculate pericarp;O: fruit with smooth pericarp. –A from *S. hasta OIH80*; B from *S. scintillans OIH141*; C, G & H from *S. limiana OIH118*; D from *S. penyamar OIH137*; E from *S. biru OIH75*; F & J from *S. graveolens OIH116*; I from *S. polyphylla OIH119*; K from *S. kunstleri OIH162*; L from *S. petiolata OIH71*; M from *S. kunstleri OIH163*; N from *S. lanjakensis OIH309*; O from *S. petiolata OIH78* – © Ooi I. H.

Borneo possess pulvinate petiole base but it is less conspicuous in the polyphyllous species (Polyphylla Group and *S. multifolia*).

3.3.1.3 Flowering Sequence

The flowering sequence of all observed *Scaphochlamys* species developed from base to apex. In general, the flowering began from the first flower of the cincinnus at base till the first flower of the cincinnus at apex and then it repeated with the second flower of the cincinnus at base till apex again (second round). Thus, the acropetalous flowering sequence remains a good characteristic for identification to genus level.

3.3.1.4 Inflorescence

The arrangement of the inflorescence are laxly arranged (Figure 3.1D), tightly congested (Figure 3.1E), or imbricated (Figure 3.1C). In lax inflorescence, the rachis is visible especially in the Anomala Group but closed by the bract in the Polyphylla Group. The axis of tightly congested or imbricated inflorescence is reduced greatly in length so that the whole cincinnus is packed into the base of the bract, the flowers alone protruding.

3.3.1.5 Bracts

The texture and arrangement of bracts are reliable characters to be used in identifying *Scaphochlamys* species. The bracts could be either coriaceous (Figure 3.1C) or membranous (Figure 3.1D & E; most Bornean species except *S. graveolens*, *S. calcicola* A. D. Poulsen & R. J. Searle, Limiana Group and Polyphylla Group). The bracts are arranged in a spiral or distichous (*S. calcicola*) pattern up the rachis. The apex of bracts could be

recurved, flattened, or incurved pointed. Bract margin of several non-Bornean species are crispulate.

3.3.1.6 Bracteoles

The first bracteole arises opposite the bract with a single flower in its axis. Successive bracteoles arise within and at 180 ° to the preceding one, again each with its own flower (Holttum, 1950). The inflorescence can build up to consist of many bracts each containing many bracteoles and flowers. On the other hand reduction to one or a few bracts can occur, as well as reduction to one bracteole and flower per bract (Searle, 2010). Bracteoles are either resembling bracts (Figure 3.1F) or distinguishable from the associated bracts (Figure 3.1G). Bracteoles are membranous but it can be either longer (sometimes, only the first bracteole) or shorter than the associated bract. First bracteole often more or less keeled (Bornean species, except Polyphylla group and Limiana group), or 2-side folding inwards (non-Bornean species, Polyphylla group and Limiana group). This is similar to prophyll in other plant families (Gramineae, Cyperaceae, and Marantaceae) (Holttum, 1974). In these families a 2-keeled prophyll occurs at the base of every new branch, whether large or small, and its back is usually curved to fit the parent axis against which it is compressed (Holttum, 1974). Elsewhere in Zingiberaceae, 2-keeled first bracteole occurs in *Myxochlamys* and *Distichochlamys* as well (Newman, 1995, Takano & Nagamasu, 2007). In *Scaphochlamys*, the 2-keeled first bracteole functions as an additional (basal) secondary bract on the first axis of the cincinnus and has either one or two flowers in its axil (Holttum, 1974). The rest of the cincinnus in *Scaphochlamys* has normal bracteoles but they are usually smaller than the 2-keeled first bracteole.

3.3.1.7 Flowers and Labella

Flowers are small (< 5 cm long) with either c. 1 cm (Anomala Group and Petiolata Group) or 1.5 cm long labellum (Limiana Group and Polyphylla Group), or large (≥ 5 cm long) with c. 2 cm labellum (Calcicola Group and Graveolens Group). The labellum is white with a yellow median band, violet with a yellow median band, partially violet along a yellow median band or white with purple streaks near base beside a yellow median band. For non-Bornean *Scaphochlamys*, flowers could be small (< 5 cm long) with 1.5 cm long labellum (*S. malaccana*) or large (≥ 5 cm long) with c. 2 cm labellum (*S. kunstleri*). *Scaphochlamys* species from Northern Peninsular Malaysia and Thailand possess labellum with white or yellow with or without red streaks near base; sometimes it is fully red, like in *S. kunstleri* var. *rubra*.

3.3.1.8 Anther Spurs

One of the key diagnostic characters for the genus is theca terminating in a short spur at the base (Searle, 2010). The anthers of observed non-Bornean species (*S. malaccana*, *S. kunstleri*, and *S. biloba*) are spurred. Many Bornean species are spurless, including Anomala Group, *S. calcicola*, Graveolens Group, and most of the species belonging to Petiolata Group (*S. durga*, *S. hasta*, *S. stenophylla*, and *S. reticosa*). However, in the Petiolata Group, the presence of an anther spur is not consistent; some flowers are without spur within a population of a single species. In addition to this, there are various types of anther spurs found in *Scaphochlamys* species: such as long tapering end (c. 0.5 mm) or short blunt end (< 0.5 mm), curved outward or downward, with various positioning (middle or on the side) (Figure 3.1H-M).

3.3.1.9 Fruits

Fruits of *Scaphochlamys* were reported to be trilocular (Searle, 2010), unilocular or trilocular with basal placentation (Holttum, 1950, Takano & Nagamasu, 2007). In this study, fruits of all observed *Scaphochlamys* are pseudomonomerous (three locules in the early stage of development but only one locule developed) with pluriovulate (between 3 to 6 of basal placentation). However, this observation needs further investigation. Most species have three ovules but *S. calcicola* has c. 5 ovules, *S. graveolens* has c. 10 ovules, and *S. kunstleri* has between 5 to 6 ovules. In this study, the pericarps of the fruits are found to be useful in identification. The fruits are either colliculate (Figure 3.1N; Anomala Group) or smooth (Figure 3.1O).

3.3.2 Taxonomy

3.3.2.1 Generic Delimitation

Scaphochlamys is readily defined by the flowering mode from base to apex, 2-flowered usually in cincinni (except *S. biloba*, *S. nigra* and *S. uniflora*), first bracteole 2-keeled, arising opposite to bract, bracteoles split to base, and pseudomonomerous fruits. The Bornean *Scaphochlamys* differs by having membranous bracts (except Limiana Group and Polyphylla Group), faintly 2-keeled first bracteole (except Limiana Group and Polyphylla Group), and pulvinate petiole base.

3.3.2.2 Taxonomic Groupings Based on Morphological Characters

There are six groups in Bornean *Scaphochlamys* species: Anomala Group, Calcicola Group, Graveolens Group, Limiana Group, Petiolata Group, and Polyphylla Group. The groups are differentiated by a set of combined characters: arrangement of inflorescence and its

bracts, bracts and bracteoles, flowers, and fruits. A set of characters (lamina shape, lamina surface, variegation, midrib, main lateral veins, tertiary veins, petiole length, bracts colour, ovary, fruit pericarps and floral odour) was used to identify taxa to species level. A key to the species groups on Borneo is shown as follows.

3.3.2.3 Key to Species Groups in Borneo

1. First bracteoles distinguishable from bracts, 2-side folding inwards ……..…...…….. 2
– First bracteoles similar to bracts, more or less 2-keeled ...……..……...……..…… 3
2. Bracts laxly arranged; peduncle short, 2–5 cm long …….....(**6) Polyphylla Group**
– Bracts imbricating (rosette-like); peduncle long, 10–15 cm long …….……...
…….……..…..(**4) Limiana Group**
3. First bracteole (sometimes subsequent bracteoles) longer than bracts; inflorescence laxly arranged ……..……..……..… 4
– First bracteole and subsequent bracteoles shorter than bracts; inflorescence tightly congested ……...……..……... 5
4. Bracts spirally arranged, small flowers, c. 2.5 cm long; labellum c. 1 cm long; fruit pericarp colliculate …….....……...……...…..…..(**1) Anomala Group**
– Bracts distichously arranged, large flowers, c. 5.5 cm long; labellum c. 2 cm long; fruit pericarp smooth ……...……...…….……...…….(**2) Calcicola Group**
5. Small flowers, c. 4 cm long; labellum c. 1 cm long; floral odour none or mildly pleasant ……..……...……(**5) Petiolata Group**
– Large flowers, c. 7cm long; labellum c. 2 cm long; floral odour foul smelling ……
……..……...……..(**3) Graveolens Group**

(1) Anomala Group

Anomala Group is defined by the lax inflorescence, bracts spirally arranged, membranous bracts, bracteoles resembling bracts but longer (mostly) than bracts, first bracteole very faintly 2-keeled and obscure, small flowers, c. 2.5 cm long with white labellum c. 1 cm long, and fruits with a colliculate pericarp. Anomala Group is restricted to occur above the Lupar Line (The Lupar Line suture zone is a 15 km wide, trending east-south-east through Engkilili and Lubok Antu (Hutchinson, 1996)). This group comprises of seven species.

Key to the species in Anomala Group

1. Lamina elliptic to broadly elliptic ……..……...……. 2
– Lamina ovate to lanceolate ……..……... 3
2. Lamina adaxial surface satiny with variegation ……...….**1.7**) ***S. scintillans***
– Lamina adaxial surface matte without variegation ……...…..…… **..1.3) *S. iporii***
3. Inflorescences slightly lax, less than 7.5 cm long ……..……...…. 4
– Inflorescences lax, more than 7.5 cm long ……...……...…… .**1.2) *S. gracilipes***
4. Inflorescences borne near leaf base ...……..……...… 5
– Inflorescences terminal within sheaths (without developed leaf) …...…**1.1) *S. anomala***
5. Lamina base cordate …….....**1.6) *S. salahuddiana***
– Lamina base not cordate ……. 6
6. Long creeping, lamina variegated, base attenuate …….**1.5) *S. penyamar***
– Tufted, lamina plain (rarely variegated), base cunneate to rounded ...**1.4) *S. lanjakensis***

1.1) *Scaphochlamys anomala* (Hallier f.) R. J. Searle, Edinburgh J. Bot. (2010: 85).

Type:—Cult. Bogor, originally from Borneo (Kalimantan), Hallier s.n. (holotype BO, presumed lost (Valeton 1918)).–Lectotype: Figure drawn from Hallier s.n., cult. Bogor, originally from Borneo (Kalimantan), published as t. IX, Fig. 3., Bull. Herb. Boissier 6: 357. 1898, designated by Searle (2010).

≡ *Kaempferia anomala* Hallier f., Bull. Herb. Boissier (1898: 357).

≡ *Gastrochilus hallieri* (Hallier f.) Ridl., J. Straits Branch Roy. Asiat. Soc. (1899: 109).

≡ *Gastrochilus anomalum* (Hallier f.) K.Schum., Pflanzenr. IV, 46 (Heft 20) (1904: 92).

≡ *Boesenbergia anomala* (Hallier f.) Schltr., Repert. Spec. Nov. Regni Veg. (1913: 315).

Discussion:—The lectotype depicts a laxly arranged inflorescence and a longer first bracteole than bract. The white labellum with veins (Searle, 2010) is also highly similar to other species in this group. However, the inflorescence is terminal within sheaths and not borne on a peduncle near leaf base like all the other species in this group. It is highly probable that the type is not lost but is instead in BOKR (see Hay & Yuzammi (2000) for discussion of BOKR).

1.2) *Scaphochlamys gracilipes* (K. Schum.) S. Sakai & Nagam., Blumea (2006: 110).

Type:—BORNEO. Sarawak: 1st Division, Gunung Wah, November 1866, *Beccari 2839* (holotype FI!, isotype K, P).

≡ *Haplochorema gracilipes* K. Schum., Pflanzenr. IV, 46 (Heft 20) (1900: 332).

≡ *Boesenbergia gracilipes* (K. Schum.) R. M. Sm., Bot. J. Linn. Soc. (1982: 43).

Discussion:—This species is placed in this group because the holotype shows the laxly arranged inflorescences and the length of the first bracteole is longer than the bract. The exact location of Gunung Wah is not known. It is suspected that Gunung Wah might not be far from Gunung Braang (Braam), Daerah Padawan, Kuching Division, owing to the fact that several Beccari's collections came from SW Sarawak during the time (see the discussion within the type specimen of *Bucephalandra elliptica*, Wong & Boyce, 2014).

1.3) *Scaphochlamys iporii* Meekiong & Ampeng, Folia Malaysiana (2011: 19).

Type:—MALAYSIAN BORNEO. Sarawak: Kapit Division, Lanjak Entimau Wildlife Sanctuary, Bukit Menyarin, 3 April 2008, *K. Meekiong, I. B. Ipor, A. Ampeng, B. Marzuki & Y. Isa MK1839* (holotype SAR!, isotype HUMS!).

≡ *Borneocola iporii* (Meekiong & Ampeng) Y.Y. Sam, PhytoKeys (2016: 47)

Discussion:— Similar to *S. salahuddiniana*, the flowers of *S. iporii* fit into this group but the lamina of *S. iporii* is matte adaxially with a cuneate base (Meekiong et al., 2011).

1.4) *Scaphochlamys lanjakensis* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.2)

Scaphochlamys lanjakensis possesses long petioles similar to *S. petiolata* but the inflorescences, flowers and fruits resemble those of *S. salahuddiana*.

Type:—MALAYSIAN BORNEO. Sarawak: Sri Aman Division, Lubok Antu, Lanjak Entimau Wildlife Sanctuary, Sungai Engkari, Nanga Segerak, 01°24'47.9"N, 112°00'41.9"E, 364 m, 15 April 2015, *Ooi Im Hin, Peter C. Boyce & Wong Sin Yeng OIH305* (holotype SAR).



Figure 3.2: *Scaphochlamys lanjakensis* — A: plant in habitat; B: lamina, adaxial surface; C: lamina, abaxial surface; D: plant with a flower; E: inflorescence; F: infructescence with marcescent bracts artificially opened to show the fruit; G: flower, front view; H: flower, side view; I: fruit, cross section. –A-C, E from *OIH305*; D, G-H from *OIH310*; F, I from *OIH309* – © Ooi I. H.

Herbs perennial, evergreen, terrestrial to c. 30 cm tall. Rhizome partially buried on ground, c. 5 mm in diam., externally light to medium brown, internally yellowish white. Elements 0.5–7 cm apart, 1-foliate, juvenile up to 5-foliate; leafless sheaths c. 3, 0.9–7.5 cm long, sparsely pubescent, light brown, decaying with age; leaf sheath c. 1 cm long, membranous, glabrous, brownish green, decaying with age, ligule obscure; petiole 12–16 cm long, canaliculate, pubescent, brownish green, base pulvinate, light brown; lamina 10–14 × 6–9 cm, ovate to lanceolate, chartaceous, margin slightly undulate, base cuneate to rounded, apex acute; adaxial surface matte, glabrous, medium green to dark dull green, occasionally variegated, midrib sunken, pubescent, light green to whitish green, main lateral veins slightly raised; abaxial surface sparsely pubescent, light green, midrib raised, pubescent, medium green, main lateral veins slightly visible. Inflorescence 6–7.5 cm long, emerging from near leaf base inside leaf sheaths, laxly arranged, comprised of c. 5 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle 3–5 cm long, glabrous, whitish light green, covered with marcescent leafless sheath; bracts c. 5, c. 4 × 3 mm, spirally arranged, ovate, sparsely pubescent, brown, apex acute, each bract subtending c. 2 flowers; bracteoles c. 2, 10–12 mm long, longer than bracts but barely distinguishable from bract, brown; flowers c. 2.5 cm long, without noticeable floral odour; calyx c. 10 mm long, sparsely pubescent, light brown, apex bidentate; floral tube 12–13 mm long, sparsely pubescent, white to slightly brownish white; corolla lobes 8–9 mm long, lanceolate, glabrous, white to slightly brownish white, apex acute, hooded; staminodes 4.5–5 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex rounded; labellum 9–11 × 9–10 mm, spathulate, adaxial surface covered with glandular hairs, white with a light yellow median band, apex 2-lobed, slightly fan-shaped, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 5 × 1.5 mm, covered

with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 4 mm long, spurless, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 24 mm long, glabrous, white; ovary c. 2 mm long, 1-locular, densely pubescent, light green, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, white. Fruit c. 13 × 8 mm, dehiscent capsule, ovoid, pubescent, greenish brown, pericarp colliculate, subtended by marcescent bracts. Seeds c. 2, c. 11 × 3 mm, slightly elongated ovoid, glabrous, green; aril c. 5 mm, lacerate, brownish white; perisperm white.

Etymology:—This species epithet is named after the type locality, Lanjak Entimau Wildlife Sanctuary.

Distribution and ecology:— *Scaphochlamys lanjakensis* is known only from the type locality. Mesophytes in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 360 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. No odour was detected.

Discussion:—The inflorescence axis of *S. lanjakensis* elongates in the same manner as that of *S. gracilipes*, but never reaches the length of the latter.

1.5) *Scaphochlamys penyamar* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.3)

The laxly arranged inflorescences and small white flowers of *S. penyamar* are similar to *S. salahuddiniana* and *S. iporii* but is readily distinguishable from the latter two species by the creeping habit and the variegated laminae.



Figure 3.3: *Scaphochlamys penyamar* — A: plant in habitat; B: rhizome; C: lamina, abaxial surface; D: flower, side view; E: flower, artificially opened showing ovary, epigynous glands, floral tube and labellum; F: inflorescence with leafless sheath artificially opened; G: flower, front view; H: stamen, noted spurless anther thecae; I: Calyx and ovary. –A-I from *OIH137* – © Ooi I. H.

Type:—MALAYSIAN BORNEO. Sarawak: Sarikei Division, Pakan, Berasok, 01°54'36.4"N, 111°38'52.3"E, 56 m, 21 April 2014, *Ooi Im Hin & Bakong ak Frinsa OIH137* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 16 cm tall. Rhizome creeping above ground with stilt roots, c. 4 mm in diam., externally light greenish brown, internally brownish white. Elements 3–5 cm apart, 1-foliate, juvenile not seen; leafless sheaths c. 3, 0.8–5 cm long, glabrous, light brown, drying and shredding with age; leaf sheath c. 0.4 cm long, membranous, glabrous, light green, drying and shredding with age, ligule obscure; petiole 4.5–6.5 cm long, canaliculate, glabrous, medium green with scattered white dots, base pulvinate, light green; lamina 9–12 × 6.5–8 cm, ovate, chartaceous, margin slightly undulate, base attenuate, apex acute; adaxial surface matte, glabrous, medium green, variegated with two refractive grey broad longitudinal bands on each side of midrib, midrib sunken, glabrous, medium green, main lateral veins slightly visible; abaxial surface sparsely pubescent, light green, midrib raised, glabrous, medium green, main lateral veins inconspicuous. Inflorescence 3–4 cm long, emerging from near leaf base inside leaf sheaths, laxly arranged, comprised of c. 5 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 2 cm long, glabrous, whitish green, covered with marcescent leafless sheath; bracts c. 5, c. 4 × 2.5 mm, spirally arranged, ovate, glabrous, brown, apex acute, each bract subtending c. 2 flowers; bracteoles c. 2, 7–9 mm long, longer than bracts but barely distinguishable from bract, brown; flowers c. 2.5 cm long, floral odour mild torch ginger-like; calyx c. 10 mm long, sparsely pubescent, light brown, apex bidentate; floral tube 14–15 mm long, sparsely pubescent, white to slightly brownish white; corolla lobes 8–10 mm long, lanceolate, glabrous, white to slightly

brownish white, apex acute, hooded; staminodes 4–5 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex rounded; labellum 8–11 × 9–10 mm, spathulate, adaxial surface covered with glandular hairs, white with a light yellow median band, apex 2-lobed, slightly fan-shaped, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 4 × 1.5 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 3 mm long, spurless, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 24 mm long, glabrous, white; ovary c. 2 mm long, 1-locular, densely pubescent, light green, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, brownish white. Fruits and seeds not seen.

Etymology:—The specific epithet *penyamar* is a Malay word for impostor referring to that the species is easily mistaken as an aroid from distance when sterile.

Distribution & ecology:— *Scaphochlamys penyamar* is known only from the type locality along the stream. Mesophytes in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 55 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A mild torch ginger-like odour was detected within 1 cm radius.

Discussion:—The adaxial surface of the lamina is variegated with two refractive grey broad longitudinal bands on each side of midrib. Several members (*S. scintillans* and occasionally *S. lanjakensis*) in this group also have a similar refractive variegation but not as striking.

1.6) ***Scaphochlamys salahuddiniana*** Meekiong, Ampeng & Ipor, Folia Malaysiana (2011: 22).

Type:—MALAYSIAN BORNEO. Sarawak: Kapit, Ulu Katibas, Lanjak Entimau, Bukit Sepali, 30 April 2008, *K. Meekiong, I. B. Ipor, B. Marzuki, K. Stephen & Apai Keroh M. K. 1856* (holotype SAR!, isotype HUMS!).

≡ *Borneocola salahuddinianus* (Meekiong, Ampeng & Ipor) Y.Y. Sam, PhytoKeys (2016: 48).

Discussion:—The flowers of *S. salahuddiana* fit well into this group by its relatively smaller dimension, white labellum with veins, and colliculate fruit pericarp.

1.7) ***Scaphochlamys scintillans*** I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.4)

The satiny (glittering-like) dark green lamina adaxially with two refractive grey bands of variegation (feathered pattern) is distinctive from all other *Scaphochlamys* species.

Type:—MALAYSIAN BORNEO. Sarawak: Betong Division, Roban, Sebangkoi, 01°57'29.7"N, 111°26'16.9"E, 97 m, 22 April 2014, *Ooi Im Hin & Bakong ak Frinsa OIH141* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 18 cm tall. Rhizome buried in ground, c. 5 mm in diam., externally dark greenish brown, internally brownish white. Elements 0.1–1 cm apart, 1-foliate, juvenile not seen; leafless sheaths c. 3, 0.7–4.5 cm long, glabrous, light brown, drying and shredding with age; leaf sheath c. 1 cm long, membranous, glabrous,



Figure 3.4: *Scaphochlamys scintillans* — A: plant in habitat; B: inflorescence, artificially opened showing bracts and first brateoles; C: lamina, adaxial surface; D: flower, top view; E: lamina, abaxial surface; F: stamen, note spurless anther thecae; G: flower, front view; H: lamina, adaxial surface, enlarged showing the variegation. –A-H from *OIH141* – © Ooi I. H.

light green, drying and shredding with age, ligule obscure; petiole 3.5–4.5 cm long, canaliculate, glabrous, medium green, base pulvinate, yellowish green; lamina 10–14 × 4–7 cm, elliptic to broad elliptic, coriaceous, margin entire, base cuneate to rounded, apex obtuse to mucronate; adaxial surface satiny (glittering-like), glabrous, dark green, variegated (refractive grey bands, feathered pattern on each side), midrib sunken, glabrous, dark green, main lateral veins inconspicuous; abaxial surface glabrous, glaucous greenish white, midrib raised, pubescent, light green, main lateral veins slightly visible. Inflorescence 3–4 cm long, emerging from near leaf base inside leaf sheaths, slightly lax, comprised of c. 7 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 2 cm long, glabrous, whitish light green, covered with marcescent leafless sheath; bracts c. 7, c. 4 × 3 mm, spirally arranged, ovate, glabrous, brown, apex acute, each bract subtending c. 2 flowers; bracteoles c. 2, 10–12 mm long, longer than bracts but barely distinguishable from bract, brown; flowers c. 2.4 cm long, without noticeable floral odour; calyx c. 9 mm long, sparsely pubescent, light brown,

apex bidentate; floral tube 10–13 mm long, sparsely pubescent, white to slightly greenish white; corolla lobes 7–8 mm long, lanceolate, glabrous, white to slightly brownish white, apex acute, hooded; staminodes 4–5 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex rounded; labellum 8–11 × 9–10 mm, spathulate, adaxial surface covered with glandular hairs, white with a light yellow median band (sometimes slightly tinged lilac), apex 2-lobed, slightly fan-shaped, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 4 × 1.5 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 3 mm long, spurless, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 23 mm long, glabrous, white; ovary c. 2 mm long, 1-locular,

densely pubescent, light green, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, brownish white. Fruits and seeds not seen.

Etymology:—The specific epithet is referring to the glittering-like satiny lamina surface.

Distribution and ecology:—*Scaphochlamys scintillans* is known only from the type locality. Mesophytes in shady kerangas (tropical heath forest) on red-yellow podzolic soils over shales, at c. 95 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. No odour was detected.

Discussion:—The satiny lamina adaxial surface is unique in Bornean *Scaphochlamys* species. Odour was not detected from *S. scintillans*.

(2) Calcicola Group

Calcicola Group is defined by the slightly lax inflorescence, bracts spirally or distichously arranged, membranous bracts, bracteoles resembling bracts but first bracteole longer (sometimes) than bracts, first bracteole faintly 2-keeled and slightly obscure, large flowers, c. 5.5 cm long with labellum c. 2 cm long, and fruits with a smooth pericarp. So far, two species belong to this group. Calcicola Group is restricted to Daerah Bau, Kuching Division.

Key to the species in Calcicola Group

1. Lithophyte, up to 60cm tall, main lateral veins raised, bracts distichously arranged, labellum white, anther spurless ……..…..…… **2.1**) ***S. calcicola***

– Mesophyte, up to 25cm tall, main lateral veins flattened, bracts spirally arranged, labellum white with violet along light yellow median band till lobes, anther spurred ……..…….. **2.2) *S. uniflora***

2.1) *Scaphochlamys calcicola* A. D. Poulsen & R. J. Searle, Gard. Bull. Singapore (2005: 29). (Figure 3.5)

Type:—MALAYSIAN BORNEO. Sarawak: 20 June 2003, *Poulsen, Jugah & Clausager 2022* (holotype SAR, isotype AAU, E, K, L).

≡ *Borneocola calcicola* (A.D. Poulsen & R.J. Searle) Y.Y. Sam, PhytoKeys (2016: 46).

Additional specimen examined:—MALAYSIAN BORNEO. SARAWAK: Kuching Division, Bau, Seromah, 01°22'37.2"N, 110°11'33.9"E, 34 m, 12 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH81* (SAR).

Discussion:—This species is the only *Scaphochlamys* species in Borneo with distichously arranged inflorescences and therefore, its inclusion in *Scaphochlamys* was slightly doubtful (Poulsen & Searle, 2005). In this study, its placement in *Scaphochlamys* is further confirmed by the observation of acropetalous flowering sequence. Poulsen and Searle (2005) stated the species is unique in having spurless anthers. However, spurless thecae were also found in many other Bornean *Scaphochlamys* species (refer to above).

2.2) *Scaphochlamys uniflora* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.6)

Scaphochlamys uniflora is similar to *S. durga* vegetatively but is readily distinguishable by the much larger flower with longer labellum c. 2 cm (*vs* c. 1 cm), light green bracts (*vs* light brown), first bracteole longer than bract (*vs* shorter), white with tinged violet anther crest (*vs* white) and the presence of anther spurs (*vs* spurless).



Figure 3.5: *Scaphochlamys calcicola* — A: plant in habitat, note the lamina abaxial surface; B: plant in habitat, noted the lamina adaxial surface; C: inflorescence, note the distichous arrangement; D: young infructescence; E: infructescence, the persistent bract was artificially opened to show the fruit; F: flower, front view; G: flower, side view. –A-G from *OIH81* – © Ooi I. H.



Figure 3.6: *Scaphochlamys uniflora* — A: plant with variegation in habitat; B: plant without variegation in habitat; C: lamina, adaxial surface; D: lamina, abaxial surface; E: inflorescence, artificially opened showing the bract and bracteole; F: flower, front view; G: flower, side view; H: flower, artificially opened, note the labellum; I: stamen, note the anther spurs. –A-I from *OIH82* – © Ooi I. H.

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Seromah, 01°22'37.2"N, 110°11'33.9"E, 34 m, 12 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH82* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 25 cm tall. Rhizome creeping on ground, c. 5 mm in diam., externally light brown, internally brownish white. Elements 2–10 cm apart, 1-foliate, juvenile up to 8-foliate; leafless sheaths c. 3, 0.5–6 cm long, glabrous, light green to light brown, degrading with age; leaf sheath c. 2 cm long, membranous, glabrous, brownish light green, drying and shredding with age, ligule obscure; petiole 5–10 cm long, canaliculate, pubescent, medium green, base pulvinate, light to yellowish green; lamina 9–12 × 3–4 cm, ovate to lanceolate, coriaceous, margin slightly undulate, base attenuate, apex acute; adaxial surface semi-glossy, glabrous, medium green, sometimes variegated (white shades between midrib and margins except main lateral veins), midrib sunken, glabrous, dark green, main lateral veins slightly visible; abaxial surface glabrous, whitish green, midrib raised, glabrous, dark green, main lateral veins inconspicuous. Inflorescence c. 6.5 cm long, emerging from near leaf base inside leaf sheaths, comprised of 1-flowered solitarily borne on a peduncle; peduncle c. 0.5 cm long, glabrous, whitish light green, covered with degraded leafless sheaths; bract 1, c. 20 × 4 mm, spirally arranged, lanceolate, glabrous, membranous, brownish light green, apex acuminate, each bract subtending 1 flower; bracteole 1, c. 22 mm long, longer than bracts but barely distinguishable from bract, brownish light green; flowers c. 55 mm long, floral odour mild torch ginger-like; calyx c. 16 mm long, tubular, glabrous, white, apex slightly tridentate; floral tube c. 40 mm long, glabrous, white; corolla lobes c. 12 mm long, lanceolate, glabrous, white, apex acute, hooded; labellum c. 20 mm × c. 17 mm, spathulate, adaxial surface covered with glandular

hairs, white with violet along light yellow median band till lobes, apex 2-lobed, indented c. 5 mm; stamen c. 11 × 2 mm, covered with glandular hairs, white with purplish at crest; filament c. 6 mm long; anther thecae c. 3 mm long, spurred, crest c. 1.5 mm long, slightly 3-lobed; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 45 mm long, glabrous, white; ovary c. 2 mm long, 1-locular, sparsely pubescent, light green, placentation basal; epigynous glands 2, c. 4 mm long, free, needle-like, yellowish white. Fruits and seeds not seen.

Etymology:—The specific epithet, *uniflora*, refers to the single-flowered inflorescence.

Distribution and ecology:—*Scaphochlamys uniflora* is only known from the type locality. Mesophytes in shady limestone forest on mollisolic black soils at c. 35 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. Mild torch ginger-like floral odour was detected at c. 1 cm radius.

Additional specimen examined (paratype):—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Seromah, 01°22'37.2"N, 110°11'33.9"E, 34 m, 11 January 2015, *Ooi Im Hin & Jeland ak Kisai OIH291* (SAR).

Discussion:—This species has a very peculiar combination of *S. durga*-like lamina, *S. graveolens*-like labellum, *S. polyphylla*-like anther, *S. stenophylla*-like odour and its inflorescence only consists of a single flower with a bract and a bracteole. Although it is impossible to see the arrangement of the single-flowered inflorescence, it is considered as the second species of *S. calcicola* group because of the relatively larger flower and the bracteole is slightly longer than the bract.

(3) Graveolens Group

The Graveolens Group is defined by the tightly congested inflorescence, spirally (bulb-like) arranged, membranous bracts, bracteoles resembling bracts but shorter than bracts, first bracteole very faintly two keeled and obscure, large flowers, c. 7 cm long with white labellum with violet along a yellow median band extending to lobes, c. 2 cm long, fruits with a smooth pericarp, and a foul floral odour; This group comprises two species. Graveolens Group is restricted to SW Sarawak.

Key to the species in Graveolens Group

1. Height up to 70 cm tall, laminae ovate to oblong-elliptic, matte adaxially, bracts light brown to light greenish brown, anther crest tinged violet …...…… **3.1) *S. graveolens***
– Height up to 25 cm tall, laminae broadly ovate to broadly elliptic, glossy adaxially, bracts light green, anther crest white …….……..….. **3.2) *S. lucens***

3.1) *Scaphochlamys graveolens* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.7)

Scaphochlamys graveolens is readily distinguished from the rest of the species on Borneo with its large paddle-shaped leaves.

Type:—MALAYSIAN BORNEO. Sarawak: Samarahan Division, Serian, Pichin, 01°08'03.7"N, 110°27'00.3"E, 90 m, 06 April 2014, *Ooi Im Hin & Jeland ak Kisai OIH116* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 70 cm tall. Rhizome below ground, c. 1 cm diam., externally light brown to medium brown, internally brownish white. Elements c. 1 −

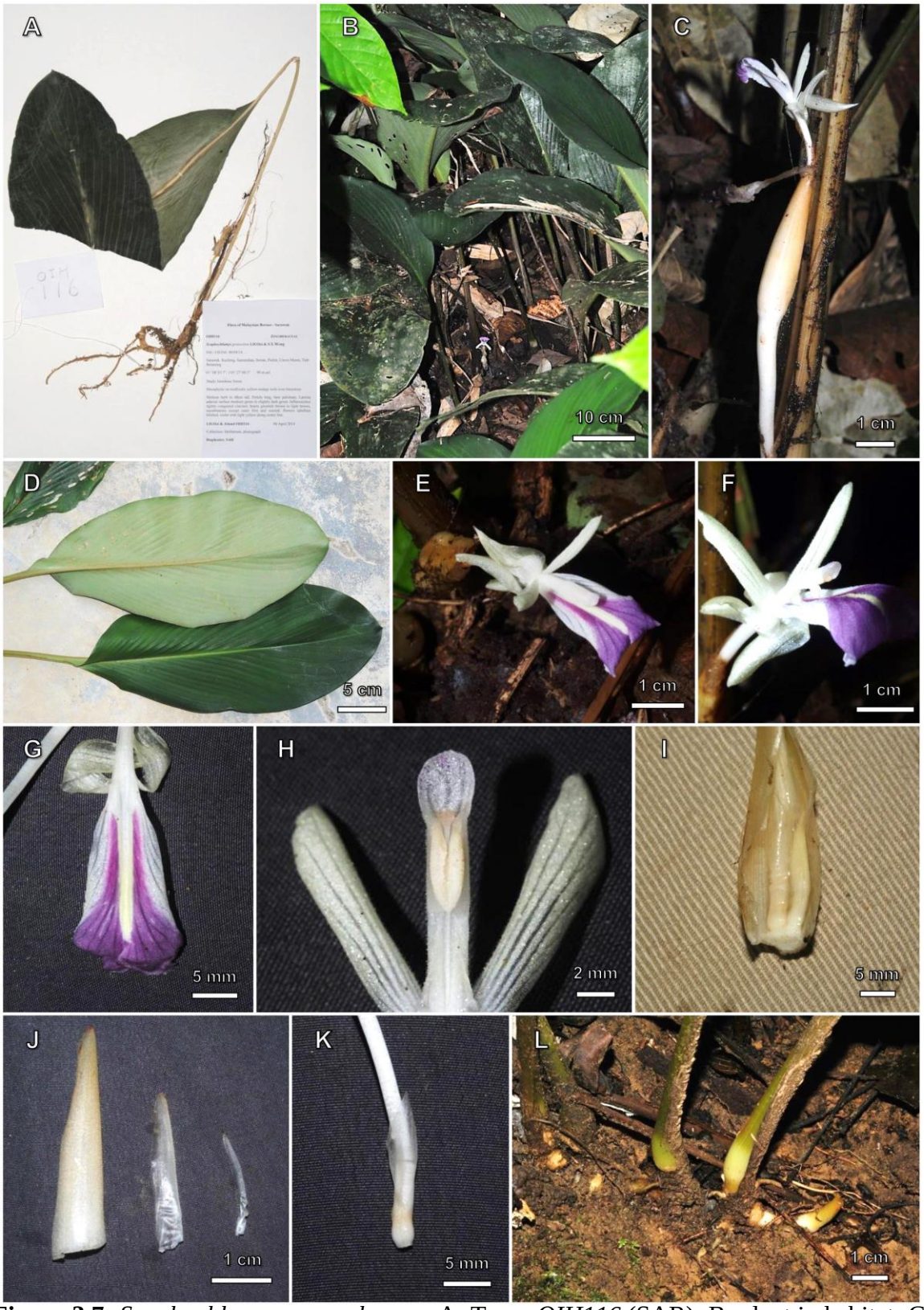


Figure 3.7: *Scaphochlamys graveolens* — A: Type, *OIH116* (SAR); B: plant in habitat; C: inflorescence; D: lamina; E: flower, top view; F: flower, side view; G: labellum; H: stamen, note the spurless anther and slightly purplish crest; I: bract, subtending two flowers; J: bract and bracteoles; K: calyx and ovary; L: petiole base and rhizome. –A-E, H-L from *OIH116*; F-G from *ZI568* – © Ooi I. H.

5 cm apart, 1-foliate, juvenile up to 3-foliate ; leafless sheaths 3–4, 3 − 14.5 cm long, glabrous, brownish green to medium green, margin membranous, decaying with age; leaf sheath c. 4 cm long, membranous, glabrous, light green, decaying with age; ligule pubescent, obscure; petiole 18 − 32 cm long, canaliculate, pubescent, brownish green, base pulvinate, white to light green; lamina 20–35 cm × 9–12.5 cm, ovate to oblong-elliptic, coriaceous, margin entire, base attenuate, apex mucronate, often slightly recurved; adaxial surface matte, glabrous, medium green to dark green, midrib sunken, sparsely pubescent at base, brownish green to light green, main lateral veins slightly raised; abaxial surface pubescent, light green, midrib raised, densely pubescent, brownish green, main lateral veins slightly visible. Inflorescence 10–12.5 cm long, emerging from near leaf base inside sheaths, tightly congested, bulb-like, comprised of 4–6 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle 2.5–5 cm long, glabrous, white, exposed, slightly covered by the remaining decayed leafless sheaths; bracts 4–6, c. 4 × 1.6 cm, spirally arranged, lanceolate, glabrous, membranous except first and second bracts at outermost layer sometimes slightly coriaceous, light brown to greenish light brown, apex acute, each bract subtending 2 flowers; bracteoles c. 2, 1.5–3 cm long, barely distinguishable from bracts, light brown to brownish white; flowers c. 7 cm long, floral odour foul (liquid of domestic waste-like); calyx c. 18 mm long, white, apex acute, pubescent at base; floral tube 40 − 45 mm long, glabrous, white; corolla lobes c. 22 mm long, lanceolate, glabrous, white to light yellow, apex acute, hooded; staminodes 18–20 mm long, linear to slightly oblanceolate, white to slightly light yellow, apex rounded to acute, adaxial surface covered with glandular hairs; labellum c. 25 × 15 mm, spathulate, adaxial surface covered with glandular hairs, white with violet along light yellow median band extending to lobes, apex 2-lobed, indented c. 5 mm, recurved, lobes slightly

overlapping; stamen c. 12 × 2 mm, covered with glandular hairs, white with tinged violet at crest; filament c. 5 mm long; anther thecae c. 5 mm long, spurless, crest c. 2 mm long; stigma less than 1 mm

long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 55 mm long, glabrous, white; ovary c. 4 mm long, 1-locular, sparsely pubescent but densely at apex, white, placentation basal; epigynous glands 2, c. 6 mm long, free, needle-like, brownish white. Fruits and seeds not seen.

Etymology:—The specific epithet, *graveolens*, was chosen based on the foul floral odour, which is unique in *Scaphochlamys* (most of the *Scaphochlamys* flowers have either no smell or pleasant smell).

Distribution and ecology:—*Scaphochlamys graveolens* is known from the type locality and Kampung Segu, Padawan. Mesophytes on mollisolic yellow-orange soils in limestone forest near stream at c. 90 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A foul odour (liquid of domestic waste-like) was detected from 3 cm radius.

Additional specimen examined (paratype):—MALAYSIAN BORNEO. SARAWAK: Samarahan Division, Serian, Pichin, 01 °08'03.7"N, 110 °27'00.3"E, 90 m, 20 August 2004, *Simon Kutuh ak Paru ZI568* (SAR); Kuching Division [‘First Division’], Penrissen Road, Kampung Segu, 26 May 1975, *B. L. Burtt B. 8798* (E).

Discussion:—*Scaphochlamys graveolens* is, so far, the largest *Scaphochlamys* on Borneo. The Burtt’s collection (*B. 8798*) recorded from Kampung Segu, Penrissen Road is identified as *S. graveolens* based on its much larger elements, attenuate lamina base, mucronate lamina apex and long roots with very short tertiary roots. Smith (1987) and Searle (2010) included this collection in *S.* aff. *breviscapa* Holttum. However, *S.*

breviscapa has chartaceous lamina with pubescent midrib abaxially, acuminate lamina apex, imbricating inflorescences with short peduncle (1–3.5 cm), small coriaceous bracts (2.5–3 cm), small flowers (less than 4 cm long), white labellum with lilac streaks on both side of light yellow median band near base and was described from Ulu Bendong, Kemaman, Terengganu, Peninsular Malaysia.

3.2) *Scaphochlamys lucens* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.8)

The flowers of *S. lucens* are similar to *S. graveolens* but *S. lucens* distinctly differs by having broadly ovate to broadly elliptic and glossy laminae adaxially.

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Padawan, Gunung Temugan, 01°15'38.6"N, 110°15'31.4"E, 50 m, 14 April 2014, *Ooi Im Hin & Jeland ak Kisai OIH125* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 25 cm tall. Rhizome creeping on ground, c. 5 mm diam., externally light brown to brownish green, internally white. Elements 0.5 − 10 cm apart, 1-foliate, juvenile up to 4-foliate ; leafless sheaths c. 3, 1.2 − 3.5 cm long, glabrous, light to medium green, decaying with age; leaf sheath c. 3 cm long, membranous, glabrous, light green, decaying with age; ligule membranous, obscure; petiole 10 − 16 cm long, canaliculate, pubescent, medium green, base pulvinate, white to yellowish light green; lamina 9–12 × 6–7 cm, broadly ovate to broadly elliptic, coriaceous, margin entire, base obtuse, apex acute, often recurved; adaxial surface glossy, glabrous, medium green to slightly dark green, midrib sunken, glabrous, medium green to slightly dark green, main lateral veins slightly raised; abaxial surface sparsely pubescent, whitish green, midrib raised, densely pubescent, medium green, main lateral veins slightly visible. Inflorescence



Figure 3.8: *Scaphochlamys lucens* — A: Type, *OIH125* (SAR); B: plant in habitat; C: petiole base and rhizome; D: inflorescence; E: lamina, adaxial surface; F: lamina, abaxial surface; G: bract and bracteoles; H: flower, side view; I: flower, front view; J: flower, top view; K: calyx and ovary; L: stamen, note the spurless anther; M: anther crest and stigma. – A-M from *OIH125* – © Ooi I. H.

c. 7 cm long, emerging from near leaf base inside leaf sheaths, tightly congested, bulb-like, comprised of c. 4 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle 1.5 − 2 cm long, glabrous, greenish white, exposed, slightly covered by the remaining decayed leafless sheaths; bracts c. 4, c. 3.5 × 1 cm, spirally arranged, lanceolate, membranous, sparsely pubescent, light green, apex acuminate, each bract subtending c. 2 flowers; bracteoles c. 2, 15–30 mm long, shorter than bracts but barely distinguishable from bract, light green; flowers 6.5 − 7 cm long, floral odour foul (liquid of domestic waste-like); calyx c. 18 mm long, sparsely pubescent, brownish white, apex acute; floral tube 45 − 50 mm long, glabrous, white; corolla lobes 17–18 mm long, lanceolate, glabrous, white to slightly yellowish white, apex acute, hooded; staminodes 13–18 mm long, linear to slightly oblanceolate, white to light yellow, apex acute, adaxial surface covered with glandular hairs; labellum 20–25 × 10 − 12 mm, spathulate, adaxial surface covered with glandular hairs, white with violet along light yellow median band extending to lobes, apex 2-lobed, indented c. 5 mm, recurved, lobes sometimes slightly overlapping; stamen c. 11 × 2 mm, covered with glandular hairs, white; filament c. 5 mm long; anther thecae c. 5 mm long, spurless, crest c. 1 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 45 mm long, glabrous, white; ovary c. 3 mm long, 1-locular, densely pubescent, white, placentation basal; epigynous glands 2, c. 3 mm long, free, needle-like, yellowish white. Fruits and seeds not seen.

Etymology:—The specific epithet, *lucens*, is the Latin word for shining, indicates the light-reflecting glossy lamina adaxial surface.

Distribution and ecology:—*Scaphochlamys lucens* is known from the type locality and the surrounding limestone areas. Mesophytes in shady limestone forest on mollisolic black soils at c. 50 m elevation.

Additional specimen examined (paratype):—MALAYSIAN BORNEO. SARAWAK: Kuching Division, Padawan, Gua Tut 01°17'07.2"N, 110°15'08.8"E, 65 m, 5 October 2014, *Peter C. Boyce & Wong Sin Yeng OIH263* (SAR); Kuching Division, Padawan, Gunung Temugan, 01°15'38.6"N, 110°15'31.4"E, 50 m, 14 April 2014, *Ooi Im Hin & Jeland ak Kisai OIH126* (SAR); Kuching Division, Padawan, Gunung Temugan, 01°15'35.0"N, 110°17'37.7"E, 35 m, 21 October 2014, *Wong Sin Yeng & Peter C. Boyce OIH264* (SAR).

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A mild foul odour (liquid of domestic waste-like) was detected within 1.5 cm radius.

Discussion:—*Scaphochlamys lucens* is suggested to be related to *S. graveolens* by sharing several remarkable characteristics, especially the tightly congested bulb-like inflorescence, white labellum with violet along light yellow median band extending to lobes and foul floral odour.

(4) Limiana Group

The Limiana Group is defined by the imbricated (rosette-like) inflorescence, spirally arranged, coriaceous bracts, bracteoles distinguishable from bracts and shorter than bracts, first bracteole 2-side folding inward and prominent, small flowers, c. 3 cm long with c. 1.5 cm labellum (purple streaks near base), and fruits with a smooth pericarp. This group comprises one species. Limiana Group is restricted to the tip of W Sarawak.

4.1) *Scaphochlamys limiana* Meekiong & K. Yazid, Folia Malaysiana (2015: 33). (Figure 3.9)

Type:—MALAYSIAN BORNEO. Sarawak: Sematan, Samumsam Wildlife Sanctuary Extension, Trail to Ranger Post, kerangas forest, sandy soil, near to the stream, on thick

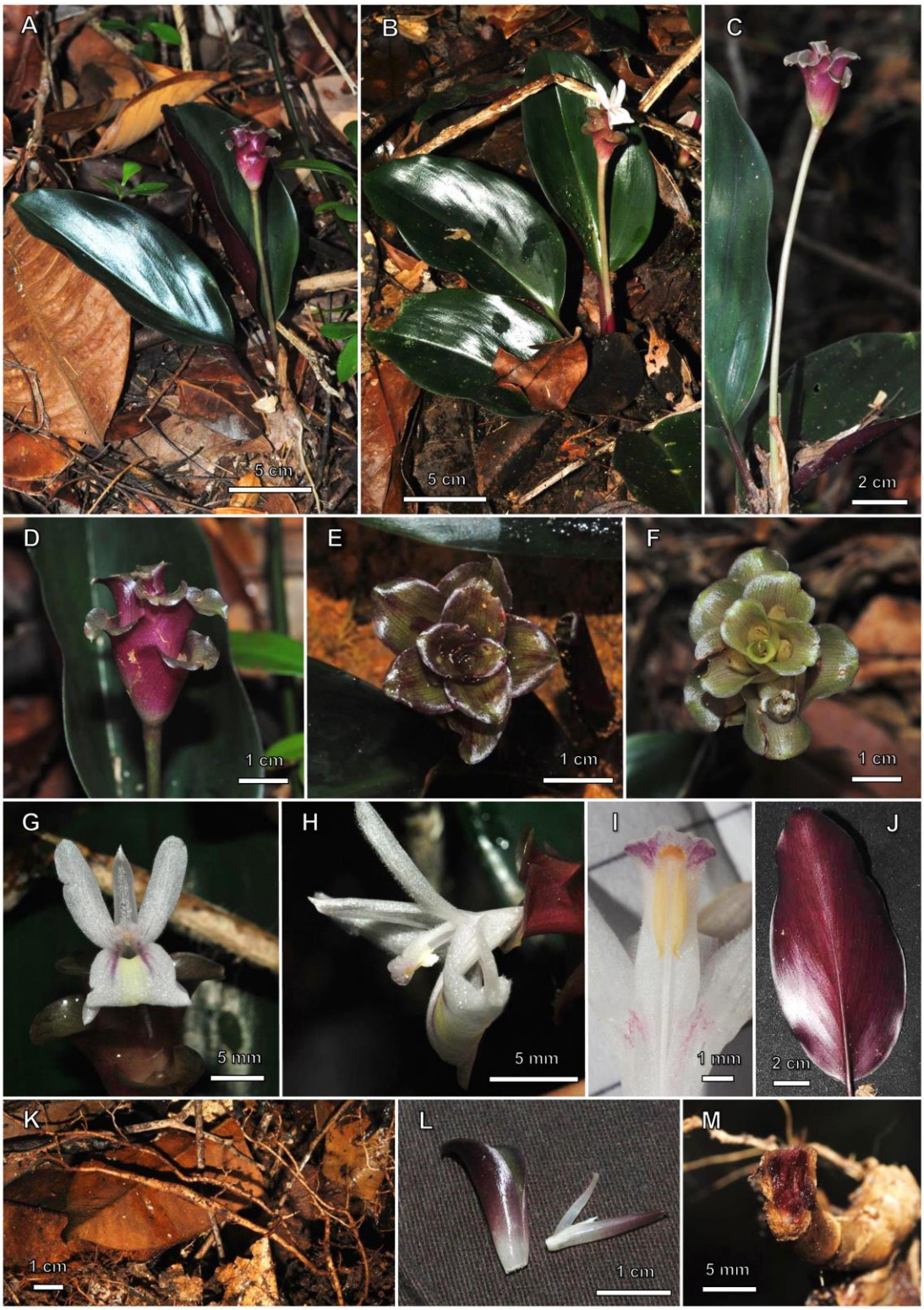


Figure 3.9: *Scaphochlamys limiana* — A: plant in habitat; B: plant with flower in habitat; C: inflorescence; D: bracts, side view; E: bracts, top view; F: bracts and a mature seed, noted paler bracts during fruiting G: flower, front view; H: flower, side view; I: stamen, noted the anther spurs and purplish white crest; J: lamina, abaxial surface; K: roots, note the pseudo-tuberous root; L: bracts and bracteoles; M: rhizome, noted the dark purplish red interior. –A, C-F, I-J, L-M from *OIH118*; B & K from *OIH122*; G-H from *OIH121*– © Ooi I. H.

humus layer, 25 October 2014, *K. Meekiong, K. Yazid, W, Yahud & Dami, MK2344* (holotype SAR!; paratype HUMS!).

Herbs perennial, evergreen, terrestrial to c. 19 cm tall. Rhizome slightly creeping below ground, c. 5 mm diam., externally medium brown, internally dark purplish red, roots sometimes pseudo-tuberous. Elements 0.2 − 2 cm apart, 1-foliate, juvenile not seen; leafless sheaths c. 4, 0.8 − 6 cm long, glabrous, dark purplish red with white near base, marcescent with age; leaf sheath c. 2 cm long, membranous, glabrous, reddish white, marcescent with age; ligule membranous, obscure, marcescent with age; petiole c. 5 cm long, canaliculate, sparsely pubescent, dark purplish red, base pulvinate, dark pinkish white to dark purplish red; lamina 11–14 × 5–6.5 cm, slightly ovate to elliptic, coriaceous, conduplicate, margin slightly undulate, base obtuse, apex acute,; adaxial surface glossy, glabrous, medium green to dark green, midrib sunken, main lateral veins inconspicuous; abaxial surface, glabrous, dark purplish red, midrib raised, sparsely pubescent, main lateral veins slightly visible. Inflorescence c. 18 cm long, emerging from near leaf base inside leaf sheaths, imbricating, rosette-like, comprised of 7–11, 2–3-flowered cincinni borne on a long peduncle, flowering spirally from base to apex; peduncle 10–14.5 cm long, glabrous, light reddish green to medium reddish green, subtended by marcescent leafless sheaths at base; bracts 7–11, 1.5–2 × 1.2 cm, spirally arranged, broadly obovate, coriaceous, glabrous, reddish medium green adaxially, dark purplish red abaxially, turn paler during fruiting, margin entire but slightly undulate at apex, base slightly incurved, apex mucronate, slightly recurved, each bract subtending 2–3 flowers; first bracteole c. 15 mm long, opposite bract, keeled, inflexed, reddish white; subsequent bracteoles 1–2, c. 12 mm long, similar but smaller and not keeled; flowers c. 30 mm long, floral odour very mild resinous; calyx c. 7

mm long, tubular, glabrous, white, apex slightly tridentate; floral tube c. 19 mm long, glabrous, white; corolla lobes c. 10 mm long, lanceolate, glabrous, white, apex acute, hooded; staminodes 10–11 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, white, apex obtuse to rounded; labellum 12–15 × 9 mm, spathulate, adaxial surface covered with glandular hairs, white with violet streaks from base at both sides of light yellow median band, apex 2-lobed, indented c. 3 mm, recurved, lobes sometimes slightly overlapping; stamen c. 6.5 × 1.5 mm, covered with glandular hairs, white with purplish at crest; filament c. 2 mm long; anther thecae c. 3 mm long, spurred, crest c. 1.5 mm long, recurved, slightly 3-lobed; stigma less than 1 mm long, funnel-shaped, ostiole ciliate, forward facing; style c. 24 mm long, glabrous, white; ovary c. 2 mm long, 1-locular, glabrous, white, placentation basal; epigynous glands 2, c. 3.5 mm long, free, needle-like, yellowish white. Fruits, c. 10 mm when dried, dehiscent capsule, pericarp split halfway into three revealing the seeds when mature, calyx persist prior mature, subtended by persistent bracts; seeds c. 8.5 mm, obovoid, light brown with black dots when mature, aril c. 0.7 mm, lacerate, perisperm yellowish white.

Distribution and ecology:— *Scaphochlamys limiana* is known only from the North West Sarawak. Mesophytes in slightly shady kerangas (heath) forest with quartz-rich soils on granite bed at c. 20-40 m elevation.

Additional specimen examined:—MALAYSIAN BORNEO. SARAWAK: Kuching Division, Lundu, Gunung Pueh, 01°50'03.5"N, 109°40'35.4"E, 19 m, 13 April 2014, *Ooi Im Hin, Scott Hyndman & Jepom ak Tisai OIH118* (SAR); 01°49'59.1"N, 109°40'27.2"E, 38 m, 13 April 2014, *Ooi Im Hin, Scott Hyndman & Jepom ak Tisai OIH121 & OIH122* (SAR).

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A very mild resinous smell was mildly detected within c. 0.5 cm radius.

Discussion:—This species is unique among the Bornean *Scaphochlamys*. The dark purplish red rhizome interior, purplish red lamina abaxially and the long pedunculate rosette-like imbricating inflorescences were only known for species of Peninsular Malaysia, such as *S. abdullahii* and *S. sylvestris* (Sam & Saw, 2005; Searle, 2010). Both *S. limiana* and *S. polyphylla* are morphologically closer to *Scaphochlamys* species of Peninsular Malaysia than to the Bornean species but *S. limiana* clearly do not belong to the Polyphylla group.

(5) Petiolata Group

The Petiolata Group is defined by the tightly congested inflorescence, spirally arranged, membranous bracts, bracteoles resembling bracts, first bracteole shorter than bracts, very faintly two keeled and obscure, small flowers, c. 4 cm long with c. 1 cm violet labellum (mostly), and fruits with a smooth pericarp. This group comprises 10 species. Petiolata Group is restricted to West Sarawak.

Key to species in Petiolata Group

1. Lamina adaxial surface with conspicuous tessellate venations ……..…… 2
– Lamina adaxial surface without conspicuous tessellate venations ……...….. 3
2. Lamina adaxially with tessellate venation prominently raised; lamina glabrous abaxially; bracts glabrous and light brown; ovary densely pubescent and white ……..……**5.9) *S. reticosa***

– Lamina adaxially with tessellate venation visible but faintly raised; lamina sparsely pubescent abaxially; bracts sparsely pubescent and brownish light green; ovary moderately pubescent and light green ……...……..……..…… **5.8) *S. pseudoreticosa***

3. Main secondary veins inconspicuous adaxially ……...……..……..... 4

– Main secondary veins conspicuous adaxially ……...……..……..…….. 5

4. Lamina narrowly lanceolate to linear …...……..…. **5.10) *S. stenophylla***

– Lamina broad ovate, ovate to lanceolate ……..……..……. 6

5. Main secondary veins slightly sunken adaxially ……...…..……..… **5.4) *S. hasta***

– Main secondary veins raised abaxially ……..……. 7

6. Petiole ≥ 10cm long; lamina bright light green to medium green …...…..… **5.2) *S. biru***

– Petiole < 10cm long; lamina medium to very dark green …….....……. 8

7. Main lateral veins prominently raised; petiole < 10cm long ……..… **5.1) *S. argentea***

– Main lateral veins slightly raised; petiole ≥ 10cm long ……..…...…… 9

8. Each bract subtending a flower; lamina dark to very dark green; single flower per bract ……..…… **5.6) *S. nigra***

– Each bract subtending 2 or more flowers; lamina medium to slightly dark green, often variegated; 2-3 flowered cincinni per bract ……...…….…… **5.3) *S. durga***

9. Monophyllous adult form; lamina medium to dark green throughout; inflorescence emerging from near leaf base, laxly arranged ……...……..… **5.7) *S. petiolata***

– Polyphyllous adult form; lamina light to medium green, often yellowish at midrib; inflorescence terminal within sheath, tightly congested ……...… **5.5) *S. multifolia***

5.1) ***Scaphochlamys argentea*** R. M. Sm., Notes Roy. Bot. Gard. Edinburgh (1987: 209). (Figure 3.10)

Type:—MALAYSIAN BORNEO. Sarawak: 1st Division, Lundu, near base of G. Perigi, 6 August 1962, *Burtt & Woods B2700* (holotype E!).

≡ *Borneocola argenteus* (R.M. Sm.) Y.Y. Sam, PhytoKeys (2016: 46).

= *Scaphochlamys depressa* Mas Izzaty, Ampeng & Meekiong, Folia Malaysiana (2013: 22). Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Lundu, Pueh Range, Runggang Camp, hill dipterocarp forest, on the slope in shaded area ca. 600–850 m alt., 13 June 2013, *Mas Izzaty, M., Angela G., Noor Ain C. M., Norhashimah A. R., Ogary K., Meekiong, K., Mas 002* (holotype SAR!; isotype HUMS!).

Additional specimen examined:—MALAYSIAN BORNEO. SARAWAK: Kuching Division, Lundu, Pueh, 01°48'03.9"N, 109°43'02.9"E, 59 m, 8 July 2015, *Ooi Im Hin, Jepom ak Tisai & Julia ak Lindoi OIH320* (SAR).

Discussion:—*Scaphochlamys depressa* is treated as a synonym to *S. argentea* upon investigating *S. argentea* in the type locality. The secondary veins are paler adaxially in the living plants but more conspicuous and became silvery when dried. In addition, individuals with white or violet labellum lobes can be present together within same population (the type specimen has white labellum lobes). The flower may look as if it was emerging from lamina because the peduncle is enclosed by the canaliculate petiole and leafless sheaths (Figure 3.10E, F & G).



Figure 3.10: *Scaphochlamys argentea* — A: Type, *B2700* (E); B: lamina of Type, *B2700*, enlarged to show lamina adaxial surface with prominent raised main lateral veins; C: dried lamina specimen showing the same traits as the type specimen D: plant in habitat from Gunung Pueh; E: flower; F: petiole and leafless sheaths; G: inflorescence, artificially opened to show the peduncle –A-B from *B2700* – Royal Botanic Garden Edinburgh (E); C-G from *OIH320* – © Ooi I. H.

5.2) ***Scaphochlamys biru*** Meekiong, Folia Malaysiana (2015: 37). (Figure 3.11)

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Matang Wildlife Centre, mixed dipterocarp forest, on the forest floor, sandy clay soil, 21 May 2014, *K. Meekiong, G. Angela, M. Mas Izzaty & C. A. Noor Ain MK s. n.* (holotype SAR!; paratype HUMS!).

≡ *Borneocola biru* (Meekiong) Y.Y. Sam, PhytoKeys (2016: 46).

Herbs perennial, evergreen, terrestrial, to c. 35 cm tall. Rhizome slightly creeping on ground, c. 5 mm in diam., externally brownish green, internally yellowish brown. Elements 0.5–7 cm apart, 1-foliate, juvenile up to 3-foliate; leafless sheaths c. 4, 0.7–3.5 cm long, sparsely pubescent, medium green, drying with age; leaf sheath c. 0.8 cm long, membranous, glabrous, greenish white, drying with age, ligule obscure; petiole 10–25 cm long, canaliculate, glabrous, medium green with scattered tiny white dots, base pulvinate, greenish white; lamina 7–10 × 3.5–4 cm, ovate to lanceolate, chartaceous, margin slightly undulate, base sub-truncate to slightly rounded, apex acute to acuminate; adaxial surface slightly glossy, glabrous, bright light green to medium green, midrib sunken, lateral veins inconspicuous; abaxial surface sparsely pubescent, light green, midrib raised, main lateral veins slightly visible. Inflorescence 5.5–7 cm long, emerging from near leaf base inside sheaths, tightly congested, comprised of c. 3 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle 3–4 cm long, glabrous, light green with dense tiny white dots, covered by sheaths; bracts c. 3, c. 20 × 4 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, light green, apex acute, each subtending c. 2 flowers, drying from apex with age; bracteoles c. 2, 5–15 mm long, shorter than bracts but barely distinguishable from bract, light green to greenish white; flowers 3.5–4 cm long, floral odour mild lemon grass-like; calyx 8–10 mm long, sparsely pubescent, brownish



Figure 3.11: *Scaphochlamys biru* — A: plant in habitat with flower, noted the bluish purple labellum; B: plant in habitat; C: lamina, adaxial surface, note the inconspicuous lateral veins; D: plant in habitat, top view, note the lamina with inconspicuous lateral veins; E: petiole base and rhizome; F: flower, noted the labellum with violet expression; G: bract and bracteoles; H: calyx and ovary; I: fruit; J: seed aril and pericarp. –A-C, F-J from *OIH87*; D-E from *OIH254* – © Ooi I. H.

white, apex acute; floral tube 2.5–3 cm long, sparsely pubescent, white; corolla lobes c. 10 mm long, lanceolate, glabrous, yellowish white, apex acute, hooded; staminodes c. 5 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, yellowish white, apex obtuse to truncate; labellum 11–13 × 9–11 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 2.5 mm, lobes sometimes slightly overlapping; stamen c. 5 × 1.5 mm, covered with glandular hairs, white; filament c. 1 mm long; anther thecae c. 3.5 mm long, spurred c. 0.5 mm basal at one side, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 3.5 cm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, densely pubescent at 2/3 from apex, light green; epigynous glands 2, c. 2 mm long, free, needle-like, white. Fruits c. 12 × 4 mm, dehiscent capsule, elongated ovoid, sparsely pubescent, whitish green (white translucent cuticle-like pericarp enclosing green seed), subtended by marcescent bracts. Seeds c. 10 × 3 mm, slightly elongated ovoid, glabrous, green; aril c. 4 mm, lacerate, brownish white; perisperm white.

Distribution and ecology:— NW Borneo, Sarawak, Kuching Division, Bau district to Matang district. Mesophytes on podzolic black soils over sandstone, in shady gallery forest at c. 30 m elevation; ridge kerangas (tropical heath forest) at c. 90 m elevation.

Additional specimens examined:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Sungai Adis, 01°33'12.8"N, 110°09'33.1"E, 61 m, 14 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH87* (SAR); Kuching Division, Bau, Gunung Buan, 01°33'28.9"N, 110°08'35.2"E, 92 m, 21 November 2013, *Ooi Im Hin & Jepom ak Tisai OIH75* (SAR); Kuching Division, Matang, Sungai Rayu, 01°36'40.0"N, 110°09'48.0"E, 30 m, 24 July 2014, *Ooi Im Hin OIH254* (SAR); Kuching Division, Matang, Sungai Rayu

(Sungau Rayu), 01°37'N, 110°10'E, 50 m, 26 April 2004, *A. D. Poulsen 2309* (E); Kuching Division, Bau, Sungai Adis, 01°33'12.8"N, 110°09'33.1"E, 61 m, 26 July 2014, *Ooi Im Hin & Davidson ak Jepom OIH255* (SAR); Kuching Division, Bau, Gunung Buan, 01°33'28.9"N, 110°08'35.2"E, 92 m, 26 July 2014, *Ooi Im Hin & Davidson ak Jepom OIH256* (SAR).

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A mild lemon grass-like odour was detected within c. 2 cm radius.

Discussion:—Recollection of *S. petiolata* from the type locality, Gunung (Mt.) Singai, Bau, Sarawak, revealed that *S. petiolata* is restricted to above 400 m on Gunung Singai, an isolated sandstone massif, and the more widespread lowland entities are *S. biru*. The laminae of *S. biru* with the inconspicuous lateral veins are obviously different from *S. petiolata* with the conspicuous slightly raised main lateral veins (resulted in a plicate look).

5.3) *Scaphochlamys durga* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.12)

Scaphochlamys durga is similar to *S. stenophylla* by the inflorescences and flowers, but is readily distinguishable by its moderately long (*vs* very short) petiole, ovate to lanceolate (*vs* long linear to narrowly lanceolate) lamina and lamina adaxial surface often variegated (white shades between midrib and margins except main lateral veins *vs* never variegated).

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Lundu, Kampung Jugan, 01°29'29.4"N, 110°05'20.9"E, 63 m, 13 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH84* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 23 cm tall. Rhizome creeping on ground, c. 5 mm in diam., externally slightly greenish brown, internally brownish white. Elements 1–10

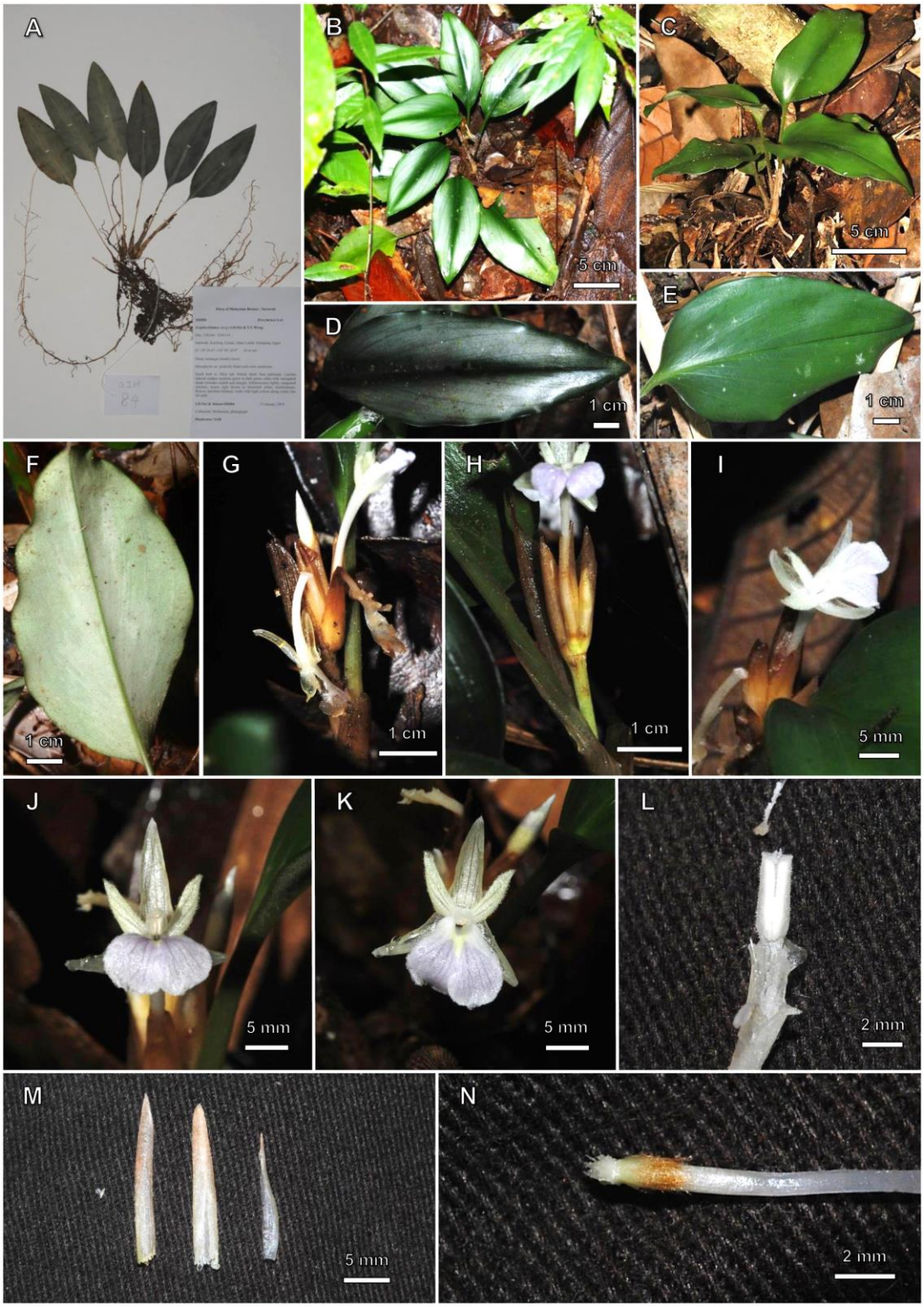


Figure 3.12: *Scaphochlamys durga* — A: Type, *OIH84* (SAR); B: plant in habitat with lamina variegation; C: plant in habitat without variegation; D: lamina adaxial surface with variegation; E: lamina adaxial surface without variegation; F: lamina abaxial surface with variegation; G: inflorescence; H: inflorescence, artificially revealed the peduncle; I: flower, side view; J: flower, front view; K: flower, top view, note the labellum; L: stamen, note the spurless anther; M: bract and bracteoles; N: ovary. –A-B, D, F-N from *OIH84*; C from *OIH97*; E from *OIH235* – © Ooi I. H.

mm apart, 1-foliate, juvenile not seen; leafless sheaths c. 4, 0.5–5.5 cm long, glabrous, brownish light green, degrading with age; leaf sheath c. 0.9 cm long, membranous, glabrous, greenish white, drying and shredding with age, ligule obscure; petiole 8–9 cm long, canaliculate, glabrous, medium green with scattered white dots, base pulvinate, white to yellowish green; lamina 10–14 × 4–5 cm, ovate to lanceolate, coriaceous, margin slightly undulate, base attenuate, apex acute; adaxial surface semi-glossy, glabrous, medium green to dark green, often variegated (white shades between midrib and margins except main lateral veins), midrib sunken, glabrous, medium green to dark green, main lateral veins slightly visible; abaxial surface glabrous, whitish green, often variegated (white shades between midrib and margin), midrib raised, glabrous, medium green, main lateral veins inconspicuous. Inflorescence 8–10 cm long, emerging from near leaf base inside leaf sheaths, tightly congested, comprised of 4–5 2–3 flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 6 cm long, glabrous, whitish light green, covered with degraded leafless sheaths; bracts 4–5, c. 18 × 4 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, light brown, apex acuminate, each bract subtending 2–3 flowers; bracteoles 2–3, 13–17 mm long, shorter than bracts but barely distinguishable from bract, light brown; flowers 2.8–3.5 cm long, floral odour torch ginger-like; calyx 10–11 mm long, sparsely pubescent, brownish white, apex acute; floral tube 18–23 mm long, sparsely pubescent, white to slightly brownish white; corolla lobes 8–10 mm long, lanceolate, glabrous, light yellow, apex acute, hooded; staminodes 4–6 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex acute to rounded; labellum 11–13 × 10–12 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 5 ×

1.5 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 4 mm long, spurless, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 25 mm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, densely pubescent, light green, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, brownish white. Fruits and seeds not seen.

Etymology:—The specific epithet *durga* is named after the Hindu Goddess, Durga, known for her many incarnations (in mild or wrathful forms) to reflect the two forms of the laminae.

Distribution and ecology:— *Scaphochlamys durga* is known from the type locality and its province. Mesophytic in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 65 m elevation.

Additional specimens examined (paratype):—MALAYSIAN BORNEO. Sarawak: Kuching Division, Lundu, Kampung Stungkur, 01°26'17.7"N, 109°56'07.5"E, 77 m, 5 July 2014, *Ooi Im Hin, Jepom ak Tisai & Julia ak Lindoi OIH235* (SAR); Kuching Division, Lundu, Kampung Stenggang, 01°28'46.4"N, 110°05'08.5"E, 50 m, 4 August 2014, *Brian Williams, Scott Hyndman & Jepom ak Tisai OIH260* (SAR); Kuching Division, Lundu, Kampung Jugan, 01°29'29.7"N, 110°05'19.9"E, 61 m, 23 March 2014, *Ooi Im Hin, Jepom ak Tisai & Arnold ak Jepom OIH97* (SAR); Kuching Division, Lundu, Kampung Jugan, 01°29'29.4"N, 110°05'20.9"E, 63 m, 23 March 2014, *Ooi Im Hin, Jepom ak Tisai & Arnold ak Jepom OIH96* (SAR).

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A mild torch ginger-like odour was detected about c. 1.5–3 cm radius.

Discussion:—*Scaphochlamys durga* was often identified as a variation of *S. argentea* but the inconspicuous lateral veins adaxially (*vs* prominent raised main lateral veins) are readily distinguishable. This species is often variegated but unlike the species in the Salahuddiniana Group, the variegation is not refractive. The tightly congested inflorescences of *S. durga* clearly belong to the Petiolata Group.

5.4) *Scaphochlamys hasta* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.13)

Scaphochlamys hasta is readily distinguishable by its long lanceolate lamina with long slender petiole (spear head-like), dark green midrib, and slightly sunken main lateral veins adaxially but visible abaxially.

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Bogag, 01 °21'35.5"N, 110 °03'44.5"E, 84 m, 11 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH80* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 40 cm tall. Rhizome slightly below ground, c. 5 mm in diam., externally greenish light brown, internally yellow. Elements c. 1–15 mm apart, 1-foliate, juvenile polyphyllous, up to 6-foliate; leafless sheaths c. 4, 0.5–13 cm long, glabrous, light green to light brown, drying with age; leaf sheath c. 1.5 cm long, membranous, glabrous, white, drying and shredding with age, ligule obscure; petiole 11–17 cm long, canaliculate, glabrous, light to medium green with white dots, base pulvinate, greenish white to brownish green; lamina 17–22 × 3–4 cm, lanceolate, semi-coriaceous, margin entire to slightly undulate, base attenuate, apex acuminate; adaxial surface semi-glossy, glabrous, light green to medium green, midrib sunken, glabrous, dark green, main lateral veins slightly sunken; abaxial surface glabrous, glaucous green, midrib raised,



Figure 3.13: *Scaphochlamys hasta* — A: plant in habitat; B: plant before pressing; C: lamina, adaxial surface, note sunken main lateral veins; D: lamina, abaxial surface, note visible dark green main lateral veins; E: inflorescence; F: flower; G: stamen, note spurless anthers; H: bract and bracteoles. –A-H from *OIH80* – © Ooi I. H.

glabrous, dark green, main lateral veins visible. Inflorescence c. 7–9.5 cm long, emerging from near leaf base inside leaf sheaths, tightly congested, comprised of 3–5 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 4–6.5 cm long, glabrous, greenish white, covered with marcescent leafless sheaths; bracts 3–5, c. 22 × 6 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, light brown, apex acuminate, each bract subtending 2 flowers; bracteoles 2, 12 –19 mm long, shorter than bracts but barely distinguishable from bract, light brown; flowers 4–4.5 cm long, without noticeable floral odour; calyx 12–13 mm long, sparsely pubescent, white, apex acute; floral tube 30–40 mm long, sparsely pubescent, white; corolla lobes 8–9 mm long, lanceolate, glabrous, yellowish white, apex acute, hooded; staminodes 4–6 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex acute to rounded; labellum 9–11 × 8–10 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 5 × 2 mm, covered with glandular hairs, white; filament c. 1 mm long; anther thecae c. 3.5 mm long, spurless, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 42 mm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, pubescent, white, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, yellowish white. Fruits and Seeds not seen.

Etymology:—The specific epithet, is spear in Latin, *hasta*, indicates the spear head-like leaf appearance.

Distribution and ecology:—*Scaphochlamys hasta* is only known from the type locality. Mesophytic in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 80 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. No floral odour was detected.

Discussion:—*Scaphochlamys petiolata* has been widely applied to almost all Bornean *Scaphochlamys* specimens with long slender petiole. However, recollection of *S. petiolata* from its type locality enable us to examine the plants and concluded that the species is restricted to Gunung Singai (c. 460 m elevation) and led recognize several distinctive but related taxa (*S. biru, S. multifolia* and *S. hasta*).

5.5) *Scaphochlamys multifolia* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.14)

Scaphochlamys multifolia is readily distinguishable by having polyphyllous elements, tightly congested terminal inflorescences within persistent leafless sheaths and lamina often with yellowish green midrib.

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Gunung Moi, 01°31'52.7"N, 110°07'42.5"E, 118 m, 30 March 2014, *Ooi Im Hin & Jepom ak Tisai OIH111* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 40 cm tall. Rhizome slightly below ground, c. 5 mm in diam., externally brownish light green, internally brownish white. Elements c. 5–20 mm apart, polyphyllous, up to 8-foliate, juvenile up to 8-foliate; leafless sheaths 0–3, 0.5–3.5 cm long, sparsely pubescent, medium green, drying with age; leaf sheath c. 1 cm long, membranous, glabrous, white, drying and shredding with age, ligule obscure; petiole 12–24 cm long, canaliculate, glabrous, light to medium green, base slightly pulvinate, white to light green; lamina 12–15 × 5.5–9.5 cm, ovate to lanceolate, chartaceous, margin slightly



Figure 3.14: *Scaphochlamys multifolia* — A: plant in habitat, side view; B: plant in habitat, top view; C: lamina, adaxial surface; D: lamina, abaxial surface; E: flower, side view; F: infructescence, artificially revealed the fruit; G: young infructescence; H: flower, front view; I: stamen, note the very short anther spurs; J: bract and bracteoles. –A-J from *OIH111* – © Ooi I. H.

undulate, base rounded, apex acute to obtuse; adaxial surface semi-glossy, glabrous, light green to medium green, midrib sunken, glabrous, often light yellowish green, main lateral veins slightly raised; abaxial surface sparsely pubescent, light green, midrib raised, sparsely pubescent, yellowish green, main lateral veins inconspicuous. Inflorescence c. 6–12.5 cm long, terminal within leafless sheaths, tightly congested, comprised of c. 5 2–3-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 2–3.5 cm long, glabrous, greenish white, covered with persistent leafless sheaths; bracts c. 5, c. 16 × 5 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, light to medium green, apex acuminate, each bract subtending 2–3 flowers; bracteoles 2–3, c. 14 mm long, shorter than bracts but barely distinguishable from bract, light green; flowers 3–3.5 cm long, without noticeable floral odour; calyx 9–11 mm long, sparsely pubescent, white, apex tridentate; floral tube 23–27 mm long, sparsely pubescent, white; corolla lobes 9–11 mm long, lanceolate, glabrous, yellowish white, apex acute, hooded; staminodes 6–7 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex acute to rounded; labellum 9–11 × 8–10 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 4 × 2 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 3 mm long, with very short basal spur, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 25 mm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, densely pubescent, white, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, brownish white. Fruit c. 12 × 5 mm, dehiscent capsule, elongated ovoid, sparsely pubescent, whitish green (greenish white translucent cuticle-like pericarp enclosing green seed), subtended by persistent bracts.

Seeds c. 2, c. 10 × 2 mm, elongated ovoid, glabrous, green; aril c. 4 mm, lacerate, brownish white; perisperm white.

Etymology:—The specific epithet, *multifolia*, refers to the polyphyllous element with many leaves.

Distribution and ecology:—*Scaphochlamys multifolia* is only known from the type locality. Mesophytes in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 120 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. No floral odour was detected.

Discussion:—Leaves of *S. multifolia* are slightly similar to *S. petiolata* but remained to be polyphyllous in adult form. Besides, inflorescences of *S. multifolia* are terminal within sheaths and not emerging from near leaf base like most of the *Scaphochlamys* species (perhaps owing to the much reduced leaves). *Scaphochlamys anomala* is the only other species reported to have terminal inflorescences within sheaths in Bornean *Scaphochlamys* but it belongs to the Anomala Group.

5.6) *Scaphochlamys nigra* I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.15)

Scaphochlamys nigra is readily distinguishable from the other Bornean species by the shortly broad ovate and coriaceous laminae with very deep dark green adaxial surface (almost black), and solitary flower per bract.

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Gunung Buan, 01°33'28.9"N, 110°08'35.2"E, 92 m, 21 November 2013, *Ooi Im Hin & Jepom ak Tisai OIH76* (holotype SAR).



Figure 3.15: *Scaphochlamys nigra* — A: plant in habitat; B: inflorescence; C: lamina, adaxial surface, note the very dark colour; D: lamina, abaxial surface; E: flower; F: fruit; G: bract and bracteole; H: stamen, note the anther spurs. –A-H from *OIH76* – © Ooi I. H.

Herbs perennial, evergreen, terrestrial to c. 10 cm tall. Rhizome slightly below ground, c. 5 mm in diam., externally light brown to greenish light brown, internally brownish white. Elements c. 5 mm apart, 1-foliate, juvenile not seen; leafless sheaths c. 3, 0.5–2 cm long, sparsely pubescent, brownish light green, drying with age; leaf sheath c. 0.5 cm long, membranous, glabrous, white, drying and shredding with age, ligule obscure; petiole 2–4 cm long, canaliculate, glabrous, medium green, base pulvinate, white to light green; lamina 4–6 × 2.5–3.5 cm, short broad ovate, coriaceous, margin entire, base rounded, apex obtuse; adaxial surface semi-glossy, glabrous, dark green to very deep dark green, midrib sunken, glabrous, dark green, main lateral veins inconspicuous; abaxial surface sparsely pubescent near midrib,

glaucous green, midrib raised, glabrous, dark green, main lateral veins inconspicuous. Inflorescence c. 6 cm long, emerging from near leaf base inside leaf sheaths, tightly congested, comprised of c. 3 solitary flowers borne on a peduncle, flowering spirally from base to apex; peduncle c. 2.2 cm long, glabrous, whitish light green, covered with degraded leafless sheaths; bracts c. 3, c. 15 × 3 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, light brown, apex acuminate, each bract subtending a flower; bracteoles 1, c. 12 mm long, shorter than bracts but barely distinguishable from bract, light brown; flowers 2.9–3.4 cm long, without noticeable floral odour; calyx 8–10 mm long, sparsely pubescent, white, apex acute; floral tube 18–23 mm long, sparsely pubescent, white; corolla lobes 8–10 mm long, lanceolate, glabrous, yellowish white, apex acute, hooded; staminodes 4–6 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex acute to rounded; labellum 9–11 × 8–10 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 4 mm, lobes sometimes slightly overlapping; stamen c. 4.5

× 1.5 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 3.5 mm long, with very short basal spur, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 25 mm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, densely pubescent, white, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, white. Fruit c. 12 × 4 mm, dehiscent capsule, elongated ovoid, sparsely pubescent, whitish green (greenish white translucent cuticle-like pericarp enclosing green seed), subtended by marcescent bracts. Seeds c. 10 × 3 mm, slightly elongated ovoid, glabrous, green; aril c. 4 mm, lacerate, yellowish white; perisperm white.

Etymology:—The specific epithet, *nigra*, refers to the very deep dark green lamina that is almost black.

Distribution and ecology:—*Scaphochlamys nigra* is only known from the type locality. Mesophytes in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 90 m elevation.

Additional specimen examined (paratype):—Malaysian Borneo. Sarawak: Kuching Division, Bau, Gunung Buan, 01°33'28.9"N, 110°08'35.2"E, 92 m, 11 February 2014, *Ooi Im Hin, John D. Mood & Jepom ak Tisai OIH90* (SAR).

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. No floral odour was detected.

Discussion:—This is the only *Scaphochlamys* species on Borneo with solitary flower per bract. The other species that reported to have solitary flower is *S. biloba* (Ridl.) Holttum from South Thailand and North Peninsular Malaysia, which are totally different from *S. nigra*, by having reddish-brown coriaceous bract, larger flower, white labellum sometimes

with red streaks along yellow median band near base, lanceolate to narrowly elliptic lamina usually with white variegated bands and sometimes flushed purple lamina abaxial surface.

5.7) ***Scaphochlamys petiolata*** (K. Schum.) R. M. Sm., Notes Roy. Bot. Gard. Edinburgh (1987: 210). (Figure 3.16)

Type:—BORNEO. Sarawak: 1st Division, Gunung Singai (Mt. Singhi), 11 Dec 1892, *Haviland 2026* (lectotype K; isolectotype SAR).

≡ *Haplochorema petiolatum* K. Schum., Pflanzenr. IV, 46 (Heft 20) (1904: 90).

≡ *Borneocola petiolatus* (K. Schum.) Y.Y. Sam, PhytoKeys (2016: 47).

Additional specimens examined:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Gunung Singai, 01°30'14.6"N, 110°09'57.9"E, 461 m, 17 November 2013, *Ooi Im Hin* & *Jepom ak Tisai, OIH71, OIH 72 & OIH73* (SAR); Kuching Division, Bau, Gunung Singai, 01°30'14.6"N, 110°09'57.9"E, 461 m, 21 December 2013, *Ooi Im Hin OIH78* (SAR); Kuching Division, Bau, Gunung Singai, 01°30'14.6"N, 110°09'57.9"E, 461 m, 19 July 2014, *Ooi Im Hin OIH253* (SAR).

Discussion:—*Scaphochlamys petiolata* occurs at c. 460 m elevation on Gunung Singai with relatively dry and high elevation. This is an unusual habitat for Bornean *Scaphochlamys.* The fruits are brownish green dehiscent capsule (brown translucent cuticle-like pericarp enclosing green seed) subtended by marcescent bracts.



Figure 3.16: *Scaphochlamys petiolata* — A: plant in habitat; B: flower bud; C: inflorescence; D: flowers; E: germinating seed. –A-E from *OIH71* – © Ooi I. H.

5.8) ***Scaphochlamys pseudoreticosa*** I. H. Ooi, K. Meekiong & S. Y. Wong, sp. nov. (Figure 3.17)

Scaphochlamys pseudoreticosa is similar to *S. reticosa* but differs by having sparsely pubescent lamina abaxially (*vs* glabrous), tertiary veins faintly visible but never raised (*vs* prominently raised), sparsely pubescent and brownish light green bracts (*vs* glabrous and light brown) and light green with moderately pubescent ovary (*vs* white with densely pubescent).

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Seromah, 01°22'36.5"N, 110°11'32.2"E, 40 m, 12 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH83* (holotype SAR).

Herbs perennial, evergreen, terrestrial to c. 15 cm tall. Rhizome creeping on ground, c. 5 mm in diam., externally light to medium brown, internally yellowish white. Elements c. 1–25 mm apart, 1-foliate, juvenile not seen; leafless sheaths c. 3, 0.7–3.2 cm long, glabrous, light green, drying with age; leaf sheath c. 1.5 cm long, membranous, glabrous, white, drying and shredding with age, ligule obscure; petiole 5–9 cm long, canaliculate, glabrous, light to yellowish green, base pulvinate, white to light green; lamina 6–9 × 4.5–6 cm, ovate, semi-coriaceous, margin entire to slightly undulate, base cordate, apex acute; adaxial surface semi-glossy, glabrous, light green to medium green, midrib sunken, glabrous, medium green, main lateral veins slightly raised, tertiary veins slightly raised; abaxial surface sparsely pubescent, light green, midrib raised, pubescent, medium green, main lateral veins inconspicuous. Inflorescence c. 6–7 cm long, emerging from near leaf base inside leaf sheaths, tightly congested, comprised of c. 4 2-flowered cincinni borne on a peduncle, flowering spirally from base to apex; peduncle c. 2–3 cm long, glabrous,



Figure 3.17: *Scaphochlamys pseudoreticosa* — A: plant in habitat; B: inflorescence; C: lamina, adaxial surface; D: lamina, adaxial surface, note the slightly raised tertiary veins; E: flower; F: bract and bracteoles; G: calyx and ovary; H: lamina, abaxial surface; I: stamen, note the anther spurs; J: stamen, note the spurless anthers. –A-J from *OIH83* – © Ooi I. H.

greenish white, covered with marcescent leafless sheaths; bracts c. 4, c. 18 × 5 mm, spirally arranged, lanceolate, sparsely pubescent, membranous, brownish light green, apex acuminate, each bract subtending 2 flowers; bracteoles 2, c. 15 mm long, shorter than bracts but barely distinguishable from bract, brownish light green; flowers 3.6–4 cm long, floral odour very mild torch ginger-like; calyx 12–13 mm long, sparsely pubescent, white, apex acute; floral tube 26–30 mm long, sparsely pubescent, white; corolla lobes 7–8 mm long, lanceolate, glabrous, yellowish white, apex acute, hooded; staminodes 4–6 mm long, linear to slightly oblanceolate, adaxial surface covered with glandular hairs, light yellow, apex acute to rounded; labellum 8–10 × 7–9 mm, spathulate, adaxial surface covered with glandular hairs, white at base and violet till apex with a light yellow median band, apex 2-lobed, indented c. 3 mm, lobes sometimes slightly overlapping; stamen c. 4.5 × 2 mm, covered with glandular hairs, white; filament c. 0.5 mm long; anther thecae c. 3.5 mm long, sometimes with very short basal spur, crest c. 0.5 mm long; stigma less than 1 mm long, club-shaped with 2 dorsal knobs, ostiole ciliate, forward facing; style c. 32 mm long, sparsely pubescent, white; ovary c. 2 mm long, 1-locular, pubescent, light green, placentation basal; epigynous glands 2, c. 1 mm long, free, needle-like, yellowish white. Fruits and Seeds not seen.

Etymology:—The specific epithet, *pseudoreticosa*, is in allusion to the similarity of this species to *S. reticosa*.

Distribution and ecology:—*Scaphochlamys pseudoreticosa* is only known from the type locality. Mesophytes in shady limestone forest on mollisolic black soils at c. 40 m elevation.

Phenology:—The flowers are one-day diurnal flowering and degraded by the next day. A very mild torch ginger-like floral odour was detected when in close contact with the flower.

Discussion:—The anther spurs could be present or absent in *S. pseudoreticosa* but is always absent in *S. reticosa*. The tertiary venation of the leaf laminae of *S. pseudoreticosa* is faintly raised tessellate reticulum adaxially but never prominently raised like *S. reticosa*.

5.9) *Scaphochlamys reticosa* (Ridl.) R. M. Sm., Notes Roy. Bot. Gard. Edinburgh (1987: 209). (Figure 3.18)

Type:—Cultivated Singapore Botanic Gardens, originally from Borneo, Sarawak, Kuching [‘1st Division’], Bidi, 22 September 1904, *Ridley s.n.* (holotype SING!).

≡ *Boesenbergia reticosa* (Ridl.) Merr., Bibl. Enum. Born. Pl. (1921: 122).

≡ *Borneocola reticosus* (Ridl.) Y.Y. Sam, PhytoKeys (2016: 47).

Additional specimens examined:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Taiton, 01°23'41.8"N, 110°08'12.0"E, 48 m, 11 January 2014, *Ooi Im Hin & Jeland ak Kisai OIH79* (SAR); Kuching Division, Bau, Gunung Juita, 01°23'48.7"N, 110°08'07.2"E, 35 m, 30 December 2014, *P. C. Boyce & Jeland ak Kisai ZI139* (SAR).

Discussion:—The tertiary veins of laminae are tessellate reticulum and prominently raised which is unique feature to *S. reticosa*.

5.10) *Scaphochlamys stenophylla* I. H. Ooi & S. Y. Wong, Willdenowia (2014: 242). (Figure 3.19)

Type:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Bau, Gunung Buan, 01°33'28.9"N, 110°08'35.2"E, 92 m, 21 November 2013, *Ooi Im Hin & Jepom ak Tisai OIH74* (holotype SAR!).

≡ *Borneocola stenophyllus* (Ooi & S.Y. Wong) Y.Y. Sam, PhytoKeys (2016: 48).

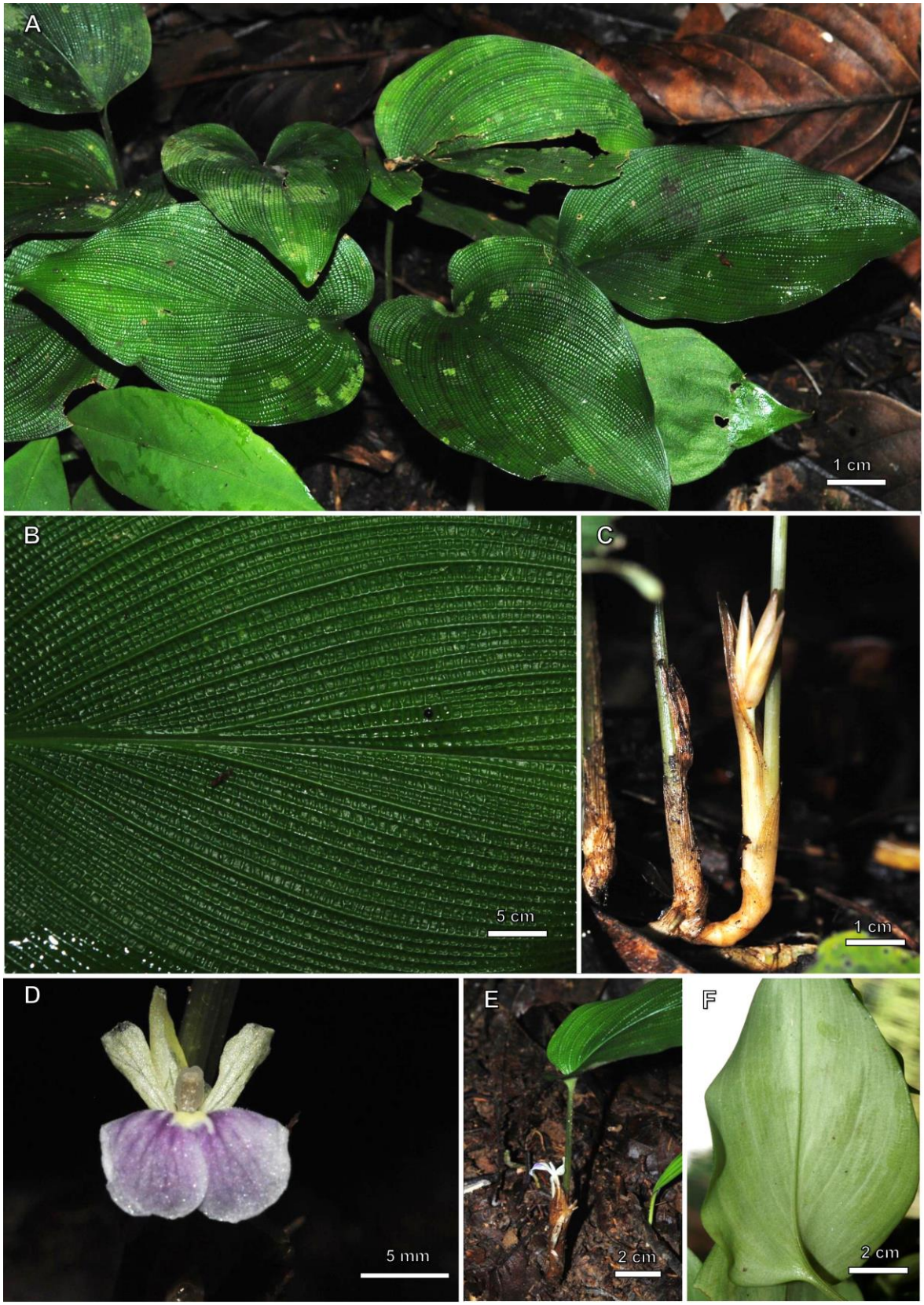


Figure 3.18: *Scaphochlamys reticosa* — A: plant in habitat; B: lamina, adaxial surface, note the prominent raised tertiary veins; C: inflorescence; D: flower; E: inflorescence; F: lamina, abaxial surface. –A-F from *OIH79* – © Ooi I. H.



Figure 3.19: *Scaphochlamys stenophylla* – A: plant in habitat; B: pulvinate petiole base; C: inflorescence with bud and wilted flower; D: lamina adaxial surface; E: lamina abaxial surface; F: bud with visible violet veins; G: corolla lobes opening, labellum uncoiling; H: flower at anthesis, labellum violet with light yellow band along median line until distal cleft; I: corolla lobes reflexed; J: semi-erect fruit; K: immature fruit cross-section; L: stigma and crest; M: spurless anther (specimen in alcohol); N: bracts and bracteoles, artificially opened. – A, C, F, G, I & J from *OIH74* (type); B, D, E, H, K, L & M from *OIH171*; N from *OIH91* – adopted from Ooi & Wong (2014)

Additional specimen examined:—MALAYSIAN BORNEO. SARAWAK: Kuching Division, Bau, Gunung Moi, 01 °31'52.7"N, 110 °07'42.5"E, 118 m, 30 March 2014, *Ooi Im Hin & Jepom ak Tisai OIH106* (SAR).

Discussion:—The linear to very narrow lanceolate lamina are very distinctive (with grass-like appearance) but the lamina length is quite variable in different population.

(6) Polyphylla Group

The Polyphylla Group is defined by the laxly arranged inflorescence, spirally arranged, coriaceous bracts, bracteoles distinguishable from bracts, bracteoles shorter than bracts, first bracteole 2-side folding inward, small flowers, c. 3 cm long with c. 1.5 cm labellum (purple streaks near base). This group comprises two species. Polyphylla Group is restricted to the tip of W Sarawak.

Key to the species in Polyphylla Group (extracted from Meekiong et al., 2015)

1. Leaves 4–6 per plant; lamina elliptic; floral bract recurving, cymbiform; flower white ……..……. **6.1) *S. polyphylla***

– Leaves 3–4 per plant; lamina broadly elliptic or lanceolate; floral bract erect, clasping; flower whitish purple ……...……..…….…….... **6.2) *S. samunsamensis***

6.1) *Scaphochlamys polyphylla* (K. Schum.) B. L. Burtt & R. M. Sm., Notes Roy. Bot. Gard. Edinburgh (1972: 315). (Figure 3.20)

Type:—BORNEO. Sarawak: 1st Division, Lundu, *Beccari 2324* (holotype FI!).

≡ *Haplochorema polyphyllum* K. Schum., Bot. Jahrb. (1900: 332).

= *Gastrochilus bractescens* Ridl., J. Straits Branch Roy. Asiat. Soc. (1910: 57).



Figure 3.20: *Scaphochlamys polyphylla* — A: plant in habitat; B: plant with young inflorescence; C: inflorescence, top view; D: inflorescences, side view; E: inflorescence with a flower; F: lamina, abaxial surface; G: flower, before fully opened. –A-J from *OIH83* – © Ooi I. H.

≡ *Boesenbergia bractescens* (Ridl.) Merr., Bibl. Enum. Born. Pl. (1921: 122). Type:—BORNEO. Sarawak: 1st Division, Lundu, *Foxworthy 42* (holotype SING).

= *Gastrochilus laxiflorum* Valeton, Bull. Jard. Bot. Buitenzorg (1918: 100).

≡ *Boesenbergia laxiflora* (Valeton) Loesen., Prantl, Nat. Pflanzenfam. Ed. 2, 15A (1930: 572). Type:—BORNEO. Kalimantan: Monterado, Opi Mountains, *Teysmann 10916* (holotype BO, isotype FI).

Additional specimen examined:—MALAYSIAN BORNEO. Sarawak: Kuching Division, Lundu, Lundu Road, Kerangas forest, 15 June 1991, *Yahud et al. S. 61966* (SAR); Kuching Division, Lundu, Setunggang, Kerangas forest, 130 m, 20 December 1995, *Lai, Rantai et al. S. 54477* (SAR); Kuching Division, Lundu, Gunung Pueh, 01°50'03.5"N, 109°40'35.4"E, 19 m, 13 April 2014, *Ooi Im Hin, Scott Hyndman & Jepom ak Tisai OIH119* (SAR); Sri Aman Division, Engkramut Selepong Berangan, Kerangas Forest, 20 m, 15 August 1991, *Runi, Lai et al. S. 59662* (SAR); Sri Aman Division, Engkramut, Selepong Berangan, 01°03'12.5"N, 111°21'14.3"E, 61 m, 30 December 2014, *Ooi Im Hin OIH289* (SAR).

Discussion:—This species is morphologically similar to *S. malaccana* from Peninsular Malaysia than the other Bornean species by having laxly arranged inflorescences with the bracts tightly incurved near base but flattened near apex. *Scaphochlamys polyphylla* are distinguished by having narrower c. 2–3 cm laminae with glabrous abaxial surface (*vs* broader c. 4.5 cm lamina with pubescent abaxial surface) and flowers with very mild foul odour (*vs* strongly fragrant jasmine-like odour). This species is widespread and may represent a species complex. Overall, the plants from different localities are utterly similar. However, individual plants from different populations may have few different

characteristics, including the presence of red colouration (on petiole, lamina abaxial surface, peduncle and bracts), length of staminodes and floral odour. Species with colour variations are not uncommon in *Scaphochlamys* (such as *S. biloba, S. breviscarpa* and *S. kunstleri*) and length of staminodes may differ even within same populations (Ooi pers. obs.). The bracts of *S. polyphylla* clasp before gradually elongating and becoming lax to typical appearance. Thus, young inflorescences may be seemed differently from mature inflorescences (Figure 3.19B, C & D). Differences in floral odour may be worth noted (the collections from Lundu emitted a very mild foul smell but floral odour was not detected from the collections from Sri Aman).

6.2) *Scaphochlamys samunsamensis* Meekiong & Hidir Folia Malaysiana (2015: 34).

Type:—MALYASIAN BORNEO. Sarawak: Kuching Division, Samunsam Wildlife Sanctuary, kerangas forest, on the forest floor, sandy soil with thick humus, 12 November 2014, *K. Meekiong, Tasha & M. Hidir MK2364* (holotype SAR!; paratype HUMS!).

Discussion:—This species is closely similar to *S. polyphylla* in their polyphyllous appearances and might be a conspecific species (refer to discussion above on *S. polyphylla*).

CHAPTER 4

MOLECULAR ANALYSES

4.1 Introduction

Molecular studies based on combined nuclear (ITS) and plastid region (*trn*K-*mat*K) of *Scaphochlamys* were carried out to establish the inter-specific relationships in *Scaphochlamys*. Within Bornean *Scaphochlamys,* so far, only one species (Searle & Hedderson, 2000) and seven species (Sam et al., 2016) were included in the phylogenetic analyses. Only Sam et al. (2016) dealt with the phylogeny of *Scaphochlamys* but focusing on the species from Peninsular Malaysia and Southern Thailand. In this chapter, the phylogeny of 27 species of *Scaphochlamys* (including *Myxochlamys*) were investigated using ITS and *trn*K-*mat*K regions.

4.2 Materials and Methods

4.2.1 Taxa Sampling

A total of 27 species (37 accessions) of *Scaphochlamys* (including *Myxochlamys*) were included in the study. Sequences of 24 species (34 accessions) of *Scaphochlamys* were newly generated and submitted to GenBank with the accession numbers from KY492397 to KY492466. Two sequences of *Scaphochlamys*, one sequence of *Myxochamys mullerensis* and *Distichochlamys* sp. each, were downloaded from GenBank. Sequences of *Tamijia*, *Kaempferia*, *Haniffia*, *Zingiber*, *Boesenbergia* and *Haplochorema* were downloaded from GenBank and chosen as outgroups for the study. The outgroups were selected based on Kress et al. (2002). Collection locality, GPS, voucher information and GenBank accession numbers are provided in Table 4.1.

Table 4.1: The taxa included in the phylogeny are listed with the information of the collection locality, GPS, voucher number and GenBank accession number.

Species	Collection locality	GPS	Voucher number	GenBank accession number	
				ITS	matK
Scaphochlamys argentea	Malaysia, Sarawak, Lundu	N01 °48'03.9"; E109 °43'02.9"	OIH320	KY492429	KY492464
Scaphochlamys biloba	-	-	Kress #99-6576 US	AF478788	AF478889
Scaphochlamys biloba	Malaysia, Kelantan		OIH326	KY492430	KY492465
Scaphochlamys biloba	Malaysia, Kelantan		OIH327	KY492431	KY492466
Scaphochlamys biru	Malaysia, Sarawak, Bau	N01 °33' 12.8"; E110 °09'33.1"	OIH87	KY492401	KY492436
Scaphochlamys biru	Malaysia, Sarawak, Matang	N01 °36' 40.0"; E110 °09'48.0"	OIH254	KY492402	KY492437
Scaphochlamys calcicola	Malaysia, Sarawak, Bau	N01 °22' 37.2"; E110 °11'33.9"	OIH81	KY492399	KY492434
Scaphochlamys durga	Malaysia, Sarawak, Bau, Jugan	N01 °29' 29.4"; E110 °05'20.9"	OIH84	KY492407	KY492442
Scaphochlamys durga	Malaysia, Sarawak, Bau, Stungkur	N01 °26' 17.7"; E109 °56' 07.5"	OIH235	KY492408	KY492443
Scaphochlamys graveolens	Malaysia, Sarawak, Serian	N01 °08' 03.7"; E110 °27' 00.3"	OIH116	KY492417	KY492452
Scaphochlamys hasta	Malaysia, Sarawak, Bau	N01 °21' 35.5"; E110 °03'44.5"	OIH80	KY492412	KY492447
Scaphochlamys aff. *klossii*	Cultivated in Penang Botanic Gardens	-	OIH168	KY492427	KY492462
Scaphochlamys kunstleri	-	-	Kress #99-6539 US	AF478789	AF478890
Scaphochlamys kunstleri var kunstleri	Cultivated in Penang Botanic Gardens	-	OIH161	KY492423	KY492458

Table 4.1 continued

Scaphochlamys kunstleri var speciosa	Cultivated in Penang Botanic Gardens	-	OIH162	KY492424	KY492459
Scaphochlamys kunstleri var speciosa	Cultivated in Penang Botanic Gardens	-	OIH163	KY492425	KY492460
Scaphochlamys lanjakensis	Malaysia, Sarawak, Kapit	N01 °24'46.4"; E112 °00'16.8"	OIH309	KY492420	KY492455
Scaphochlamys limiana	Malaysia, Sarawak, Lundu	N01 °49' 59.1"; E109 °40' 27.2"	OIH122	KY492415	KY492450
Scaphochlamys lucens	Malaysia, Sarawak, Padawan	N01 °15' 38.6"; E110 °15' 31.4"	OIH125	KY492418	KY492453
Scaphochlamys malaccana	Malaysia, Johor, Sagil	N02 °20' 31.9"; E102 °37' 01.4"	OIH159	KY492426	KY492461
Scaphochlamys multifolia	Malaysia, Sarawak, Bau	N01 °31' 52.7"; E110 °07'42.5"	OIH111	KY492410	KY492445
Scaphochlamys nigra	Malaysia, Sarawak, Bau	N01 °33' 28.9"; E110 °08'35.2"	OIH76	KY492409	KY492444
Scaphochlamys cf. *nigra*	Malaysia, Sarawak, Matang	N01 °35' 16.3"; E110 °13' 00.2"	OIH227	KY492414	KY492449
Scaphochlamys penyamar	Malaysia, Sarawak, Sarikei	N01 °54' 36.4"; E111 °38' 52.3"	OIH137	KY492413	KY492448
Scaphochlamys petiolata	Malaysia, Sarawak, Bau	N01 °30'14.6", E110 °09'57.9"	OIH71	KY492400	KY492435
Scaphochlamys picturata	Malaysia, Sarawak, Serian	N01 °07' 16.6"; E110 °26' 51.2"	ZI656	KY492419	KY492454
Scaphochlamys pseudoreticosa	Malaysia, Sarawak, Bau	N01 °22' 36.5"; E110 °11'32.2"	OIH83	KY492422	KY492457
Scaphochlamys polyphylla	Malaysia, Sarawak, Lundu	N01 °50' 03.5"; E109 °40' 35.4"	OIH119	KY492403	KY492438
Scaphochlamys polyphylla	Malaysia, Sarawak, Sri aman	N01 °03'12.5" E111 °21'14.3"	OIH289	KY492404	KY492439

Table 4.1 continued

Scaphochlamys reticosa	Malaysia, Sarawak, Bau, Taiton	N01 °23' 41.8"; E110 °08'12.0"	OIH79	KY492405	KY492440
Scaphochlamys reticosa	Malaysia, Sarawak, Bau, Juita	N01 °23' 48.7"; E110 °08' 07.2"	ZI139	KY492406	KY492441
Scaphochlamys scintillans	Malaysia, Sarawak, Betong	N01 °57' 29.7"; E111 °26' 16.9"	OIH141	KY492416	KY492451
Scaphochlamys stenophylla	Malaysia, Sarawak, Bau, Buan	N01 °33' 28.9"; E110 °08'35.2"	OIH74	KY492398	KY492433
Scaphochlamys stenophylla	Malaysia, Sarawak, Bau, Adis	N01 °33' 20.5"; E110 °09'44.7"	OIH88	KY492397	KY492432
Scaphochlamys cf. *stenophylla*	Malaysia, Sarawak, Bau, Sirup	N01 °32' 31.7"; E109 °54'18.0"	OIH93	KY492411	KY492446
Scaphochlamys uniflora	Malaysia, Sarawak, Bau	N01 °22' 36.8"; E110 °11'36.0"	OIH82	KY492421	KY492456
Boesenbergia pulcherrima	-	-	BK:J. Mood 08P276	JX992748	JX992809
Distichochlamys sp.	-	-	Kress #01-6848 US	AF478745	AF478844
Haniffia cyanescens	Malaysia	-	FRIM FR56069	JF825533	JF825538
Haplochorema aff. *uniflorum*	Malaysia, Sarawak, Bau	N01 °31' 52.7"; E110 °07'42.5"	OIH113	KY492428	KY492463
Kaempferia rotunda	-	-	Kress #99-6304 US	AF478767	AF478868
Myxochlamys mullerensis	Indonesia	-	KT-671	AB245522	AB269791
Tamijia flagellaris	-	-	Kazuyuki S55 - Kyoto	AF478797	AF478898
Zingiber officinale	India	N31°43'12.0"; E76°58'12.0"	IMGHPMD033	KC582866	AB047756

4.2.2 DNA Extraction and Polymerase Chain Reaction (PCR) Amplification and Sequencing

Total genomic DNA was extracted from the fresh young leaf tissues using a modified 2x CTAB protocol (Doyle & Doyle, 1987) with the addition of PVP (Polyvinylpyrrolidone). The nuclear ITS region and plastid *trn*K-*mat*K gene region were targeted for polymerase chain reaction (PCR) amplification. Primers used were provided in Table 4.2. PCR Amplifications for ITS *trn*K-*mat*K regions were performed in a Bio-Rad thermal cycler with the PCR profile set to 2 min at 94 ℃, followed by 30 cycles of 94 ℃ for 1 min, 48.5 – 56.5 ℃ for 1 min, and 72 ℃ for 2 min, with a final extension of 72 ℃ for 10 min. The PCR products were viewed on a 1.5 % agarose gels, and purified using a PCR purification kit (Fermentas, Vilnius, Lithuania). Purified products were viewed again using a 1 % agarose gel, and if a single clear band was present the products were sent for sequencing to Beijing Genomics Institute Laboratories, Guangdong, China. Sequencing reactions were carried out using the same primer pairs during PCR amplification and the ABI PRISM BigDye® Terminator Version 3.0 Cycle Sequencing Kit on an ABI® 377 DNA automated sequencer (Applied Biosystem, Foster City, CA, USA).

4.2.3 Sequence Alignment and Phylogenetic Analyses

Newly generated sequences were assembled using BioEdit version 5.0.6 (Hall, 1999) and manually adjusted following the similarity criterion (Simmons, 2004). Indels were treated as missing data (Appendix 1 & 2). The most suitable nucleotide substitution model for ITS, *trn*K-*mat*K and combined regions (ITS + *trn*K-*mat*K) was selected in jModeltest ver. 0.1.1 (Posada, 2008) using Akaike information criterion (AIC; Akaike, 1974). The jModeltest identified that the Tamura-Nei plus Gamma (TrN+G) as best fit for gene ITS, Transversion

Table 4.2: The primers used in this study are listed with the information of the sequences, references and the annealing temperature.

DNA Region	Primer	Primer sequence	Reference	Annealing temperature (^{o}C)
*trn*K/*mat*K	trnK1	CTCAACGGTAGAGTACTCG	Manos & Steele, 1997	51.5
	mIR	CGTTTCACAAGTACTGAACTA	Kress et al., 2002	
	AFo	CTATATCCACTTCTCTTTCAAG	Modified from Ooi et al., 1995	52.5
	ZNRo	CGAAGAATTAATTTGTACACTTG	Modified from Sakai et al., 2013	
	5Fb	CTCTATGGATTTTCAAGGAT	Mood et al., 2013	48.5
	trnK2R	AACTAGTCGGATGGAGTAG	Steele & Vilgalys, 1994	
ITS	17SE	ACGAATTCATGGTCCGGTGAAGTGTTCG	Sun et al., 1994	56.5
	26SE	TAGAATTCCCCGGTTCGCTCGCCGTTAC	Sun et al., 1994	

Model plus Gamma (TVM+G) as best fit for *trn*K-*mat*K and General Time Reversible plus Gamma (GTR+G) as best fit for gene ITS + *trn*K-*mat*K. Maximum likelihood (ML) analyses were carried out using maximum likelihood (ML; Felsenstein, 1981) optimization with the software RAxML (7.3.2; Stamatakis, 2006) and RAxML- Gui (Silvestro & Michalak, 2012), RAxML 3.0 (Guindon et al., 2010). ML bootstrap values were obtained by running 10,000 replicates. Bayesian phylogenetic analyses were performed with MrBayes ver.3.1.2 (Huelsenbeck & Ronquist, 2001). Markov chain Monte Carlo (MCMC) was repeated twice to assure parameter convergence. The MCMC algorithm was run for 2,000,000 (*trn*K-*mat*K), 2,000,000 (ITS) and 2,000,000 (ITS + *trn*K-*mat*K) generations with one cold and three heated chains, starting from random trees and sampling one out of every 100 generations. Convergence was assessed by using the standard deviation of split frequencies as convergence index with values 0.005 – 0.01. The first 10 % of trees were discarded as burn-in. Remaining trees were used to construct 50 % majority rule consensus trees. In interpreting phylogenetic confidence, ML bootstrap support: 50 – 74 % represents weak support, 75 – 84 % moderate support, and 85 – 100 % represents strong support. Bayesian posterior probability (BPP): 0.50 – 0.74 represents weak support, 0.75 – 0.94 represents moderate support, and 0.95 – 1.00 represents strong support.

4.3 Results and Discussion

4.3.1 Matrix Characteristics

The total aligned nucleotides for the ITS region has 730bp, 290 (39.73%) variable characters, 114 (15.62%) informative characters, a tree length of 479 steps, 0.4369 consistency index (CI), 0.7514 retention index (RI) and 3961.34 (BPP)/ 3900.51 (ML) log likelihood value; the total aligned nucleotides for the *trn*K-*mat*K region has 2874bp, 261

(9.08%) variable characters, 66 (2.30%) informative characters, a tree length of 155 steps, 0.6842 consistency index (CI), 0.9147 retention index (RI) and 5894.35 (BPP)/ 5838.09 (ML) log likelihood value; the total aligned nucleotides for the combined region (ITS + *trn*K-*mat*K) has 3596bp, 556 (15.46%) variable characters, 186 (5.17%) informative characters, a tree length of 681 steps, 0.4428 consistency index (CI), 0.7582 retention index (RI) and 10464.04 (BPP)/ 10382.59 (ML) log likelihood value. The incongruence length difference (ILD; Farris et al., 1994) test between the ITS and *trn*K-*mat*K regions were congruent (P > 0.05). Therefore, the two regions were combined for further analyses.

4.3.2 Phylogenetic Analyses

4.3.2.1 ITS Region

The tree generated from ITS region by using RAxML and Bayesian analyses were shown in Figure 4.1 and Figure 4.2. *Distichochlamys* sp was placed as sister to the *Scaphochlamys* + *Myxochlamys* clade (ML=55%; BP=0.92). Next, Peninsular Malaysia + Southern Thailand *Scaphochlamys* were placed together with *Scaphochlamys* Limiana Group and Polyphylla Group from Borneo with strong support (ML=90%; BP=1.00). There were three clear separate sub-clades within this clade: *Scaphchlamys kunstleri*, *S. malaccana* + Polyphylla Group, and *S. biloba*. The type of *Scaphochlamys, S. malaccana* was grouped together with Polyphylla Group and *S.* aff. *klossii* (ML=93%; BP=1.00). Polyphylla group is morphologically close to *S. malaccana* by sharing laxly arranged inflorescences with bracts tightly incurved near base but flattened near apex (Ooi et al., in press). The two varieties of *S. kunstleri* were not supported in the molecular phylogeny as the two accessions of *S. kunstleri* var. *speciosa* did not grouped together.

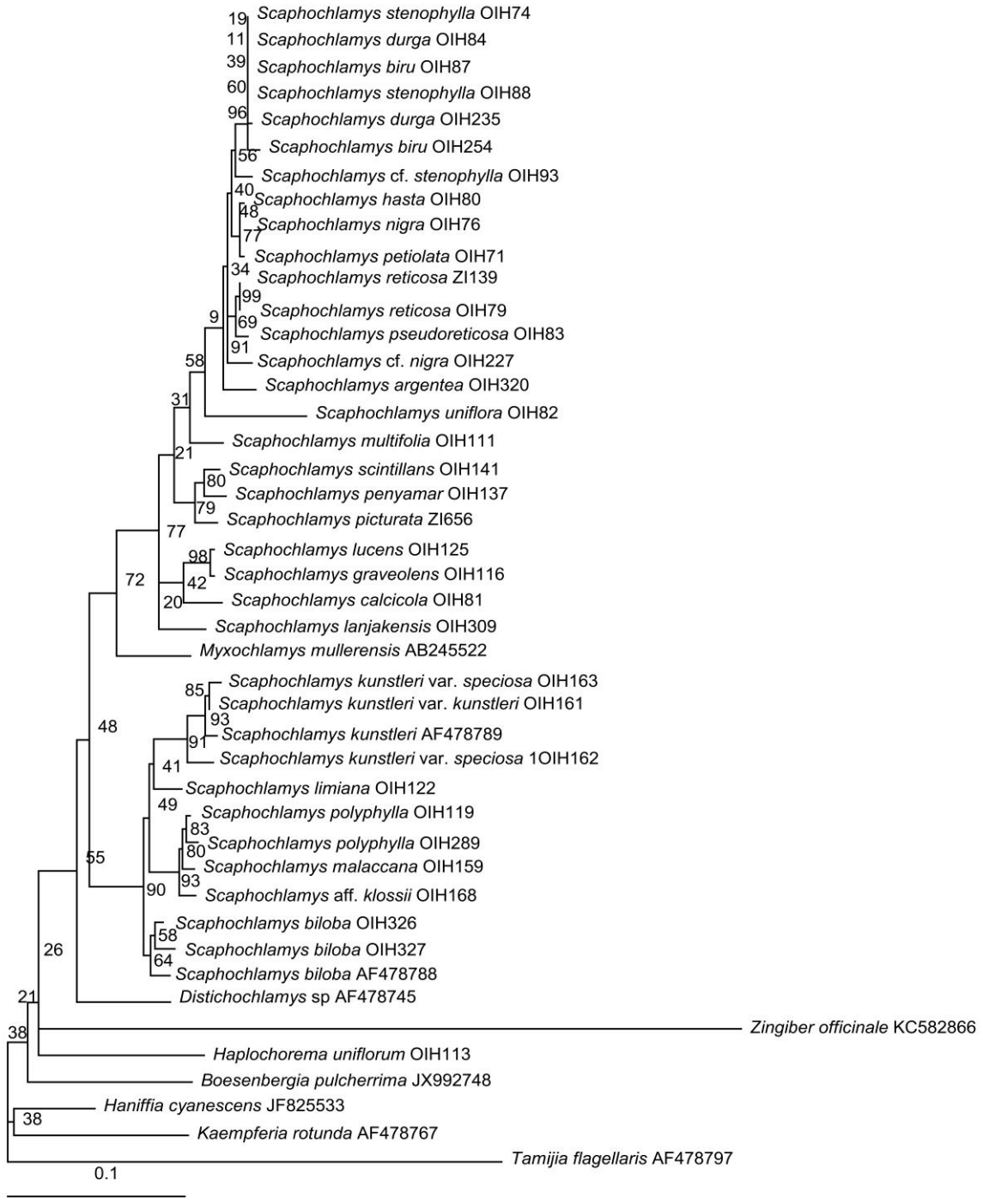


Figure 4.1: Single best Maximum Likelihood (ML) tree based on ITS region sequence data with the support/bootstrap (BS) values shown.

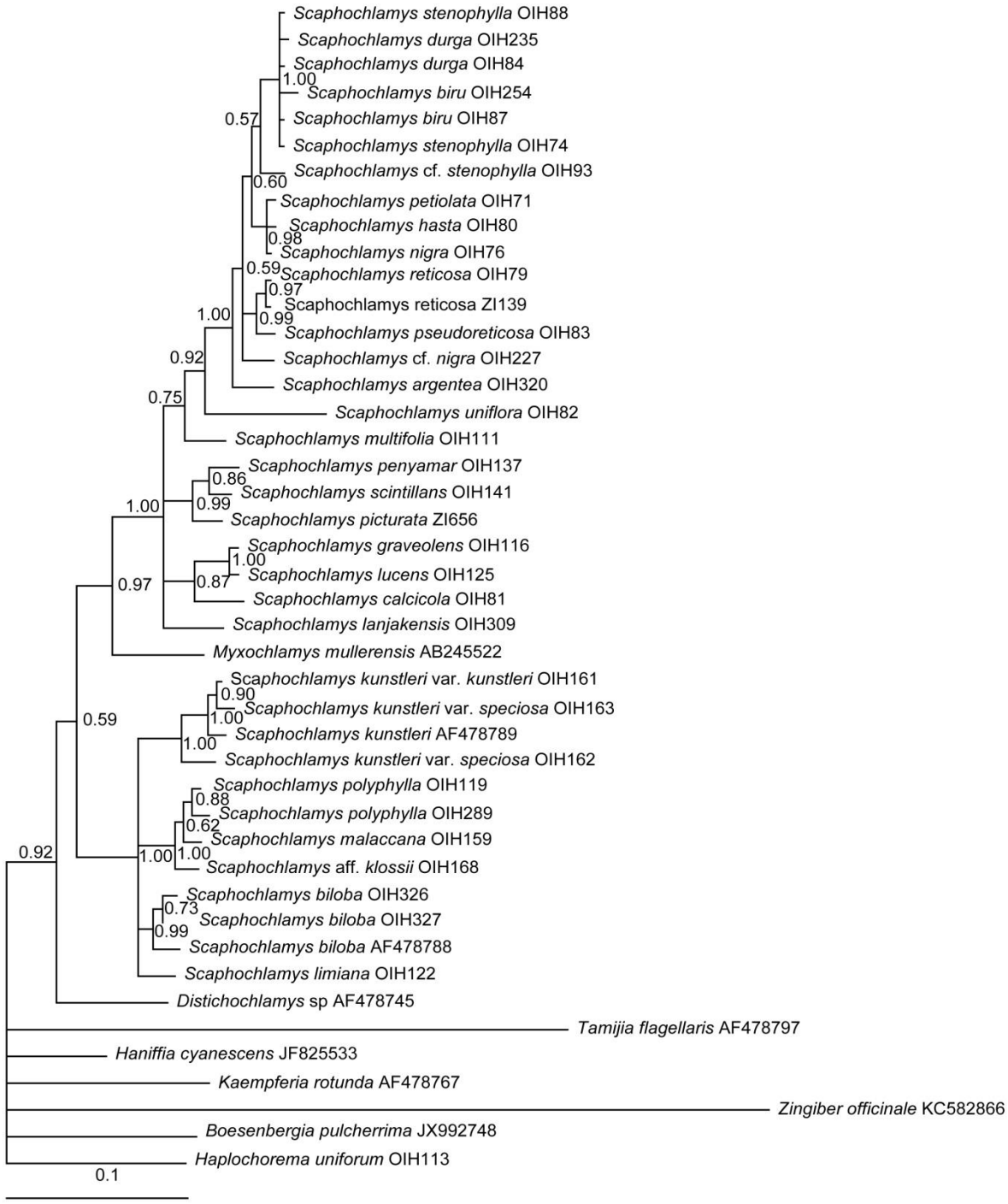


Figure 4.2: Bayesian majority-rule consensus tree based on ITS region sequence data with the support/posterior probabilities (PP) values shown.

The rest of the Bornean *Scaphochlamys* was placed in the same clade with *Myxochlamys mullerensis* as sister taxon (ML=72%; BP=0.97). A recently described, *S. lanjakensis* from Lanjak Entimau Wildlife Sanctuary, although was placed in the Anomala Group based on its morphological similarities, did not grouped together here with the other species in the Anomala Group, *S. penyamar*, *S. scintillans*, and *S. picturata*. The Anomala Group received moderate bootstrap support 79% (ML) and 0.99 (BP). The Calcicola Group was not supported with *S. calcicola* placed in the same clade with the Graveolens Group with weak supports (ML=42%; BP=0.87). The Graveolens Group which includes *S. graveolens* and *S. lucens* was strongly supported (ML=98%; BP=1.00). The other species belonging to the Calcicola Group, *S. uniflora* resulted in the position within the Petiolata Group, together the clade was weakly supported (ML=58; BP=0.75). The Petiolata Group is by far, the richest group on Borneo with 12 species described so far. Within the group, *S. reticosa* is closely related to *S. pseudoreticosa* with moderate supports (ML=69%; BP=0.99). *Scaphochlamys reticosa* and *S. pseudoreticosa* are highly distinguishable from the rest of the taxa in the Petiolata Group by sharing tessellate tertiary venation on adaxial lamina surface (conspicuously raised in *S. reticosa*, less conspicuous in *S. pseudoreticosa*). *Scaphochlamys stenophylla*. *S. durga*, and *S. biru* were supported in both maximum likelihood (96%) and Bayesian analysis (BP=1.00) where else, *S. hasta*, *S. nigra* and *S. petiolata* were supported in a separate sub-clade (ML=77%; BP=0.98).

4.3.2.2 *trn*K-*mat*K Region

The tree generated from *trn*K-*mat*K region by using RAxML and Bayesian analyses were shown in Figure 4.3 and Figure 4.4. *Distichochlamys* sp. was embedded within the outgroup taxa in both maximum likelihood and Bayesian analyses. However, in a separate

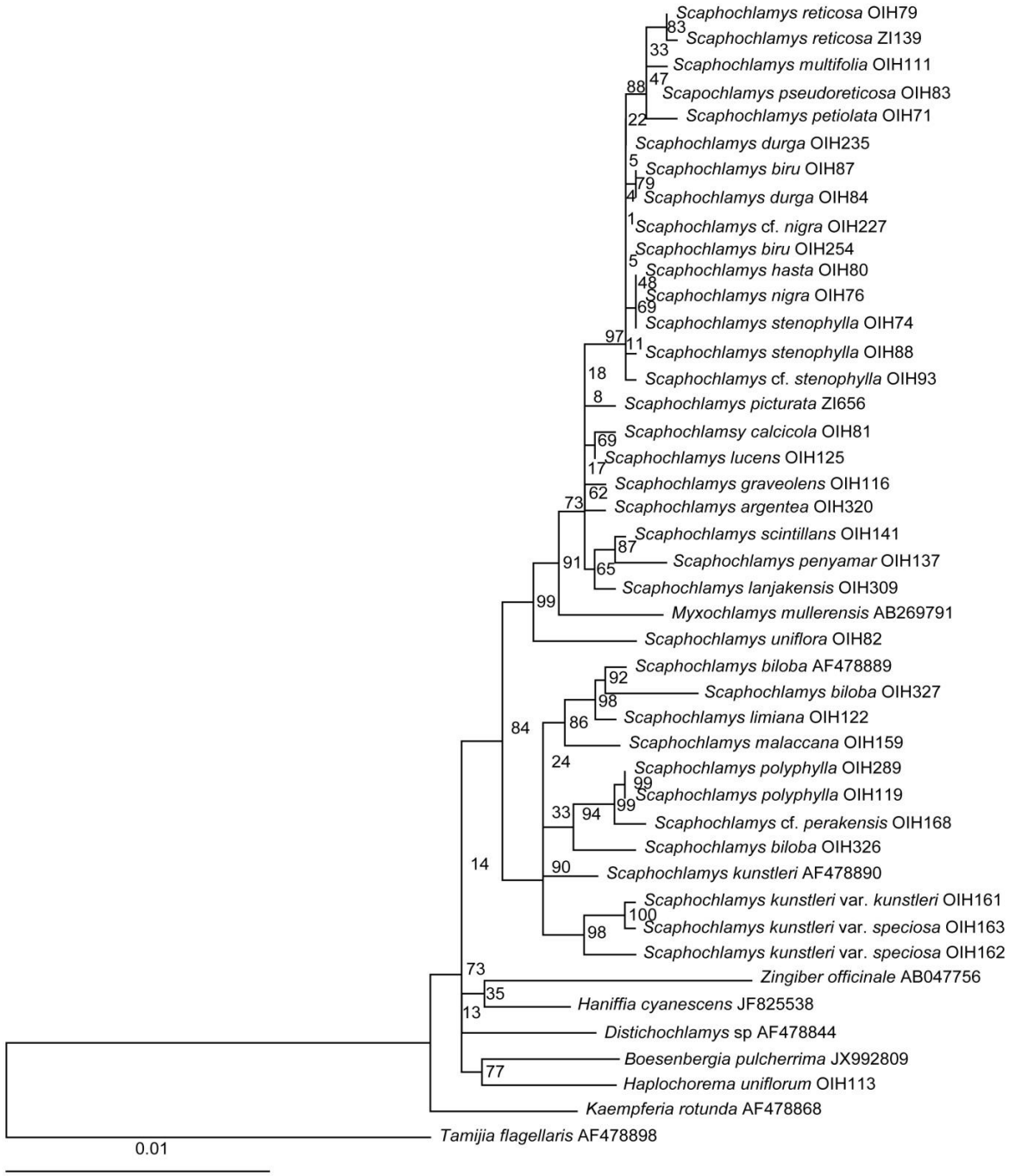


Figure 4.3: Single best Maximum Likelihood (ML) tree based on *trn*K-*mat*K region sequence data with the support/bootstrap (BS) values shown.

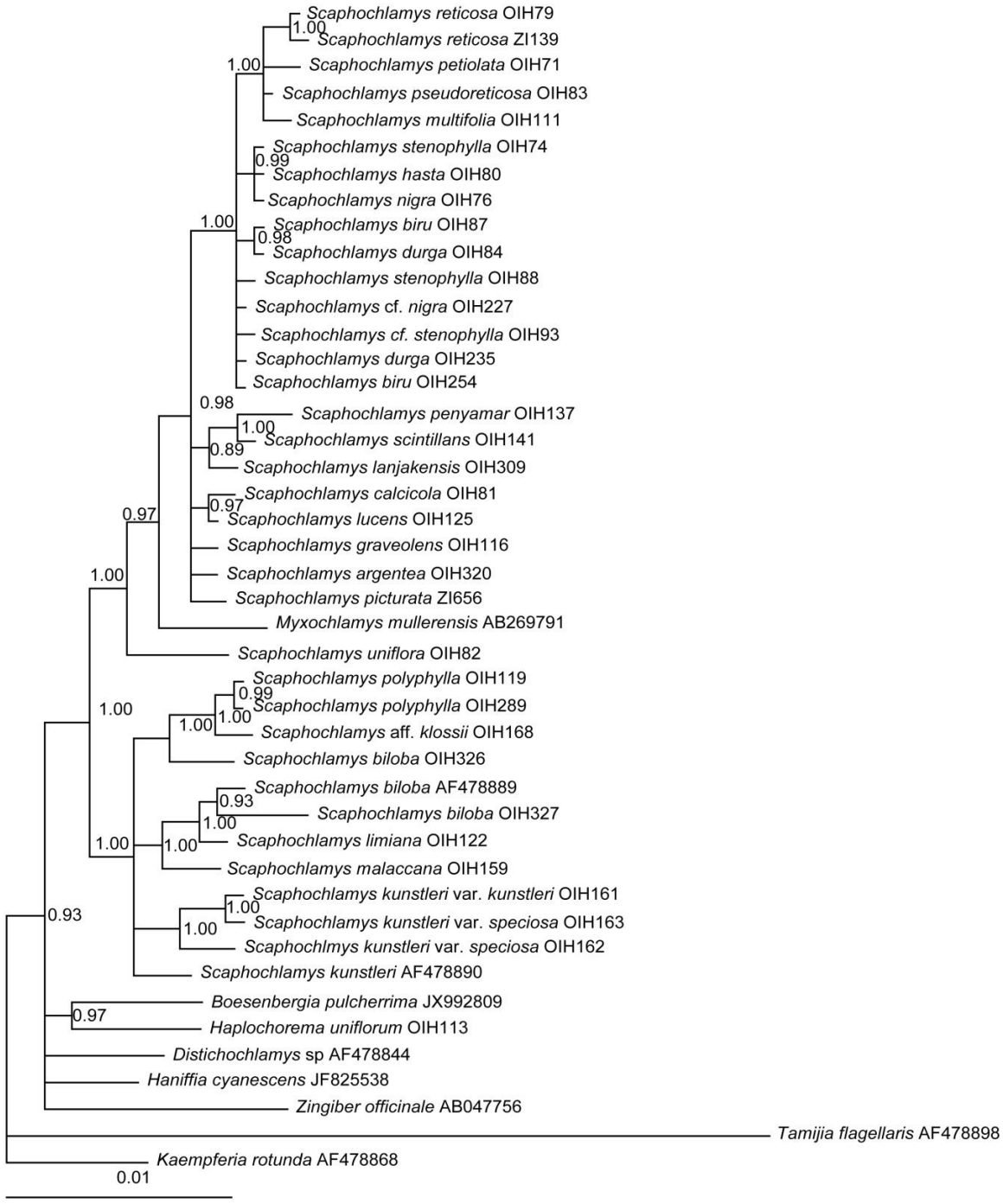


Figure 4.4: Bayesian majority-rule consensus tree based on *trn*K-*mat*K region sequence data with the support/posterior probabilities (PP) values shown.

dataset (Wong, pers. comm.) which included all the sequences of *Boesenbergia* species available from Genbank and three accessions of *Distichochlamys*, *Distichochlamys* was nested as sister taxon to *Scaphochlamys* and *Myxochlamys*. Similar to ITS region, *Scaphochlamys* (together with *Myxochlamys*) was divided into two major clades with strong support (ML=84%; BP=1.00). First clade grouped taxa from Peninsular Malaysia together with Limiana Group and Polyphylla Group (ML=90%; BP=1.00). The type of *Scaphochlamys*, *S. malaccana* belonged to the same clade with *S. limiana* and two accessions of *S. biloba* which are dissimilar to the results obtained in the ITS region (ML=86%; PP=1.00). The other accession of *S. biloba* was placed together with two accessions of *S. polyphylla* and *S.* aff. *klossii* (ML=94%; BP=1.00). Three accessions of *S. kunstleri* belonged to the same sub-clade with *S. kunstleri* var. *kunstleri* next to *S. kunstleri* var. *speciosa* (ML= 98%; BP=1.00).

For the second major clade, *S. uniflora* was placed as sister to the rest of the Bornean *Scaphochlamys* and *Myxochlamys* with strong supports (ML=99%; BP=1.00). *Scaphochlamys uniflora* was placed in the Calcicola Group based on the morphological characters (relatively larger flower, persistent bract and first bracteole slightly longer than bract) but this species is unique by having only one flower (observed so far) per inflorescence and peculiar combination of characteristics (Ooi et al., in press). Next, *Myxochlamys mullerensis* was placed as sister to the rest of the Bornean *Scaphochlamys* with strong supports (ML=91%; BP=0.97). The Anomala Group was weakly and moderately supported with the exclusion of *S. picturata* (ML=65%; BP=0.89). *Scaphochlamys picturata*, *S. argentea*, *S. graveolens*, *S. lucens*, and *S. calcicola* formed

polytomies with unresolved relationship. The rest of taxa belonging to the Petiolata Group were supported in a sub clade (ML=97%; BP=1.00).

4.3.2.3 Combined Regions

Similar to the phylogenetic tree obtained in the ITS region, *Distichochlamys* was supported as sister to *Scaphochlamys* and *Myxochlamys* (ML=82%; BP=1.00; Figure 4.5 and Figure 4.6). As with the results obtained from separate ITS and *trn*K-*mat*K analyses, *Scaphochlamys* was divided into two major clades (ML= 87%; BP=1.00). The first clade grouped the Peninsular Malaysian *Scaphochlamys* with Limiana Group and Polyphylla Group with strong supports (ML=100%; BP=1.00). The type of *Scaphochlamys*, *S. malaccana* belonged to the same sub-clade with Polyphylla Group and *S.* aff. *klossii* (ML=81%; BP=1.00). *Scaphochlamys biloba* was supported to be in the same sub-clade with Limiana Group with weak to moderate support (ML= 63%; BP=0.92). *Scaphochlamys kunstleri* was again supported in a group but still with the placement of the varieties not supporting its taxonomic grouping (ML=64%; BP=1.00) because the classification of *S. kunstleri* varieties is solely based on the colour of the flowers.

Myxochlamys mullerensis was the sister to the second clade in the phylogeny in both maximum likelihood and Bayesian analyses with strong support (ML=100%; BP=1.00). In the maximum likelihood analysis, *S. uniflora* was sister to the rest of the Bornean *Scaphochlamys* (ML=82%), however, this was not supported in the Bayesian analysis. In the Bayesian analysis, *S. uniflora* was grouped together with *S. calcicola* (BP=0.69), conforming to the grouping of the Calcicola Group based on morphological characters (Ooi, et al., in press). *Scaphochlamys lanjankensis* was again, not supported to

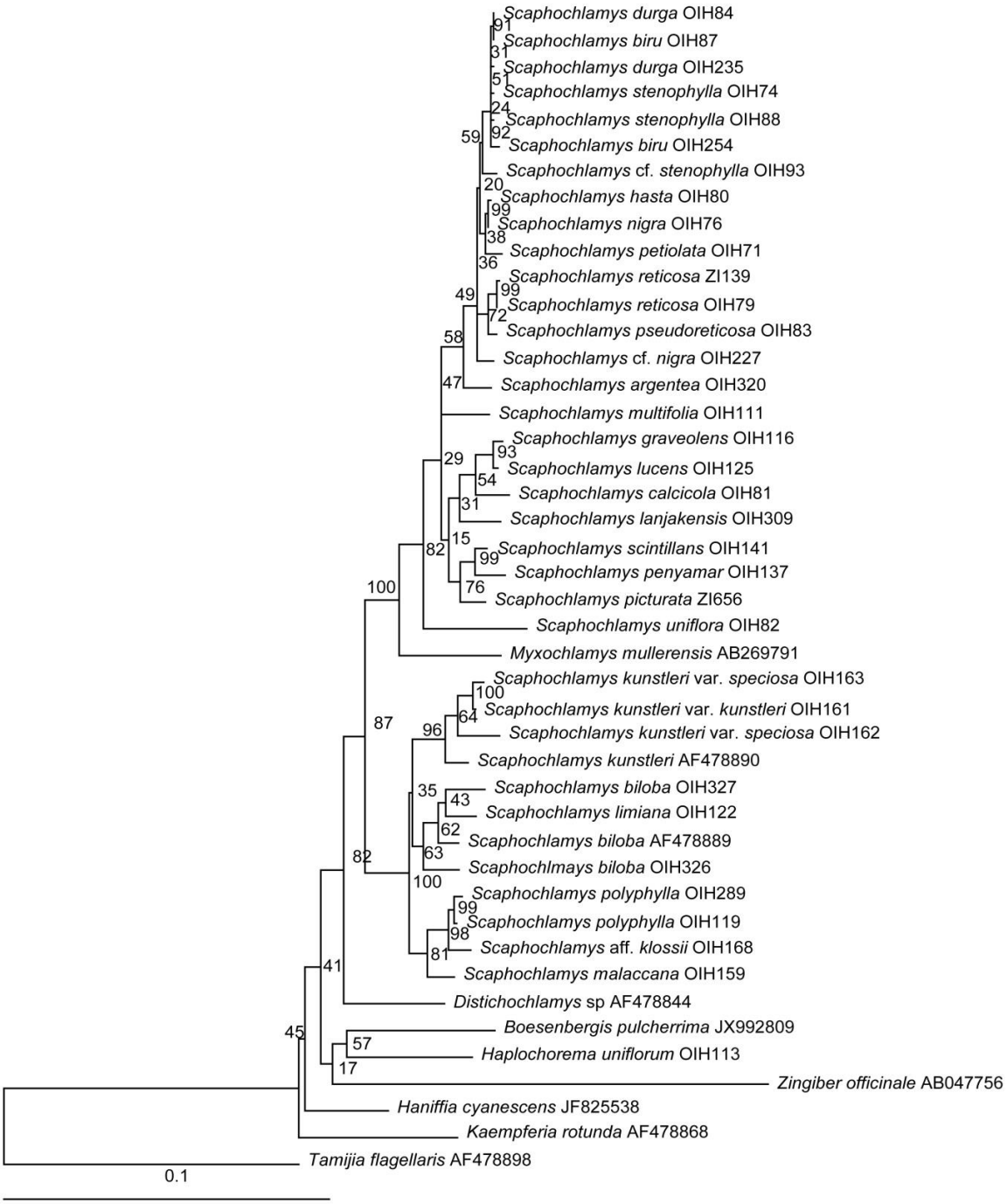


Figure 4.5: Single best Maximum Likelihood (ML) tree based on combined regions (ITS + *trn*K-*mat*K) sequence data with the support/bootstrap (BS) values shown

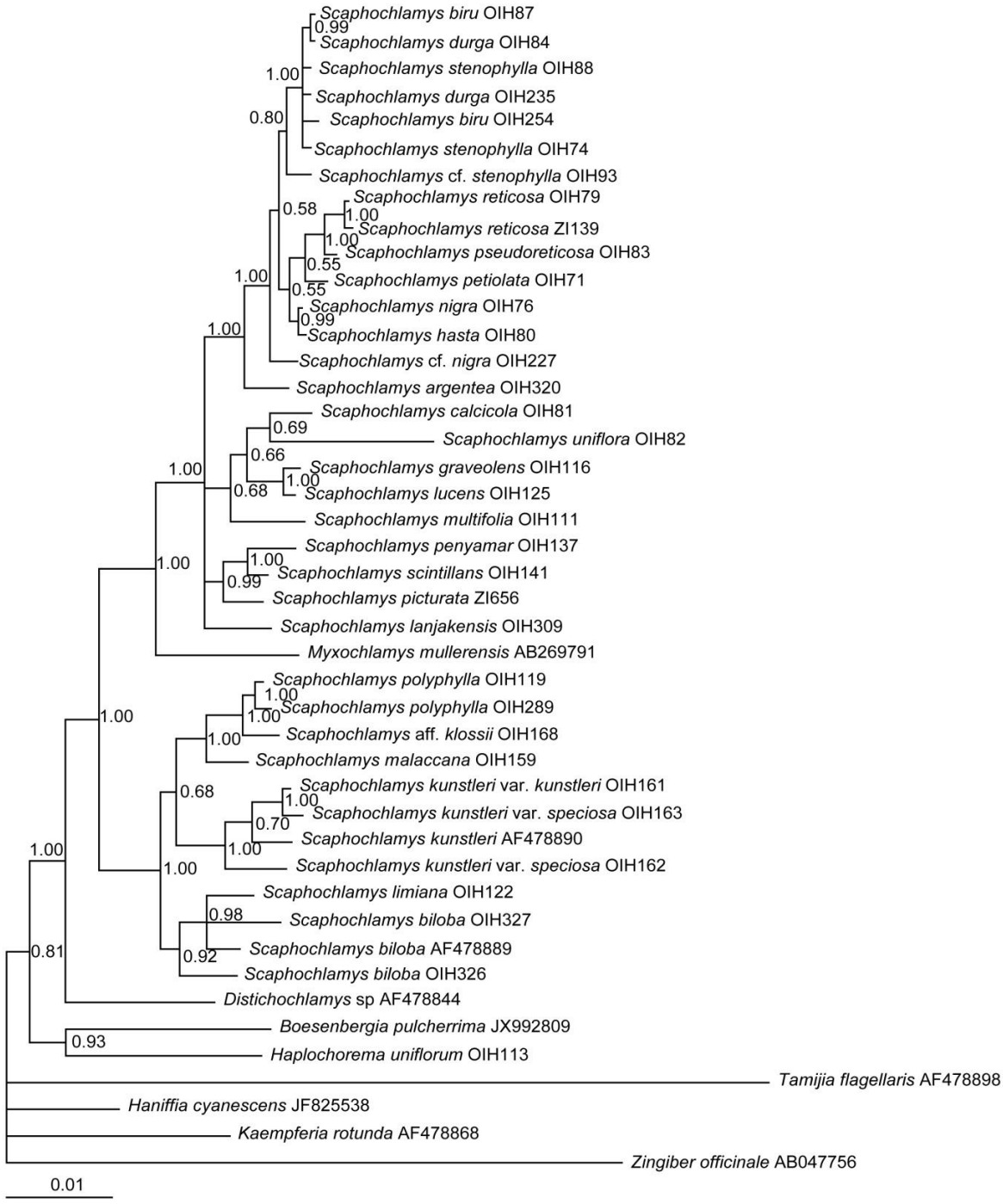


Figure 4.6: Bayesian majority-rule consensus tree based on combined regions (ITS + *trn*K-*mat*K) sequence data with the support/posterior probabilities (PP) values shown.

belong to the Anomala Group. The Anomala Group comprises *S. scintilans*, *S. penyamar* and *S. picturata* (ML=76%; BP=0.99). The Graveolens Group which comprises sampled *S. graveolens* and *S. lucens*, formed a sub-clade with strong supports (ML=93%; BP=1.00). *Scaphochlamys calcicola* was supported as sister to *S. uniflora* in the Bayesian analysis but with very low support (BP=0.69). Surprisingly, *S. multifolia* which belongs to the Petiolata Group formed either a polytomy in the maximum likelihood analysis or grouped together with the Graveolens Group and Calcicola Group (BP=0.68). The rest of the species belonging to the Petiolata Group was supported in one clade (ML=58%; BP=1.00). Within the Petiolata Group, two sub-clades were formed which conformed to the results obtained in the *trn*K-*mat*K region.

4.3.3 Discussion

4.3.3.1 Phylogenetic Relationship

Based on the results obtained from *ITS* and *trn*K-*mat*K regions, *Scaphochlamys* is divided into two major clades: (1) the Bornean *Scaphochlamys* Limiana Group and Polyphylla Group together with the species belonging to Peninsular Malaysia and Southern Thailand and (2) *Myxochlamys* and the rest of the Bornean *Scaphochlamys*. A recent paper by Sam et al. (2016) recognized the *Borneocola* as a new genus to represent the Bornean *Scaphochlamys* with the exclusion of *S. polyphylla* and *S. samunsamensis*. Sam et al. (2016) sampled *B. biru*, *B. calcicola*, *B. stenophyllus*, *B. petiolatus*, *B. reticosus*, and two unknown *Borneocola* species for their study. Therefore, the study sampled four species belonging to the Petiolata Group (Ooi et al. in press) and one species belonging to the Calcicola Group but did not sample any taxa belonging to the Graveolens and Anomala groups (Ooi et al. in press). Both species of *Myxochlamys*, *M. mullerensis* and *M. nobilis*

were included into their analyses and resulted as sister to *Borneocola*. *Myxochlamys* was classified as a different genus by having bracts with mucilage glands, versatile anthers and groove inner floral tube (Takano & Nagamasu, 2007) but the groove inner floral tube is present in *Scaphochlamys* and *Borneocola* as well (Sam et al., 2016, Ooi, per. obs.).

The results from this study show that *Borneocola* is a superfluous paraphyletic genus with poor generic delimitation and missing at least 15 species to represent all the currently recognized groupings from Borneo. The Anomala Group, Graveolens Group and Petiolata Group are generally supported in all the phylogenetic analyses with two exceptions: *S. multifolia* which is morphologically closest to *S. petiolata* but differs by having inflorescences terminal within persistent leafless sheaths as separate element and remains polyphyllous in adult form (Ooi et al., in press); and *S. lanjakensis* which belongs to the Anomala Group morphologically but is polytomy among other members of Anomala groups and *S. calcicola* + the Graveolens Group. *Scaphochlamys calcicola* is a unique obligate lithophytic species by possessing inflorescences with distichously arranged bracts and was initially placed together with *S. uniflora* in the Calcicola Group. However, *S. uniflora* is unique as it is so far the only species with one flower per inflorescence (Ooi et al., in press).

On the other hand, the Polyphylla Group and Limiana Group belong to the same clade with the *Scaphochlamys* species from Peninsular Malaysia and Southern Thailand. These two groups share the similar morphologies in having 2-fold inwards first bracteoles, persistent bracts, c. 1.5cm long white labellum with purple streaks. The Polyphylla Group is closer to *S. malaccana*, the Type of the genus. Sam et al. (2016) sampled *S.*

samunsamensis which might be a variation of *S. polyphylla* owing to reddish variation is not uncommon in *Scaphochlamys* and the bracts of *S. polyphylla* young inflorescences is clasping at first before gradually elongate to typical lax mature inflorescence. The Limiana Group only comprises of a single species, *S. limiana* as the group is unique by having pseudo-tuberous roots, purplish rhizome flesh and long pedunculate imbricating inflorescences (rosette-like; probably closer to *S. abdullahii*).

Species occurring in Peninsular Malaysia and Southern Thailand, is divided into three sub-clades: *S. kunstleri*, *S. biloba* and *S. malaccana*. *Scaphochlamys malaccana* is closer to the Polyphylla Group from Borneo (as above) than to other species in Peninsular Malaysia. This is not surprise because both *S. malaccana* and *S. polyphylla* have lax inflorescences with persistent bracts that tightly incurved near base but flattened near apex, relatively much smaller first bracteole, possible present of purple streaks on labellum and broom-like stigma. Unlike *S. malaccana*, *S. kunstleri* inflorescences are known to be *Curcuma*-like, with partially overlapping imbricating bracts, first bracteoles about half of bract and beak-like stigma. The varieties are based on the floral colouration, white with red streaks on labellum, yellow or red (Lim, 2001) but never purple. *Scaphochlamys biloba* has lax inflorescences (but the bracts are not completely enclosing the rachis), first bracteole slightly longer than bract, solitary flower (one flower per bract), labellum with red/pink streaks and beak-like stigma.

Distichochlamys, a genus described from Vietnam (Newman, 1995), is sister to the *Scaphochlamys* and *Myxochlamys*. This is similar to the results obtained in previous studies (Kress et al., 2002; Leong-Škorničková et al., 2011, Sam et al., 2016).

Distichochlamys is morphologically differentiated by inflorescences with distichously arranged bracts, partially split tubular first bracteole, trilocular ovary with axile placentation and beak-like stigma.

4.3.3.2 Phytogeography

Based on the results obtained in this chapter, it appears that *Scaphochlamys* in Borneo has two origins with the Polyphylla and Limiana groups are closer to the species in Peninsular Malaysia and Southern Thailand, and the second group comprises the Petiolata Group, Graveolens Group, Anomala Group and Calcicola Group with *Myxochlamys* as sister taxon. *Scaphochlamys limiana* and *S. polyphylla* are probably relictual taxa from fairly recent times as the age of crown-group Zingiberaceae is about 70 m.y. (Auvray et al., 2010). However, the age is highly debatable as the age of crown-group Zingiberales varies between c. 80 m.y. (Janssen & Bremer 2004) to c. 100 m.y. (Kress & Specht, 2005, 2006). Both *S. limiana* and *S. polyphylla* occur at Lundu, the north western tip of Sarawak. This part of Sarawak, is slightly drier than the nearest biogeographical assemblage, for example, 350-400 mm per month at West Sarawak where the overall rainfall is between 400-800 mm per month (Malaysian Meteorological Department, 2014). The climate where *S. limiana* and *S. polyphylla* occur is much similar to Peninsular Malaysia with drier seasons between 100-400 mm per month (Malaysian Meteorological Department, 2014).

On Borneo, the major diversification of *Scaphochlamys* occurs in the Petiolata Group, Graveolens Group, Anomala Group and Calcicola Group with the increase in the number of species by 100% fold (Ooi et al, in press). All the species belonging to the Petiolata Group is found in West Sarawak which is rich with herbaceous flora, among

others, in the family Araceae (Boyce & Wong, 2008; Wong & Boyce, 2010; 2014), Zingiberaceae (Ooi & Wong, 2014; Meekiong et al., 2015), and Taccaceae (Boyce & Julia, 2004). The Anomala Group mainly occurs above the Lupar Line with an exception, *S. picturata* (refer to Chapter Three). Anomala Group is restricted to occur above the Lupar Line (The Lupar Line suture zone is a 15 km wide, trending east-south-east through Engkilili and Lubok Antu (Hutchinson, 1996). The Graveolens Group comprises two species, *S. graveolens* and *S. lucens*, both species are endemic to the base of limestone hills. *Scaphochlamys calcicola* is also highly localized to limestone hills in Bau. The limestone flora is one of the richest habitats for herbaceous plants (Kiew, 1991). Anderson (1965) estimated that the limestone flora of Sarawak numbered more than 600 species. From Bau alone, understory flowering plants (excluding trees) already number 444 species (Kiew et al., 2004). As it has been shown that with karst limestones in Malaysia, with the level of endemism in the herbaceous plants level, Bau limestone is phytogeographically distinct from the nearby Padawan-Serian limestone (Kiew et al., 2004). Given the strong boundaries of demarcation on the occurrence of the species groups of *Scaphochlamys* on Borneo, there is a clear separation of the morphological grouping based on molecular phylogeny and geographical areas.

The total species count for Bornean *Boesenbergia* is c. 32 (Smith, 1987; Poulsen, 1993; Cowley, 2000; Sakai & Nagamasu, 2006b; 2009; Meekiong et al., 2011) as compared to 27 *Scaphochlamys* on Borneo (Ooi et al. in press). However, while *Boesenbergia* occurs throughout Borneo (especially Sabah and Sarawak, where the botanical exploration is much more active than in Kalimantan, the Indonesian Borneo), *Scaphochlamys* has yet to be found above north of Central Sarawak and beyond, extending

till Sabah. The distributional pattern of Kalimantan is still premature to make any scientific statement. Furthermore, the Indonesian Kalimantan provinces, covering 2/3 of Borneo have the lowest collection density of the entire Malesian region with only 12 collections per 100km^2; whereas Sabah, with Mt. Kinabalu, and Sarawak together with Brunei, have 126 and 76 collections per 100km^2, respectively (Johns, 1995). This bias in collection intensities is better known as the 'Wallacean shortfall' (Whittaker et al., 2005).

CHAPTER 5

FLORAL BIOLOGY

5.1 Introduction

The ancestral pollination syndrome of Zingiberaceae is insect or bee pollination (Specht et al., 2012). In Borneo, three pollination guilds were reported for the gingers of Lambir Hills National Park, Sarawak, Malaysia, which are Halictid bee, *Amegilla* bee and Spiderhunter bird (Sakai et al., 1999), and the carpenter bee pollination was reported for *Alpinia nieuwenhuizii* in Kinabatangan, Sabah, Malaysia (Takano et al., 2005). Early floral development of *S. kunstleri* was investigated by Kirchoff (1998). However, there was no record on floral biology and pollination mechanisms of *Scaphochlamys* species. Thus, this study was carried out to provide an overview for the floral biology and pollination mechanisms of the Bornean *Scaphochlamys* species. In addition to this, this study also investigated on the pollination mechanism of three taxa of ex-Bornean *Scaphochlamys*, three *Boesenbergia* species (sister genus to *Scaphochlamys*) and *Plagiostachys* (utilizes similar pollination guild). Thus, this study aimed to determine the types of pollination guilds in *Scaphochlamys* (with comparison to *Boesenbergia* and *Plagiostachys*), with a focus on the floral biology and pollination mechanisms in Bornean *Scaphochlamys*.

5.2 Materials and Methods

5.2.1 Study Localities

5.2.1.1 Anomala Group

The studied locality of *S. lanjakensis* (c. 122 individuals) was around Nanga Segerak Ranger Station, West side of Lanjak Entimau Wildlife Sanctuary, Kapit Division, Sarawak,

Malaysia. This species is mesophyte in shady kerangas (tropical heath forest) on podzolic black soils over sandstone, at c. 360 m elevation.

5.2.1.2 Calcicola Group

Scaphochlamys calcicola's study site (c. 15 individuals) was at the limestone area in Jambusan, Bau district, Kuching Division, Sarawak, Malaysia. This species was found exclusively on boulders, an obligate lithophyte, in lowland limestone forest at the base or shoulder of limestone hills about 35 m above sea level.

The studied locality of *S. uniflora* (c. 12 individuals) is in Jambusan, Bau district, Kuching Division, Sarawak, Malaysia as well but it is at slightly deeper forest area. This species is mesophyte in shady limestone forest on mollisolic black soils at c. 35 m elevation.

5.2.1.3 Graveolens Group

Scaphochlamys graveolens (c. 56 individuals) occurs nearby the forest stream at Umon Murut, Pichin, Serian district, Samarahan Division, Sarawak, Malaysia. This species is a mesophyte growing on mollisolic yellow-orange soils in limestone forest near stream at c. 90 m elevation.

Two populations of *S. lucens* (c. 67 and c. 14 individuals respectively) were found at Gunung Temugan, Padawan district, Kuching Division, Sarawak, Malaysia. Both populations are adjacent to each other (c. 75 m apart) on mollisolic black soils in shady limestone forest at c. 50 m elevation.

5.2.1.4 Limiana Group

The studied locality of *S. limiana* (c. 34 individuals) was at Pueh Range, Lundu district, Kuching Division, Sarawak, Malaysia. This mesophytic species is in slightly shady dry kerangas forest with quartz-rich soils on granite bed at c. 20-40 m elevation.

5.2.1.5 Petiolata Group

Scaphochlamys argentea (c. 68 individuals) is studied at the population c. 50 m away from Sebat Waterfall, Pueh Range, Lundu district, Kuching Division, Sarawak, Malaysia. This understory plant is in slightly dryer shady kerangas forest with quartz-rich soils on granite bed.

Two populations of *S. biru* (c. 15 and c. 64 individuals respectively) were studied. Both populations are in Bau district, Kuching Division, Sarawak, Malaysia but one at the ridge kerangas on the shoulder of the mountain at c. 90 m elevation and another along the river at c. 60 m elevation on podzolic black soils over sandstone, in shady gallery forest.

For *S. durga*, two populations (c. 33 and c. 25 individuals respectively) in Bau district, Kuching Division, Sarawak, Malaysia were included: one is at c. 65 m above sea level and the other is at c. 120 m above sea level. Both populations are the podzolic black soil mesophytes in shady kerangas over sandstone bed with small waterfall c. 200 m away.

Scaphochlamys hasta (c. 63 individuals) occurs in shady kerangas on podzolic black soils over sandstone at c. 80 m elevation at Jagoi area, Bau district, Kuching Division, Sarawak, Malaysia.

Scaphochlamys multifolia's studied locality (c. 102 individuals) was at Gunung Moi, Bau district, Kuching Division, Sarawak, Malaysia. This species is a mesophyte in shady kerangas forest on podzolic black soils over sandstone at c. 120 m elevation near small rocky streams.

Scaphochlamys nigra (c. 22 individuals) is studied at Gunung Buan, Bau district, Kuching Division, Sarawak, Malaysia. This mesophyte occurs in much shady kerangas forest on podzolic black soils over sandstone at c. 90 m elevation beside forest stream.

The studied locality of *S. petiolata* (c. 38 individuals) is at Gunung Singai, Bau district, Kuching Division, Sarawak, Malaysia, an isolated sandstone massif at c. 460 m elevation. This species is mesophytic in shady hill dipterocarp forest on slightly dry black podzolic soils over sandstone at slanting mountainside.

Scaphochlamys pseudoreticosa (c. 14 individuals) occurs in Seromah, Bau district, Kuching Division, Sarawak, Malaysia at the foot of the limestone hill. This mesophytic species is at the shady limestone forest on mollisolic black soils at c. 40 m elevation.

Scaphochlamys reticosa's studied locality (c. 12 individuals) was in Taiton, Bau district, Kuching Division, Sarawak, Malaysia. This species grew at the edge of shady limestone forest on mollisolic orange-black soils at c. 50 above sea level.

Three populations of *S. stenophylla* were studied in two localities, one (c. 33 individuals) at Gunung Buan, Bau district, Kuching Division, Sarawak, Malaysia at c. 90 m elevation and two adjacent populations (c. 68 and c. 27 individuals respectively) in Gunung Moi, Bau district, Kuching Division, Sarawak, Malaysia at c. 120 m elevation. All populations are on podzolic black soils over sandstone bed in shady kerangas.

5.2.1.6 Other Taxa

In addition to investigating *Scaphochlamys* taxa in Sarawak, the study also investigated on the floral biology of three ex-Bornean *Scaphochlamys* (*S. malaccana*, *S. kunstleri* var. *kunstleri*, *S. kunstleri* var. *speciosa*), three species of *Boesenbergia* (sister genus to *Scaphochlamys*) and a *Plagiostachys* species. These seven taxa served as outgroups for comparison on the floral biology of Bornean *Scaphochlamys* taxa vs. ex-Bornean *Scaphochlamys* taxon, *Scaphochlamys* vs. *Boesenbergia* and unrelated genus, *Scaphochlamys* vs. *Plagiostachys* but utilizing similar pollination guild.

Scaphochlamys malaccana (c. 24 individuals) at Gunung Ledang, Asahan, Johor, Malaysia was studied. This species occurs along the forest streams with granite boulders, on quartz-rich soils in shady lowland gallery forest. In addition, three *Boesenbergia parva* populations (c. 16, c. 21 and c. 4 respectively) from Bau district, Kuching Division, Sarawak, Malaysia and a *B.* aff. *puchella* population (c. 17 individuals) from Serian district, Samarahan division, Sarawak, Malaysia occur at the nearby the subject taxa were also surveyed. The information on the populations of investigated species was summarized in Table 5.1.

Table 5.1: The population size, number of inflorescences, number of fruits and number of seeds of the investigated species.

	Species name	Accession number (n=number of surveys)	Population size/number of individuals (mean)	Total number of inflorescences found	Total number of mature inflorescences	Total number of fruits found	Duration for fruit ripening	Number of seeds in a fruit
Anomala group	*S. lanjakensis*	OIH310 (n=1)	122	39	6	6	-	Up to 2
Calcicola group	*S. calcicola*	OIH81 (n=4)	15	11	4	1	-	Up to 4
	S. uniflora	OIH291 (n=1)	12	1	0	0	-	-
Graveolens group	*S. graveolens*	OIH116 (n=2)	56	7	4	0	-	-
	S. lucens	OIH125 (n=2)	67	9	4	0	-	-
	S. lucens	OIH125 (n=2)	14	0	0	0	-	-
Limiana group	*S. limiana*	OIH118 (n=1)	34	3	0	1	-	1
Petiolata group	*S. argentea*	OIH320 (n=1)	68	4	1	0	-	-
	S. biru	OIH75 (n=4)	15	10	3	2	-	1
	S. biru	OIH87 (n=2)	64	33	3	2	c. 5 weeks	1
	S. durga	OIH84 (n=1)	33	10	4	0	-	-
	S. durga	OIH108 (n=1)	25	8	2	2	-	1

Table 5.1 continued

	S. hasta	OIH80 (n=1)	63	15	3	0	-	-
	S. multifolia	OIH111 (n=3)	102	25	1	16	c. 5 weeks	Up to 2
	S. nigra	OIH76 (n=3)	22	7	1	3	-	1
	S. petiolata	OIH71 (n=2)	38	14	5	3	-	1
	S. pseudoreticosa	OIH83 (n=2)	14	2	0	0	-	-
	S. reticosa	OIH79 (n=3)	12	8	0	0	-	-
	S. stenophylla	OIH74 (n=4)	33	30	7	4	c. 4 weeks	1
	S. stenophylla	OIH106 (n=4)	68	26	7	4	c. 4 weeks	1
	S. aff. *stenophylla*	OIH107 (n=2)	27	7	1	1	c. 6weeks	1
Other taxa	*S. malaccana*	OIH302 (n=3)	24	9	3	3	-	1
	B. parva	OIH109 (n=2)	16	4	1	0	-	-
	B. parva	OIH261 (n=3)	21	13	1	1	-	-
	B. parva	OIH290 (n=1)	4	0	0	0	-	-
	B. aff. *puchella*	OIH117 (n=2)	17	4	2	1	-	Up to 4

5.2.2 Flowering Mechanism and Pollination Observation

This study included *in situ* and *ex situ* observations of at least one representative species in six informal intrageneric groups in Bornean *Scaphochlamys*, with three taxa of *Scaphochlamys* from Peninsular Malaysia, three *Boesenbergia* species and a *Plagiostachys* (only pollination mechanism). As the natural flowering event is not a human control factor, it is not possible to gather complete dataset on all species as was reported in many published floral biology work, not only in Zingiberaceae, but in many other plant families as well (Williams & Whitten 1983; Kirchoff 1988; Ippolito & Armstrong, 1993; Kirchoff & Kunze 1995; Kishore et al. 2012; Low et al. 2015; Hoe et al. 2016). However, fieldwork was carried out at least once a week to check on flowering plants in its natural habitat from November 2013 till April 2016. *In situ* observations of floral biology (flower opening, stigma secretion, pollen releasing, degradation and odour emission) were conducted on *S. biru* OIH87 (n=1), *S. calcicola* OIH81 (n=1), *S. durga* OIH84 (n=3), *S. durga* OIH108 (n=1), *S. lanjakensis* OIH305 (n=1), *S. lucens* OIH125 (n=1), *S. malaccana* OIH302 (n=1), *S. multifolia* OIH111 (n=1), *S. nigra* OIH76 (n=1), *S. petiolata* OIH71 (n=1), *S. pseudoreticosa* OIH83 (n=2), *S. stenophylla* OIH106 (n=1), *S.* aff. *stenophylla* OIH107 (n=1) and *H.* aff. *extensum* OIH304 (n=1). *Ex situ* observations were conducted from November 2013 till July 2016 on the living collections at the Botanical Research Centre, Semenggoh, Kuching, Sarawak for *S. argentea* OIH320 (n=4), *S. biru* OIH87 (n=1), *S. calcicola* OIH81(n=3), *S. durga* OIH84 (n=11), *S. durga* OIH96 (n=6), *S. durga* OIH97 (n=1), *S. durga* OIH108 (n=3), *S. hasta* OIH80 (n=8), *S.* aff. *klossii* OIH166 (n=1), *S. kunstleri* var. *kunstleri* OIH161 (n=1), *S. kunstleri* var. *speciosa* OIH162 (n=2), *S. limiana* OIH118 (n=3), *S. malaccana* OIH302 (n=4), *S. multifolia* OIH112 (n=2), *S.* aff. *nigra* OIH77 (n=3), *S.* aff. *nigra* OIH90 (n=2), *S. penyamar* OIH137(n=4), *S. petiolata* OIH71

(n=4), *S. polyphylla* OIH119 (n=8), *S. pseudoreticosa* OIH83 (n=8), *S. scintillans* OIH141 (n=7), *S. stenophylla* OIH88 (n=1), *S. stenophylla* OIH106 (n=2), *S.* aff. *stenophylla* OIH92 (n=1), *B.* aff. *puchella* OIH100 (n=1), *B.* aff. *puchella* OIH123 (n=2), *B.* aff. *puchella* OIH127 (n=1), *H.* aff. *uniflorum* OIH101 (n=1), *H.* aff. *uniflorum* OIH113 (n=3) and *H.* aff. *uniflorum* OIH153 (n=1). Images were taken using a Nikon D3000 digital camera.

Field observation on the pollination process was carried out from November 2013 to January 2016 for *S. biru* OIH75 (n=3), *S. biru* OIH87 (n=3), *S. calcicola* OIH81 (n=5), *S. durga* OIH84 (n=4), *S. graveolens* OIH116 (n=1), *S. lanjakensis* OIH309 (n=1), *S. lanjakensis* OIH310 (n=6), *S. lucens* OIH125 (n=4), *S. malaccana* OIH302, *S. multiflora* OIH111 (n=4), *S. nigra* OIH76 (n=3), *S. petiolata* OIH71 (n=9), *S. stenophylla* OIH74 (n=4), *S. stenophylla* OIH106 (n=2) and *B. parva* OIH109 (n=2). Insect visitation was observed and recorded. Images were captured by using a Nikon D3000 digital camera. Only the insect visitors that touched both stigma and anther were considered as effective pollinators (Sakai et al., 1999). Vouchers of pollinators were collected (using insect net), measured, identified (by Christopher Darling, University of Toronto; Royal Ontario Museum) and deposited in Sarawak Zoology Museum.

5.2.2.1 Stigma Receptivity Test

The stigma was tested hourly with Peroxtesmo esterase indicator paper liquid following Dafni and Maués (1998). Due to a stigma can be tested once only, the stigmas of same species from different flowers in different hour were tested (pseudo-chronological sequences). Once the first end time of receptivity was recorded, the test was repeated four

times (if all stigmas remained negative result; n=5) for the stigma in the same hour. If the stigma showed positive result, the test was repeated for the stigma in one more hour until the maximum end time of receptivity was recorded. The tested species were *S. argentea* OIH320, *S. calcicola* OIH81, *S. kunstleri* var. *kunstleri* OIH161, *S. limiana* OIH118, *S. polyphylla* OIH119, *S. pseudoreticosa* OIH83 and *S. malaccana* OIH302.

5.2.2.2 Pollen Germination Test

The anthers were collected from the blooming flowers. The mature pollen was obtained from the anthers and tested using hanging drop method with various sucrose solutions initially (0%, 5%, 10%, 15%, 20%, 25%; with boric acid and calcium nitrate; modified from Rodriguez-Riano and Dafni (2000)). After the optimum concentration was obtained, the first-day, second-day and third-day pollen (anthers were stored in 1.5 ml tubes at room temperature; n=5) was tested with the solution with the optimum concentration. The germinated pollen was counted under a light microscope (MOTIC BA210). The species included in this test were *S. calcicola* OIH81, *S. limiana* OIH118 and *S. malaccana* OIH302.

5.2.2.3 Self-pollination/autogamy Test

Two self-pollination tests were carried out for *S. argentea* OIH320, *S. calcicola* OIH81, *S. durga* OIH84, *S. hasta* OIH80, *S. kunstleri* var. *kunstleri* OIH161, *S. limiana* OIH118, *S. lucens* OIH125, *S. malaccana* OIH302, *S. petiolata* OIH71, *S. pseudoreticosa* OIH83 and *S. scintillans* OIH141:

1) Bagging test - Five inflorescences were bagged before flower opening to assess the possibility of natural self-pollination (modified from Zhang et al., 2011).

2) Artificial self-pollination test - The inflorescences were bagged after the pollen was artificially transferred on the stigma of the same flower (n=5; modified from Zhang et al., 2011).

5.2.2.4 Floral Microstructures

Attempts were made for inspecting floral microstructures of *S. biru* OIH87, *S. biru* OIH254, *S. calcicola* OIH81, *S. durga* OIH84, *S. graveolens* OIH116, *S.* aff. *klossii* OIH168, *S. kunstleri* var. *kunstleri* OIH161, *S. lucens* OIH125, *S. malaccana* OIH302, *S.* aff. *nigra* OIH76, *S. petiolata* OIH71, *S. petiolata* OIH72, *S. polyphylla* OIH289, *B. parva* OIH109 and *Plagiostachys crocydocalyx* OIH269. Mature flowers were fixed with FAA fixative solution (50% alcohol, 10% formaldehyde, 5% acetic acid, 35% water) and preserved in 70% ethanol. The floral parts were dissected and dehydrated with a series of graded ethanol until absolute ethanol and temporary stored in acetone before processed to Critical Point Drying (CPD) with CO_2 as transitional medium. After mounting the specimens on metal stubs, the specimens were gold-coated and viewed under JEOL JSM-6390LA Scanning Electron Microscope (SEM) (modified from Low et al., 2015).

5.2.2.5 Pollen Morphology

The pollen was sampled from fresh stamen (pollen from preserved materials showed shrinkage of c. 10 μm, Ooi, per. obs.) and spread on metal stubs. The investigated species were *S. argentea* OIH320, *S. biru* OIH87, *S. calcicola* OIH81, *S. durga* OIH84, *S. durga* OIH96, *S. graveolens* OIH116, *S. hasta* OIH80, *S.* aff. *klossii* OIH166, *S. kunstleri* var. *kunstleri* OIH161, *S. kunstleri* var. *speciosa* OIH163, *S. limiana* OIH118, *S. lucens* OIH125, *S. malaccana* OIH302, *S. multifolia* OIH112, *S. nigra* OIH76, *S.* aff. *nigra* OIH77,

S. penyamar OIH137, *S. petiolata* OIH71, *S. polyphylla* OIH119, *S. pseudoreticosa* OIH83, *S. reticosa* OIH79, *S. reticosa* ZI139, *S. scintillans* OIH141, *S. stenophylla* OIH106, *S.* aff. *stenophylla* OIH92, *S. uniflora* OIH82, *B. orbiculata* OIH299, *B. parva* OIH261, *B.* cf. *parva* OIH128, *B.* aff. *puchella* OIH99, *B.* aff. *puchella* OIH100, *B.* aff. *puchella* OIH117, *B.* aff. *puchella* OIH123, *B.* aff. *puchella* OIH127, *B. variegata* OIH294, *H.* aff. *magnum* OIH133, *H.* aff. *uniflorum* OIH113, *H.* aff. *uniflorum* OIH153, *K. pulchra* OIH169 and *P. crocydocalyx* OIH269. At least five pollen grains were dissected by using scalpel under a binocular dissecting microscope (MOTIC SMZ-168). The samples were coated with gold and viewed under JEOL JSM-6390LA Scanning Electron Microscope (SEM) (modified from Low et al., 2015) at Microscopy Lab, Lower Ground, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak.

5.2.2.6 Pollen, Pollinator and Stigma

For further investigation of the interaction between the plant and the pollinator, Scanning Electron Microscopy (SEM) was employed to search the pollen attached on the insect body and the pollen deposited on stigma for *S. multifolia* OIH111. The insect was captured using a insect net when it was visiting the flower. Then, the stigma of the flower was carefully collected. The captured insect was kept in a killing jar (with ethyl acetate as killing agent) for 1 hour and dried with silica gel for three days. The samples were mounted on metal stubs and coated with gold for viewing under SEM (JEOL JSM-6390LA).

5.2.2.7 Pollen Histochemistry

For investigating the pollen's nutrition reservoir, the fresh pollen from dehiscing anthers (n=5) were collected and tested with (1) a drop of Iodine Potassium Iodide (IKI) solution

for the presence of starches and (2) a drop of Sudan IV solution for the presence of lipids separately. The species included in this test were *S. argentea* OIH320, *S. calcicola* OIH81, *S. durga* OIH84, *S. hasta* OIH80, *S. limiana* OIH118, *S. malaccana* OIH302 and *B. parva* OIH109. The pollen samples were examined under a light microscope (modified from Wang et al., 2004).

5.2.2.8 Pollen: Ovule Ratios

The stamen prior to anther dehiscing was collected and preserved in a 1.5 ml tube with 300 μl 70% ethanol for *S. argentea* OIH320 (n=3), *S. calcicola* OIH81 (n=5), *S. durga* OIH84 (n=4), *S. graveolens* OIH116 (n=3), *S. hasta* OIH80 (n=4), *S. limiana* OIH118 (n=3), *S. kunstleri* var. *kunstleri* OIH161 (n=4), *S. malaccana* OIH302 (n=3) and *B. parva* OIH109 (n=3). The suspension was stirred for 60 seconds using a voltex mixer. 50 drops (1 μl each) of the samples were transferred onto the slides. The pollen numbers were counted by using a light microscope (MOTIC BA210). The ovary was artificially opened with scalpel. After that, all ovules with placenta were put on a slide with a drop of water and counted with the aid of binocular dissecting microscope (MOTIC SMZ-168) (modified from Wang et al., 2004).

5.2.2.9 Natural Fruit Set Percentage

Inflorescences with flowers successfully pollinated were tagged and monitored weekly until fruit maturity/seed dispersal for *S. multifolia* OIH111 (n=1), *S. stenophylla* OIH74 (n=1), *S. stenophylla* OIH106 (n=2) and *S.* aff. *stenophylla* OIH107 (n=1) to observe the fruiting process. The ratio between the total number of fruits found and the total number of flowers found were calculated and defined as the fruit set percentage to assess the

effectiveness of the pollination on *S. lanjakensis* OIH310 (n=1), *S. calcicola* OIH81 (n=4), *S. uniflora* OIH82 (n=1), *S. graveolens* OIH116 (n=2), *S. lucens* OIH125 (n=2), *S. limiana* OIH118 (n=1), *S. argentea* (n=1), *S. biru* OIH75 (n=4), *S. biru* OIH87 (n=2), *S. durga* OIH84 (n=1), *S. durga* OIH108 (n=1), *S. hasta* OIH80 (n=1), *S. multifolia* OIH111 (n=3), *S. nigra* OIH76 (n=3), *S. petiolata* OIH71 (n=2), *S. pseudoreticosa* OIH83 (n=2), *S. reticosa* OIH79 (n=3), *S. stenophylla* OIH74 (n=4), *S. stenophylla* OIH106 (n=4), *S.* aff. *stenophylla* OIH107 (n=2), *S. malaccana* OIH302 (n=3), *B. parva* OIH109 (n=2), *B. parva* OIH261 (n=3) and *B.* aff. *puchella* OIH117 (n=2).

5.2.2.10 Floral Volatile Organic Compounds (VOCs) Analysis

In order to investigate the chemical compositions that are responsible for the floral odour, Floral Volatile Organic Compounds (VOCs) Analysis (modified from Hoe et al., 2016) was conducted. Floral scent of *S. argentea* OIH320 (n=2), *S. biru* OIH87 (n=2), *S. calcicola* OIH81 (n=2), *S. durga* OIH84 (n=4), *S. durga* OIH96 (n=2), *S. durga* OIH260 (n=2), *S. hasta* OIH80 (n=2), *S. limiana* OIH118 (n=2), *S. lucens* OIH125 (n=2), *S. lucens* OIH263 (n=2), *S.* aff. *klossii* OIH166 (n=2), *S. kunstleri* var. *kunstleri* OIH161 (n=2), *S. kunstleri* var. *speciosa* OIH162 (n=1), *S. malaccana* OIH302 (n=4), *S. multifolia* OIH112 (n=3), *S.* aff. *nigra* OIH77 (n=2), *S. petiolata* OIH71 (n=2), *S. pseudoreticosa* OIH83 (n=2), *S. polyphylla* OIH119 (n=2), *S. polyphylla* OIH289 (n=1), *S. stenophylla* OIH106 (n=1), *S. scintillans* OIH141 (n=2) and *B.* aff. *puchella* OIH100 (n=1) was collected using dynamic headspace method. The elements with opening flower were bagged individually at 6:00 am using PolyEthylene Terephthalate (PET) film oven bag (EasyRoast^{TM}, Bacofoil, UK). After that, the floral volatile compounds were trapped with absorbent polymer in glass tube (ORBO^{TM} 402 Tenax® TA 35/60 mesh, 100/50 mg; Sigma-Aldrich,

USA) by slowly draining the scented air at a constant flow rate (200 $mlmin^{-1}$) using the vaccum pumps (Spectrex PAS-500 Micro Air Sampler; Spectrex, USA). A preliminary experiment was carried out *S. malaccana* OIH302 to test the optimum trapping duration: 2 hours, 3 hours and 6 hours samples. The optimum trapping duration was 6 hours from 6:30 am to 12:30 pm. A control sample without flower was collected at the same time. The trapped compounds were eluted from the absorbent tube by using 4 ml hexane (≥ 98.5% purity, MERCK, Germany) as solvent and stored at -20°C until analysis.

Prior analyses, 1200 µL eluted samples were concentrated to c. 40 µL and mixed 10 µL of tetradecane (internal standard, 25 ng/µL) under the fumehood. The concentrated sample were analyzed by using Gas Chromatography Mass Spectrometer (SHIMADZU GC-2010 + SHIMADZU GC-MS-QP2010 Plus) at Gas Chromatography Lab, Lower Ground, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, with two types of columns, BPX5 intermediate polar column (29.5 m long, 0.23 mm inner diameter and 0.25 µm film thickness) and BP20 polar column (30 m long, 0.25 mm inner diameter and 0.25 um film thickness). For BPX5 intermediate polar column, the GC oven temperature was set initially at 35 ℃, increased at a rate of 2 ℃ min^{-1} to 47.5 ℃, then 3 ℃ min^{-1} to 220 ℃ and held steady for 20 min. 1 µL of *S. biru* OIH87 (n=1), *S. durga* OIH260 (n=1), *S.lucens* OIH125 (n=1), *S.* aff. *klossii* OIH166 (n=2) and *S. malaccana* OIH302 (n=2) concentrated sample was injected in splitless mode for analysis. The GC oven temperature was set at 30 ℃ for 5 min, increased at a rate of 1 ℃ min^{-1} to 32 ℃, then 3 ℃ min^{-1} to 200 ℃ and held steady for 20 min for the BP20 polar column. 1 µL of each concentrated sample was injected in splitless mode to analyze the samples of *S. argentea* OIH320 (n=2), *S. biru* OIH87 (n=2), *S. calcicola* OIH81 (n=2), *S. durga* OIH84

(n=4), *S. durga* OIH96 (n=2), *S. durga* OIH260 (n=2), *S. hasta* OIH80 (n=2), *S. limiana* OIH118 (n=2), *S. lucens* OIH125 (n=2), *S. lucens* OIH263 (n=2), *S.* aff. *klossii* OIH166 (n=2), *S. kunstleri* var. *kunstleri* OIH161 (n=2), *S. kunstleri* var. *speciosa* OIH162 (n=1), *S. malaccana* OIH302 (n=4), *S. multifolia* OIH112 (n=3), *S.* aff. *nigra* OIH77 (n=2), *S. petiolata* OIH71 (n=2), *S. pseudoreticosa* OIH83 (n=2), *S. polyphylla* OIH119 (n=2), *S. polyphylla* OIH289 (n=1), *S. stenophylla* OIH106 (n=1), *S. scintillans* OIH141 (n=2) and *B.* aff. *puchella* OIH100 (n=1).

The injector temperature of both columns were set to 200 ℃, gas flow of the carrier was maintained at a constant 100 psi pressure, quadrupole and MS source temperatures were set at 220 ℃ and 200 ℃ respectively and mass spectra were taken from m/z 35 – 350 in EI (electron ionization) mode. The Kovats Retention Indexes (KIs) of the VOCs were obtained with an external standard ($C_7 – C_{40}$ saturated alkanes, Supelco, USA). Compounds were identified by comparing their retention indexes and mass spectra with the authentic references available in nist08 Library Mass Spectral Database, a commercially available mass spectral library. The relative amounts of each compound were determined by the integrated peak areas on the chromatograms. Kruskal-Wallis test with Mann-Whitney pairwise comparison was performed using Paleontological Statistics (PAST) version 2.17 (Hammer et al., 2001) for the relative amount of the floral VOCs.

5.3 Results and Discussion

5.3.1 Flowering Mechanism and Pollination Observation

As mentioned in previous chapters, the members of the *Scaphochlamys* clade possessed various types of inflorescences from the emerged position, elongation of the rachis, bracts

arrangements to the number of flowers within a bract. However, the flowering sequence was observed to be always from base to apex and repeated from base to apex for those species with two or more flowers within a bract (second round or more) because, basally, the fertile elements and inflorescences of these species have the same basic architecture in the structure and diversified to various appearances. Mostly, the inflorescences of the Bornean species are borne at the base of a leaf, only one upper branch developed into full leaf (with lamina and leaf sheath; Figure 5.1A). Occasionally, *S. graveolens* and *S. lucens* may have inflorescences between two fully developed leaves with leafless sheaths at the base of the element (Figure 5.1B) like *S. kunstleri*, *S. malaccana* (sometimes) and *S. polyphylla* (sometimes). Perhaps these plants were on the late transition stage from juvenile polyphyllous form to monophyllous adult form but the capability of reproduction already started (adolescent stage). For *S. multifolia*, the inflorescences are terminal within leafless sheaths because the lamina is not developed? (Figure 5.1C). Sometimes, for polyphyllous species like *S. malaccana* and *S. polyphylla*, all leaf laminae are fully developed without the presence of the leafless sheaths (Figure 5.1D). Thus, the position of the inflorescence on the fertile elements may appear to vary.

An inflorescence of *Scaphochlamys* comprises one to many cincinni (with bracteoles and flowers), each subtended by a bract as stated in previous studies (Smith, 1987; Searle, 2010; Figure 5.2A). The first bracteole was observed to be always more or less keeled (see Section 3.3.1.6 Bracteoles), this structure is the prophyll (true bract) of an inflorescence and the subsequence bracteoles are the cataphylls. The bracts are modified leafless sheaths. Although the number and dimensions of cincinni may vary in each species

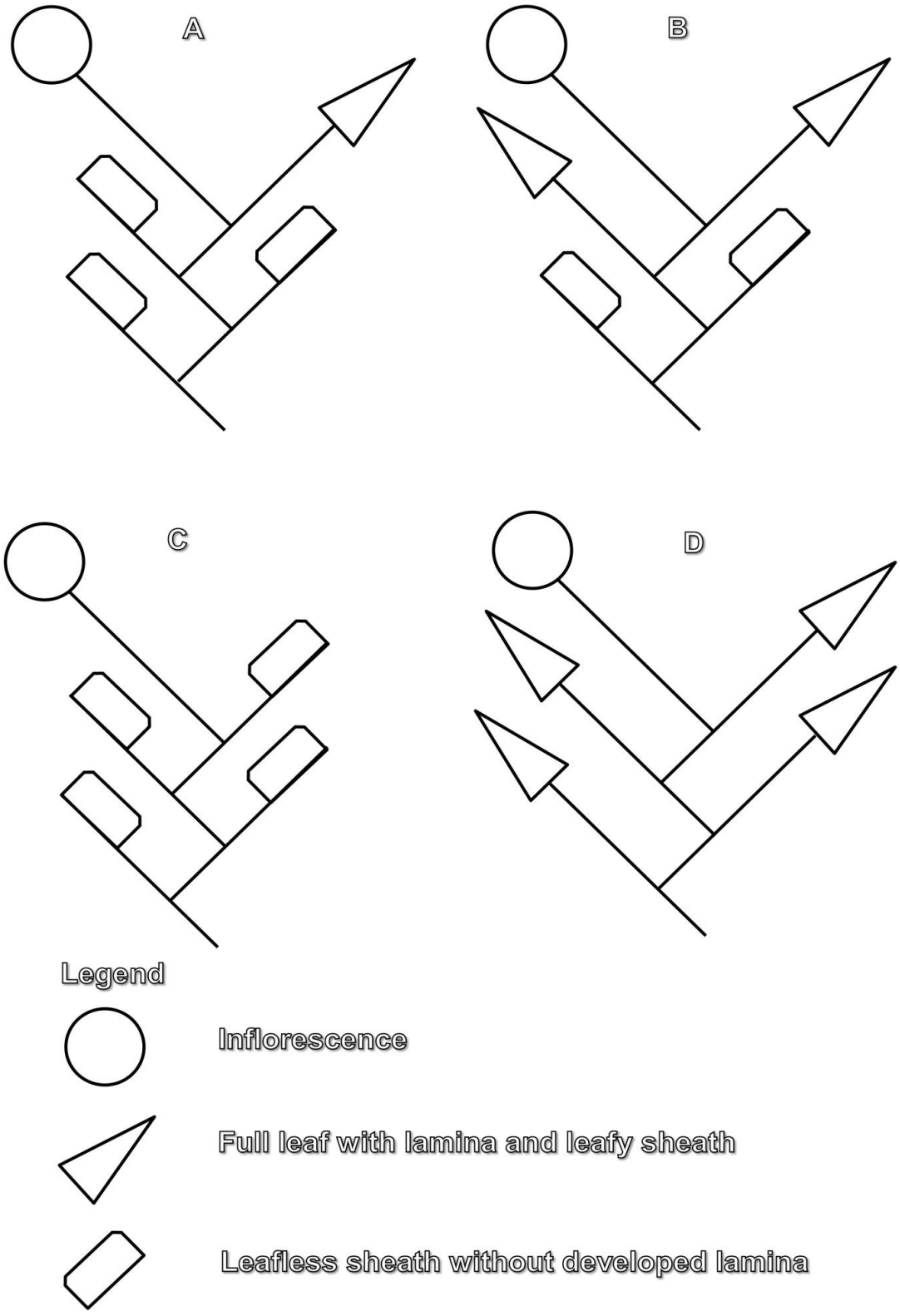


Figure 5.1: Schismatic diagram of fertile elements — A: inflorescence that borne at base of a full leaf within leafy sheath; B: inflorescence emerged between two or more leaves with leafless sheaths at the base of the element; C: inflorescence that terminal within leafless sheaths; D: inflorescence that terminal between the upper two leaves with multiple full leaves and no leafless sheaths; (not to exact number of branches nor measurement) – illustrated by Ooi I. H.

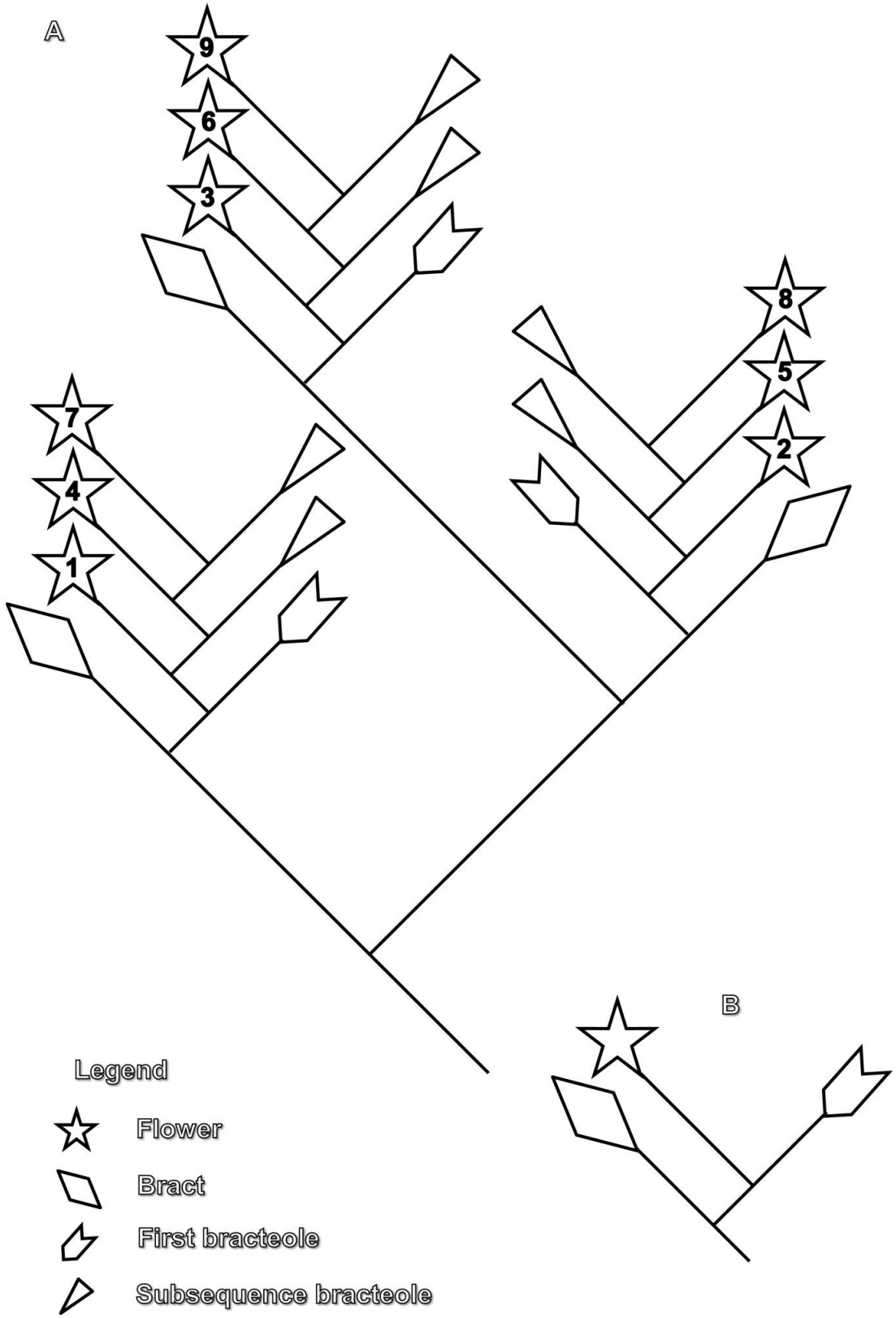


Figure 5.2: Schismatic diagram of inflorescence structure — A: typical inflorescence with the position of bracts, first bracteole, subsequence bracteoles and flowers, noted the number showing flowering sequence; B: a solitary cincinnus, only single flower and first bracteole, without subsequence braches developed (not to exact number of branches nor measurement) – illustrated by Ooi I. H.

or sometimes within populations, the architecture and flowering sequence is always similar (Figure 5.2A).

This is different from *Boesenbergia* (Sakai & Nagamasu, 2006a). The flowering sequence of *Scaphochlamys* was observed to be acropetalous, from the flower within the first bracteole of the cincinnus at base to the flower within the first bracteole of a cincinnus at apex. Then, the flowering continued (on the secondary or later branching), repeated acropetalously from the flower within the subsequence bracteole of the cincinnus at base to the flower within the subsequence bracteole of a cincinnus at apex and so on. In *S. biloba, S. nigra,* and *S. uniflora,* the subsequence branching is not developed or reduced with only one flower in a cincinnus (Figure 5.2B).

Only a single flower per inflorescence bloomed at a time (perhaps for promoting allogamy, least likely to be geistonogamy) but two flowers might open (rare occurrence) at the same time. The flowers of all observed *Scaphochlamys* specie are one-day diurnal flowering. When the emerged bud was near mature, the floral tube elongated (opening soon on the next day, usually can be estimated by the corolla lobes/petals reached the 'mature' length). The flowers open in the next morning. After revealing the stigma and anthers, the stigma secreted liquid. The anthers dehisced longitudinally from the middle till both end to release the pollen either simultaneously with stigma secretion or later. In the afternoon, the flowers gradually wilted and degraded by the next morning without any stigma movement. Thus, the one-day flowering process of *Scaphochlamys* is different to the two-day flowering *Boesenbergia* and *Haplochorema*. Besides, *Boesenbergia* and *Haplochorema* species were observed to have stigma movement; the stigma gradually

distanced from the anther crest till curved down (the *Boesenbergia* flower is more or less perpendicular to inflorescence axis) or partially blocking the entrance to floral tube (the *Haplochorema* flowers are more or less upright). The summarized flowering mechanism data is presented in Table 5.2. The observations on each investigated species were included in the following part Section 5.3.1.1.

5.3.1.1 Observation on the Investigated Taxa

1) Anomala group

1.1) *Scaphochlamys lanjakensis* (Figure 5.3)

The mature bud began to open in the early morning at c. 0645 (local time, UTC + 0800). The flower gradually opened to expose the stigma and stamen. The stigma secreted the stigmatic secretion at c. 0730. The anthers dehisced and began to release pollen from the middle of the thecae at c. 0830. There was no noticeable odour during anthesis. Small traplining Halictid bees (c. 10mm long; Halictidae: Halictinae: *Sphecodes* sp) visitations were encountered (since c. 0825 until c. 1240). The bees landed on the flower, crawled on the labellum, moved towards the floral tube to consume the nectar and departed with revisitations. While trusting in towards the floral tube, the head of the bees and occasionally the thorax (especially the front part of the head) were slightly lifted and brushed through the stigma and touched the anthers. Occasionally, yellow ants came to collect the pollen from anthers without touching stigma. The flower began to wilt after c. 1400 in the afternoon and degraded by the next morning.

Table 5.2: The anthesis timing, stigma movement and floral odour of the investigated taxa are listed.

	Species name	Accession number	Anthesis start/flower opening (Mean & range)	Stigma secretion visible	Pollen released	Anthesis end/flower start degrading	Stigma movement	Odour
Anomala group	*S. lanjakensis*	OIH305[1]*	6:45 am 6:45 am	7:30 am 7:30 am	8:30 am 8:30 am	By 2:00 pm degraded by next day	No	No
	S. penyamar	OIH137[4]	6:15 am 6:00 – 6:45 am	7:07am 6:45 – 8:00am	8:56 am 8:00 – 9:45 am	By 2:00 pm degraded by next day	No	Very mild torch ginger-like
	S. scintillans	OIH141[7]	6:51 am 6:45 – 7:00 am	7:32 am 7:15 – 8:15 am	8:10 am 7:15 – 8:45 am	By 2:00 pm degraded by next day	No	No
Calcicola group	*S. calcicola*	OIH81[4]*	5:56 am 5:00 – 6:45 am	6:41 am 6:15 – 7:15 am	7:30 am 7:00 – 8:30 am	By 2:00 pm** degraded by next day	No	No
Graveolens group	*S. lucens*	OIH125[1]*	6:00 am 6:00 am	6:30 am 6:30 am	7:15 am 7:15 am	By 2:00 pm degraded by next day	No	Foul
Limiana group	*S. limiana*	OIH118[3]	5:55 am 5:00 – 6:30 am	6:50 am 6:15 – 7:45 am	8:35 am 8:00 – 9:15 am	By 2:00 pm** degraded by next day	No	Very mild resinous
Petiolata group	*S. argentea*	OIH320[4]	6:00 am 6:00 am	6:48 am 6:45 – 7:00 am	7:56 am 7:15 – 9:45 am	By 2:00pm** degraded by next day	No	No

Table 5.2 continued

S. biru	OIH87[2]*	6:00 am 6:00 am	6:37 am 6:00 – 6:45 am	7:22 am 7:15 – 7:30 am	By 2:00 pm degraded by next day	No	Mild lemon grass-like
S. durga	OIH84[14]*	5:58 am 4:45 – 7:30 am	6:50 am 6:00 – 7:45 am	7:46 am 6:30 – 8:30 am	By 2:00 pm degraded by next day	No	Mild torch ginger-like
S. durga	OIH96[6]	7:37 am 6:30 – 9:45 am	8:10 am 7:00 – 10:00 am	8:47 am 7:30 – 10:15 am	By 2:00 pm degraded by next day	No	Mild torch ginger-like
S. durga	OIH97[1]	6:00 am 6:00 am	7:00 am 7:00 am	11:00 am 11:00 am	By 2:00 pm degraded by next day	No	Mild torch ginger-like
S. durga	OIH108[4]*	5:11 am 5:00 – 5:30 am	6:26 am 5:30 – 7:15 am	7:52 am 7:15 – 8:45 am	By 2:00 pm degraded by next day	No	Mild torch ginger-like
S. hasta	OIH80[8]	6:18 am 4:15 – 7:45 am	7:13 am 6:15 – 8:00 am	7:46 am 6:30 – 8:45 am	By 2:00 pm degraded by next day	No	No
S. multifolia	OIH111[1]*	6:00 am 6:00 am	7:15 am 7:15 am	7:45 am 7:45 am	By 2:00 pm degraded by next day	No	No
S. multifolia	OIH112[2]	6:00 am 5:00 – 7:00 am	6:45 am 6:00 – 7:30 am	7:30 am 7:30 am	By 2:00 pm degraded by next day	No	No
S. nigra	OIH76[1]*	6:30 am 6:30 am	7:30 am 7:30 am	7:45 am 7:45 am	By 2:00 pm degraded by next day	No	No
S. aff. *nigra*	OIH77[3]	5:50 am 5:30 – 6:30 am	7:20 am 7:00 – 7:45 am	8:55 am 8:30 – 9:15 am	By 2:00 pm degraded by next day	No	No

Table 5.2 continued

	S. aff. *nigra*	OIH90[2]	5:37 am 5:30 – 5:45 am	7:37 am 7:15 – 8:00 am	No No	By 2:00 pm degraded by next day	No	No
	S. petiolata	OIH71[5]*	6:33 am 4:30 – 8:30 am	7:09 am 5:45 – 8:45 am	7:30 am 6:15 – 8:45 am	By 2:00 pm degraded by next day	No	No
	S. *pseudoreticosa*	OIH83[10]	7:43 am 5:45 – 9:45 am	8:19 am 6:30 – 10:00 am	8:57 am 7:45 – 10:00 am	By 2:00 pm** degraded by next day	No	Very mild torch ginger- like
	S. stenophylla	OIH88[1]	5:45 am 5:45 am	6:45 am 6:45 am	8:00 am 8:00 am	By 2:00 pm degraded by next day	No	Torch ginger- like
	S. stenophylla	OIH106[3]*	6:45 am 6:30 – 7:00 am	7:10 am 6:45 – 7:30 am	8:00 am 7:45 – 8:30 am	By 2:00 pm degraded by next day	No	Torch ginger- like
	S. aff. *stenophylla*	OIH92[1]	6:00 am 6:00 am	6:30 am 6:30 am	7:00 am 7:00 am	By 2:00 pm degraded by next day	No	Torch ginger- like
	S. aff. *stenophylla*	OIH107[1]*	5:00 am 5:00 am	6:30 am 6:30 am	8:00 am 8:00 am	By 2:00 pm degraded by next day	No	Mild torch ginger-like
Polyphylla group	*S. polyphylla*	OIH119[8]	5:07 am 4:30 – 5:30 am	7:05 am 6:45 – 7:30 am	9:05 am 8:15 – 10:15 am	By 2:00 pm** degraded by next day	No	Mild slightly foul
Other taxa	*S.* aff. *klossii*	OIH166[1]	5:30 am 5:30 am	6:30 am 6:30 am	6:30 am 6:30 am	By 2:00 pm degraded by next day	No	Mild sweet fruity lipstick- like

Table 5.2 continued

S. kunstleri var. *kunstleri*	OIH161[1]	4:45 am 4:45 am	5:30 am 5:30 am	7:00 am 7:00 am	By 2:00 pm** degraded by next day	No	Mild woody/gaharu-like
S. kunstleri var. *speciosa*	OIH162[2]	4:22 am 4:15–4:30 am	6:30 am 6:00 – 7:00 am	7:00 am 7:00 am	By 2:00 pm degraded by next day	No	Mild woody/gaharu-like
S. malaccana	OIH302[5]*	5:42 am 5:30 – 6:00 am	6:42 am 6:30 – 6:45 am	6:42 am 6:30 – 6:45 am	By 3:00 pm** degraded by next day	No	Jasmine-like
B. aff. *puchella*	OIH100[1]	3:45 am 3:45 am	-	5:15 am 5:15 am	Last until next day	Stigma curved downward	Very mild 'five spices'-like
B. aff. *puchella*	OIH123[2]	4:00 am 3:45 – 4:15 am	-	5:52 am 5:45 – 6:00 am	Last until next day	Stigma curved downward	No
B. aff. *puchella*	OIH127[1]	4:15 am 4:15 am	-	6:00 am 6:00 am	Last until next day	Stigma curved downward	No
H. aff. *extensum*	OIH304[1]*	2:00 am 2:00 am	-	6:00 am 6:00 am	Last until next day	Stigma distanced from anther crest	No

Table 5.2 continued

H. aff. *uniflorum*	OIH101[3]	4:30 am 4:15 – 4:45 am	-	7:20 am 6:00 – 9:30 am	Last until next day	Stigma distanced from anther crest	Very mild jasmine
H. aff. *uniflorum*	OIH113[1]	3:30 am 3:30 am	-	6:00 am 6:00 am	Last until next day	Stigma distanced from anther crest	No
H. aff. *uniflorum*	OIH153[1]	5:00 am 5:00 am	-	6:30 am 6:30 am	Last until next day	Stigma distanced from anther crest	Very mild sweet flowery

Superscript numbers (e.g. $^{2, 3, 4\ldots}$) show the number of replicates
* indicates that *in situ* observation was included
** indicated that tested with stigma receptivity test

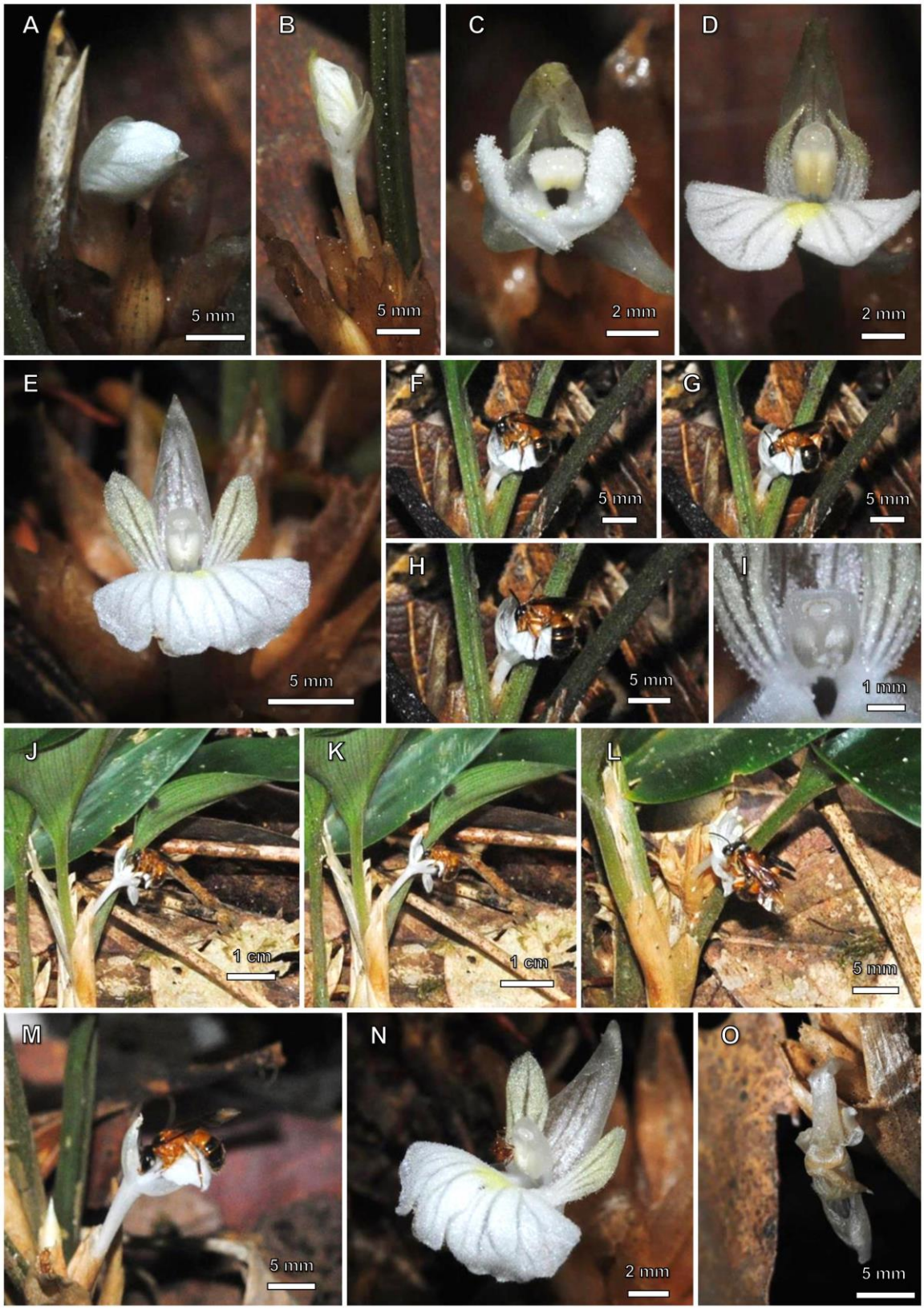


Figure 5.3: *Scaphochlamys lanjakensis* — A: flower bud; B: flower opening; C: stigmatic secretion; D: pollen releasing; E: full-bloomed flower; F-H, J-L & M: Halictid bee visitation, the head was in contact with stigma and pollen during nectar foraging; I: scattered pollen after bee visiting; N: the ant visitation, collecting pollen from aside without touching stigma; O: degraded flower – A-I, M-O from *OIH310*; J-L from *OIH309* – © Ooi I. H.

1.2) *Scaphochlamys penyamar* (Figure 5.4, A-I)

In the early morning, the mature bud started to open at c. 0615. While the flower was gradually opening and partially revealed the stigma and anthers, a drop of the stigmatic fluid was secreted at c. 0707. The pollen released via the dehiscent of longitudinal anthers thecae at c. 0856. During the anthetic period, the flower emitted a very mild torch-ginger-like odour (hardly detected, less than 0.5 cm radius). In the afternoon, the floral scent was no longer detected and the flower began to wilt around 1400. The flower degraded by the next morning.

1.3) *Scaphochlamys scintillans* (Figure 5.4, J-T)

The flower bud started to open at c. 0651 in the early morning. The flower gradually opened to expose the stigma and stamen. At c. 0732, a drop of stigmatic secretion was visible on the stigma. The longitudinal anthers released the pollen from the middle of thecae at around 0810. No odour was detected (via human nose) throughout the anthetic period. The flower began to wilt since c. 1400 and degraded by the next morning. Insect visitors were not observed to visit *S. scintillans* throughout the observational period.

2) Calcicola group

2.1) *Scaphochlamys calcicola* (Figure 5.5)

The flower blooming started at c. 0556 in the morning. The flower opened gradually to reveal the stigma and anthers. A drop of the stigmatic secretion was observed at c. 0641. The longitudinal anthers thecae released the pollen at c. 0730. There was no detectable odour throughout the anthesis. Large traplining *Amegilla* bees (c. 15 mm long; Apidae: Apinae: *Amegilla pendleburyi*) visitations to the flowers was observed (from c. 0835 to c.

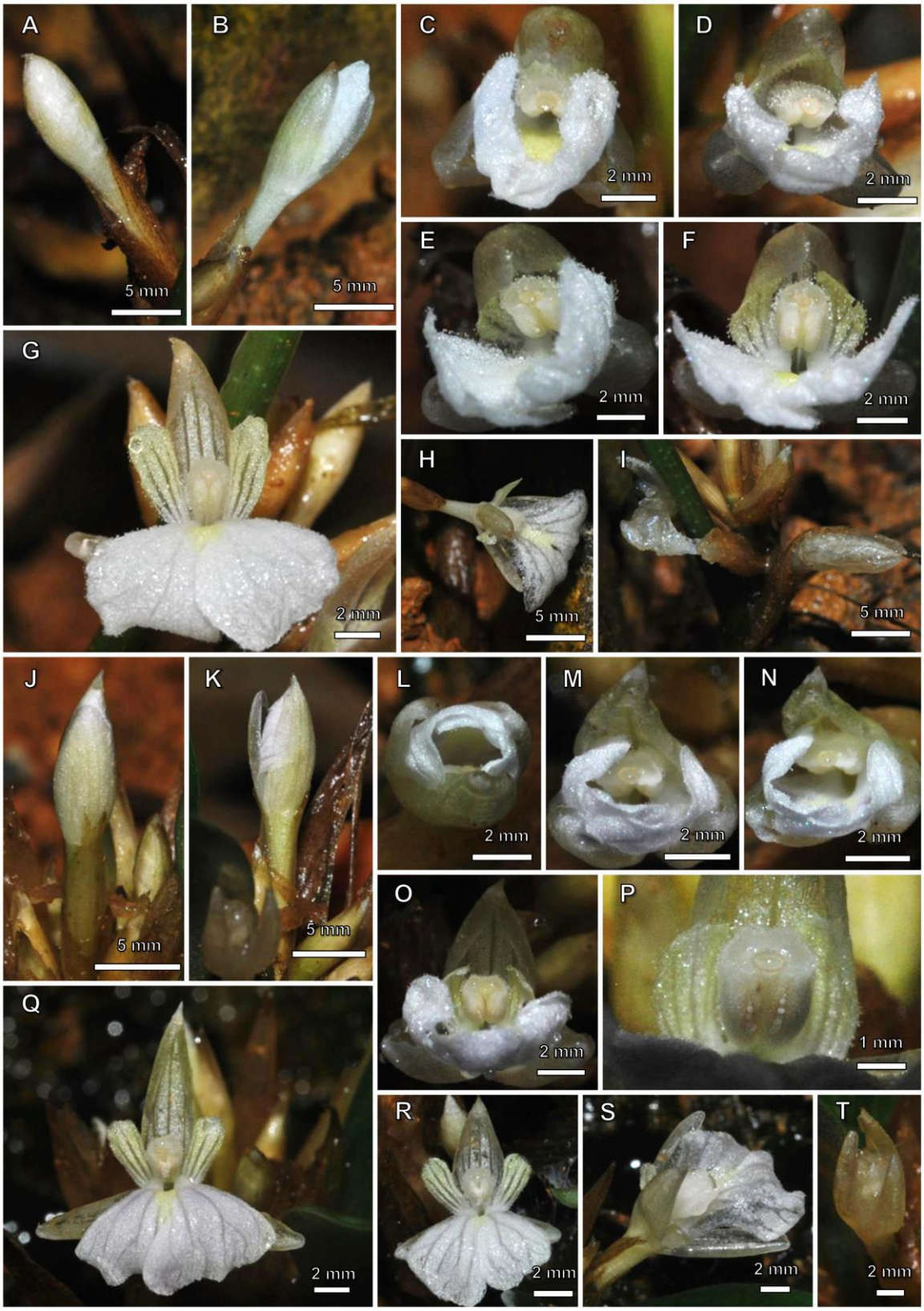


Figure 5.4: *Scaphochlamys penyamar* — A: flower bud; B: flower opening; C & D: stigmatic secretion; E & F: pollen releasing; G: full-bloomed flower; H: flower degrading; I: degraded flowers; *Scaphochlamys scintillans* — J: flower bud; K & L: flower opening; M & N: stigmatic secretion; O & P: pollen releasing; Q & R: full-bloomed flower; S: flower degrading; T: degraded flower – A-I from *OIH137*; J-T from *OIH141* – © Ooi I. H.

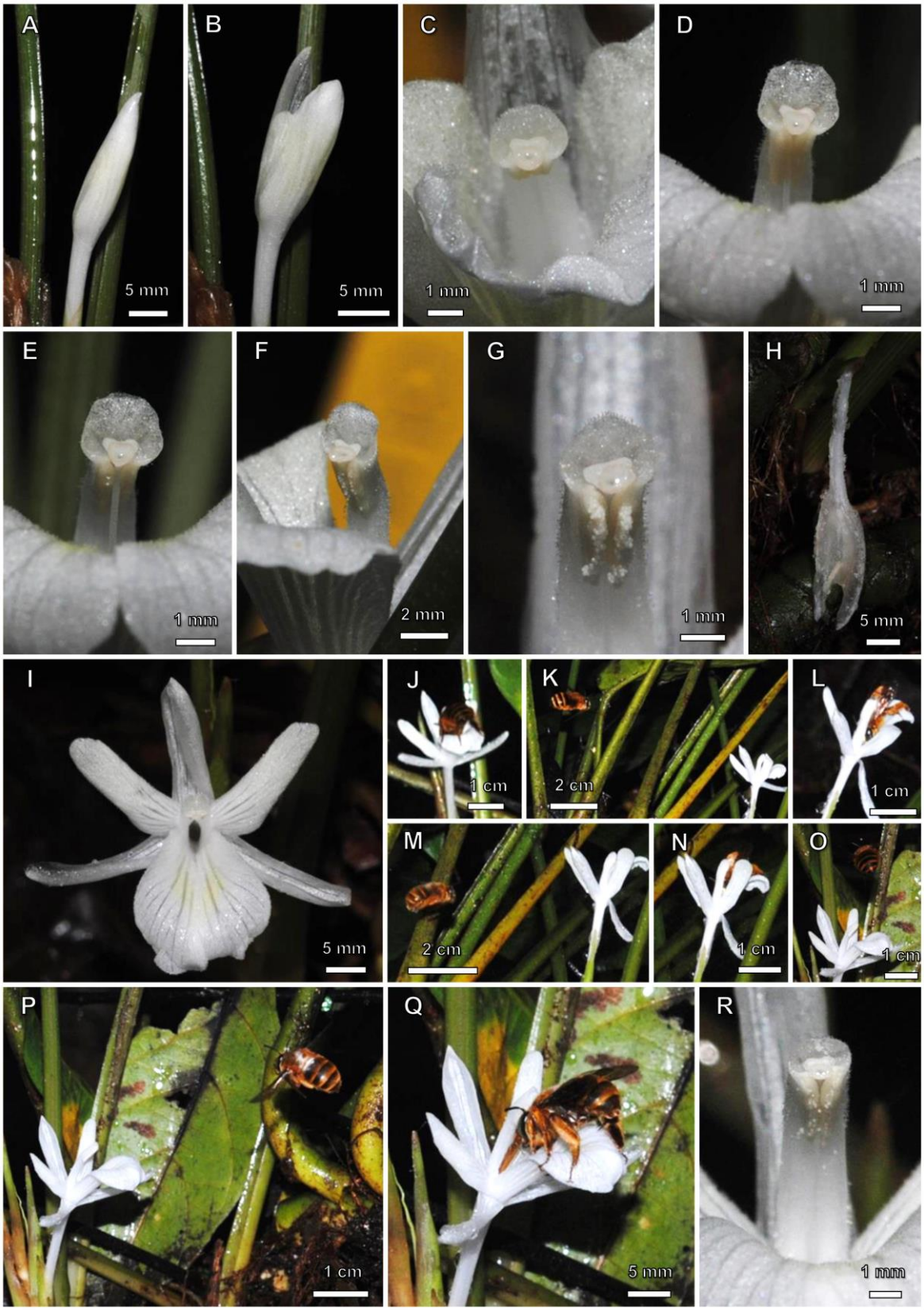


Figure 5.5: *Scaphochlamys calcicola* — A: flower bud; B: flower opening; C & D: stigmatic secretion; E-G: pollen releasing; H: degraded flower; I: full-bloomed flower; J-Q: *Amegilla* bee visitation, head and thorax were in contact with stigma and pollen during nectar foraging; R: scattered pollen after bee visiting – A-R from *OIH81* – © Ooi I. H.

1325). These bees landed on the labellum, pushed in to put the proboscis into the floral tube to consume the nectar. Then, the bees retreated and departed (usually would revisit later). While pushing in to put the proboscis into floral tube, the head and the thorax of the bees (especially the front part of the thorax) slightly lifted the stamen together with the stigma, rubbing through the stigma and physically in contact with the anthers. Around 1400, the degradation of the flower began and was fully degraded by the next morning.

3) Graveolens group

3.1) *Scaphochlamys graveolens* (Figure 5.6, A-H)

Around 1000 to c. 1020, small traplining Halictid bees visited the flower. The bees landed on labellum, crawled towards floral tube, consumed the nectar, departed and revisited later. Due to the relatively larger flower of *S. graveolens* with relatively wider gap between stigma and labellum (c. 3 mm), the Halictid bee body parts did not touch the stigma or lift/shake the stamen. The bees were probably only in contact with the excessively released pollen. Therefore, the status of Halictid bees as the pollinator need to be further investigated.

3.2) *Scaphochlamys lucens* (Figure 5.7)

At c. 0600, the flower began to bloom in the early morning. The blooming flower gradually revealed the stigma and anthers, a drop of secretion was observed at the stigma around 0630. The anthers released pollen at c. 0715. The floral odour was foul (like the remaining water of domestic waste, c. 2 cm radius). The flowers were visited by large traplining *Amegilla* bees from c. 0900 to c. 1300). These bees landed on the labellum, trusted towards floral tube and used proboscis to consume nectar. After that, the bees left

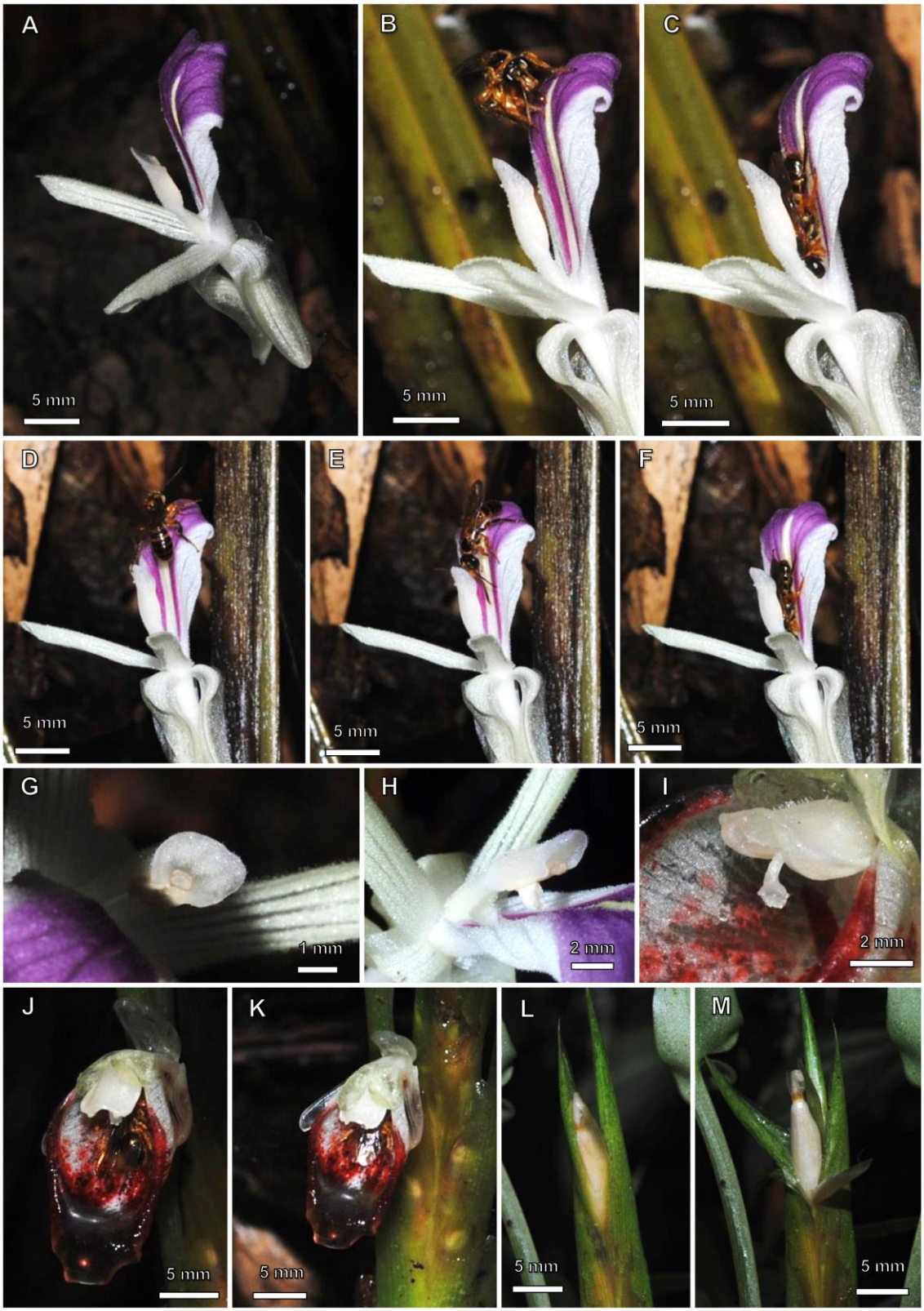


Figure 5.6: *Scaphochlamys graveolens* — A: Blooming flower; B-F: Halictid bee visitation, only in contact with excessively released pollen sometimes but not with stigma, noted the stamen was not moving; G: stigmatic secretion; H: pollen releasing; *Boesenbergia* aff. *puchella* — I: stigma of second-day flower after Halictid bee visitation; J-K: Halictid bee visitation, in contact with the curved stigma; L: fruit; M: fruit, bract and bracteole artificially opened – A-H from *OIH116*; I-M from *OIH117* – © Ooi I. H.

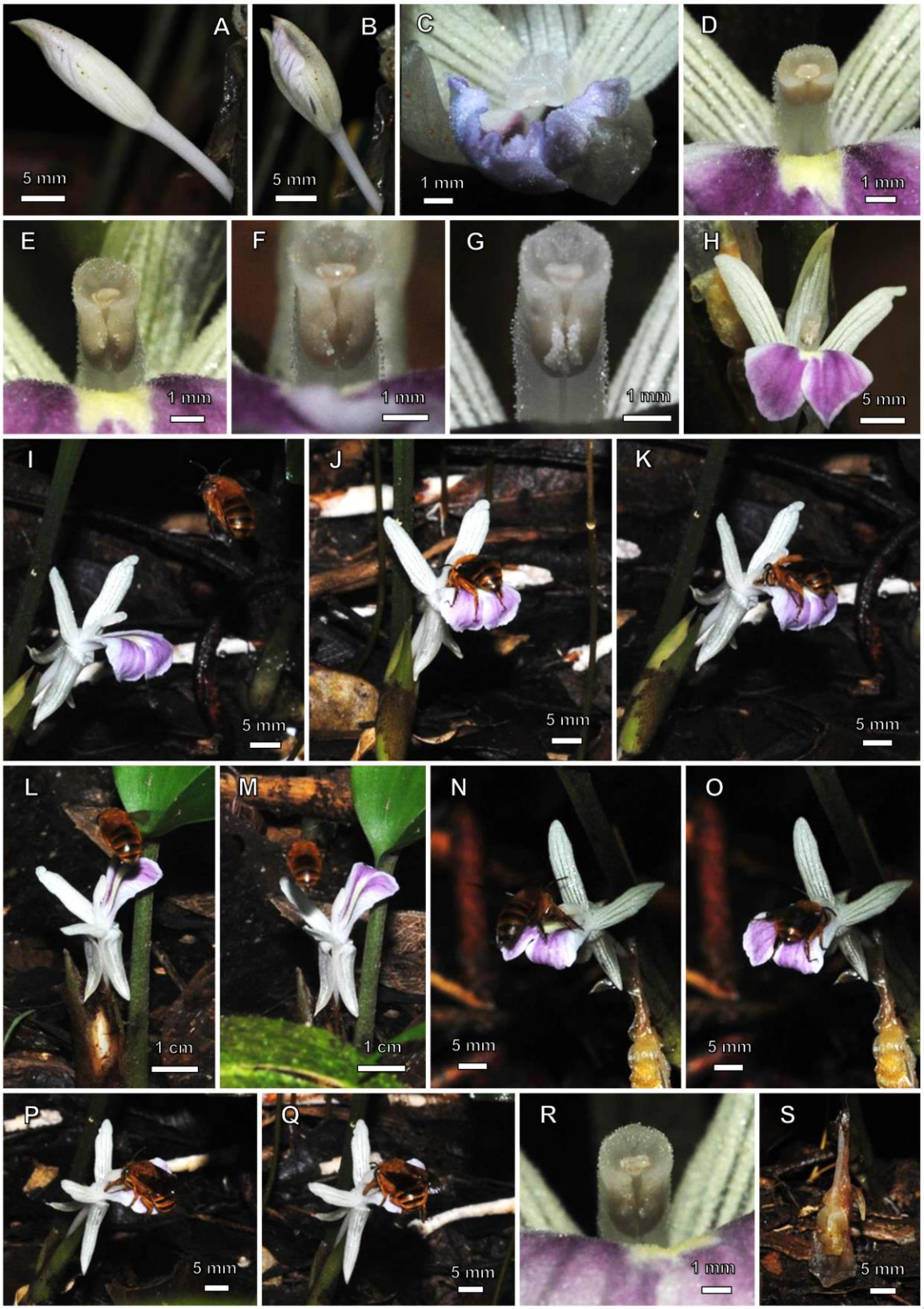


Figure 5.7: *Scaphochlamys lucens* — A: flower bud; B: flower opening; C & D: stigmatic secretion; E-G: pollen releasing; H: full-bloomed flower; I-Q: *Amegilla* bee visitation, head and thorax were in contact with stigma and pollen during nectar foraging; R: scattered pollen after bee visiting; S: degraded flower – A-S from *OIH125* – © Ooi I. H.

the flower but would usually revisit later. While trusting towards floral tube for nectar foraging, the bees slightly lifted the stamen together with the stigma. The head and the thorax of the bees (especially the front part of the thorax) brushed the stigma and were physically in contact with the anthers. The flower started to wilt at c. 1400 and degraded by the next morning.

4) Limiana group

4.1) *Scaphochlamys limiana* (Figure 5.8, A-I)

In the early morning, the mature bud opened at c. 0555. When the stigma and anthers were partially revealed, the stigma secreted a drop of liquid at c. 0650. The pollen was released around 0835. The flower emitted a very mild resinous odour during anthesis (hardly detected, less than 0.5 cm radius). The floral scent was no longer detectable in the afternoon. Meanwhile, the flower started to wilt around 1400. The flower was degraded by the next morning. Insect visitors were not observed to visit *S. limiana* throughout the observational period.

5) Petiolata group

5.1) *Scaphochlamys argentea* (Figure 5.8, J-S)

The mature bud opened at c. 0600 at dawn. The stigma and anthers were revealed after the labellum uncoiled. At the meantime, a drop of secretion was visible on the stigma at c. 0648. The anthers released the pollen at c. 0856. There was no floral odour detected throughout the anthesis. The flower degradation began c. 1400. The flower was degraded by the next morning. Insect visitors were not observed to visit *S. argentea* throughout the observational period.

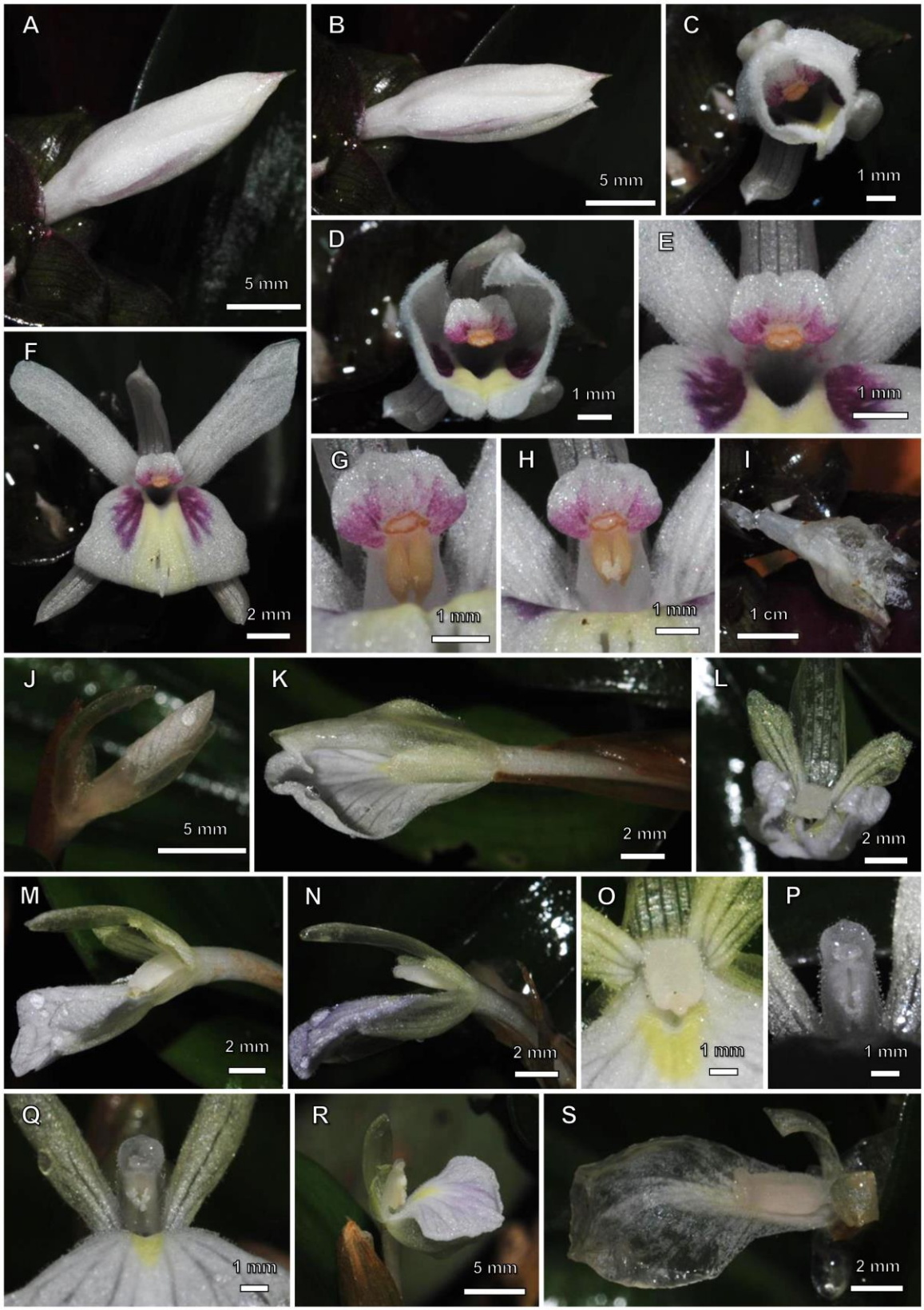


Figure 5.8: *Scaphochlamys limiana*— A: flower bud; B & C: flower opening; D & E: stigmatic secretion; F: full-bloomed flower; G & H: pollen releasing; I: degraded flower; *Scaphochlamys argentea* — J-N: flower opening, flower with white (M) and lilac (N) labellum; O: stigmatic secretion; P-Q: pollen releasing; R: full-bloomed flower; S: flower degrading; T: degraded flower – A-I from *OIH118*; J-S from *OIH320* – © Ooi I. H.

5.2) *Scaphochlamys biru* (Figure 5.9, A-M)

At c. 0600 in the early morning, the mature bud began to open gradually. After the labellum uncoiled, the stigma and anthers were revealed. The stigma was secreting stigmatic fluid at c. 0637. Subsequently, the pollen was released at c. 0722 through the dehiscent of anther thecae. A mild lemon grass-like odour was detectable at c. 1 cm radius around the flower. The flower started to wilt at c. 1400 and degraded by the next morning. If the flower was successfully pollinated, the fruit pericarp split into three to allow the seed to be dispersed when the fruit was ripe after c. 5 weeks. Sometimes, the developing fruit was left with chewed-marks on the cuticle-like pericarp by some unknown herbivores (probably grasshoppers). Insect visitors were not observed to visit *S. biru* throughout the observational period.

5.3) *Scaphochlamys durga* (Figure 5.9, N-AA)

Around 0615 in the morning, the flower bud began to open. At c. 0706, a drop of liquid secretion on the stigma was observed. The anther released pollen via longitudinal thecae at c. 0809. There was a mild torch ginger-like odour at c. 1 cm radius around the flower. The flower began to wilt at c. 1400 and degraded by the next morning. Insect visitors were not observed to visit *S. durga* throughout the observational period.

5.4) *Scaphochlamys hasta* (Figure 5.10, A-N)

The blooming of the flower began at c. 0618 in the morning. The stigma secreted a drop of liquid around 0713. The pollen was released at c. 0746. The flower has no distinctive floral odour. The flower began to wilt c. 1400 and degraded by the next morning. In a cultivated living collection, the ants were observed to collect pollen from the anther without touching

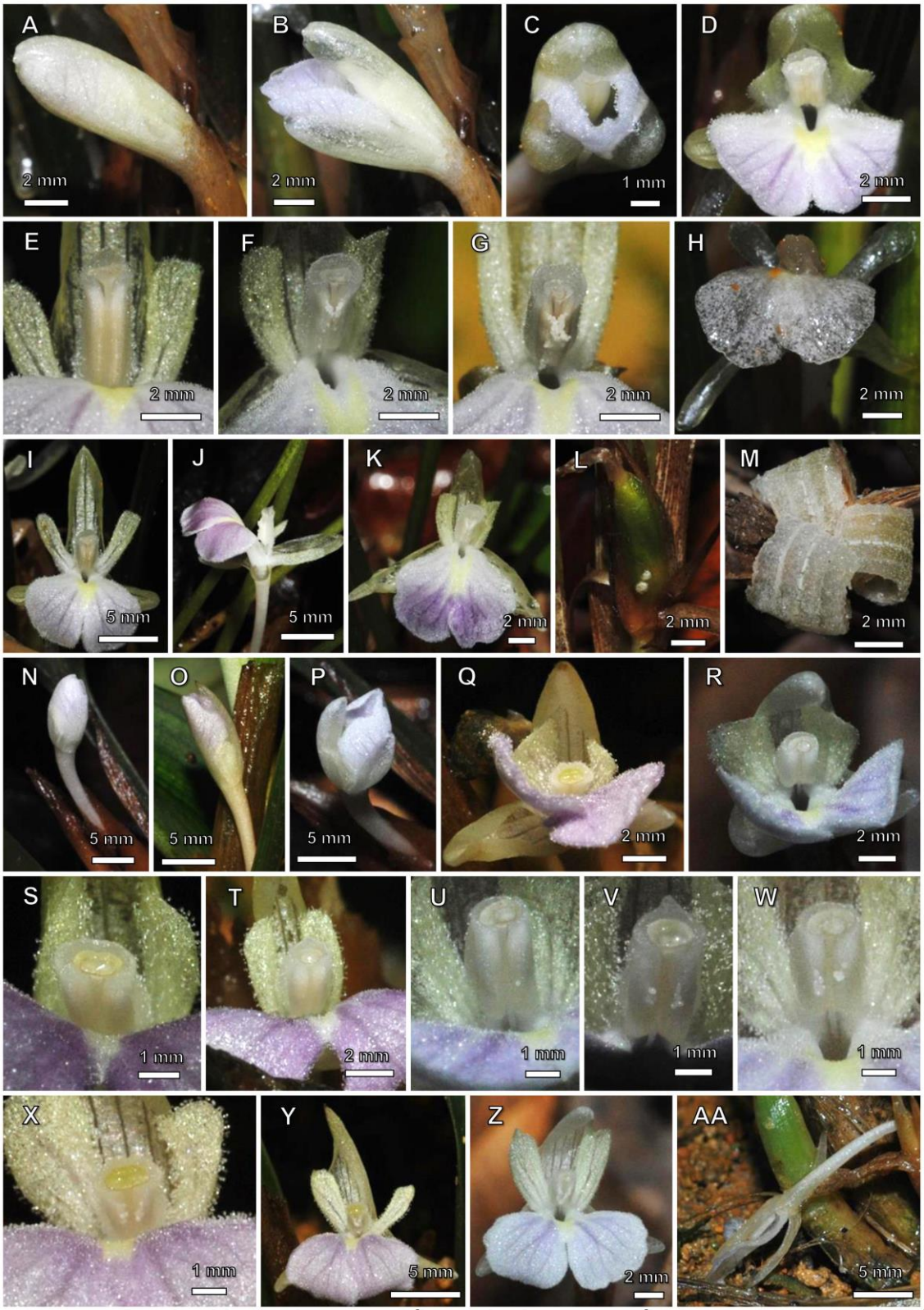


Figure 5.9: *Scaphochlamys biru*— A: flower bud; B & C: flower opening; D: stigmatic secretion; E-G: pollen releasing; H: degraded flower; I-K: full-bloomed flower, labellum colour from tinged lilac to purple; L: fruit, bitten; M: remaining pericarp after seed dispersal; *Scaphochlamys durga* — N-P: flower opening; Q-T: stigmatic secretion; U-X: pollen releasing; Y & Z: full-bloomed flower; AA: degraded flower – A-M from *OIH87*; N-AA from *OIH84* – © Ooi I. H.

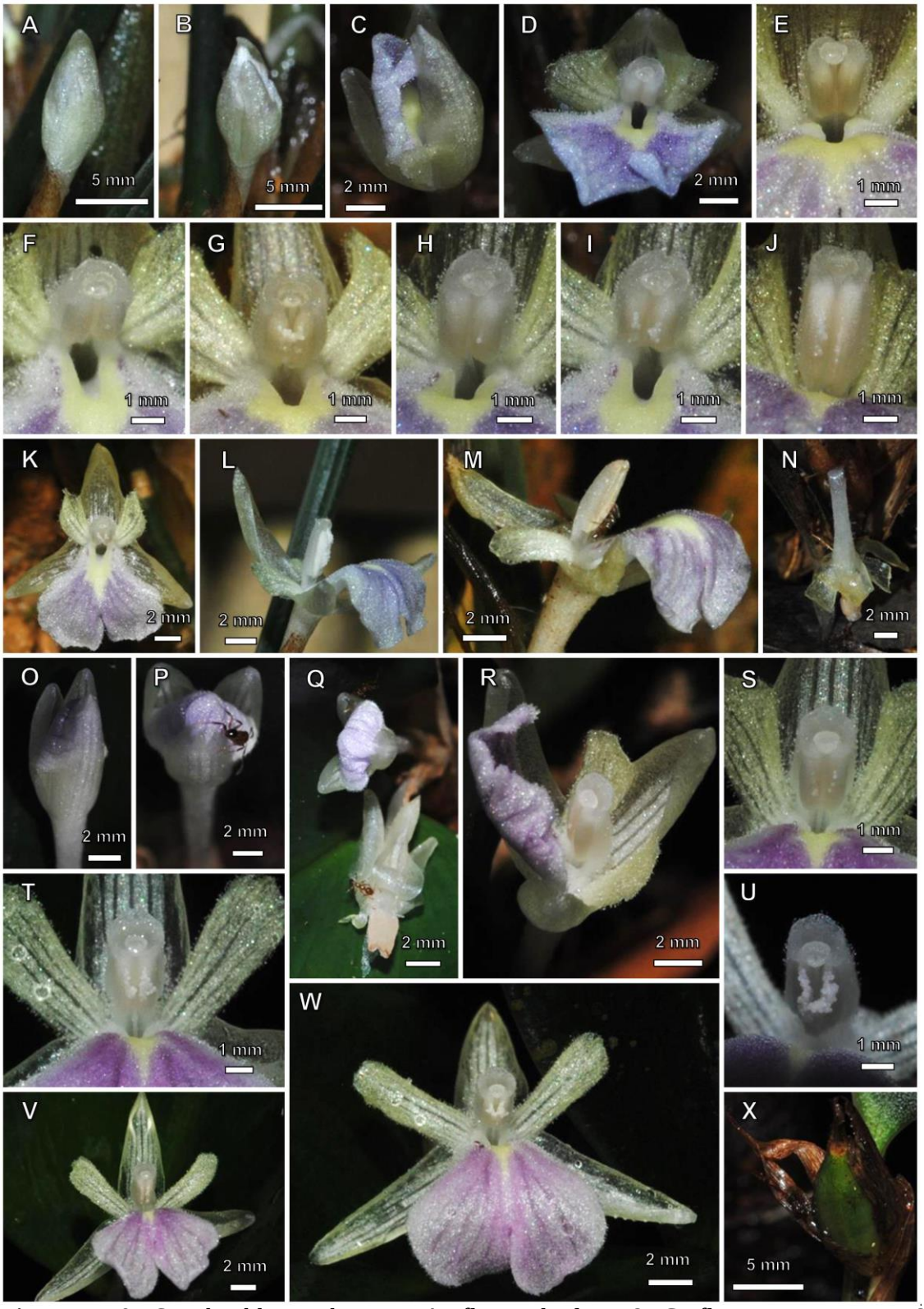


Figure 5.10: *Scaphochlamys hasta*— A: flower bud; B & C: flower opening; D & E: stigmatic secretion; F & J: pollen releasing; K & L: full-bloomed flower; M: ant collecting pollen from the flower (*ex situ* cultivated); N: degraded flower; *Scaphochlamys nigra*— O-Q: flower opening, wandering ants on flower (*ex situ* cultivated, P & Q) and degraded flower (Q); R: stigmatic secretion; S-U: pollen releasing; V & W: full-bloomed flower; X: fruit – A-N from *OIH80*; O-X from *OIH76* – © Ooi I. H.

the stigma. Insect visitors were not observed to visit *S. hasta* throughout the observational period.

5.5) *Scaphochlamys multifolia* (Figure 5.11)

In the morning, the mature bud began to open at c. 0600. The stigma secreted the stigmatic fluid at c. 0655. The anthers dehiscent began and released pollen from middle of the thecae at c. 0735. There was no traceable odour to human nose. Small traplining Halictid bees visited the flower from c. 0935 until c. 1250. After landing on the flower, the bees crawled to the labellum and moved towards the floral tube to consume the nectar. Then, the bees departed and usually revisited later. While moving towards the floral tube for nectar foraging, the head of the bees (especially the front part and occasionally the front part of the thorax) slightly lifted the stamen and touched both stigma and anthers. In the afternoon, the flower started to wilt around 1400 and degraded by the next morning. Fruits were developed upon successful pollination and took c. 5 weeks to reach maturity. When the fruit was ripe, the pericarp split into three to release the seed.

5.6) *Scaphochlamys nigra* (Figure 5.10, O-X)

At dawn, mature bud started to open at c. 0552. While the flower gradually open to reveal the stigma and anthers, the stigmatic secretion was visible on the stigma at c. 0727. The anther released pollen at c. 0837. There was no emission of human-noticeable odour throughout the anthesis. Around 1400, the flower began to wilt and degraded by the next morning. Insect visitors were not observed to visit *S. nigra* throughout the observational period.

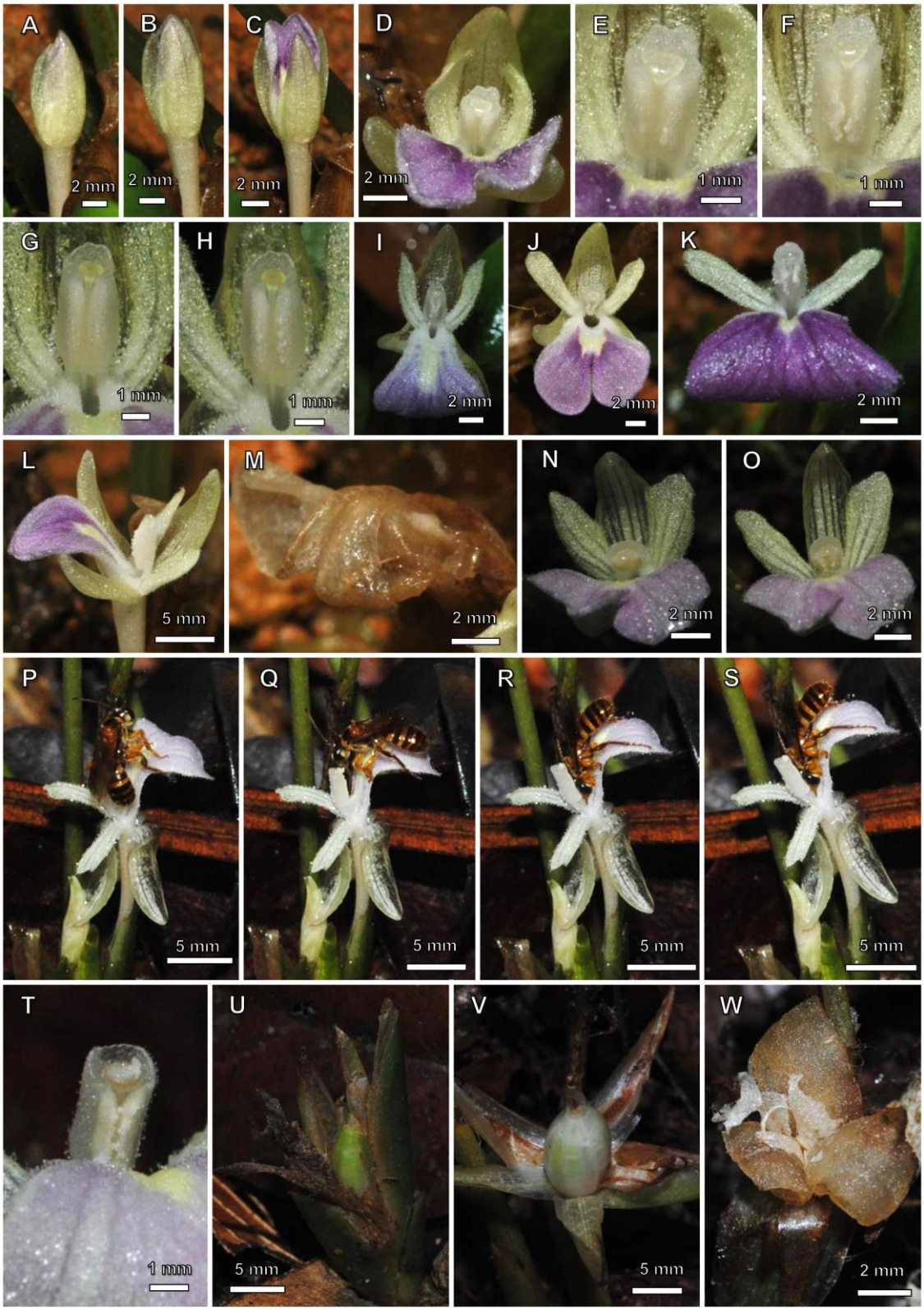


Figure 5.11: *Scaphochlamys multifolia* — A: flower bud; B & C: flower opening; D: stigmatic secretion; E-H: pollen releasing; I-L: full-bloomed flower; M: degraded flower; N: stigmatic secretion; O: pollen releasing; P-S: Halictid bee visitation, the head was in contact with stigma and pollen during nectar foraging; T: stigma and scattered pollen after bee visiting; U: fruit; V: fruit, bracts artificially opened; W: remaining pericarp after seed dispersal – A-M from *OIH112*; N-W from *OIH111* – © Ooi I. H.

5.7) *Scaphochlamys petiolata* (Figure 5.12)

The mature bud opened at c. 0552 in the morning. The flower gradually opened to reveal the stigma and anthers. Meanwhile, the stigmatic secretion was visible at c. 0727. The pollen was released from the dehisced anther at c. 0837. No odour was traceable by human nose during the anthesis. The flower wilted from c. 1400 and degraded by the second morning. Grasshoppers were occasionally consuming the floral tissue until severely damaged the flowers. Insect visitors were not observed to visit *S. petiolata* throughout the observational period.

5.8) *Scaphochlamys pseudoreticosa* (Figure 5.13, A-M)

In the morning, the flower bud began to open at c. 0743. When the flower was partially opened to reveal the stigma and anthers, the stigmatic secretion on the stigma was observable at c. 0819. Around 0857, the pollen was released from the longitudinal anthers thecae. The flower emitted a very mild torch ginger-like odour around 0.5 cm radius during anthesis. In the afternoon, the flower began to wilt at c. 1400. In the next morning, the flower was degraded. Insect visitors were not observed to visit *S. pseudoreticosa* throughout the observational period.

5.9) *Scaphochlamys reticosa* (Figure 5.13, N-U)

The flower bud began to bloom at c. 0750. When the flower was partially opened to reveal the stigma and anthers, the stigmatic secretion on the stigma was observable at c. 0821. Around 0900, the pollen was released from the longitudinal anthers thecae. The flower emitted a very mild torch ginger-like odour around 0.5 cm radius during anthesis. In the afternoon, the flower began to wilt at c. 1410. In the next morning, the flower was

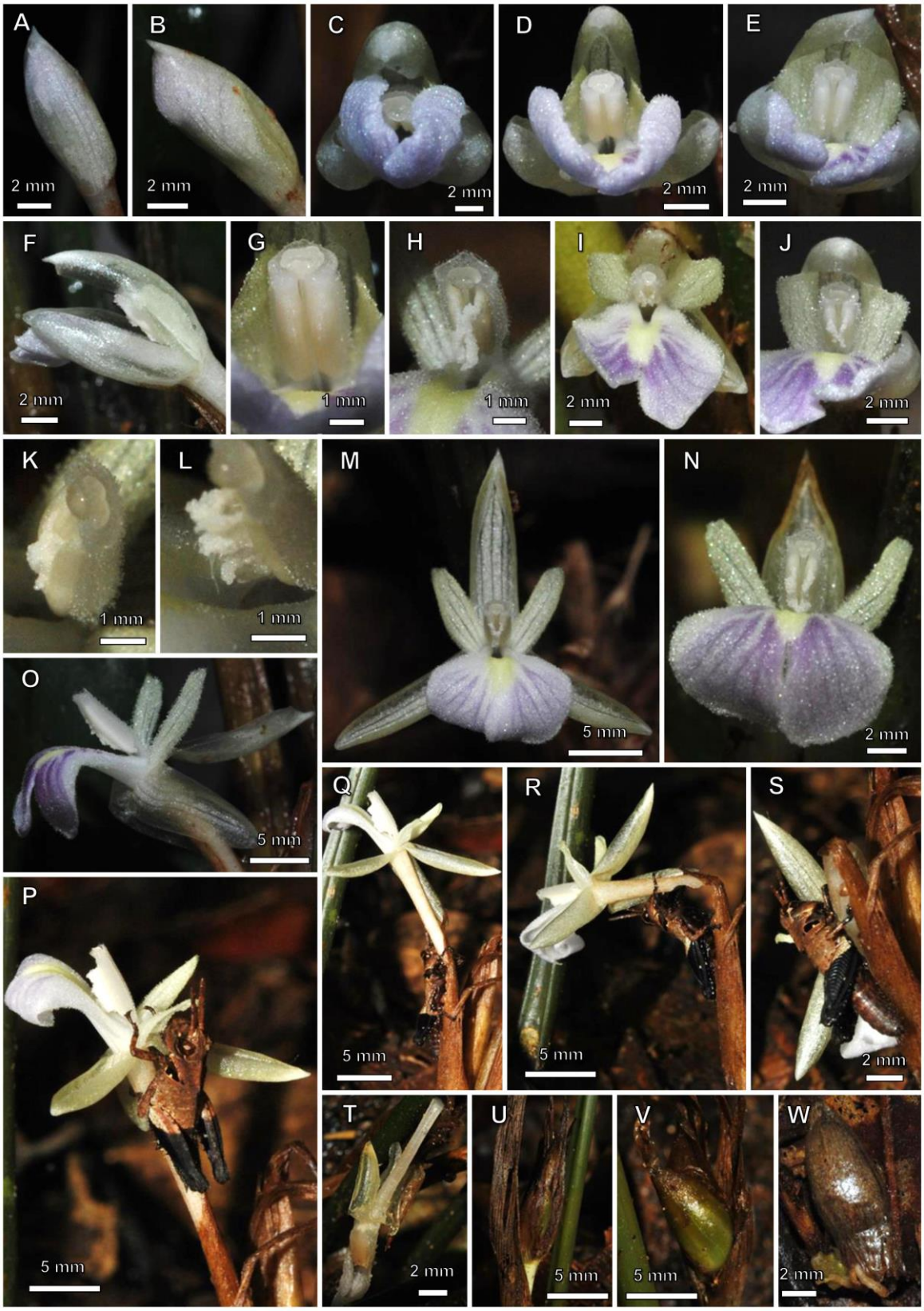


Figure 5.12: *Scaphochlamys petiolata* — A: flower bud; B: flower opening; C & D: stigmatic secretion; E-L: pollen releasing; M-O: full-bloomed flower; P-S: grasshopper visitation, preying until severely damaged the flower; T: degraded flower; U-V: fruit; W: germinating seed – A-J, M-O, V from *OIH71*; K-L, P-U from *OIH78* – © Ooi I. H.

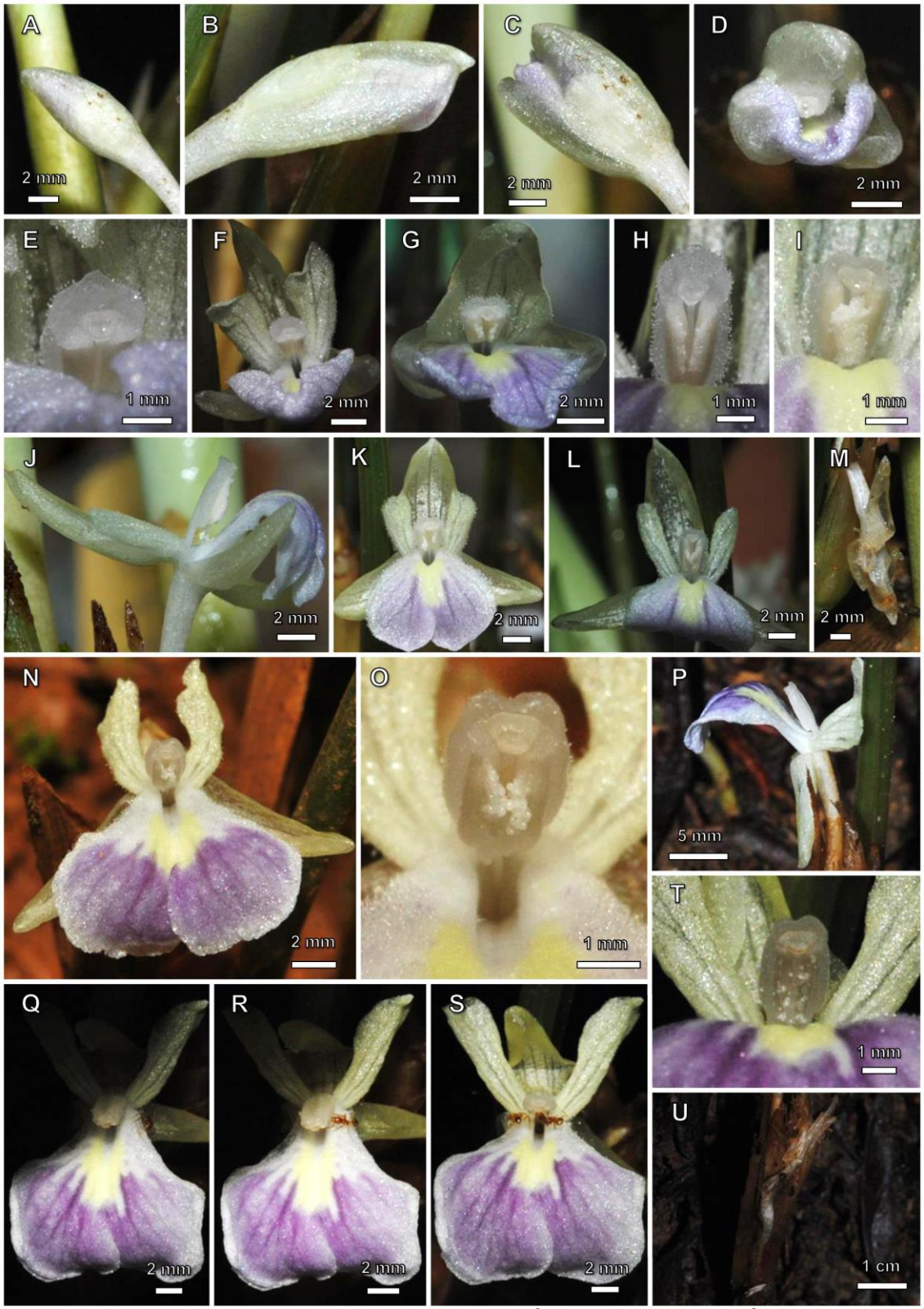


Figure 5.13: *Scaphochlamys pseudoreticosa*— A: flower bud; B & C: flower opening; D-F: stigmatic secretion; G-I: pollen releasing; J-L: full-bloomed flower; M: degraded flower; *Scaphochlamys reticosa*— N & O: stigmatic secretion and pollen releasing; P: full-bloomed flower; Q-S ants visitation, collecting pollen from flower (*ex situ* cultivated); T: scattered pollen and damaged thecae after ant visitation; U: degraded flower – A-M from *OIH83*; N-U from *OIH79* – © Ooi I. H.

degraded. Insect visitors were not observed to visit *S. reticosa* throughout the observational period. In a cultivated living collection, the yellow ants were observed to collect the pollen from the anthers without moving into the stigma.

5.10) *Scaphochlamys stenophylla* (Figure 5.14)

The flower bud began to bloom at c. 0610 in the morning. The flower gradually opened and partially exposed the stigma and stamen. The stigma produced the stigmatic secretion at c. 0652 (visible as a liquid drop on the stigma 'cup'). At c. 0750, the anthers dehisced from the middle of the longitudinal thecae and began the pollen releasing. A torch ginger-like odour was detectable by human nose at c. 4 cm radius around the flower. Small traplining Halictid bee visitations to the flower were observed. The bee visiting time was around 0815 till c. 1029. The bees landed, crawled on the labellum, pushed towards floral tube and put the proboscis into the floral tube to consume the nectar. After nectar gaining, the bees reversed and departed (usually revisited later). While moving towards the floral tube for nectar, the bee' head (especially the front part; occasionally the front part of the thorax) slightly lifted the stamen and brushed through both stigma and anthers. At c. 1400 afternoon, the flower began to wilt and degraded by the next morning. For successfully pollinated flowers, fruits developed and reached maturity after 4 – 6 weeks. The fruit pericarp split into three upon fruit ripening to allow the seed to be dispersed.

6) Polyphylla group

6.1) *Scaphochlamys polyphylla* (Figure 5.15, A-K)

The opening of the flower bud began at c. 0507 in the early morning. As the flower opened gradually, the stigma and anthers were exposed and a drop of stigmatic secretion was



Figure 5.14: *Scaphochlamys stenophylla* — A: flower bud; B & C: flower opening; D & E: stigma secretion; F-H: pollen releasing; I & J: full-bloomed flower; K-N: Halictid bee visitation, the head was in contact with stigma and pollen during nectar foraging; O & P: stigma and scattered pollen after bee visiting; Q: degraded flower; R & S: fruit; T: remaining pericarp after seed dispersal; U: dispersed seed and remaining pericarp; V: bitten dispersed seed – A-F, K-Q from *OIH106*; G-J, R-V from *OIH74* – © Ooi I. H.

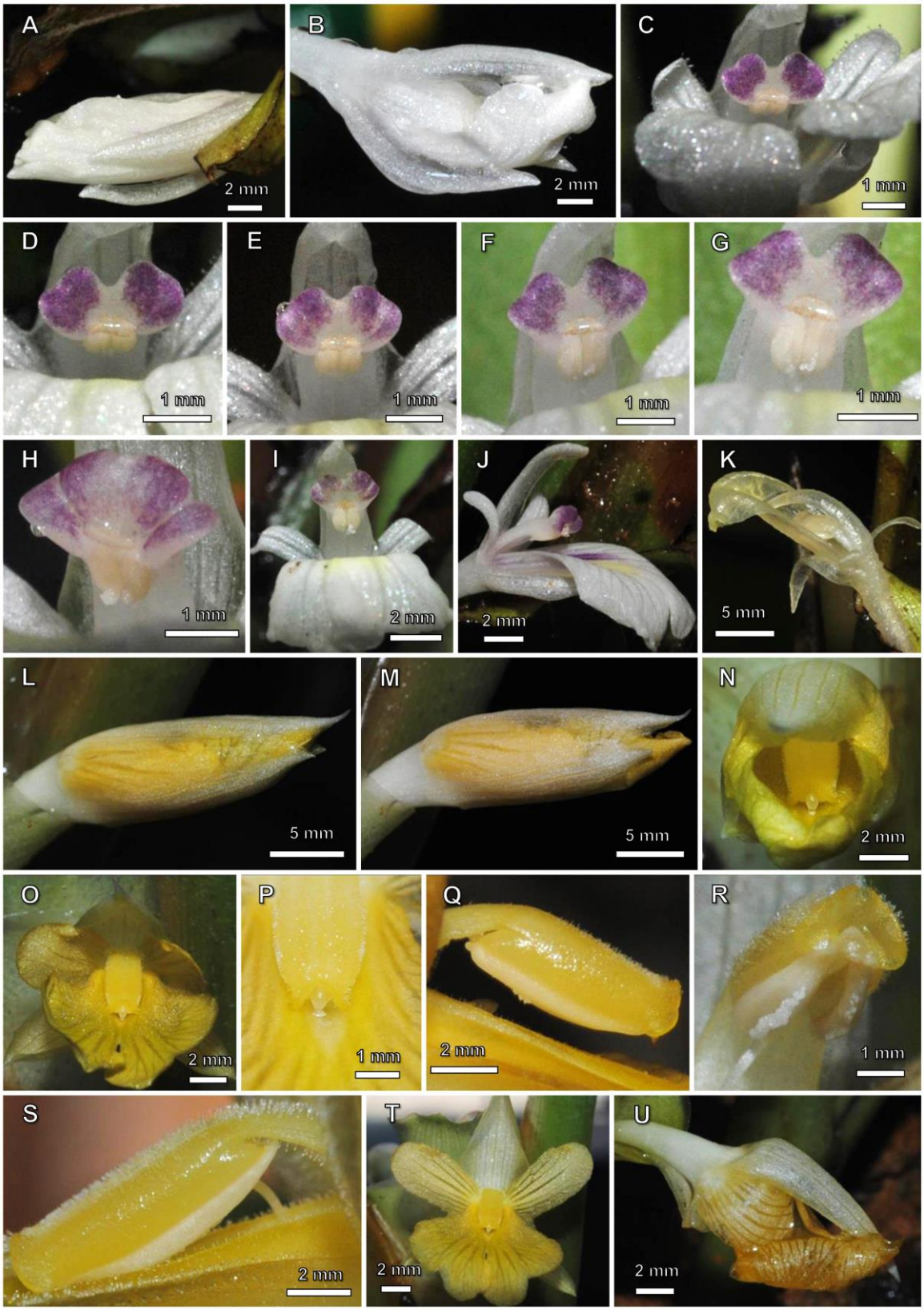


Figure 5.15: *Scaphochlamys polyphylla*— A & B: flower opening; C-E: stigmatic secretion; F-H: pollen releasing; I & J: full-bloomed flower; K: degraded flower; *Scaphochlamys kunstleri* var. *kunstleri*— L & M: flower opening; N-P: stigmatic secretion; Q-S: pollen releasing; T: full-bloomed flower; U: degraded flower – A-K from *OIH119*; L-U from *OIH161* – © Ooi I. H.

formed on the stigma at c. 0705. The anthers released the pollen from the middle of thecae at c. 0905. Sometimes, the flower emitted a mild foul odour (remaining water of domestic waste-like) at c. 1 cm radius during the process (traceable by human nose). The flower began to wilt at c. 1400 and degraded by the second morning.

7) Other taxa

7.1) *Scaphochlamys kunstleri* var. *kunstleri* (Figure 5.15, L-U)

The mature bud began to open at c. 0445 in the early morning. A drop of stigmatic secretion was visible when the flower partially opened to reveal the stigma and anthers at c. 0530. The anthers released the pollen from the middle of thecae at c. 0700 morning. During the anthesis, a mild woody/gaharu-like odour was emitted (at c. 1 cm radius, probably from the bracts). The flower wilted at c. 1400 in the afternoon and degraded (coiled) by the second morning.

7.2) *Scaphochlamys kunstleri* var. *speciosa* (Figure 5.16, A-K)

The flower bud started to open at c. 0422 in the early morning. At c. 0630, when the flower partially opened and exposed the stigma and anthers, the secreted stigmatic fluid was visible on the stigma. The pollen was released from the middle of anthers thecae at c. 0700. There was a mild woody/gaharu-like odour traceable at c. 1 cm radius (probably from the bracts). The degradation of the flower began at c. 1400 in the afternoon and ended in the next morning.



Figure 5.16: *Scaphochlamys kustleri* var. *speciosa*— A-D: flower opening; E & F: stigmatic secretion; G-I: pollen releasing; J: full-bloomed flower; K: degraded flower; *Plagiostachys crocydocalyx*— L-P: *Amegilla* bee visitation, lifting up the stamen and whole body thrusting in until the abdomen around stigma position during nectar foraging; Q-S: long tongue flies visitation (probably male horse fly), using long proboscis to consume pollen without touching stigma; T: butterfly visitation, using long proboscis to consume nectar from aside without touching stigma and pollen – A-K from *OIH162*; L-T from *OIH269* – © Ooi I. H.

7.3) *Scaphochlamys malaccana* (Figure 5.17)

In the early morning, at c. 0542, the mature bud started to open. During the flower was gradually opening to partially exposed the stigma and anthers, the stigma was secreting a drop of stigmatic fluid at c. 0642. Meanwhile, with the anthers dehiscing, the pollen was released from the middle of the thecae at c. 0642. There was a jasmine-like odour noticeable at c. 5 cm radius around the flower. The flower began to wilt at c. 1500 in the afternoon and degraded by the next morning. The flowers (occasionally the bracts and fruits as well) were often preyed by the grasshoppers until severely damaged.

5.3.1.2 Interaction between the Plants and Insect Visitors

In this study, *S. calcicola* and *S. lucens* were found to be pollinated by the large traplining *Amegilla* bees (c. 15 mm long; Apidae: Apinae: *Amegilla pendleburyi*), while *S. biru*, *S. lanjakensis*, *S. multifolia*, *S. petiolata* and *S. stenophylla* were pollinated by small traplining halictid bees (c. 10 mm long; Halictidae: Halictinae: *Sphecodes* sp). The visiting behaviours of these two bees were very similar by crawling on the labellum, trusting towards the floral tube, consuming the nectar in the floral tube by the proboscis, leaving and revisiting later. During trusting in to put the proboscis into the floral tube, the body parts of the bees brushed through the stigma and in contact with the anthers. The difference between these two types of pollinators was the differences in the body part that in contact with the stigma and anthers, which was the front part of the thorax for *Amegilla* bees and the front part of the head for Halictid bees. The sizes of these effective pollinators are correlated with the labellum and stamen sizes, in which *S. calcicola* and *S. lucens* flowers (large *Amegilla* bee-pollinated, labellum c. 20 mm long; stamen c. 10 mm long) are larger than the flowers of *S. biru*, *S. lanjakensis*, *S. multifolia*, *S. petiolata* and *S. stenophylla*

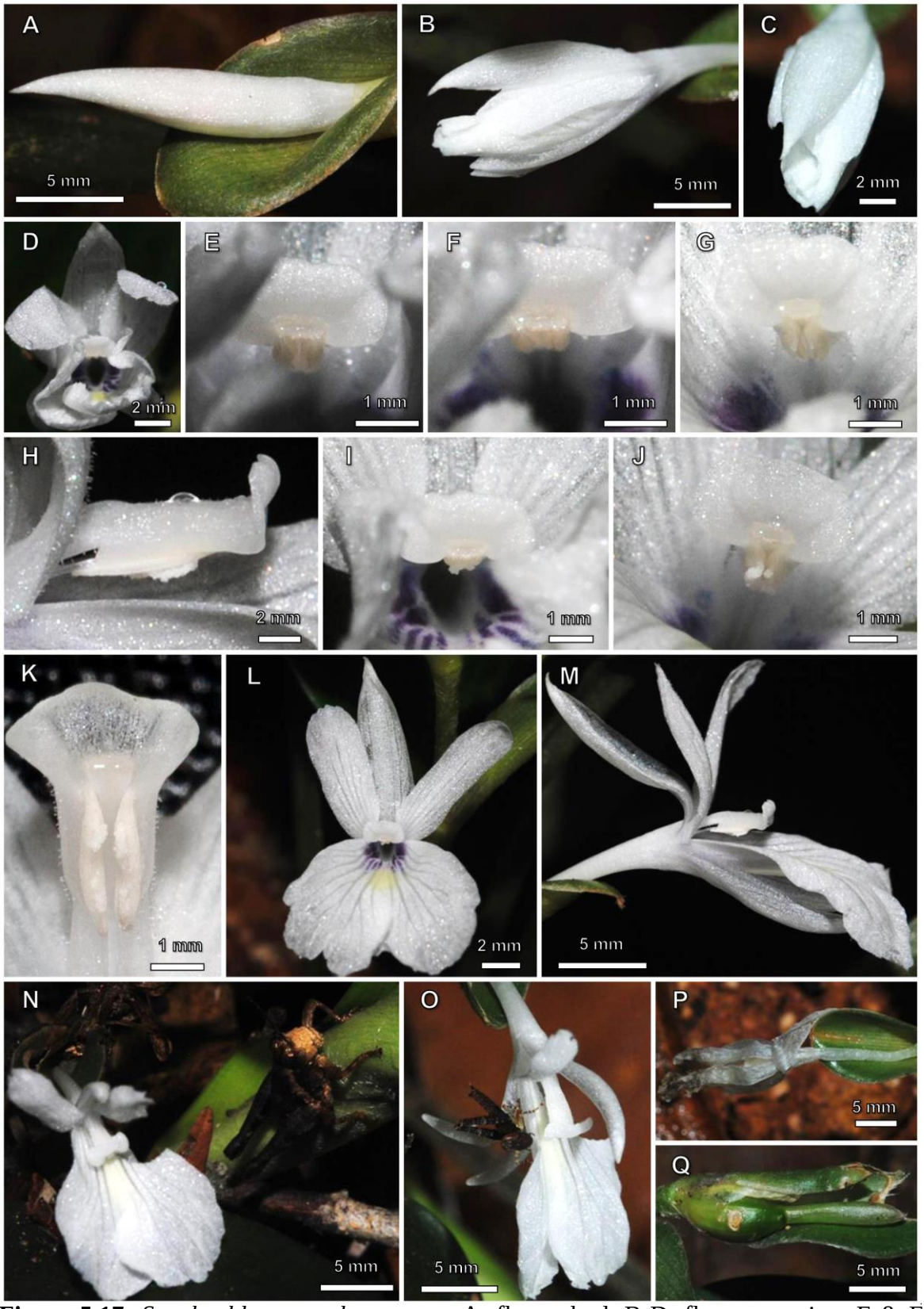


Figure 5.17: *Scaphochlamys malaccana* — A: flower bud; B-D: flower opening; E & F: stigmatic secretion; G-K: pollen releasing; L & M: full-bloomed flower; N & O: grasshopper visitation, preying until flower severely damaged; P: degraded flower; Q: fruit – A-Q from *OIH302* – © Ooi I. H.

(small Halictid bee-pollinated, labellum c. 10 mm long; stamen c. 5 mm). These two bees were also reported as the pollinators for other Zingiberaceae species in Sarawak (Kato, 1996, Momose et al., 1998, Sakai et al., 1999). Some of the flowers of *Scaphochlamys* were visited by ants and grasshoppers. However, the ants are counted as the pollen robbers and not pollinators because the ants crawled into the stamen and collected pollen without being in contact with the stigma. The grasshoppers preyed on the floral tissues until severely damaged the flowers. Therefore, grasshoppers were not considered as the visitors but as the predators. The pollinators and insect visitors of each investigated taxa were showed in Table 5.3.

In this study, these bees were also found to pollinate other Zingiberaceae flowers, such as *B. parva* (Halictid bee-pollinated, Figure 5.18, nearby the populations of *S. multifolia* and *S. stenophylla*), *B.* aff. *puchella* (Halictid bee-pollinated, next to the population of *S. graveolens*) and *P. crocydocalyx* (*Amegilla* bee-pollinated, near the population of *S. lucens*). Several interesting interactions between the plants and the insects were observed. While the Halictid bees were just the visitors of *S. graveolens* (Figure 5.6, I-M), the same bees were observed to pollinate the nearby flowers of *B.* aff. *puchella*. During the duration of this study, there were no encountering of the fruiting events in *S. graveolens* population but fruits were found in *B.* aff. *puchella*. Besides, the *Amegilla* bees were also found to be the pollinator of *P. crocydocalyx* (Figure, 5.16, L-P, similar results to Sakai et al., 1999) which was found nearby the population of *S. lucens* (Figure 5.8, L-T).

All *S. multifolia*, *S. stenophylla* and *B. parva* in the area utilize the same type of bee as the pollinator with only a slight overlapping flowering event. *Scaphochlamys*

Table 5.3: The insect visitors of investigated species with the visiting frequencies.

	Species name	Accession number	Visiting frequency of insect visitors					
			Halictid bee	*Amegilla* Bee	ants	grasshopper	butterfly	Stingless bee
Anomala group	*S. lanjakensis*	OIH309 (n=1)	4*	-	-	-	-	-
	S. lanjakensis	OIH310 (n=6)	15*	-	3	-	-	-
Calcicola group	*S. calcicola*	OIH81 (n=5)	-	12*	-	-	-	-
Graveolens group	*S. graveolens*	OIH116 (n=1)	3	-	-	-	-	-
	S. lucens	OIH125 (n=4)	-	13*	-	-	-	-
Petiolata group	*S. biru*	OIH75 (n=3)	1*	-	-	-	-	-
	S. biru	OIH87 (n=3)	-	-	1	-	-	-
	S. durga	OIH84 (n=4)	-	-	-	-	-	-
	S. multifolia	OIH111 (n=4)	13*	-	-	-	-	-
	S. nigra	OIH76 (n=3)	-	-	1	-	-	-
	S. petiolata	OIH71 (n=9)	1*	-	-	3	-	-
	S. stenophylla	OIH74 (n=4)	1*	-	-	-	-	-
	S. stenophylla	OIH106 (n=2)	4*	-	-	-	-	-

Table 5.3 continued

Other taxa	*S. malaccana*	OIH302 (n=3)	-	-	-	3	-	-
	B. parva	OIH109 (n=2)	21*	-	-	2	4	13

* indicates the pollinator (in contact with both pollen and stigma)



Figure 5.18: *Boesenbergia parva*, first-day flower— A & B full-bloomed flower, pollen released; C: butterfly, consuming nectar; D & E: stingless bees, orange (D) and black (E), on labellum; F-K: Halictid bee visitation, head and thorax in contact with pollen; *Boesenbergia parva*, second-day flower— L & M: full-bloomed flower, curved stigma with secretion; N: butterfly, consuming nectar; O & P: stingless bees, black (O) and orange (P) and), on labellum; Q-T: Halictid bee visitation, head and thorax in contact with the curved stigma, especially the back of the head; U: grasshopper, preying stingless bee; V: fruit fly on labellum; W: juvenile plants grew from bulbils– A-W from *OIH109* – © Ooi I. H.

stenophylla flowered from early October to mid-October, followed by *S. multifolia* around mid-October, and *B. parva* flowered at late October when *S. stenophylla* and *S. multifolia* were in fruiting stage. Later of the year, *B. parva* flowered around early December followed by *S. multifolia* around mid-December. The differences of peak flowering season of these sympatric gingers suggest an incomplete temporal isolation for utilizing the shared pollinators. Thus, beyond the competition for same type of pollinators, the plants may be functioned as a 'team' to support the pollinator population continuously, as a single population of a species may not enough for the pollinator population. In a study on passion fruit's pollinator, the bees might be visiting at least 40 species of plants gathering the resources required for survival (Silva et al., 2012). Perhaps this is the reason that the Bornean understory gingers were reported to be flowering irregularly with weak intraspecific synchronization and having only few types of pollinators for many species without clear segregation (Sakai et al., 1999; Sakai, 2000).

Furthermore, *S. lucens* and *P. crocydocalyx* were observed to be utilising the different body parts of the same *Amegilla* species, mostly the thorax for *S. lucens* and the abdomen for *P. crocydocalyx*. About Halictid bees, the body parts that in contact the stigmas were mostly the front part of the head with *S. multifolia* and *S. stenophylla* but mostly on the back part of the head with *B. parva*. This type of pollen depositions on different parts of pollinator body is not impossible. As an example, Franceschinelli (2005) reported that the pollen from different plant species was deposited on the top of the head, under the tail or on the abdomen of hummingbird.

Boesenbergia parva and *P. crocydocalyx* were visted by more than one type of visitors but *B. parva* was pollinated by Halictid bees only and *P. crocydcocalyx* by *Amegilla* bees only. This is similar to *Amomum subulatum* Roxb. in India that was reported to have six types of visitors but only one was considered as effective pollinator (Kishore et al., 2012). However, there were not many visitors for any Bornean *Scaphochlamys* species. Therefore, on the course of maximizing pollination success, rather than competitively reducing others' pollen, *Scaphochlamys* flowers seemed to be more specialized in screening out other visitors so the resources are not wasted to non-pollinators in general. The flower part that responsible for this selection is still unclear. This is speculated that the foul or slightly pungent (torch ginger-like and lemon grass-like) floral odour may be limiting the visitors to only Hymenoptera (including ants) as there was no visitation of other types of visitors to the flowers with these types of odour.

The presence of violet colour on the labellum did not seem to play a role in pollinator selection. Both types of bees visited the flower with or without violet/purple colouration. However, all the labellum of these *Scaphochlamys* always has a yellow median band. Maybe the yellow median band is the nectar guide for the bees (*B.* aff. *puchella* with red dots on labellum, *B. parva* and *P. crocydcalyx* has similar yellow band but the *Elettariopsis* sp without the band was visited by butterfly only and not visited by bees, Ooi per. obs.). More detailed ultraviolet (UV) floral patterning study could be a direction of future study for better understanding of this matter.

In short, the subject species may be sharing the pollinators with the other species but each species may have its own modification for maximizing pollination success (either

competitively or collaboratively). A long term phenology and pollination study focusing on all species with the same pollinator in a single locality is needed for further investigation of this complex interaction between the plants and the pollinators.

5.3.2 Stigma Receptivity Test

The end time of stigma receptivity of all tested species was by 2:00 pm except the stigma receptivity of *S. malaccana* from Peninsular Malaysia ended by 3:00 pm. These results show there is no clear separation of anthetic stages in the *Scaphochlamys* species as the stigma was still receptive during and after the pollen releasing.

5.3.3 Pollen Germination Test

The pollen in the solution with 15% sucrose had the highest germination percentage (34%). The pollen collected on the first day of its release had the highest germination percentage (*S. calcicola*, 35%–45%; *S. limiana*, 34%–44%; *S. malaccana*, 34%–47%). The germination percentage was slightly lower for the second-day pollen (*S. calcicola*, 21%–27%; *S. limiana*, 22%–31%; *S. malaccana*, 21%–31%) and dropped dramatically for the third-day pollens (*S. calcicola*, 1%–3%; *S. limiana*, 0%–2%; *S. malaccana*, 0%–2%). The germination percentages of first-day, second-day and third-day pollen were significantly different (One-way ANOVA, $F>535.6$) but the pollen germination percentage of three investigated species (*S. calcicola*, *S. limiana* and *S. malaccana*) were not significantly different (One-way ANOVA, first-day, $F<0.1978$; second-day, $F<0.3247$; third-day, $F<2.5$).

5.3.4 Self-pollination/autogamy Test

Although stigma receptivity and pollen released overlapped, the results showed that *Scaphochlamys* species is not autogamous selfing but promotes cross-pollinated/xenogamy as there was no fruit found in both tests. These tests did not assess the degree of self-incompatibility. Perhaps more tests can be applied in future study (preliminary result shows very low, 1.6%, pollen germination for artificial self-pollinated pollen; Ooi, unpublished data).

5.3.5 Floral Microstructures (Figure 5.19 & 5.20)

Although the flowering mechanism is similar, the flowers of *Scaphochlamys* clearly vary. Depict the colours and dimensions of the showy parts, the much smaller structures of the fertile portions (stamen and pistil) vary, notably the anther spurs and stigma. Initiative was taken to view these floral structures under Scanning Electron Microscope (SEM). The structures of the indumentum on the bracts, calyx and floral tube are the narrowly long hairs. The grandular hair on labellum, stamen and staminode for all inspected species was similar (short with globose tip). The various types of anther spurs (as stated in Chapter Three) were found to differ in the microstructures. The anther spurs that prominently tapering at the middle (as in *S. malaccana*) have papillate cells (Figure 5.19E). The base of the anthers in *S. calcicola, S. graveolens* and *S. lucens* might have a taper end that sometimes looked like having spurs but actually not (Figure 5.19F). The anther spurs in the members of Petiolata group can be present (*S. argentea*, *S. biru*, *S. multifolia*, *S. nigra*, *S. petiolata, S. pseudoreticosa*) or absent (*S. durga*, *S. hasta*, *S. stenophylla*, and *S. reticosa*). When the spur is absent, the anther has a blunt end (Figure 5.19G). However, when the spur is present, it is only shortly on a side with blunt end (Figure 5.19H). *Scaphochlamys*

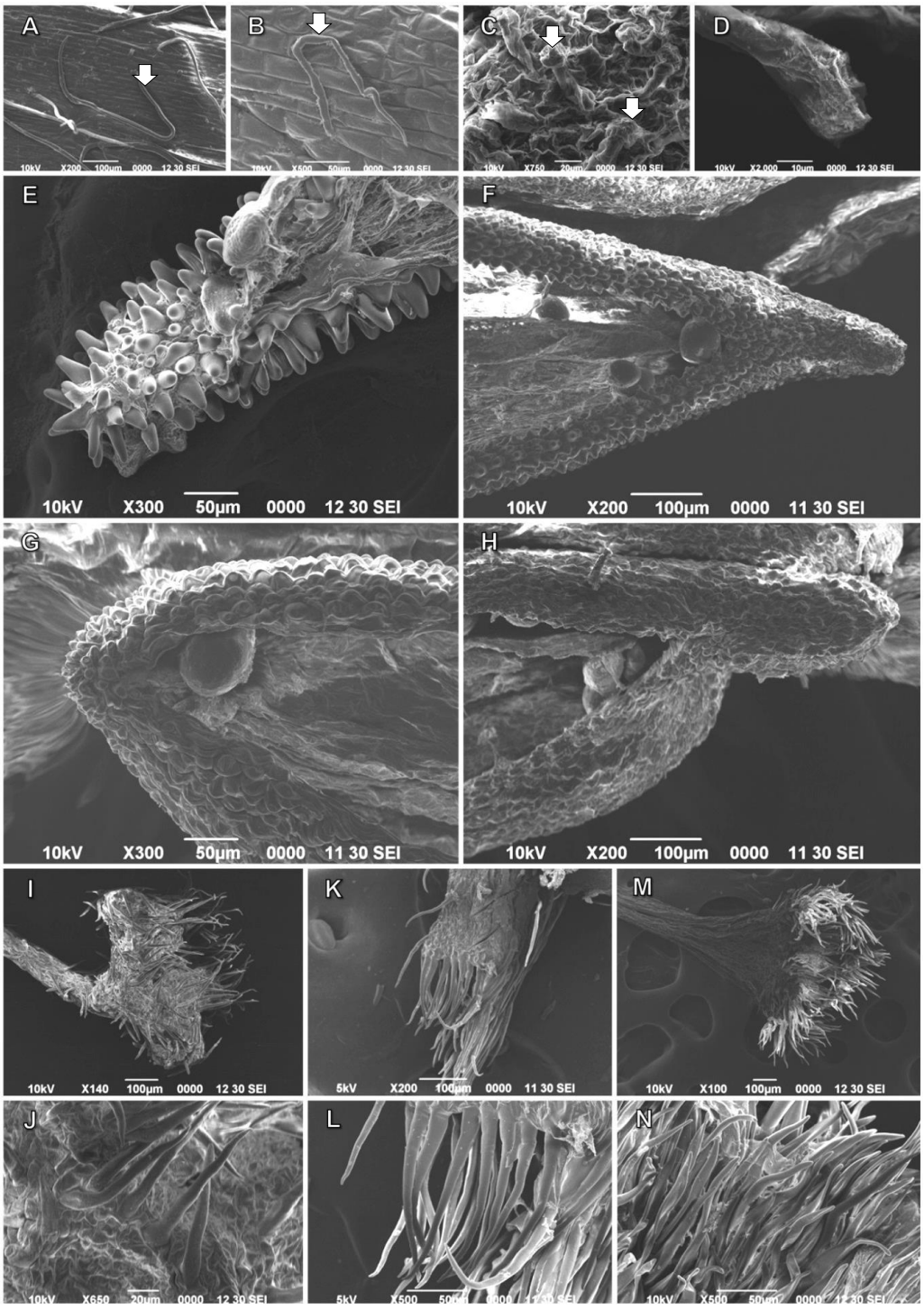


Figure 5.19: Floral microstructures — A & B: hairs on bracts; C & D: glandular hairs; E: tapering anther spur at middle; F: spurless anther with taper end; G: spurless anther with blunt end; H: anther spur on one side with blunt end; I: club-shaped stigma with two dorsal knobs (bone-like); J: short hairs sparsely on the 'bone-like' stigma knobs; K: club-shaped stigma without knobs and narrowing at tip (beak-like); L: long uni-directional hairs at tip of 'beak-like' stigma; M: flattened funnel-shaped stigma (broom-like); N: shorter radiating hairs in 'broom-like' stigma – A, E & N from *S. malaccana OIH302*; B from *S. lucens OIH125*; C from *S. durga OIH84*; D & H from *S. petiolata OIH71*; F from *S. calcicola OIH81*; G from *S.* aff. *nigra OIH77*; I & J from *S. biru OIH87*; K & L from *S. kunstleri* var. *kunstleri OIH161*; M from *S.* aff. *klossii OIH168* – © Ooi I. H.

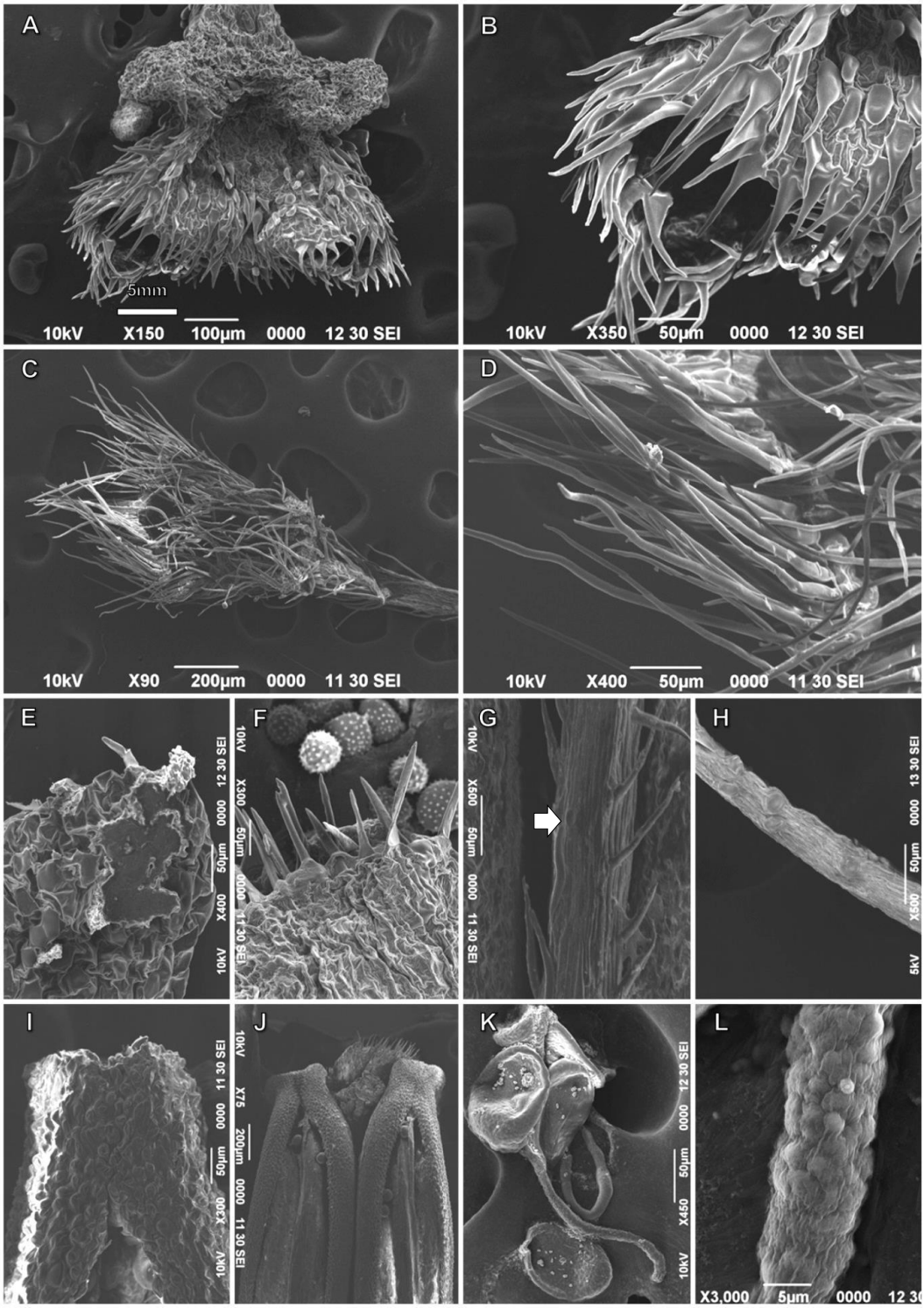


Figure 5.20: Floral microstructures — A: 'bone-like' stigma with fewer hairs on knobs; B: short spiky-like hairs on the stigma; C: 'bone-like' stigma with dense hairs on the knobs; D: long narrow hairs of the stigma; E: *B. parva* stigma with short hairs sparsely at margin and the remnants of pollen outside the 'cup'; F: *P. crocydocalyx* stigma with short hairs sparsely at margin; G: style between anthers with sparsely distributed hairs H: style inside floral tube with stubs; I & J: apex of anther; K: germinating pollen; L: pollen tube – A, B & J, *S. calcicola OIH81*; C & D from *S. lucens OIH125*; E from *B. parva* OIH109; F from *P. crocydocalyx OIH269*; G from *S. petiolata OIH71*; H from *S. petiolata OIH72*; I *S.* aff. *nigra* OIH77; K & L from *S. polyphylla OIH289* – © Ooi I. H.

kunstleri has similar spur which is shortly on a side with a blunt end but slightly curved outward (together with the lower portion of the anther).

Several variations of stigma of *Scaphochlamys* species were encountered along the flowering study as well. Most of the Bornean *Scaphochlamys* have club-shape ostiole ciliate with two dorsal knobs stigma (bone-like), except *S. polyphylla* and *S. limiana*. The stigmas of *S. kunstleri* from Peninsular Malaysia (*S. biloba* as well) are also club-shape but without dorsal knobs and ostiole ciliate at the tip (beak-like). The other two species from Peninsular Malaysia (*S. malaccana* and *S.* aff. *klossii*) have flattened funnel-shape ostiole ciliate stigma (broom-like), which is the same with *S. polyphylla* and *S. limiana* from Borneo. This is agreed with the light microscopic inspection of stigma morphology in Sam et al. (2016). However, among the species with the 'bone-like' stigma, the ciliates and the distribution on the dorsal knobs vary: short narrow hair and sparsely pubescent at knobs in the Petiolata group (Figure 5.19, I-J); long narrow hair, short spiky-like hair and almost naked at knobs in the Calcicola group (Figure 5.20, A-B) and densely pubescent at knobs in the Graveolens group (Figure 5.20, C-D). Similarly, the ciliates of 'beak-like' and 'broom-like' stigma are also different: long narrow hair and a uni-direction arranged at tip in 'beak-like' stigma; but shorter narrow hair and protuding at all directions in 'broom-like' stigma. As a comparison, the stigmas of *B. parva* and *P. crocydocalyx* are flattened funnel-shape and mostly naked with very sparsely arranged short teeth-like hairs. Perhaps these modifications of the stigmas were related to the pollen depositions on pollinators. The pollen of *Scaphochlamys* species were observed to be most probably deposited on front part of head or thorax so the ciliate stigma of *Scaphochlamys* species may 'comb' the pollinators' body to retrieve the pollen. In contrast, the pollen of *B. parva* and *P.*

crocydocalyx were most probably at the back part of head and abdomen respectively so the curved and less hairy stigma may not collect the unwanted pollen (probably blocking away) from the front body parts and only retrieve the pollen when the bee was reversing and departing.

In addition, the styles of Bornean *Scaphochlamys* species (except *S. polyphylla* and *S. limiana*) are usually sparsely pubescent near the stamen and much smoother in the floral tube. Perhaps these tiny structures help to support the stigma to stay in position during pollination as the Petiolata group flowers are smaller (more delicate) and Calcicola and Graveolens group are pollinated with relatively larger (stronger) *Amegilla* bees. So far, there were no differences in the anthers apex.

5.3.6 Pollen Morphology

The average pollen size of all investigated *Scaphochlamys* species was 82.46 μm long × 64.82 μm wide. The data on pollen morphology of each species was summarized in Table 5.4. The pollen of all investigated *Scaphochlamys* species were spheroidal to ellipsoidal and more or less psilate without prominent exine ornaments, only sometimes with slightly raised (up to three) longitudinal striate sculptured lines (Figure 5.21B, H & M; 5.22A, D, E, H, J & M; 5.23B, D, E, M & O). On slightly less-fresh samples, the pollen surfaces usually became vaguely vermiculate (such as in Figure 5.21H; 5.22Q; 5.23D & O) or slightly scale-like (only in *S. kunstleri*, Figure 5.23A & B) with more conspicuous striate lines. The starch granules inside the dissected pollen of all inspected *Scaphochlamys* species are more or less elongated-ellipsoidal (rod-shape) with the average size of 4.14 μm long × 2.18 μm wide. Although pollen from other genera with psilate surface were found (e.g. *B. parva*, *B.*

Table 5.4: The pollen measurements, exine ornaments and starch measurements of the investigated species are shown.

	Species name	Accession number	Pollen length (n=5; mean ± SD μm)	Pollen width (n=5; mean ± SD μm)	Starch length (n=5; mean ± SD μm)	Starch width (n=5; mean ± SD μm)	Exine ornament	Sculptured lines
Anomala group	*S. penyamar*	OIH137	88.53 ± 4.42	63.68 ± 16.82	3.54 ± 0.80	2.95 ± 0.51	psilate	may present
	S. scintillans	OIH141	77.23 ± 8.57	61.69 ± 5.80	4.16 ± 0.79	2.35 ± 0.12	psilate	may present
Calcicola group	*S. calcicola*	OIH81*	73.07 ± 7.11	65.86 ± 3.98	4.12 ± 0.90	1.93 ± 0.53	psilate	may present
	S. uniflora	OIH82	72.53 ± 8.91	60.97 ± 9.88	5.10 ± 1.01	2.55 ± 0.32	psilate	may present
Graveolens group	*S. graveolens*	OIH116	75.49 ± 4.76	68.19 ± 3.24	5.16 ± 1.48	3.01 ± 0.78	psilate	may present
	S. lucens	OIH125	90.45 ± 2.90	75.22 ± 7.64	4.21 ± 1.52	1.93 ± 0.19	psilate	may present
Limiana group	*S. limiana*	OIH118*	72.74 ± 9.53	59.71 ± 0.56	3.17 ± 0.89	1.87 ± 0.25	psilate	may present
Petiolata group	*S. argentea*	OIH320*	92.82 ± 11.96	67.27 ± 3.56	3.70 ± 0.82	1.70 ± 0.33	psilate	may present
	S. biru	OIH87	79.02 ± 6.49	67.19 ± 1.73	4.13 ± 0.73	2.16 ± 0.16	psilate	may present
	S. durga	OIH84*	90.54 ± 21.74	67.60 ± 7.08	4.04 ± 0.68	2.23 ± 0.10	psilate	may present
	S. durga	OIH96	96.28 ± 10.84	64.31 ± 4.53	4.96 ± 0.72	2.38 ± 0.19	psilate	may present
	S. hasta	OIH80*	96.52 ± 13.37	78.41 ± 1.41	4.96 ± 0.70	2.57 ± 0.16	psilate	may present
	S. multifolia	OIH112	83.55 ± 4.06	65.35 ± 5.38	4.05 ± 0.75	2.20 ± 0.20	psilate	may present

Table 5.4 continued

	S. nigra	OIH76	82.39 ± 7.71	71.42 ± 3.66	5.11 ± 1.51	2.64 ± 0.21	psilate	may present
	S. aff. *nigra*	OIH77	88.93 ± 14.22	71.81 ± 1.54	4.19 ± 0.98	1.85 ± 0.12	psilate	may present
	S. petiolata	OIH71	78.73 ± 7.84	71.70 ± 3.00	4.26 ± 0.52	2.13 ± 0.20	psilate	may present
	S. pseudoreticosa	OIH83	77.08 ± 4.03	68.08 ± 1.51	4.17 ± 0.92	2.32 ± 0.12	psilate	may present
	S. reticosa	OIH79	80.51 ± 6.04	68.52 ± 3.82	3.70 ± 0.49	2.09 ± 0.11	psilate	may present
	S. reticosa	ZI139	77.94 ± 17.45	63.16 ± 7.54	4.75 ± 0.83	2.47 ± 0.42	psilate	may present
	S. stenophylla	OIH106	94.41 ± 12.85	64.11 ± 5.27	3.86 ± 0.39	2.07 ± 0.41	psilate	may present
	S. aff. *stenophylla*	OIH92	72.77 ± 12.61	56.98 ± 6.36	4.23 ± 1.15	2.00 ± 0.15	psilate	may present
Polyphylla group	*S. polyphylla*	OIH119	75.32 ± 8.02	54.90 ± 6.93	4.52 ± 1.15	2.43 ± 0.36	psilate	may present
Other taxa	*S.* aff. *klossii*	OIH166	76.06 ± 10.89	62.45 ± 2.87	3.34 ± 0.29	1.96 ± 0.16	psilate	may present
	S. kunstleri var. *kunstleri*	OIH161	83.56 ± 8.41	52.39 ± 4.53	2.67 ± 0.45	1.28 ± 0.17	psilate	may present
	S. kunstleri var. *speciosa*	OIH163	86.58 ± 14.12	57.39 ± 5.87	3.04 ± 0.25	1.25 ± 0.14	psilate	may present
	S. malaccana	OIH302*	81.03 ± 13.41	56.96 ± 2.23	4.50 ± 0.57	2.42 ± 0.57	psilate	may present
	B. orbiculata	OIH299	64.92 ± 4.23	56.60 ± 2.75	2.58 ± 0.63	1.60 ± 0.11	psilate	absent
	B. parva	OIH261	65.93 ± 17.70	57.48 ± 11.49	2.23 ± 0.28	1.51 ± 0.19	psilate	absent

Table 5.4 continued

B. cf. *parva*	OIH128	62.98 ± 2.98	59.71 ± 2.20	2.21 ± 0.37	1.40 ± 0.30	psilate	absent
B. aff. *puchella*	OIH99	85.50 ± 10.48	83.87 ± 8.78	2.21 ± 0.27	1.75 ± 0.23	echinate	absent
B. aff. *puchella*	OIH100	85.62 ± 4.45	84.17 ± 4.29	2.46 ± 0.51	1.90 ± 0.41	echinate	absent
B. aff. *puchella*	OIH117	92.15 ± 12.08	90.25 ± 10.36	1.80 ± 0.28	1.40 ± 0.15	echinate	absent
B. aff. *puchella*	OIH123	95.22 ± 4.94	89.57 ± 2.76	2.25 ± 0.46	1.64 ± 0.24	echinate	absent
B. aff. *puchella*	OIH127	82.87 ± 17.26	79.19 ± 15.46	2.64 ± 0.42	1.92 ± 0.35	echinate	absent
B. variegata	OIH294	64.70 ± 5.32	63.08 ± 7.02	3.06 ± 0.62	2.56 ± 0.50	echinate	absent
H. aff. *magnum*	OIH133	83.64 ± 6.41	70.92 ± 4.66	2.58 ± 0.19	1.77 ± 0.22	psilate	absent
H. aff. *uniflorum*	OIH113	84.82 ± 10.99	75.39 ± 8.19	2.83 ± 0.62	1.98 ± 0.28	psilate	absent
H. aff. *uniflorum*	OIH153	78.06 ± 10.38	70.97 ± 6.86	2.82 ± 0.51	2.04 ± 0.30	psilate	absent
K. pulchra	OIH169	62.31 ± 2.68	57.93 ± 0.66	2.15 ± 0.19	1.70 ± 0.11	psilate	absent
P. crocydocalyx	OIH269	64.95 ± 3.47	62.62 ± 4.95	3.49 ± 0.49	1.41 ± 0.19	echinate	absent

* indicates also tested with the pollen histochemistry test

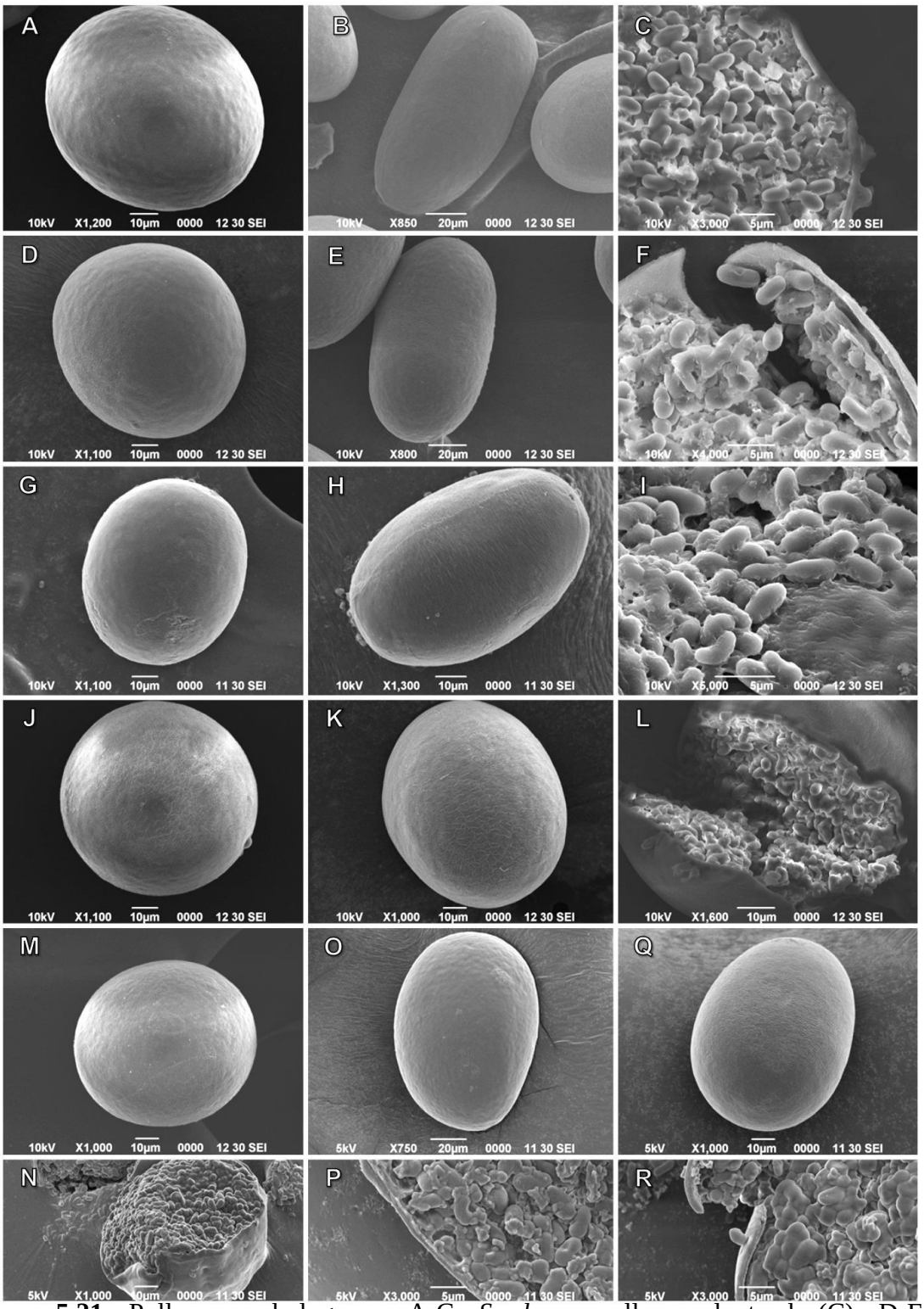


Figure 5.21: Pollen morphology — A-C: *S. durga* pollen and starch (C); D-F: *S. stenophylla* pollen and starch (F); G-I: *S. polyphylla* pollen and starch (I); J-L: *S. petiolata* pollen and starch (L); M & N: *S. nigra* pollen and starch (N); O & P: *S. hasta* pollen and starch (P); Q & R: *S. multifolia* pollen and starch (R) – A & B from *S. durga OIH96*; C from *S. durga OIH84*; D & E from *S. stenophylla OIH106*; F from *S. stenophylla OIH92*; G-I from *S. polyphylla OIH119*; J-L from *S. petiolata OIH71*; M from *S. nigra OIH76*; N from *S. nigra OIH77*; O & P from *S. hasta OIH80*; Q & R from *S. multifolia OIH112* – © Ooi I. H.

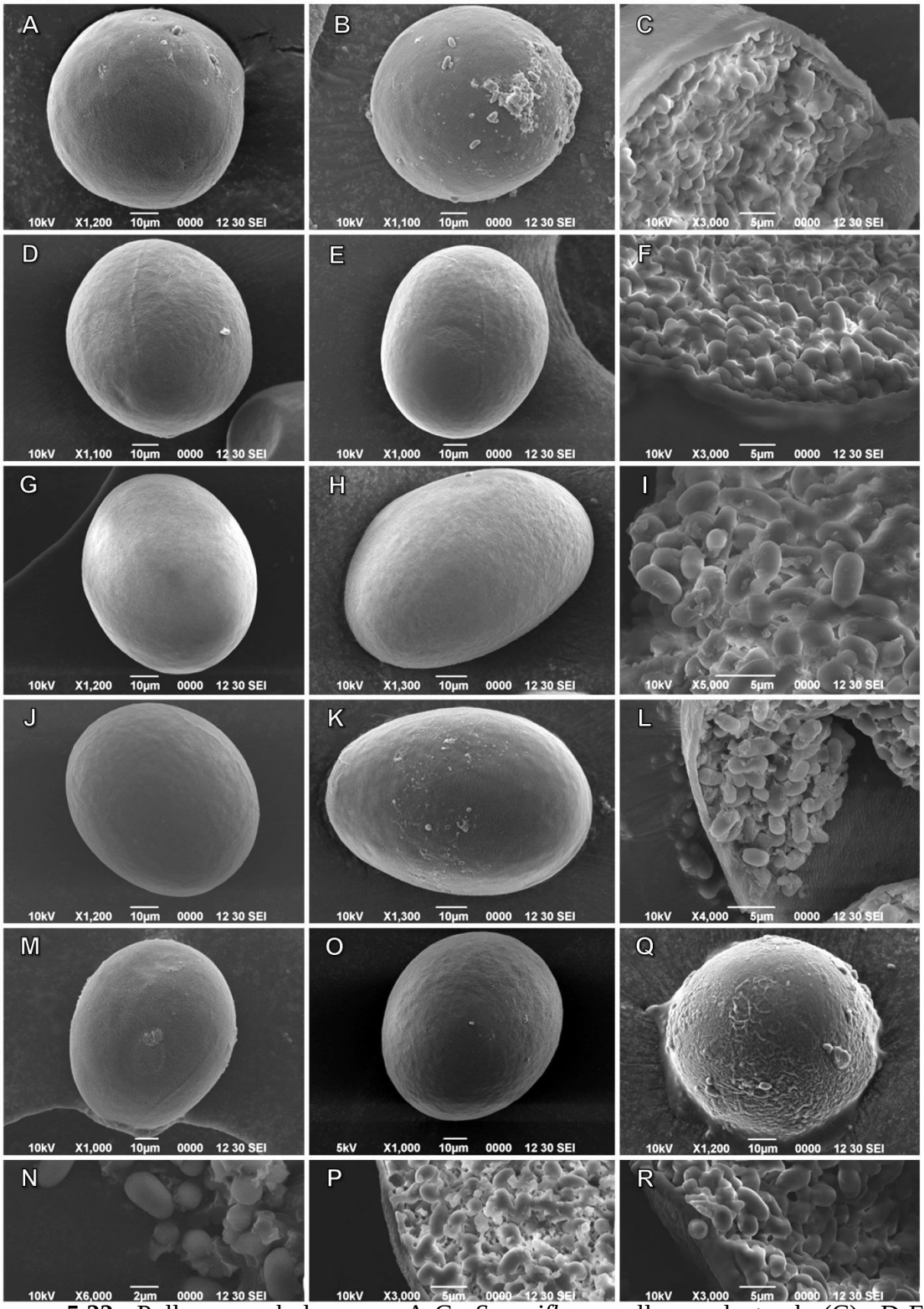


Figure 5.22: Pollen morphology — A-C: *S. uniflora* pollen and starch (C); D-F: *S. pseudoreticosa* pollen and starch (F); G-I: *S. scintillans* pollen and starch (I); J-L: *S. limiana* pollen and starch (L); M & N: *S. biru* pollen and starch (N); O & P: *S. calcicola* pollen and starch (P); Q & R: *S. graveolens* pollen and starch (R) – A-C from *S. uniflora OIH82*; D-F from *S. pseudoreticosa OIH83*; G-I from *S. scintillans OIH141*; J-L from *S. limiana OIH118*; M & N from *S.biru OIH87*; O & P from *S. calcicola OIH81*; Q & R from *S. graveolens OIH116* – © Ooi I. H.

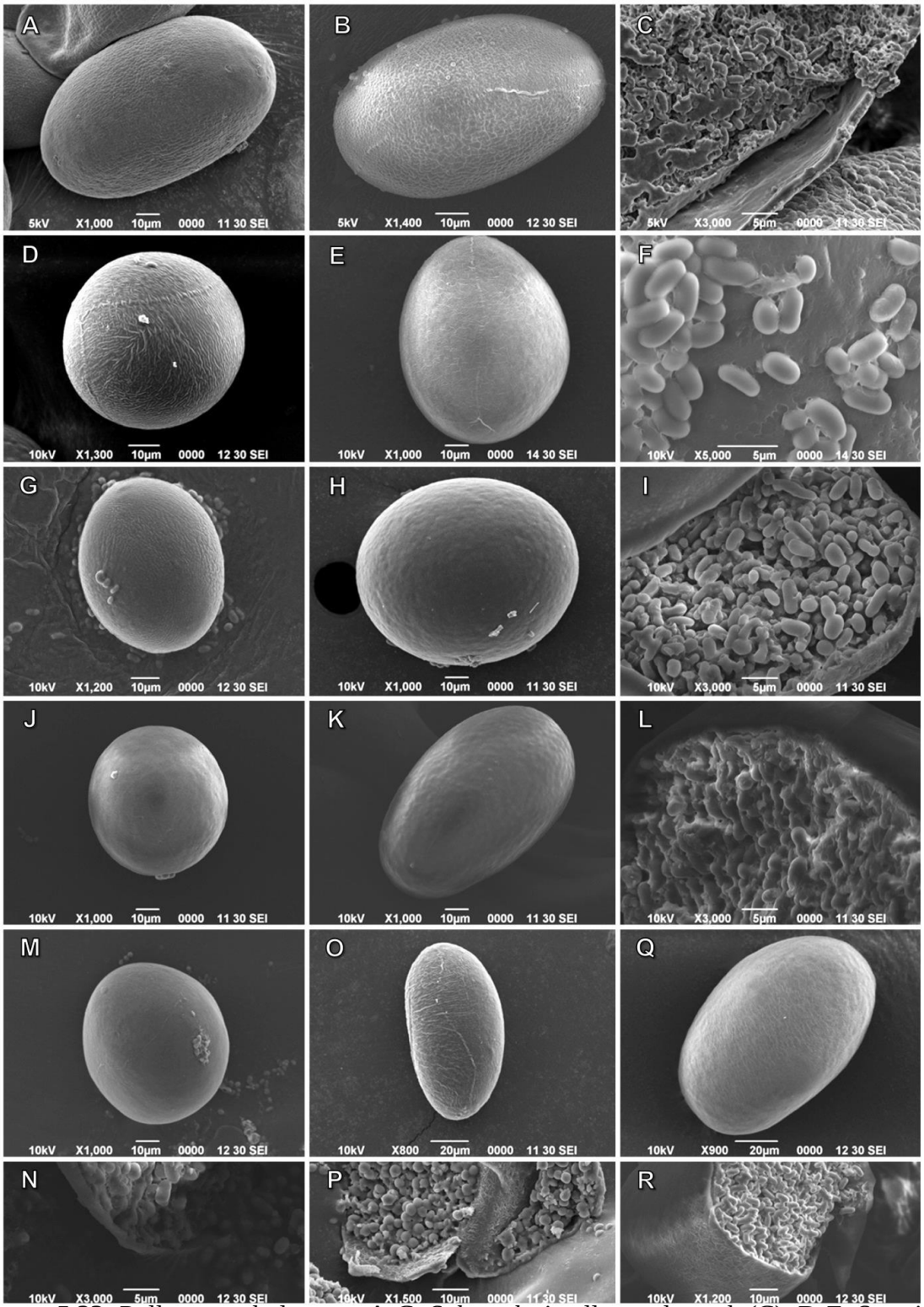


Figure 5.23: Pollen morphology — A-C: *S. kunstleri* pollen and starch (C); D-F: *S. reticosa* pollen and starch (F); G-I: *S. lucens* pollen and starch (I); J-L: *S. malaccana* pollen and starch (L); M & N: *S.* aff. *klossii* pollen and starch (N); O & P: *S. penyamar* pollen and starch (P); Q & R: *S. argentea* pollen and starch (R) – A & C from *S. kunstleri* var. *speciosa OIH163*; B from *S. kunstleri* var. *kunstleri OIH161*; D from *S. reticosa ZI139*; E & F from *S. reticosa OIH79*; G-I from *S. lucens OIH125*; J-L from *S. malaccana OIH302*; M & N from *S.aff. klossii OIH166*; O & P from *S. penyamar OIH137*; Q & R from *S. argentea OIH320* – © Ooi I. H.

orbiculata, *H. uniflorum*, *H. magnum* and *K. pulchra*; Figure 5.24G, I-K, M & O); these were more to spheroidal (around 70.92 μm long × 64.01 μm wide) and did not have the striate sculptured lines. Additionally, the rod-shaped starch in the pollen of *Scaphochlamys* differs from the spherical/rounded or bean-like starch in the pollen of *Boesenbergia*, *Haplochorema* and *Kaempferia* (around 2.45 μm long × 1.78 μm wide). The pollen of *B. puchella* complex and *B. variegata* and *P. crocydocalyx* was echinate (similar to the *Boesenbergia* from Brunei in Poulsen, 1993) and could be easily distinguished from *Scaphochlamys*.

In Bornean *Scaphochlamys*, the pollen of the *Amegilla*-pollinated species (*S. calcicola* and *S. lucens*) and Halictid-pollinated species (*S. biru*, *S. multifolia*, *S. petiolata* and *S. stenophylla*) do not have any distinctive morphological differences and not significantly different in both length (Kruskal-Wallis test with Mann-Whitney pairwise comparisons, $p>0.7562$) and width (Kruskal-Wallis test with Mann-Whitney pairwise comparisons, $p>0.1766$). The pollen of Halictid-pollinated *B. parva* that also observed to touch the insects' head part was also psilate. However, the *Amegilla*-pollinated *P. crocydocalyx* pollen was slightly echinate and observed to be in contact with the insects' abdomen part rather than brushing the insects' thorax in *S. lucens*.

5.3.7 Pollen, Pollinator and Stigma

Attempts were made to observe the insect's body and the stigma for the deposited pollen. Several remnants of pollen were found on various parts of the body (Figure 5.25; 5.26, A-C). However, the hair on the various parts of the insect's body is vary, not only the types of hair but also the distribution/arrangement. This finding somehow supported the speculation

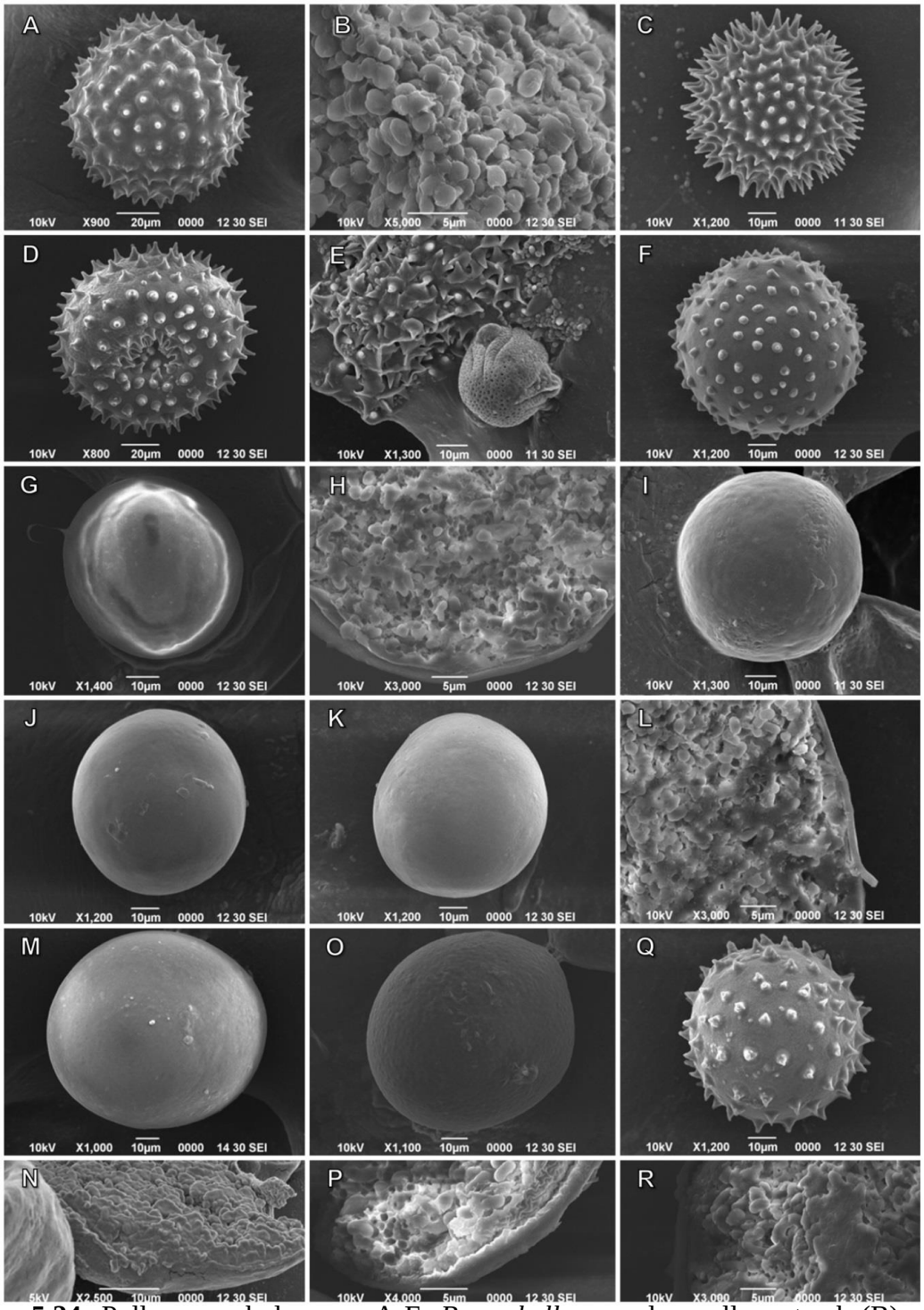


Figure 5.24: Pollen morphology — A-E: *B. puchella* complex pollen, starch (B) and the shred echinate ektexine revealing porate endexine (E); F: *B. variegata* pollen; G & H: *B. parva* pollen and starch (H); I: *B.* cf. *parva* pollen; J: *B. orbiculata* pollen; K & L: *K. pulchra* pollen and starch (L); M & N: *H. uniflorum* pollen and starch (N); O & P: *H. magnum* pollen and starch (P); Q & R: *P. crocydocalyx* pollen and starch (R) – A from *B.* aff. *puchella OIH100*; B from *B.* aff. *puchella OIH99*; C from *B.* aff. *puchella OIH127*; D from *B.* aff. *puchella OIH117*; E from *B.* aff. *puchella OIH123*; F from *B. variegata OIH294*; G & H from *B. parva OIH261*; I from *B.* cf. *parva OIH128*; J from *B. orbiculata OIH299*; K & L from *K. pulchra OIH169*, M from *H. uniflorum OIH113*; N from *H. uniflorum OIH153*; O & P from *H. magnum OIH133*; Q & R from *P. crocydocalyx OIH269* – © Ooi I. H.

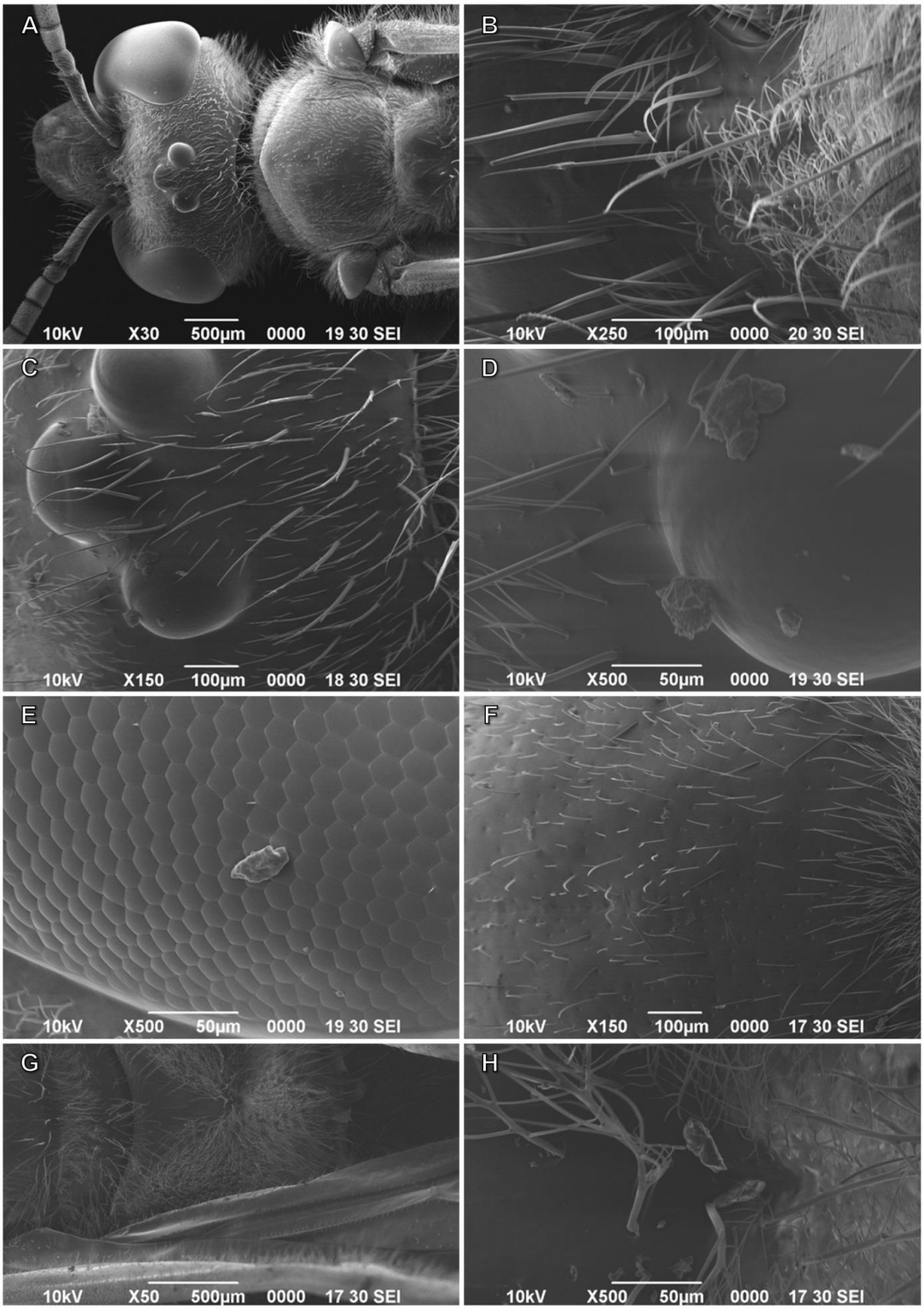


Figure 5.25: Halictid bee — A: the bee's head and thorax; B: long slightly curved hairs and short woolly branching hairs at the front part of the head; C: long curved hairs with short branchings at the back part of the head; D: the remnants of unidentified pollen on the head; E: the unidentified debris on the eyes; F: Short fine hairs at the dorsal part of thorax; G: the intersect between thorax and abdomen between wings; H: long branching hairs near back part of the intersect with the unidentified debris – A-H from the Halictid bee captured during the anthesis of *S. multifolia OIH111* flower – © Ooi I. H.

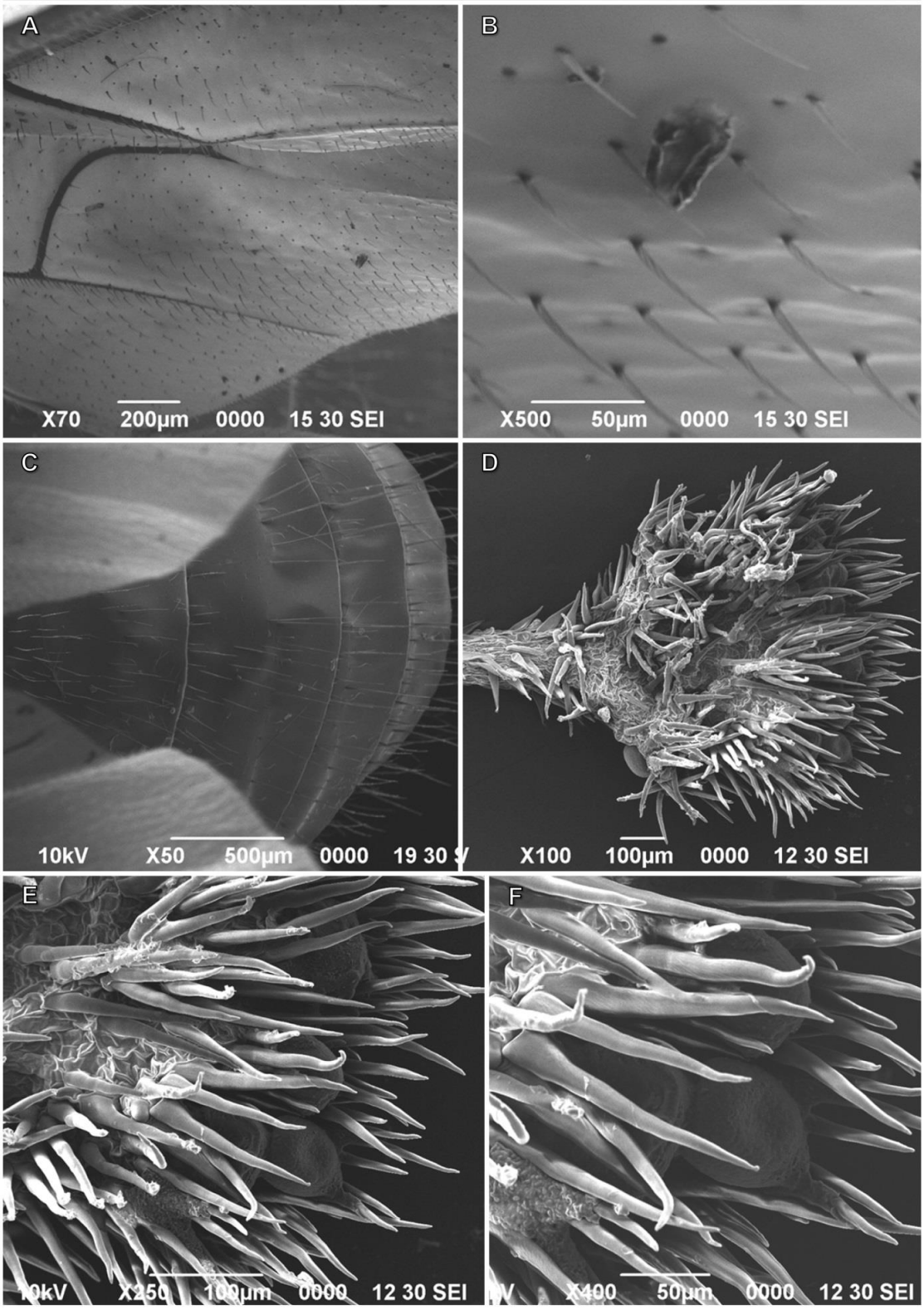


Figure 5.26: Halictid bee — A: the bee's wing; B: short spiky hairs and a unidentified debris on the wing; C: abdomen of the bee with long straight sparsely arranged hairs with the scattered remnants of unidentified pollen; *Scaphochlamys multifolia* — D: the stigma of the flower visited bees; E & E: the ciliate stigma with pollen inside the 'cup' – A-C from the Halictid bee captured during the anthesis of *S. multifolia OIH111* flower; D-F from *S. multifolia OIH111* – © Ooi I. H.

at the previous part in this chapter about the pollen morphology may be complexly adapted to the 'depositing surface' on the insect body parts and the 'retrieving surface' on the stigma. In this case, the stigma did successfully retrieve the pollen from the insect's body (Figure 5.26, D-F). During field observation, the pollen was deposited on the front part of the bee's head. This body surface has two types of hair growing together, long slightly curved hair and short woolly branching hair. On the other hand, in *S. multifolia*, the stigma has short ciliate hair around the 'cup' with stigmatic secretion and the pollen is psilate without prominent exine ornaments. Perhaps, with insect body mixed hairy surface, the pollen do not need the much sophisticated exine ornaments to deposit and is easier for the stigma ciliate hairs to 'comb' through the hair on the insect head to retrieve. Nevertheless, the various adaptations of the pollen to each type of surface combinations are yet to be investigated.

5.3.8 Pollen Histochemistry

All tested pollen showed positive staining results in having both starch (very dark brown to black) and lipid (reddish orange). These results agreed with a speculation of Baker and Baker (1979) that large pollen tends to be starchy. Baker and Baker (1979) also suggested that the bee or fly-pollinated plants may be selected to produce starch-less pollen especially those offers pollen as rewards. However, *Scaphochlamys* produces nectar as a reward so the pollen remain starchy. Perhaps the starch and lipid-richness in the large pollen of *Scaphochlamys* (c. 80 μm long) provided sufficient energy to the pollen to germinating fast through relatively long styles in limited time (within a day before the flower wilted) and also channelled to ovules for helping the initial growth of the fruits (see

Figure 5.20L). Moreover, these starchy pollen explained the occasional presence of the pollen robbing ants on the flowers.

5.3.9 Pollen : Ovule Ratios (P/O)

For all investigated species, the numbers of pollen were highly varied with large range but the numbers of ovules were more consistent (Table 5.5). This is similar to those Zingiberaceae species reported in Wang et al. (2004) but the P/O values of these species are much higher than most of the species reported in Wang et al. (2004). Cruden (2000) hypothesized that the low P/O ratios shows the plants have more efficient pollination systems. The results of this study with high P/O values may be due to the less efficient pollination systems. The P/O ratio of *Amegilla*-pollinated *S. calcicola* is 757.26 ± 45.77 and the P/O ratio of Halictid-pollinated *B. parva* is 664.67 ± 127.03. Kruskal-Wallis test with Mann-Whitney pairwise comparisons ($p>0.2967$) shows no significant different between the P/O ratios between these two species. Although the bees are in different guilds, the traplining visiting behaviour was highly similar. Thus, those may be the reasons of no significant different shown in the P/O ratios.

5.3.10 Natural Fruit Set Percentage

The natural fruit set percentage of all investigated species were very low (Table 5.6). The average fruit set percentages of *Amegilla*-pollinated (*S. calcicola* and *S. lucens*) and Halictid-pollinated (*S. lanjakensis, S. biru, S. multifolia, S. petiolata, S. stenophylla* and *B. parva*) species are 0.35% and 1.92% respectively. There were no significant different between the fruit set percentages of these two pollination guilds based on Kruskal-Wallis test with Mann- Whitney pairwise comparisons, $p>0.1065$). These low percentages

Table 5.5: The numbers of pollen, numbers of ovules and the pollen : ovules (P/O) ratios of the investigated taxa are presented.

	Species name	Accession number	Pollen (mean ± SD)	Ovule (mean ± SD)	P/O ratio (mean ± SD)
Calcicola group	*S. calcicola*	OIH81 (n=5)	3649 ± 519	4.8 ± 0.5	757.26 ± 45.77
Graveolens group	*S. graveolens*	OIH116 (n=3)	3840 ± 1392	10.7 ± 0.6	357.47 ± 117.30
Limiana group	*S. limiana*	OIH118 (n=3)	2367 ± 322	3.0 ± 0.0	789.00 ± 107.47
Petiolata group	*S. argentea*	OIH320 (n=3)	3001 ± 548	3.0 ± 0.0	1000.33 ± 182.77
	S. durga	OIH84 (n=4)	2937 ± 598	3.0 ± 0.0	979.00 ± 199.28
	S. hasta	OIH80 (n=4)	2885 ± 749	3.0 ± 0.0	961.67 ± 249.75
Other taxa	*S. malaccana*	OIH302 (n=3)	2675 ± 1052	3.0 ± 0.0	891.78 ± 350.61
	S. kunstleri var. *kunstleri*	OIH161 (n=4)	4320 ± 652	5.5 ± 0.6	783.05 ± 45.46
	B. parva	OIH109 (n=3)	1994 ± 381	3.0 ± 0.0	664.67 ± 127.03

Table 5.6: The total numbers of flowers, numbers of fruits and the calculated fruit set percentage of all investigated taxa is shown.

	Species name	Accession number	Number of inflorescence	Mean number of flowers in an inflorescences	Total number of flowers	Number of Fruits	Fruitset percentage (%)
Anomala group	*S. lanjakensis*	OIH310	39	10	390	6	1.54
Calcicola group	*S. calcicola*	OIH81	11	13	143	1	0.70
	S. uniflora	OIH291	1	1	1	0	0.00
Graveolens group	*S. graveolens*	OIH116	7	10	70	0	0.00
	S. lucens	OIH125	9	8	72	0	0.00
Limiana group	*S. limiana*	OIH118	3	23	69	1	1.45
Petiolata group	*S. argentea*	OIH320	4	7	28	0	0.00
	S. biru	OIH75	10	7	70	2	2.86
	S. biru	OIH87	33	7	231	2	0.87
	S. durga	OIH84	10	11	110	0	0.00
	S. durga	OIH108	8	11	88	2	2.27
	S. hasta	OIH80	15	8	120	0	0.00
	S. multifolia	OIH111	25	13	325	16	4.92

Table 5.6 continued

	S. nigra	OIH76	7	3	21	3	14.29
	S. petiolata	OIH71	14	15	210	3	1.43
	S. pseudoreticosa	OIH83	2	8	16	0	0.00
	S. reticosa	OIH79	8	8	64	0	0.00
	S. stenophylla	OIH74	30	6	180	4	2.22
	S. stenophylla	OIH106	26	6	156	4	2.56
	S. aff. *stenophylla*	OIH107	7	6	42	1	2.38
Other taxa	*S. malaccana*	OIH302	9	25	225	3	1.33
	B. parva	OIH109	4	20	80	0	0.00
	B. parva	OIH261	13	20	260	1	0.39
	B. aff. *pulchella*	OIH117	4	11	44	2	4.55

revealed the low efficiency of the *Scaphochlamys* species natural pollination system, which is congruent with the previous high P/O values results. Although the pollination system of these species was found to be solely xenogamy, all *Scaphochlamys* species are capable of vegetative reproduction via rhizome. The low fruit set may be due to the high competition of utilizing the same species of pollinators. The pollen may be lost when the bees visited other species as mentioned in the previous part of this chapter.

5.3.11 Floral Volatile Organic Compounds (VOCs) Analysis

Among all samples analysed by GC-MS with BPX5 intermediate polar column, only one compound was found in the *S. malaccana* sample (benzyl acetate, KRI=1173). In contrast, a total of 321 compounds was found in the samples analysed by GC-MS with BP20 polar column, which also included the only compound found when using the BPX5 intermediate polar column. The mean relative peak areas of the chemical composition (%) and the average floral scent emission of each species ($\mu g hr^{-1}$) analysed by GC-MS with BP20 polar column in splitless mode were listed in Table 5.7 and Table 5.8. The numbers of compounds found were highly variable among the sampled species, ranged from 0 to 130 compounds. Majority of the compounds were unique to a species, only 78 compounds were found to be shared with two or more species. Each species has their own blends of floral VOCs with very different profiles. Similarly, in a study of six orchid species in the same genus by Niet et al. (2014), the interspecific variation in scent emission were shown among the six species.

Although there were many compounds found in these samples, the floral VOCs of every species were emitted at low rate (< 175 $\mu g hr^{-1}$). Among the 321 compounds, 48 of these

Table 5.7: The mean relative peak areas (%) of the floral VOCs chemical composition analysed by using GC-MS with BP20 polar column in splitless mode were listed for each investigated species.

Odour compounds	Retention index	Anomala group	Calcicola group	Graveolens group	Limiana group	Petiolata group									Polyphylla group	Other taxa				
		S. scintillans	*S. calcicola*	*S. lucens*	*S. limiana*	*S. argentea*	*S. biru*	*S. durga*	*S. hasta*	*S. multifolia*	*S.* aff. *nigra*	*S. petiolata*	*S. pseudoreticosa*	*S. stenophylla*	*S. polyphylla*	*S.* aff. *klossii*	*S. kunstleri* var. *kunstleri*	*S. kunstleri* var. *speciosa*	*S. malaccana*	*B.* aff. *puchella*
Unidentified1	861	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Unidentified2	863	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified3	866	-	-	-	-	-	-	-	-	48.4	-	-	-	-	-	-	-	-	-	-
Unidentified4	867	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Ethyl-1-pentanol	900	-	-	-	-	-	-	-	-	41.0	-	-	-	-	-	-	-	-	-	-
Unidentified5	904	-	-	-	-	0.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified6	939	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified7	980	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
Unidentified8	1003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6	-	-
Unidentified9	1004	-	-	-	-	-	-	-	-	-	-	75.0	-	-	-	-	2.8	-	-	-
2-Methyldecane	1046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	-	-	-
b-Linalool	1080	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified10	1081	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.9	-	-	-
Linalool	1082	-	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified11	1108	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-

Table 5.7 continued

Unidentified12	1116	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Chlorononane	1143	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentanoic acid, hydrazide	1153	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified13	1157	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-
2-Nonen-1-ol	1170	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	2.4	-	-	-
Limonene	1173	-	-	0.1	-	-	-	-	-	-	-	-	-	7.1	-	-	-	-	0.2	-
Unidentified14	1175	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-
D-Limonene	1176	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	74.2	-	-
Cineole	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34.4	-	-	-	-
Unidentified15	1183	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.2	-	-	-
Unidentified16	1185	-	-	-	-	-	-	-	-	-	-	-	-	13.4	-	-	-	-	-	-
2-Methyl-5-propylnonane	1195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.9	-	-	-
Unidentified17	1208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	-	-	-
Unidentified18	1210	-	-	-	-	-	-	-	-	-	-	-	-	16.2	-	-	-	-	-	-
Unidentified19	1218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
Unidentified20	1223	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified21	1236	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
beta-Ocimene	1239	-	-	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	-	-
Megastigma-3,7(E),9-triene	1257	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-
Unidentified22	1310	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,6,10-Trimethyldodecane	1311	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Hepten-2-one,6-methyl-	1321	-	-	-	-	-	-	-	59.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified23	1327	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-
Unidentified24	1348	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified25	1364	-	-	0.1	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified26	1389	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified27	1400	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
1,9-Nonanediol	1401	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Butyl-1-octanol	1403	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Hexenoic acid, 2-acetyl-2, 4-dimethyl-, ethyl ester, (E)-	1407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified28	1414	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-	-	-
Unidentified29	1415	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4	-	-	-	-	-
Unidentified30	1417	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified31	1428	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified32	1429	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Heptafluorobutyric acid	1444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
3-(2-Methoxyethyl)-1-nonanol	1453	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
dihydro myrcenol	1459	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-(Dodecyloxy)ethylene	1483	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified33	1493	-	-	-	-	-	-	-	-	-	-	-	-	-	38.7	45.2	-	-	4.8	-
Unidentified34	1494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified35	1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
Unidentified36	1503	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4	-	-	-	-	-
Unidentified37	1505	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	-
Unidentified38	1511	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-
Unidentified39	1513	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified40	1514	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified41	1521	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified42	1524	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified43	1532	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.6	-	-	-

Table 5.7 continued

verdox (cyclohexanol acetate 2-tert-butyl)	1538	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6	-
bornyl acetate	1554	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2	-	-	-
Unidentified44	1564	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified45	1592	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified46	1593	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-
Unidentified47	1627	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.7	-	-	-
Unidentified48	1630	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified49	1632	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified50	1641	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified51	1646	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-	-	-	-	-
Unidentified52	1647	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified53	1653	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7	-	-	-
Unidentified54	1657	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified55	1658	-	-	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-
Unidentified56	1660	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	12.9	-	-
Unidentified57	1663	-	-	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-
Unidentified58	1665	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
Unidentified59	1673	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
endo-Borneol	1674	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-
Unidentified60	1681	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified61	1688	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentadecanal	1692	-	-	0.1	-	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified62	1693	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptadecane	1697	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6	-	-	-	-	-
Unidentified63	1700	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl acetate	1703	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.4	-	-	37.8	-

Table 5.7 continued

1-Heptadecene	1710	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-
Unidentified64	1724	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified65	1732	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,6,11,15-Tetramethylhexadecane	1740	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified66	1741	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Pentadecanol	1748	-	-	-	-	2.4	-	-	4.9	-	-	-	-	-	-	-	-	-	-	-
Unidentified67	1770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified68	1775	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified69	1776	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified70	1777	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified71	1781	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.3	-	-
Unidentified72	1784	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl pentadecanoate	1787	-	-	-	-	1.0	-	-	4.9	-	-	-	-	-	-	-	-	-	-	-
Unidentified73	1790	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Hexyl-1-decanol	1791	-	-	0.7	-	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified74	1800	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified75	1803	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified76	1804	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified77	1812	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
(Z)-7-Hexadecenal	1817	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified78	1822	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified79	1823	0.2	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified80	1826	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified81	1831	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
1-Chlorohexadecane	1834	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified82	1835	1.8	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified83	1837	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified84	1838	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
1-Octadecene	1843	-	-	1.2	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified85	1844	3.8	-	-	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified86	1845	-	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified87	1846	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl alcohol	1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.5	-
Unidentified88	1849	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Hexadecanol	1850	-	-	0.4	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-
Unidentified89	1852	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified90	1853	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified91	1855	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified92	1856	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified93	1857	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified94	1860	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified95	1863	5.2	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified96	1864	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abieta-6,13-diene	1869	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-[2-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethyl]-6,6-dimethylbicyclo[3.1.1] hept-2-ene	1871	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dodecan-1-yl acetate	1873	-	-	0.3	-	-	-	9.8	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified97	1878	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified98	1880	-	-	0.2	-	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified99	1884	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Undecanoic acid	1887	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified100	1889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-
Unidentified101	1890	0.1	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified102	1895	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified103	1899	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified104	1901	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Epoxyoctadecane	1904	-	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-
2-Methylhexadecan-1-ol	1905	-	-	-	-	-	-	3.0	-	-	-	-	-	-	2.1	-	-	-	-
Unidentified105	1909	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified106	1911	-	-	0.6	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-
Unidentified107	1912	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified108	1914	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified109	1915	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified110	1917	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified111	1921	-	-	0.2	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
2-Methyl-4,6-bis[(2E)-1-methyl-2-butenyl]phenol	1922	6.2	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified112	1923	-	-	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified113	1924	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
Unidentified114	1931	-	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Unidentified115	1933	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-
10-Methylnonadecane	1935	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified116	1936	-	-	0.7	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified117	1959	-	-	Tr	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-
Unidentified118	1960	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified119	1962	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-[4-(4-Propylcyclohexyl)phenyl]ethanone	1965	4.4	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified120	1970	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified121	1972	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified122	1973	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified123	1975	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified124	1976	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified125	1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified126	1980	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Hexadecanamine,N,N,-dimethyl-	1985	-	-	-	-	4.3	4.5	1.2	-	-	-	-	-	-	-	-	6.6	-	-	-
Unidentified127	1987	-	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-
Unidentified128	1988	2.5	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified129	1993	1.9	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified130	1995	-	-	0.9	-	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Methyl 16-methylheptadecanoate	1996	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Eicosane	1998	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified131	2000	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified132	2001	-	-	0.5	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-
cis-9-Octadecenal	2003	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified133	2005	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified134	2006	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Octadecenal	2011	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
Unidentified135	2016	1.0	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified136	2017	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified137	2019	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified138	2021	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified139	2022	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified140	2023	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified141	2030	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified142	2031	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified143	2033	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified144	2035	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.4	-
1-Chlorooctadecane	2036	-	-	2.1	-	-	2.6	1.9	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified145	2042	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified146	2043	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Hexylpentadecane	2044	-	-	0.1	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	1.0	-
cis-1-Chloro-9-octadecene	2045	-	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified147	2047	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	2049	-	-	0.2	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	0.5	-
Unidentified148	2053	-	-	0.2	-	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified149	2057	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Methyleicosane	2059	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
Unidentified150	2061	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified151	2062	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E,E-2,13-Octadecadien-1-ol	2064	-	-	0.5	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	0.9	-
4,4-Dimethylandrost-1-en-3-one	2066	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified152	2067	-	-	0.4	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified153	2071	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	-
1,16-Dichlorohexadecane	2073	-	-	0.8	-	1.6	0.6	1.0	-	-	-	-	-	-	-	-	2.9	-	-	-
Unidentified154	2078	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonadecyl pentafluoropropionate	2080	0.4	-	-	-	-	0.8	2.4	-	-	-	-	-	-	-	-	-	-	4.2	-
Trichloroacetic acid, tridec-2-ynyl ester	2081	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

14-Isopropyl-3,7,11-trimethyl-1,3,6,10-cyclotetradecatetraene	2082	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyclopenta[a,d]cycloocten-5-one, 1,2,3,3a,4,5,6,8,9,9a,10,10a-dodecahydro-7-(1-methylethyl)-1,9a-dimethyl-4-methylene	2085	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified155	2087	-	-	0.4	-	-	1.7	1.2	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified156	2088	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-
Unidentified157	2089	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified158	2096	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-(Decyloxy)decane	2097	-	-	-	-	-	-	0.2	-	-	-	-	-	-	1.2	-	-	-	-	-
Unidentified159	2098	-	-	1.0	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	1.9	-
Unidentified160	2099	-	-	-	-	-	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified161	2103	-	-	-	-	-	-	0.2	-	-	-	-	-	-	0.9	-	-	-	-	-
12-Methyl-E,E-2,13-octadecadien-1-ol	2104	-	-	0.5	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified162	2105	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Heneicosane	2108	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	0.9	-
Phenyl 3-deoxy-.beta.-d-ribo-hexopyranoside	2109	-	-	-	-	2.5	-	3.9	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified163	2110	-	-	0.2	-	-	-		-		-	-	-	-	-	-		-		-
Unidentified164	2111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-
Unidentified165	2112	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified166	2116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-
Unidentified167	2117	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified168	2119	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-
Unidentified169	2120	-	-	-	-	-	0.3	2.9	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified170	2124	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified171	2132	2.4	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified172	2133	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified173	2134	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified174	2141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified175	2142	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified176	2145	1.4	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified177	2147	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified179	2148	-	-	0.4	-	-	-	1.3	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified180	2150	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified181	2153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-
Unidentified182	2154	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified183	2156	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Octadecanoic acid	2157	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified184	2158	-	-	-	-	-	-	-	-	10.6	-	-	-	-	-	-	-	-	-	-
2-Dodecen-1-ylsuccinic anhydride	2160	-	-	-	-	2.2	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-
3.beta.,6.beta.-Tricyclo[3.3.1.1(2,7)]decanebis(methanesulfonate)	2173	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified185	2174	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified186	2179	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified187	2181	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified189	2183	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Octadecanamine,N,N-dimethyl-	2188	3.5	-	6.8	-	14.4	15.9	-	7.5	-	-	-	-	17.9	-	-	21.9	-	-	-
Unidentified190	2196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Docosane	2198	-	-	-	-	-	1.1	7.9	-	-	-	-	-	-	1.9	-	-	-	-	-

Table 5.7 continued

Hexadecanoic acid, methyl ester	2202	1.0	-	-	-	3.7	0.7	-	-	-	-	-	-	-	5.4	-	2.5	-	-	-
Unidentified191	2204	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
1-Methyl-4-[1-methylene-5-(4-methylphenyl)-5-hexenyl]benzene	2208	4.9	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Methoxy-16,16-dimethylandrostan-17-one	2222	1.3	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Isopropyl-1,7,11-trimethyl-2,7,11-cyclotetradecatrien-1-ol	2223	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified192	2226	-	-	-	-	-	5.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified193	2227	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified194	2233	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	0.9	-
Unidentified195	2237	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified196	2242	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified197	2249	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified198	2250	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified199	2253	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified200	2259	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	1.1	-
Unidentified201	2266	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
E,E,Z-1,3,12-Nonadecatriene-5,14-diol	2271	-	-	1.6	-	-	3.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified202	2278	-	-	0.6	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	0.7	-
Octadecane, 1-chloro-	2284	-	-	1.8	-	5.7	5.1	-	1.9	-	-	-	-	8.8	-	-	11.8	-	-	-
Unidentified203	2288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-
Unidentified204	2289	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified205	2290	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Unidentified206	2298	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified207	2299	-	-	-	-	-	-	18.1	-	-	100	-	-	-	-	-	-	-	-	-
Unidentified208	2306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified209	2307	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl (Z)-5,11,14,17-eicosatetraenoate	2319	-	-	2.6	-	-	-	4.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified210	2329	-	-	-	-	-	1.8	-	-	-	-	-	-	8.1	-	-	-	-	-	-
Unidentified211	2341	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified212	2342	1.2	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	1.7	-	-	100
Unidentified213	2343	-	-	-	-	-	-	0.4	-	-	-	-	-	-	9.3	-	-	-	-	-
Unidentified214	2352	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified215	2358	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Heneicosanol	2365	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified216	2369	-	-	0.7	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Unidentified217	2370	-	-	-	-	-	0.3	-		-	-	-	-	-	-	-	-	-	-	-
Unidentified218	2374	-	-	0.1	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Unidentified219	2378	-	-	1.0	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
(5E)-8-(2,5,5,8a-Tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenyl)-6-methyl-5-octen-2-ol	2390	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified220	2393	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified221	2399	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified222	2400	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-Isopropyl-1,5,9-trimethyl-4,8,13-cyclotetradecatriene-1,3-diol	2411	-	-	1.9	-	-	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.7 continued

Octadecyl 2-chloropropanoate	2412	-	-	-	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetracosane	2414	-	-	0.5	-	-	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified223	2421	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified224	2427	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Octadecenoic acid, methyl ester, (E)-	2428	-	-	12.8	-	33.5	19.5	-	6.6	-	-	-	-	17.6	-	-	4.8	-	-	-
Unidentified225	2436	-	-	3.0	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified226	2446	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified227	2459	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified228	2460	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10,13-Octadecadienoic acid, methyl ester	2474	-	-	2.7	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified229	2475	-	-	-	-	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified230	2476	-	-	-	-	-	-	-	-	-	-	-	-	11.0	-	-	-	-	-	-
Unidentified231	2479	-	-	-	-	5.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified232	2483	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified233	2498	-	-	-	-	-	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified234	2510	-	-	-	-	-	-	1.1	-	-	-	-	-	-	5.2	-	-	-	-	-
Unidentified235	2543	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Tetracosyl pentafluoropropionate	2555	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total number of compounds	321	51	0	130	1	21	54	58	15	3	1	2	1	8	17	3	24	4	43	1

Tr = Trace amount (<0.1% of total sample)

S. scintillans OIH141, n=2; *S. calcicola* OIH81, n=2; *S. lucens* OIH125, n=2, *S. lucens* OIH263, n=2; *S. limiana* OIH118, n=2; *S. argentea* OIH320, n=2; *S. biru* OIH87, n=2; *S. durga* OIH84, n=4, *S. durga* OIH96, n=2, *S. durga* OIH260, n=2; *S. hasta* OIH80, n=2; *S. multifolia* OIH112, n=3; *S.* aff. *nigra* OIH77, n=2; *S. petiolata* OIH71, n=2; *S. pseudoreticosa* OIH83, n=2; *S. stenophylla* OIH106, n=1; *S. polyphylla* OIH119, n=2, *S. polyphylla* OIH289, n=1; *S.* aff. *klossii* OIH166, n=2; *S. kunstleri* var. *kunstleri* OIH161, n=2; *S. kunstleri* var. *speciosa* OIH162, n=1; *S. malaccana* OIH302, n=4; *B.* aff. *puchella* OIH100, n=1.

Table 5.8: The average scent emission (μghr^{-1}) by the flowers of each investigated species were listed according to the floral VOCs chemical composition analysed by using GC-MS with BP20 polar column in splitless mode.

Odour compounds	Retention index	Anomala group	Calcicola group	Graveolens group	Limiana group	Petiolata group									Polyphylla group	Other taxa				
		S. scintillans	*S. calcicola*	*S. lucens*	*S. limiana*	*S. argentea*	*S. biru*	*S. durga*	*S. hasta*	*S. multifolia*	*S.* aff. *nigra*	*S. petiolata*	*S. pseudoreticosa*	*S. stenophylla*	*S. polyphylla*	*S.* aff. *klossii*	*S. kunstleri* var. *kunstleri*	*S. kunstleri* var. *speciosa*	*S. malaccana*	*B.* aff. *puchella*
Unidentified1	861	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Unidentified2	863	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified3	866	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-
Unidentified4	867	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Ethyl-1-pentanol	900	-	-	-	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-
Unidentified5	904	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified6	939	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified7	980	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
Unidentified8	1003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-
Unidentified9	1004	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-	0.8	-	-	-
2-Methyldecane	1046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
b-Linalool	1080	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified10	1081	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-
Linalool	1082	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified11	1108	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified12	1116	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

1-Chlorononane	1143	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentanoic acid, hydrazide	1153	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified13	1157	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
2-Nonen-1-ol	1170	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Limonene	1173	-	-	0.1	-	-	-	-	-	-	-	-	-	4.7	-	-	-	-	0.1	-
Unidentified14	1175	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
D-Limonene	1176	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	2.9	-	-
Cineole	1180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-
Unidentified15	1183	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-
Unidentified16	1185	-	-	-	-	-	-	-	-	-	-	-	-	8.8	-	-	-	-	-	-
2-Methyl-5-propylnonane	1195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-
Unidentified17	1208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
Unidentified18	1210	-	-	-	-	-	-	-	-	-	-	-	-	10.7	-	-	-	-	-	-
Unidentified19	1218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Unidentified20	1223	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified21	1236	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
beta-Ocimene	1239	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Megastigma-3,7(E),9-triene	1257	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	-
Unidentified22	1310	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,6,10-Trimethyldodecane	1311	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Hepten-2-one,6-methyl-	1321	-	-	-	-	-	-	-	2-	-	-	-	-	-	-	-	-	-	-	-
Unidentified23	1327	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified24	1348	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified25	1364	-	-	0.1	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified26	1389	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified27	1400	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
1,9-Nonanediol	1401	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Butyl-1-octanol	1403	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Hexenoic acid, 2-acetyl-2, 4-dimethyl-, ethyl ester, (E)-	1407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified28	1414	-	-	-	-	-	-	-	-	-	-	-	-	-	Tr	-	-	-	-	-
Unidentified29	1415	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified30	1417	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified31	1428	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified32	1429	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Heptafluorobutyric acid	1444	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
3-(2-Methoxyethyl)-1-nonanol	1453	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
dihydro myrcenol	1459	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-(Dodecyloxy)ethylene	1483	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified33	1493	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	1.0	-	-	1.4	-
Unidentified34	1494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified35	1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified36	1503	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified37	1505	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified38	1511	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified39	1513	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified40	1514	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified41	1521	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified42	1524	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified43	1532	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-

Table 5.8 continued

verdox (cyclohexanol acetate 2-tert-butyl)	1538	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-
bornyl acetate	1554	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	-
Unidentified44	1564	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified45	1592	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified46	1593	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified47	1627	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-
Unidentified48	1630	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified49	1632	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified50	1641	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified51	1646	-	-	-	-	-	-	-	-	-	-	-	-	-	Tr	-	-	-	-	-
Unidentified52	1647	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified53	1653	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-
Unidentified54	1657	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified55	1658	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
Unidentified56	1660	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	0.5	-	-
Unidentified57	1663	-	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified58	1665	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
Unidentified59	1673	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
endo-Borneol	1674	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-	-	-
Unidentified60	1681	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified61	1688	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentadecanal	1692	-	-	0.1	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified62	1693	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptadecane	1697	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified63	1700	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl acetate	1703	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	11.1	-

Table 5.8 continued

1-Heptadecene	1710	-	-	-	-	-	-	-	-	-	-	-	3.7	-	-	-	-	-	-	-
Unidentified64	1724	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified65	1732	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,6,11,15-Tetramethylhexadecane	1740	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified66	1741	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Pentadecanol	1748	-	-	-	-	2.4	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified67	1770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified68	1775	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified69	1776	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified70	1777	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified71	1781	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-
Unidentified72	1784	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl pentadecanoate	1787	-	-	-	-	1.0	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified73	1790	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Hexyl-1-decanol	1791	-	-	0.4	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified74	1800	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified75	1803	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified76	1804	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified77	1812	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
(Z)-7-Hexadecenal	1817	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified78	1822	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified79	1823	0.2	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified80	1826	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified81	1831	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
1-Chlorohexadecane	1834	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified82	1835	2.0	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified83	1837	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified84	1838	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-
1-Octadecene	1843	-	-	0.7	-	-	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified85	1844	4.1	-	-	-	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified86	1845	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified87	1846	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzyl alcohol	1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.8	-
Unidentified88	1849	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Hexadecanol	1850	-	-	0.2	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-
Unidentified89	1852	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified90	1853	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified91	1855	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified92	1856	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified93	1857	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified94	1860	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified95	1863	5.7	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified96	1864	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abieta-6,13-diene	1869	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-[2-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethyl]-6,6-dimethylbicyclo[3.1.1]hept-2-ene	1871	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dodecan-1-yl acetate	1873	-	-	0.2	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified97	1878	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified98	1880	-	-	0.1	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified99	1884	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Undecanoic acid	1887	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified100	1889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified101	1890	0.1	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified102	1895	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified103	1899	4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified104	1901	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Epoxyoctadecane	1904	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
2-Methylhexadecan-1-ol	1905	-	-	-	-	-	-	0.2	-	-	-	-	-	-	Tr	-	-	-	-	-
Unidentified105	1909	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified106	1911	-	-	0.4	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified107	1912	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified108	1914	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified109	1915	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified110	1917	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified111	1921	-	-	0.1	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
2-Methyl-4,6-bis[(2E)-1-methyl-2-butenyl]phenol	1922	6.7	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified112	1923	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified113	1924	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified114	1931	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified115	1933	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
10-Methylnonadecane	1935	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified116	1936	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified117	1959	-	-	Tr	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified118	1960	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified119	1962	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

1-[4-(4-Propylcyclohexyl)phenyl]ethanone	1965	4.8	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified120	1970	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified121	1972	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified122	1973	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified123	1975	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified124	1976	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified125	1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified126	1980	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Hexadecanamine,N,N,-dimethyl-	1985	-	-	-	-	4.2	7.7	0.1	-	-	-	-	-	-	-	-	1.9	-	-	-
Unidentified127	1987	-	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-
Unidentified128	1988	2.7	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified129	1993	2.1	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified130	1995	-	-	0.5	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Methyl 16-methylheptadecanoate	1996	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Eicosane	1998	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified131	2000	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified132	2001	-	-	0.3	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
cis-9-Octadecenal	2003	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified133	2005	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified134	2006	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Octadecenal	2011	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
Unidentified135	2016	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified136	2017	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified137	2019	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified138	2021	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified139	2022	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified140	2023	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified141	2030	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified142	2031	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified143	2033	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified144	2035	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-
1-Chlorooctadecane	2036	-	-	1.2	-	-	4.4	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified145	2042	5.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified146	2043	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Hexylpentadecane	2044	-	-	0.1	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	0.3	-
cis-1-Chloro-9-octadecene	2045	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified147	2047	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	2049	-	-	0.1	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified148	2053	-	-	0.1	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified149	2057	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Methyleicosane	2059	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified150	2061	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified151	2062	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E,E-2,13-Octadecadien-1-ol	2064	-	-	0.3	-	-	-	-	-	-	-	-	-	-	Tr	-	-	-	0.3	-
4,4-Dimethylandrost-1-en-3-one	2066	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified152	2067	-	-	0.2	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified153	2071	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
1,16-Dichlorohexadecane	2073	-	-	0.5	-	1.6	1.0	0.1	-	-	-	-	-	-	-	-	0.8	-	-	-

Table 5.8 continued

Unidentified154	2078	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonadecyl pentafluoropropionate	2080	0.4	-	-	-	-	1.4	0.2	-	-	-	-	-	-	-	-	-	-	1.2	-
Trichloroacetic acid, tridec-2-ynyl ester	2081	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14-Isopropyl-3,7,11-trimethyl-1,3,6,10-cyclotetradecatetraene	2082	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyclopenta[a,d]cyclooc ten-5-one, 1,2,3,3a,4,5,6,8,9,9a,10 ,10a-dodecahydro-7-(1-methylethyl)-1,9a-dimethyl-4-methylene	2085	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified155	2087	-	-	0.2	-	-	2.9	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified156	2088	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Unidentified157	2089	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified158	2096	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-(Decyloxy)decane	2097	-	-	-	-	-	-	Tr	-	-	-	-	-	-	Tr	-	-	-	-	-
Unidentified159	2098	-	-	0.6	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified160	2099	-	-	-	-	-	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified161	2103	-	-	-	-	-	-	Tr	-	-	-	-	-	-	Tr	-	-	-	-	-
12-Methyl-E,E-2,13-octadecadien-1-ol	2104	-	-	0.3	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified162	2105	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Heneicosane	2108	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Phenyl 3-deoxy-.beta.-d-ribo-hexopyranoside	2109	-	-	-	-	2.5	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified163	2110	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified164	2111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified165	2112	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified166	2116	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	-	-	-
Unidentified167	2117	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified168	2119	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-
Unidentified169	2120	-	-	-	-	-	0.5	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified170	2124	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified171	2132	2.6	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified172	2133	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified173	2134	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified174	2141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified175	2142	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified176	2145	1.5	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified177	2147	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified179	2148	-	-	0.2	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified180	2150	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified181	2153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified182	2154	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified183	2156	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Octadecanoic acid	2157	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified184	2158	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
2-Dodecen-1-ylsuccinic anhydride	2160	-	-	-	-	2.2	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
3.beta.,6.beta.-Tricyclo[3.3.1.1(2,7)]decanebis(methanesulfonate)	2173	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified185	2174	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified186	2179	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified187	2181	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified189	2183	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Octadecanamine,N,N-dimethyl-	2188	3.8	-	4.0	-	14.1	27.1	-	2.5	-	-	-	-	11.8	-	-	6.3	-	-	-
Unidentified190	2196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Docosane	2198	-	-	-	-	-	1.9	0.5	-	-	-	-	-	-	Tr	-	-	-	-	-
Hexadecanoic acid, methyl ester	2202	1.1	-	-	-	3.6	1.2	-	-	-	-	-	-	-	0.1	-	0.7	-	-	-
Unidentified191	2204	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-
1-Methyl-4-[1-methylene-5-(4-methylphenyl)-5-hexenyl]benzene	2208	5.3	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Methoxy-16,16-dimethylandrostan-17-one	2222	1.4	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Isopropyl-1,7,11-trimethyl-2,7,11-cyclotetradecatrien-1-ol	2223	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified192	2226	-	-	-	-	-	8.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified193	2227	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified194	2233	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified195	2237	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified196	2242	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified197	2249	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified198	2250	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified199	2253	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified200	2259	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	0.3	-
Unidentified201	2266	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

E,E,Z-1,3,12-Nonadecatriene-5,14-diol	2271	-	-	0.9	-	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified202	2278	-	-	0.4	-	-	1.0	-	-	-	-	-	-	-	-	-	-	0.2	-
Octadecane, 1-chloro-	2284	-	-	1.1	-	5.6	8.7	-	0.6	-	-	-	-	5.8	-	-	3.4	-	-	-
Unidentified203	2288	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified204	2289	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified205	2290	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified206	2298	-	-	-	-	-	2.6	-	-	-	-	-	-	-	-	-	-	-	0.1	-
Unidentified207	2299	-	-	-	-	-	-	1.2	-	-	2.9	-	-	-	-	-	-	-	-	-
Unidentified208	2306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
Unidentified209	2307	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl (Z)-5,11,14,17-eicosatetraenoate	2319	-	-	1.5	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified210	2329	-	-	-	-	-	3.1	-	-	-	-	-	-	5.3	-	-	-	-	-	-
Unidentified211	2341	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified212	2342	1.3	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	0.5	-	-	1.1
Unidentified213	2343	-	-	-	-	-	-	Tr	-	-	-	-	-	-	0.2	-	-	-	-	-
Unidentified214	2352	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified215	2358	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Heneicosanol	2365	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified216	2369	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified217	2370	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified218	2374	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified219	2378	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

(5E)-8-(2,5,5,8a-Tetramethyl-1,4,4a,5,6,7,8,8a-octahydro-1-naphthalenyl)-6-methyl-5-octen-2-ol	2390	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified220	2393	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified221	2399	-	-	-	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified222	2400	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-Isopropyl-1,5,9-trimethyl-4,8,13-cyclotetradecatriene-1,3-diol	2411	-	-	1.1	-	-	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Octadecyl 2-chloropropanoate	2412	-	-	-	-	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetracosane	2414	-	-	0.3	-	-	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified223	2421	-	-	-	-	-	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified224	2427	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Octadecenoic acid, methyl ester, (E)-	2428	-	-	7.5	-	32.9	33.3	-	2.2	-	-	-	-	11.6	-	-	1.4	-	-	-
Unidentified225	2436	-	-	1.8	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified226	2446	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified227	2459	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified228	2460	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10,13-Octadecadienoic acid, methyl ester	2474	-	-	1.6	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified229	2475	-	-	-	-	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified230	2476	-	-	-	-	-	-	-	-	-	-	-	-	7.3	-	-	-	-	-	-
Unidentified231	2479	-	-	-	-	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified232	2483	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified233	2498	-	-	-	-	-	11.1	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8 continued

Unidentified234	2510	-	-	-	-	-	-	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-
Unidentified235	2543	-	-	-	-	-	-	Tr	-	-	-	-	-	-	-	-	-	-	-	-
Tetracosyl pentafluoropropionate	2555	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		108.8	-	58.4	0.7	98.1	170.7	6.8	33.5	1.1	2.9	0.3	3.7	66.0	1.7	2.2	28.9	3.9	29.5	1.1

Tr = Trace amount (<0.05 $\mu g hr^{-1}$)

S. scintillans OIH141, n=2; *S. calcicola* OIH81, n=2; *S. lucens* OIH125, n=2, *S. lucens* OIH263, n=2; *S. limiana* OIH118, n=2; *S. argentea* OIH320, n=2; *S. biru* OIH87, n=2; *S. durga* OIH84, n=4, *S. durga* OIH96, n=2, *S. durga* OIH260, n=2; *S. hasta* OIH80, n=2; *S. multifolia* OIH112, n=3; *S.* aff. *nigra* OIH77, n=2; *S. petiolata* OIH71, n=2; *S. pseudoreticosa* OIH83, n=2; *S. stenophylla* OIH106, n=1; *S. polyphylla* OIH119, n=2, *S. polyphylla* OIH289, n=1; *S.* aff. *klossii* OIH166, n=2; *S. kunstleri* var. *kunstleri* OIH161, n=2; *S. kunstleri* var. *speciosa* OIH162, n=1; *S. malaccana* OIH302, n=4; *B.* aff. *puchella* OIH100, n=1.

compounds were the major constituents of the floral scents (≥ 5 % for a species), 12 of the major compounds were identified, including two monoterpenes (limonene and D-limonene), three terpenoids (1,8-cineole, 6-methyl-5-Hepten-2-one, endo-borneol), two aromatic compounds (benzyl acetate and benzyl alcohol), three fatty acid derivatives (Dodecan-1-yl acetate, Hexadecanoic acid methyl ester and 9-Octadecenoic acid methyl ester), a tertiary amine (N,N-dimethyl-1-Octadecanamine) and a haloalkane (1-chloro-octadecane). Even though, these major compounds were actually released at very low rates sometimes (see Table 5.8), the insects and animals are much sensitive to trace amount of chemical compounds than human. Some of these major compounds were reported to have ecological significances in previous studies, especially the terpenes, terpenoids and aromatic compounds. Limonene and benzyl acetate were reported in the floral scents of *Daelechampia magnoliifolia* Muell. (Euphorbiaceae) and believed to be have a role in attracting male Euglossine bees (Armbruster et al., 1989). The effects of several compounds (including 1,8-cineole and benzyl acetate) to male Euglossine bees were further confirmed by Schiestl and Roubik (2003). Several pest control studies had shown positive insecticidal results with the plant essential oils containing limonene, 1,8-cineole and/or borneol (e.g. Don Pedro, 1996; Hollingsworth, 2005; Rozman et al., 2007; Abderrahmane & Lahcen, 2015). Besides, the 1,8-cineole has antifeedant effect to the mammalian herbivores as well (Bedoya-Pérez et al., 2014). The 6-methyl-5-Hepten-2-one was commonly found in *Cymbopogon* oils (e.g. Costa et al., 2013; Tofiño-Rivera et al., 2016) and reported as an alarm pheromone of ants (Duffield et al., 1977). However, the predatory herbivores may utilize these compounds as well, as an example, plum curculios uses limonene, benzyl alcohol and other compounds as the foraging cues (Prokopy et al., 2001). Moreover, it was speculated that the beavers accumulated the probably formerly

harmful compounds in their food plants (including benzyl alcohol) into the castoreum scent to mark their territory (Müller-Schwarze, 2011).

For the two *Amegilla*-pollinated species in this study, there was no compound detected in *S. calcicola* samples but 130 compounds found in *S. lucens* samples. Both the lowest and the highest number of compounds found were in these two *Amegilla*-pollinated species. On the other hand, none of the 78 shared compounds was commonly shared by all the Halictid-pollinated species (*S. biru*, *S. multifolia*, *S. petiolata*, *S. stenophylla*, *B.* aff. *puchella*). In fact, there was not a single compound universally shared by all investigated species. This finding is different from the recent floral VOCs study on aroids by Hoe et al. (2016) in Borneo with the floral VOCs appeared to be pollination-related. Perhaps the ecological significance of the floral scent emission is not limited as pollinator attractants for these ginger species because the identified major compounds were not only reported for pollinator interactions. As shown in the previous observation results, grasshoppers (as in *S. malaccana* and *S. petiolata*) or ants (e.g. *S. lanjakensis*, *S. biru* and *S. nigra*) are present in some species but not in others. Furthermore, as an example of multifunctional floral volatile compound, the function of E,E-α-farnesene was further confirmed to be able in both attracting honey bees and repelling ants by Willmer et al. (2009). Besides, Theis et al. (2007) reported that there might have different temporal floral scent emission patterns in the same species in order to avoid herbivores.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Through the field investigation to various localities conducted in this study, 74 accessions of *Scaphochlamys* species (63 from Borneo and 11 from Peninsular Malaysia) were collected. Twelve novelties were discovered and described. The recognition of these species takes current account of Bornean *Scaphochlamys* to 24 species (including Limiana and Polyphylla groups). These species were classified into six informal taxonomic groups. An identification key was produced for all recognised Bornean species. Several taxonomically important morphological characteristics such as inflorescence types, bracts and bracteoles were discussed.

A phylogenetic study using nuclear ITS and plastid *trn*K-*mat*K including 26 species of *Scaphochlamys* (36 accessions) from Borneo and Peninsular Malaysia together with other genera (eight accessions) was carried out. Bornean *Scaphochlamys* is divided into two clades: the first clade which includes *Myxochlamys*, and the second clade with two Bornean species clustered with the species of the Peninsular Malaysia. The informal taxonomic groups of Bornean *Scaphochlamys* were mostly supported except for the inconsistent placements of *S. multifolia*, *S. lanjakensis* and *S. uniflora* in the analyses with ITS or *trn*K-*mat*K regions.

Scaphochlamys flowers were found to be flowering diurnally within a day without clear differentiation of stages (undergoing both male and female anthesis almost

simultaneously). Pollen is spheroidal to elliptical, more or less psilate (sometimes with longitudinally slightly raised striate sculptured lines), starchy and lipid-rich. Two pollination guilds were recorded for *Scaphochlamys* species, *Amergilla* bees and Halictid bees. The nectars are the rewards for these traplining pollinators. The natural pollination system is entomophilous xenogamy by having one-day diurnal chasmogamous flowers. The efficiency of the natural pollination system is low with high pollen : ovules ratios and low fruit set percentages.

Floral scent analysis were carried out for 19 species (including a *Boesenbergia* species), 321 VOCs were found in the samples of the investigated species, in which 48 of these compounds were considered as major compounds (≥ 5 %). The average scent emission rates are low in all species (< 175 $\mu g h^{-1}$). Majority of the compounds belong to terpenes, terpenoids, aromatic compounds and fatty acid derivatives. Each species has its own floral VOCs profile, ranging to as high as 130 compounds.

The taxonomic novelties and the various morphological variations reported in this study clearly show the vast diversity and species richness of *Scaphochlamys* on Borneo. This integrated study with several research fields (taxonomy, phylogenetic relationship, flowering mechanism, pollination biology, microstructures inspection, floral VOCs analyses etc.) does not only provide a solid foundation for further investigation on *Scaphochlamys* but also serves as a model for understanding other numerous 'incompletely known' species on Borneo.

6.2 Recommendations or Future Prospects

As the plants clearly have both similarities and differences, the characteristics chosen for classification are widely employed from various fields nowadays. The architectural characteristics used in the traditional taxonomy are useful to see the basic architecture and their modifications. Among the colour variation, the tones (like more pinkish or reddish) may be highly varied even within the same population but the present or absent of blue pigments (as an example purple or red colour) is a good indicator as the blue pigments need relatively more complicated biochemical pathways.

For phylogenetic study, the Next Generation Sequencing (NGS) technique will provide a cladogram with better resolution for these species to understand the intrageneric relationships. The integration of morphologies and the phylogeny is still needed for congregating more synapomorphic characteristics for better generic delimitation. As some of the closely-related species share the same pollinator and within a single species, a wide range of morphological variation was observed, study of population genetics (such as microsatellites and AFLP) may be able to investigate on possible occurrence of natural hybrids. Furthermore, a detailed study on the population genetics of the widely distributed *S. polyphylla* complex may provide more supporting evidence for species delineation. So far, there were no detailed chromosonal study reported for *Scaphochlamys* as well.

Dynamic headspace method for collecting floral volatiles employed in this study is applied for the first time in Zingiberaceae. This part of the study could be further improved in future by (1) adding two or more flowers to be tested simultaneously as the floral scent emiited from *Scaphochlamys* are usually mild, and (2) separating the bracts from the

flower as the bracts are suspected to emit scent as well. Then, the floral volatiles could be compared from these samples.

Within the duration of this study, three populations found at the early stage of this study were completely deteriorated due to the conversion of land uses. Another three populations were partially affected by the nearby conversion of land uses. Hopefully, the continuous discovery of these highly threatened taxa will increase the awareness among the public and lawmakers on preserving these hidden treasures.

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APPENDICES

Appendix 1: The aligned ITS region sequences of the taxa included in the phylogenetic analyses.

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                       5         15         25         35         45
S.argenteaOIH320                  CTGAGAG--- ---------A GC--ACAGAA -CGACGGATG GCCGTGAATG
S.bilobaAF478788                  TTGAGAGAAC ---------A AC--ATAAAA -TGACGGATG GTTGTGAACG
S.bilobaOIH326                    TTGAGAGAAC ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.bilobaOIH327                    TTGAGAGAAC ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.biruOIH87                       CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.biruOIH254                      CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.calcicolaOIH81                  TTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.durgaOIH84                      CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.durgaOIH235                     CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.graveolensOIH116                TTGAGAG--- ---------A GC--ATAGAA -TGATGGATG GCTGCGAATG
S.hastaOIH80                      CTGAGAG--- ---------A GC--ACACAA -TGACGGATG GCCGTGAATG
S.aff.klossiiOIH168               TCGAGAGA-- ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.kunstleriAF478789               TTGAGAGAAC AT-------A AC--ACAAAA -TGACGGATG GTTGCGAATG
S.kunstleriOIH161                 TTGAGAGAAC AT-------A AC--ACAAAA -TGACGGATG GTTGCGAATG
S.kunstleriOIH162                 TTGAGAGAAC AT-------A AG--ATAAAA -TGACGGATG GTTGCGAATG
S.kunstleriOIH163                 TTGAGAGAAC AT-------A AC--ACAAAA -TGACGGATG GTTGCGAATG
S.lanjakensisOIH309               TTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCTGTGAATG
S.limianaOIH122                   TTGAGAG--- ---------A AC--ATAAAA ATGACGGATG GTTGTGAATG
S.lucensOIH125                    TTGAGAG--- ---------A GC--ATAGAA -TGATGGATG GCTGCGAATG
S.malaccanaOIH159                 TCGAGAGA-- ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.multifoliaOIH111                TTGAGAGAGC ATAAGCATAA GC--ATAGAA -TGACGGATG GCCGTGAACG
S.nigraOIH76                      CTGAGAG--- ---------A GC--ACAGAA -TGACGGATG GCCGTGAATG
S.cf.nigraOIH227                  CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAACG
S.penyamarOIH137                  TTGAGAG--- ---------A GC--ACAGAA -TGACGGATG GCCGTGAATG
S.petiolataOIH71                  CTGAGAG--- ---------A GC--ACAGAA -TGACGGATG GCCGTGAATG
S.picturataZI656                  TTGAGAG--- ---------A GC--ACAGAT -TGACGGATG GCTGTGAATG
S.pseudoreticosaOIH83             CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGCGAATG
S.polyphyllaOIH119                TCGAGAGA-- ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.polyphyllaOIH289                TCGAGAGA-- ---------A AC--ATAAAA -TGACGGATG GTTGTGAATG
S.reticosaOIH79                   CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.reticosaZI139                   CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.scintillansOIH141               TTGAGAG--- ---------A GC--ACAGAA -TGACGGATG GCCGTGAATG
S.stenophyllaOIH74                CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.stenophyllaOIH88                CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG GCCGTGAATG
S.cf.stenophylla2OIH93            CTGAGAG--- ---------A GC--ATAGAA -TGACGGATG TCCGTGAATG
S.unifloraOIH82                   TTGAGAGAGC AT-------A GC--ATAGAA -TGACGGATG ACCGTGAATG
H.uniflorumOIH113                 TTGAGAG--- ---------A GC--ATAGAA -TGATGGATG GTTGTGAACG
DistichochlamysspAF478745         TTGAGAG--- ---------A GC--ATATAA -TGACGGATG GTTGTGAATG
B.pulcherrimaJX992748             TTGAGAG--- ---------A GC--ATATAA -TGATGGATG GTTGTGAACG
Z.officinaleKC582866              TTGAGAG--- ---------A GCATATAGAA -TGACGGATG ATGGCGAATG
K.rotundaAF478767                 TTGAGAG--- ---------A GC--ACAGAA -CGATGGATG TTTGTGAATG
H.cyanescensJF825533              TTGAGAGAG- ---------A GC--ATAGAA -TGACGGATG ATTGTGAATG
T.flagellarisAF478797             TTGAGAG--- ---------A GC--ATGAAA --GATGGATG ACTGTTAATC
M.mullerensisAB245522             TTGAGAG--- ---------A GC--ATAGAA -TAATGGATG ATTGTGAATG
```

Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                               55         65         75         85         95
S.argenteaOIH320          TGTGAACGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.bilobaAF478788          TGTGAATGCG --TCCCTTTC CTCGCCCCG- -------CCC CA-------T
S.bilobaOIH326            TGTGAATGTG --TGCCTTTC CTCGCCCCG- -------TCC CA-------T
S.bilobaOIH327            TGTGAATGTG --TCCCTTTC CTCGCCCCA- -------CCC CA-------T
S.biruOIH87               TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.biruOIH254              TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.calcicolaOIH81          TGTGAATGTG --TCCCTTTC CTCGCCCCA- -------CGT TA-------T
S.durgaOIH84              TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.durgaOIH235             TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.graveolensOIH116        TGTGAATGTG --TCCCTTTC CTCGCCCCCC ACGTTAACGT TATGTTATGT
S.hastaOIH80              TGTGAATGTG TCTCCCTTTC CTTGCCCCC- ---------- CA-------T
S.aff.klossiiOIH168       TGTGAATGTG --TCCCTTTC CTCGCCCCG- -------CCC CG-------T
S.kunstleriAF478789       TGTGAATGTG --TCCCTTTT CTCGCCCCG- ---------- ---------C
S.kunstleriOIH161         TGTGAATGTG --TCCCTTTC CTCGCCCCG- ---------- ---------C
S.kunstleriOIH162         TGTGAATGCG --TCCCTTTC CTCGCCCCC- ------ACGC CA-------C
S.kunstleriOIH163         TGTGAATGTG --TCCCTTTC CTCGCCCCG- ---------- ---------C
S.lanjakensisOIH309       TGTGAATGTG --TCCCTTTC CTCGCCCCA- ---------- ---------T
S.limianaOIH122           TGTGAACGTG --TCCCTTTC CTCGCCCCA- ---------- ---------T
S.lucensOIH125            TGTGAATGTG --TCCCTTTC CTCGCCCCCC ACGTTAACGT TATGTTATGT
S.malaccanaOIH159         TGTGAATGTG --TCCCTTTC CTCGCCCCG- -------CCC CA-------T
S.multifoliaOIH111        TGTGAACGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.nigraOIH76              TGTGAATGTG TCTCCCTTTC CTTGCCCCC- ---------- CA-------T
S.cf.nigraOIH227          TGTGAATGTG TCTCCCTTTC CTCGCCCCC- ---------C CA-------T
S.penyamarOIH137          TGTGAATGTG --TCCCTTTC CTCGCCCCA- -------CCC CA-------T
S.petiolataOIH71          TGTGAATGTG TCTCCCTTTC CTTGCCCCC- ---------- CA-------T
S.picturataZI656          TGTGAATGTG --TCCCTTTC CTCGCCCCA- ---------- ---------T
S.pseudoreticosaOIH83     TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.polyphyllaOIH119        TGCGAATGTG --TCCCTTTC CTCGCCCCG- -------CCC CA-------T
S.polyphyllaOIH289        TGTGAATGTG --TCCCTTTC CTCGCCCCG- -------CCC CA-------T
S.reticosaOIH79           TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.reticosaZI139           TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.scintillansOIH141       TGTGAATGTG --TCCCTTTC CTCGCCCCA- -------CCC CA-------T
S.stenophyllaOIH74        TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.stenophyllaOIH88        TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.cf.stenophylla2OIH93    TGTGAATGTG --TCCCTTTC CTTGCCCCC- ---------- CA-------T
S.unifloraOIH82           CGTGAATGTT --TTCCTTTC CTTGCCCCC- ---------CC CG-------T
H.uniflorumOIH113         TGTGAATGCG --CCCCTTTC CTTGCCTTGC CCCCCGATGT CA-------T
DistichochlamysspAF478745 TGTGAATGCG --TCCCTTTC CTTGCCCCC- ------AACA TA-------T
B.pulcherrimaJX992748     TGTGAATGTG --TCCCTTTC CATGCCCGA- ---------- ---------T
Z.officinaleKC582866      CGTGAATGTG --TCCCTCTC TTCTCTCCA- ---CCCGCGT CA-------C
K.rotundaAF478767         TGTGAATGTG --TCCCTTTC CTCGCCCAC- -------CCC CA-------T
H.cyanescensJF825533      TGTGAACGCG --CCCCTTTC CTTGCCCGC- --------CG CA-------T
T.flagellarisAF478797     TGTCAACTTG --CCCCTTTC CTTGCCCA-- ---------- ---------T
M.mullerensisAB245522     TGTGAATGTG --TCCCTTTC CTTGCCCCA- ---------- ---------C
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Appendix 1 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                      105         115         125         135         145
S.argenteaOIH320                  GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.bilobaAF478788                  GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.bilobaOIH326                    GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.bilobaOIH327                    GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.biruOIH87                       GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.biruOIH254                      GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.calcicolaOIH81                  GT-----TGG CGGGCGATCG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.durgaOIH84                      GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.durgaOIH235                     GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.graveolensOIH116                GT-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.hastaOIH80                      GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.aff.klossiiOIH168               GT-----CGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.kunstleriAF478789               GT-----TGG CGGGCGAATG ACCGTAGCTC GGTGCGATCG GCACTAAGGA
S.kunstleriOIH161                 GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCG GCACTAAGGA
S.kunstleriOIH162                 GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCG GCACTAAGGA
S.kunstleriOIH163                 GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCG GCACTAAGGA
S.lanjakensisOIH309               GA-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.limianaOIH122                   GT-----TGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.lucensOIH125                    GT-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.malaccanaOIH159                 GT-----CGG CGGGCGATTG ACCGTAGCTC GGTGCGATCG GCACTAAGGA
S.multifoliaOIH111                GTTATGTTGG GGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.nigraOIH76                      GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.cf.nigraOIH227                  GT-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.penyamarOIH137                  GT-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.petiolataOIH71                  GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.picturataZI656                  GT-----TGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.pseudoreticosaOIH83             GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.polyphyllaOIH119                GT-----CGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGGA
S.polyphyllaOIH289                GT-----CGG CGGGCGATTG ACCGTAGCTC GGTGCGATCA GCACTAAGAA
S.reticosaOIH79                   GT-----CGG TGGGCGATCA ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.reticosaZI139                   GT-----CGG TGGGCGATCA ACCGTAGCTC AGTGCGATCA GCACTAAGGA
S.scintillansOIH141               GTTGGGTTGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.stenophyllaOIH74                GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.stenophyllaOIH88                GT-----CGG TGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.cf.stenophylla2OIH93            GT-----CGG CGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
S.uniflaraOIH82                   GTTATGTGGG CGGGCGATCG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
H.uniflorumOIH113                 GT-----CGG CGGGC-ATTG ACCGTAGCTC GGTGCGATCC GCACTAAGGA
DistichochlamysspAF478745         GT-----TGG CGGGCGATTG ACCRTAGCTC GGTGCGATCA GCACTAAGGA
B.pulcherrimaJX992748             CT-----TAG TGGGC-ATTG ACCGTAGCTC AGTGCGATCC GCACTAAGAA
Z.officinaleKC582866              GT-----CGG TGGGCGATTG ACGGAAGCTC GGTGCGATCG GCACTAAGGA
K.rotundaAF478767                 GTCGGTGCGG TGGGCGGTTG ACCGTAGCTC AGTGCGATCA GCACTAAGGA
H.cyanescensJF825533              GT-----TGG CCGGCAATTG ACCGCAGCTC GGTGCGATCA GCACTAAGGA
T.flagellarisAF478797             GT-----TGG TGGGTGATCG ACGGTAGCTC GGTGCGATCG GCACCAAGGA
M.mullerensisAB245522             GT-----TGG TGGGCGATTG ACCGTAGCTC AGTGCGATCG GCACTAAGGA
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Appendix 1 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     155         165         175         185         195
S.argenteaOIH320                  ACAATG----  AACTCGGAAG  CAAAGGGTCC  CCATGCCATG  CCGGCGT--G
S.bilobaAF478788                  ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.bilobaOIH326                    ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.bilobaOIH327                    ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.biruOIH87                       ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.biruOIH254                      ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.calcicolaOIH81                  ACAATGAATG  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.durgaOIH84                      ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.durgaOIH235                     ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.graveolensOIH116                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TCGGCGT--G
S.hastaOIH80                      ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.aff.klossiiOIH168               ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.kunstleriAF478789               ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.kunstleriOIH161                 ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.kunstleriOIH162                 ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.kunstleriOIH163                 ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.lanjakensisOIH309               ACAATG----  AACTCAGAAG  CAAAGGGTCC  -----C----  TGGGCGTGCG
S.limianaOIH122                   ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.lucensOIH125                    ACAATGA---  AACTCGGAAG  CAAAGGGTCC  -----C----  TCGGCGT--G
S.malaccanaOIH159                 ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.multifoliaOIH111                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.nigraOIH76                      ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.cf.nigraOIH227                  ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.penyamarOIH137                  ACAATG----  AACTCGGAAG  CAAAGGGCCC  -----C----  TTGGCGTGCG
S.petiolataOIH71                  ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.picturataZI656                  ACAATG----  AACTCGAAAG  CAAAGGGCCC  -----C----  TTGGCGTGCG
S.pseudoreticosaOIH83             ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.polyphyllaOIH119                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.polyphyllaOIH289                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
S.reticosaOIH79                   ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.reticosaZI139                   ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.scintillansOIH141               ACAATG----  AACTCGGAAG  CAAAGGGCCC  -----C----  TTGGCGTGCG
S.stenophyllaOIH74                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.stenophyllaOIH88                ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCACG  TCGGCGT--G
S.cf.stenophylla2OIH93            ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----CCATG  TCGGCGT--G
S.uniflaraOIH82                   ACAATGAATG  AACTCGGAAG  CATAGGGTCC  -----C----  TCGGCGT--G
H.uniflorumOIH113                 ACAATG----  AACTCGGAAG  CAGACGGCCC  -----C----  CCGGCGT--G
DistichochlamysspAF478745         ACATTG----  AACTCAGAAG  CAAAGGGCCC  -----C----  TTGGAAT--G
B.pulcherrimaJX992748             ACAATA----  AGCTCGAAAG  CAGAGGGCCC  -----C----  TTGGCGT--G
Z.officinaleKC582866              ACAACG----  AACTAGGAAG  CGGAGGGCCG  -----C----  TCGGCGT--G
K.rotundaAF478767                 ACAATG----  AACTCGGAAG  CAGAGGGCCC  -----C----  TTGGCGT--G
H.cyanescensJF825533              ATAATG----  AACTCGGAAG  CAGACGGCCC  -----C----  TTGGCGT--G
T.flagellarisAF478797             ACAATG----  AAATTAGAAG  CAGAGGGCCC  ----------  TTGCTAA--G
M.mullerensisAB245522             ACAATG----  AACTCGGAAG  CAAAGGGTCC  -----C----  TTGGCGT--G
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Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                              205        215        225        235        245
S.argenteaOIH320          CGC-AGG--G GGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.bilobaAF478788          CGC-AAG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.bilobaOIH326            CGC-AAG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.bilobaOIH327            CGC-AAGGAG AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.biruOIH87               CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.biruOIH254              CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.calcicolaOIH81          CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.durgaOIH84              CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.durgaOIH235             CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.graveolensOIH116        CAC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.hastaOIH80              CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.aff.klossiiOIH168       CGC-AAGGAG AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.kunstleriAF478789       CGC-AAG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.kunstleriOIH161         CGCAAAG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.kunstleriOIH162         CGC-AAG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.kunstleriOIH163         CGC-AAG--G AGCCCGATGC GTCGGAAATT CCTCGG---- --------AA
S.lanjakensisOIH309       CGC-AGG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.limianaOIH122           CGC-AAG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.lucensOIH125            CAC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.malaccanaOIH159         CGC-AAGGAG AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.multifoliaOIH111        CGC-AAG--G AGCCCGATGC GTCGGAGATT CCTCGG---- --------AA
S.nigraOIH76              CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.cf.nigraOIH227          CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.penyamarOIH137          CGC-AAG--G AGCCCAATGC GTCGGAAATT CCTCGG---- --------AA
S.petiolataOIH71          CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.picturataZI656          CGC-AAG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.pseudoreticosaOIH83     CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.polyphyllaOIH119        CGC-AAGGAG AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.polyphyllaOIH289        CGC-AAGGAG AGCCCAATGC GTCGGAGATT CCTCAG---- --------AA
S.reticosaOIH79           CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.reticosaZI139           CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.scintillansOIH141       CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.stenophyllaOIH74        CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.stenophyllaOIH88        CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.cf.stenophylla2OIH93    CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
S.uniflaraOIH82           CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
H.uniflorumOIH113         CGCAAGG--G AGGCCGATGC GTCGGAGATT CCTCGG---- --------AA
DistichochlamysspAF478745 CGC-AGG--G AGCCCAATGC GTCAGAGATT CCTCGG---- --------AA
B.pulcherrimaJX992748     CAC-AGG--G AGCCCAAAGC GTCGGAGATT CCTCGG---- --------AA
Z.officinaleKC582866      CGCAGGG--G AGCCCGATGC GTCGGAGATT CCTCGTAATC AATCAATCAA
K.rotundaAF478767         CTC-AGG--G AGCCCAATGC GTCGGAGATT CTTCGG---- ----AATCAA
H.cyanescensJF825533      CGC-AGG--G AGCCCAATGC GTCGGAGATT CCTCGG---- --------AA
T.flagellarisAF478797     TGGAGGG--C AGCCCAATGC ATCGGAGATG CCTCAG---- --------AA
M.mullerensisAB245522     CGC-AGG--G AGCCCGATGC ATCGGAGATT CCTCGG---- --------AA
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Appendix 1 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     255        265        275        285        295
S.argenteaOIH320                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.bilobaAF478788                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.bilobaOIH326                    TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.bilobaOIH327                    TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.biruOIH87                       TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.biruOIH254                      TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.calcicolaOIH81                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.durgaOIH84                      TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.durgaOIH235                     TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.graveolensOIH116                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.hastaOIH80                      TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.aff.klossiiOIH168               TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.kunstleriAF478789               TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.kunstleriOIH161                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.kunstleriOIH162                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.kunstleriOIH163                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.lanjakensisOIH309               TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.limianaOIH122                   TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.lucensOIH125                    TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.malaccanaOIH159                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.multifoliaOIH111                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.nigraOIH76                      TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.cf.nigraOIH227                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.penyamarOIH137                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAAAA
S.petiolataOIH71                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.picturataZI656                  TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.pseudoreticosaOIH83             TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.polyphyllaOIH119                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.polyphyllaOIH289                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.reticosaOIH79                   TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.reticosaZI139                   TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.scintillansOIH141               TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.stenophyllaOIH74                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.stenophyllaOIH88                TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.cf.stenophylla2OIH93            TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
S.unifloraOIH82                   TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
H.uniflorumOIH113                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
DistichochlamysspAF478745         CCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC GGATGAAGAA
B.pulcherrimaJX992748             TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
Z.officinaleKC582866              TCAAAAGACT CTCGTCAACG GATATCTTGG CTCTTGCATC -GATGAAGAA
K.rotundaAF478767                 TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATA -GATGAAGAA
H.cyanescensJF825533              TCAAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
T.flagellarisAF478797             TCAAATGACT TTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
M.mullerensisAB245522             TCGAATGACT CTCGGCAATG GATATCTCGG CTCTTGCATC -GATGAAGAA
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Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             305        315        325        335        345
S.argenteaOIH320          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.bilobaAF478788          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.bilobaOIH326            CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.bilobaOIH327            CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.biruOIH87               CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.biruOIH254              CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.calcicolaOIH81          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.durgaOIH84              CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.durgaOIH235             CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.graveolensOIH116        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.hastaOIH80              CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.aff.klossiiOIH168       CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.kunstleriAF478789       CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.kunstleriOIH161         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.kunstleriOIH162         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.kunstleriOIH163         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.lanjakensisOIH309       CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.limianaOIH122           CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.lucensOIH125            CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.malaccanaOIH159         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.multifoliaOIH111        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.nigraOIH76              CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.cf.nigraOIH227          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.penyamarOIH137          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAAAATCTC GTGAACCATT
S.petiolataOIH71          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.picturataZI656          CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.pseudoreticosaOIH83     CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.polyphyllaOIH119        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.polyphyllaOIH289        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.reticosaOIH79           CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.reticosaZI139           CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.scintillansOIH141       CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.stenophyllaOIH74        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.stenophyllaOIH88        CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.cf.stenophylla2OIH93    CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
S.uniflora0IH82           CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
H.uniflorumOIH113         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
DistichochlamysspAF478745 CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
B.pulcherrimaJX992748     CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
Z.officinaleKC582866      CGAAGTAAAA TGCGATAATT GGTGTGAATT GCAGAATATT GTGAACCATC
K.rotundaAF478767         CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
H.cyanescensJF825533      CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
T.flagellarisAF478797     CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAGCCATT
M.mullerensisAB245522     CGTAGTGAAA TGCGATACTT GGTGTGAATT GCAGAATCTC GTGAACCATT
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Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                              355        365        375        385        395
S.argenteaOIH320          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.bilobaAF478788          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.bilobaOIH326            GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.bilobaOIH327            GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.biruOIH87               GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.biruOIH254              GAGTCCTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.calcicolaOIH81          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCTGTGGTCG AGGGCACGCC
S.durgaOIH84              GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.durgaOIH235             GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.graveolensOIH116        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.hastaOIH80              GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.aff.klossiiOIH168       GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCGGGTCG AGGGCACGCC
S.kunstleriAF478789       GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGTCG AGGGCACGCC
S.kunstleriOIH161         GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGTCG AGGGCACGCC
S.kunstleriOIH162         GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGTCG AGGGCACGCC
S.kunstleriOIH163         GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGTCG AGGGCACGCC
S.lanjakensisOIH309       GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.limianaOIH122           GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.lucensOIH125            GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.malaccanaOIH159         GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.multifoliaOIH111        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.nigraOIH76              GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.cf.nigraOIH227          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.penyamarOIH137          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.petiolataOIH71          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.picturataZI656          GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.pseudoreticosaOIH83     GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.polyphyllaOIH119        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.polyphyllaOIH289        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGTCG AGGGCACGCC
S.reticosaOIH79           GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.reticosaZI139           GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.scintillansOIH141       GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTCGT-GTCG AGGGCACGCC
S.stenophyllaOIH74        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.stenophyllaOIH88        GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.cf.stenophylla2OIH93    GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCCGTGGTCG AGGGCACGCC
S.uniflaraOIH82           GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CCTGTGGTCG AGGGCACGCC
H.uniflorumOIH113         GAGTCTTTGA ACGCAAGTTG TGCCCGAGCC CTTGTGGTCG AGGGCACGCC
DistichochlamysspAF478745 GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTATGGTCG AGGGCACGCC
B.pulcherrimaJX992748     GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGCGGTCG AGGGCACGCC
Z.officinaleKC582866      GAGTATTTGA ACGCAAGTTG TGCCCGAGGC CTCGTGGCCG AGGGCGCCCC
K.rotundaAF478767         GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGCCG AGGGCACGCC
H.cyanescensJF825533      GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGCCG AGGGCACGCC
T.flagellarisAF478797     GAGTTTTTGA ACGCAAGTTG TGCCCGAGGC CTTGTGGCTG AGGGCACGCC
M.mullerensisAB245522     GAGTCTTTGA ACGCAAGTTG TGCCCGAGGC CTTCTGGACG AGGGCACGCC
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Appendix 1 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                      405         415         425         435         445
S.argenteaOIH320                  TGCTTGGGGG TCATGGCATC GTCGCCTCTT GCTC----CA T-----CATG
S.bilobaAF478788                  TGCTTGGGTG TCATGGCATC GTCGCCT-TT GCTC----CA CG----CATG
S.bilobaOIH326                    TGCTTGGGTG TCATGGCATC GTCGCCT-TT GCTC----CA CG----CATG
S.bilobaOIH327                    TGCTTGGGTG TCATGGCATC GTCGCCT-TT GCTC----CA CG----CATG
S.biruOIH87                       TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.biruOIH254                      TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.calcicolaOIH81                  TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.durgaOIH84                      TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.durgaOIH235                     TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.graveolensOIH116                TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.hastaOIH80                      TGCTTGGGGG TCATGGCATC GTCGCCT-TC GCTC----CA T-----CATG
S.aff.klossiiOIH168               TGCTTGGGTG TCATGGCATC GTCGCCT-TT GCTC----CA TG----CATG
S.kunstleriAF478789               TGCTTGGGTG TCATGGCATC GTCGCCT-TC GCTC----CA TG----CATG
S.kunstleriOIH161                 TGCTTGGGTG TCATGGCATC GTCGCCT-TC GCTC----CA TG----CATG
S.kunstleriOIH162                 TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTC----CA TG----CATG
S.kunstleriOIH163                 TGCTTGGGTG TCATGGCATC GTCGCCT-TC GCTC----CA TG----CATG
S.lanjakensisOIH309               TGCTTGGGGG TCATGGCATC GTCGCCC-TT GCTC------ ------CATG
S.limianaOIH122                   TGCTTGGGTG TCATGACATC GTCGCCT-CT GCTCCATGCA TGT---CATG
S.lucensOIH125                    TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.malaccanaOIH159                 TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTC----CA TGCATGCATG
S.multifoliaOIH111                TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.nigraOIH76                      TGCTTGGGGG TCATGGCATC GTCGCCT-TC GCTC----CA T-----CATG
S.cf.nigraOIH227                  TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.penyamarOIH137                  TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.petiolataOIH71                  TGCTTGGGGG TCATGGCATC GTCGCCT-TC GCTC----CA T-----CATG
S.picturataZI656                  TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.pseudoreticosaOIH83             TGCTTGGGGG TCATGGCATC GTCGCCT-TC GCTC----CA T-----CATG
S.polyphyllaOIH119                TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTCCATGCA TGCATGCATG
S.polyphyllaOIH289                TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTC----CA TGCATGCATG
S.reticosaOIH79                   TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.reticosaZI139                   TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.scintillansOIH141               TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
S.stenophyllaOIH74                TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.stenophyllaOIH88                TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.cf.stenophylla2OIH93            TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC----CA T-----CATG
S.unifloraOIH82                   TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
H.uniflorumOIH113                 TGCTTGGGCG TCATGGCATC GTCGCCT-TC GCTT----C- ------CATG
DistichochlamysspAF478745         TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
B.pulcherrimaJX992748             TGCTTGGGTG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
Z.officinaleKC582866              TGCTTGGGTG TCATGGCATC GTCGCCT-CT TCTC----CT C-----CATT
K.rotundaAF478767                 TGCTTGGGAG TCATGGCATT GCCGCCT-TT GCAC----CA CCAC--CATG
H.cyanescensJF825533              TGCTTGGGCG TCATGGCATC GTCGCTT-TT GCTC------ ------CATG
T.flagellarisAF478797             TGCTTGGGCG TCATGGCATC GTCGCCT-TT GCTC------ ----------
M.mullerensisAB245522             TGCTTGGGGG TCATGGCATC GTCGCCT-TT GCTC------ ------CATG
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Appendix 1 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     455        465        475        485        495
S.argenteaOIH320                  CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.bilobaAF478788                  CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.bilobaOIH326                    CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.bilobaOIH327                    CG----TTGC TGGT-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.biruOIH87                       CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.biruOIH254                      CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.calcicolaOIH81                  CG----TTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.durgaOIH84                      CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.durgaOIH235                     CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.graveolensOIH116                CG----TTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.hastaOIH80                      CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.aff.klossiiOIH168               CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.kunstleriAF478789               CG----TTGC TGGT-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.kunstleriOIH161                 CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.kunstleriOIH162                 CG----TTGC TGGT-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.kunstleriOIH163                 CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.lanjakensisOIH309               CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.limianaOIH122                   CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.lucensOIH125                    CG----TTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.malaccanaOIH159                 CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.multifoliaOIH111                CG----TTGT ---TTTGTTG GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.nigraOIH76                      CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.cf.nigraOIH227                  CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.penyamarOIH137                  CG----TCGC ---T-----G GTGTCGAGTG CGGAAATTGG CCCCGTGTGC
S.petiolataOIH71                  CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.picturataZI656                  CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.pseudoreticosaOIH83             CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.polyphyllaOIH119                CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.polyphyllaOIH289                CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.reticosaOIH79                   CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.reticosaZI139                   CG----CTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.scintillansOIH141               CG----TCGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.stenophyllaOIH74                CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.stenophyllaOIH88                CG----CTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.cf.stenophylla2OIH93            CG----CCGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
S.uniflaraOIH82                   CG----TTGC ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
H.uniflorumOIH113                 CG----TGGT ---T-----G GCG-TGAGCG CGGAAATTGG CCCCGTGTGC
DistichochlamysspAF478745         CG----TTGT TGTT-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
B.pulcherrimaJX992748             CG----TTCT ---T-----G GTGCTGAGCG CGGAAATTGA CCCCGTGTGC
Z.officinaleKC582866              CC----TCGT CGGTTGGTAG GTGCGGAGGA CGGAAAAAAG CCCCGCGTGC
K.rotundaAF478767                 AAATAAATGC ---T-----G GTGCTGAGCG -GTAAATTGG CCCCGTGTGC
H.cyanescensJF825533              CG----TTGC ---T-----G GTGCTGAGCG CGGAAATTGG CCCCGTGTGC
T.flagellarisAF478797             CT----TTGC ---T-----G GTGCCAAGCG CGGATATTGG CCCCCTGTGC
M.mullerensisAB245522             CG----TTGT ---T-----G GTGCCGAGTG CGGAAATTGG CCCCGTGTGC
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Appendix 1 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     505        515        525        535        545
S.argenteaOIH320                  ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.bilobaAF478788                  ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.bilobaOIH326                    ---CCTCGGG CACAGTCGGC CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.bilobaOIH327                    ---CCTCGGG CACAGTCGGC CGAAGATTGG GAA---GTCG -CCAATCGTC
S.biruOIH87                       ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.biruOIH254                      ---CCTCGTG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.calcicolaOIH81                  ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.durgaOIH84                      ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.durgaOIH235                     ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---CTCG -GCAATCGTC
S.graveolensOIH116                ---CCTCGGG CACAGTCGGT TAAAGAGCGG GAA---TTCG -GCAATCGTC
S.hastaOIH80                      ---CCTCGGG CACAGTCGGT TGAAGAGTGG GAA---GTCG -GCAATCGTC
S.aff.klossiiOIH168               CC-TCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.kunstleriAF478789               ---CCTCGGG CACAGTCGGC CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.kunstleriOIH161                 ---CCTCGGG CACAGTCGGC CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.kunstleriOIH162                 ---CCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.kunstleriOIH163                 ---CCTCGGG CACAGTCGGC CGAAGAATGG GAA---GTCG -GCAATCGTC
S.lanjakensisOIH309               ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.limianaOIH122                   ---CCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.lucensOIH125                    ---CCTCGGG CACAGTCGGT TAAAGAGCGG GAA---GTCG -GCAATCGTC
S.malaccanaOIH159                 ---CCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.multifoliaOIH111                ---CCTCGGG CACAGTCGGT TAAAGAGCGG GAA---GTCG -GCAATCGTC
S.nigraOIH76                      ---CCTCGGG CACAGTCGGT TGAAGAGTGG GAA---GTCG -GCAATCGTC
S.cf.nigraOIH227                  ---CCTCGGG CACAGTCGGC TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.penyamarOIH137                  CCTCCTCGGG CACAGTCGGC TAAAGAGCGG GAA---GTCG -GCAATCGTC
S.petiolataOIH71                  ---CCTCGGG CACAGTCGGT TGAAGAGTGG GAA---GTCG -GCAATCGTC
S.picturataZI656                  ---CCTCGGG CACAGTCGGT TAAAGAGCGG GAA---GTCG -GCAATCGTC
S.pseudoreticosaOIH83             ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.polyphyllaOIH119                ---CCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.polyphyllaOIH289                ---CCTCGGG CACAGTCGGT CGAAGAGCGG GAA---GTCG -GCAATCGTC
S.reticosaOIH79                   ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.reticosaZI139                   ---CCTCGGG CACAGTCGGT TAAAGAGTGG GAA---GTCG -GCAATCGTC
S.scintillansOIH141               ---CCTCGGG CACAGTCGGC TAAAGAGCGG GAA---GTCG -GCAATCGTC
S.stenophyllaOIH74                ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.stenophyllaOIH88                ---CCTCGGG CACAGTCGGT CGAAGAGTGG GAA---GTCG -GCAATCGTC
S.cf.stenophylla2OIH93            ---CCTCGGG CACAGTCGGT TGAAGAGTGG GAA---GTCG -GCAATCGTC
S.unifloraOIH82                   ---CCTCGGG CACAGTCGGT TAAAGAGCGA AAA---CTCG -GCAATCGTC
H.uniflorumOIH113                 ---CCTCGGG CACAGTCGGT CGAAGAGCGG GCAGTCGTCG -GCAATCGTC
DistichochlamysspAF478745         ---CCTCGGG CATAGTCGGT CGAAGAGTGG GAA---GTCG -ACAATCGTC
B.pulcherrimaJX992748             ---CCTTGGG CACAGTCGGT TGAAGAGTGG GTA---GTCG -GCAGTCGTC
Z.officinaleKC582866              ---CCTCGTG CGCCGCCGTC GGAAGAAGGG GTAAAAAAAG -GCAGCAGCG
K.rotundaAF478767                 ---CCTCGGG CACAGTCGGT TGAAGAGCGG GCA---GTCG -CCAATCGTC
H.cyanescensJF825533              ---CCTCGGG CACAGTCGGT TGAAGAGTGG GCA---GTCG -ACAGGCGTC
T.flagellarisAF478797             ---CCTCGGG CATAGTCGGT TAAAGAGAGG GTA---GTCG AACAGTTGTC
M.mullerensisAB245522             ---CCTCGGG CACAGTCGGT CAAAGAGTGG GAA---GTCG -GCAATCGTC
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Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             555        565        575        585        595
S.argenteaOIH320          -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.bilobaAF478788          -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.bilobaOIH326            -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.bilobaOIH327            -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.biruOIH87               -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.biruOIH254              -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.calcicolaOIH81          -GGGCACGAC GGGCGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.durgaOIH84              -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.durgaOIH235             -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.graveolensOIH116        -GGGCACGAC GGGCGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.hastaOIH80              -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.aff.klossiiOIH168       -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.kunstleriAF478789       -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.kunstleriOIH161         -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.kunstleriOIH162         -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.kunstleriOIH163         -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.lanjakensisOIH309       -GGGCACGAC GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.limianaOIH122           -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.lucensOIH125            -GGGCACGAC GGGCGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.malaccanaOIH159         -GGGCACGAT GGATGTTGGT CGCCGGGAGC GGGAACAGAA CGTCGTCCTC
S.multifoliaOIH111        -GGGCACGAC GGGCGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.nigraOIH76              -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.cf.nigraOIH227          -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.penyamarOIH137          -GGGCACGAC GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.petiolataOIH71          -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.picturataZI656          GGGGCACGAC GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.pseudoreticosaOIH83     -GAGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.polyphyllaOIH119        -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.polyphyllaOIH289        -GGGCACGAT GGATGTTGGT CGCCGTGAGC GGGAACATAA CGTCGTCCTC
S.reticosaOIH79           -GAGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.reticosaZI139           -GAGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.scintillansOIH141       -GGGCACGAC GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
S.stenophyllaOIH74        -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.stenophyllaOIH88        -GGGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.cf.stenophylla2OIH93    -GAGCACGAC GGGTGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
S.unifloraOIH82           -GGGCATGAC GGATGTTGGT CGCCGTGGGC GGGAACAGAA CGTCGTCCTC
H.uniflorumOIH113         -GGGCACGAT GGGCGTTGGT CGCCGTGAGC GGGAACAGAA CATCGTCCTC
DistichochlamysspAF478745 -GGGCACGAT GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
B.pulcherrimaJX992748     -GAGGACGAT GGGTGTTGGT CGCCATGAGC GGGAACAGAA CATCGACCTC
Z.officinaleKC582866      -GGGCGGCAC GGGGGTTGGT CGCCGTGAGC GGGAACAGCA CGTCGTCCCC
K.rotundaAF478767         -GGGCACGAT GGGTGTTGGT CGCGGTGAGC GGGAACAGAA CATCGTCCCC
H.cyanescensJF825533      -GGGCACGAT GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCCT
T.flagellarisAF478797     -ATACACGAT GGGTGTTGGC CGATGGGAGC GAGAATTTAA CGTCGTGCTC
M.mullerensisAB245522     GGGGCACGAT GGGTGTTGGT CGCCGTGAGC GGGAACAGAA CGTCGTCCTC
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Appendix 1 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                              605        615        625        635        645
S.argenteaOIH320          GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.bilobaAF478788          GTCGTTTGGA ---GATGA-- GTCCTCA--- -AGAGACCC- ----TGTG--
S.bilobaOIH326            GTCGTTTTGA ---GATGA-- GTCCTCA--- -AGAGACCC- ----TGTG--
S.bilobaOIH327            GTCGTTTTGA ---GATGA-- GTCCTCG--- -AGAGACCC- ----TGTG--
S.biruOIH87               GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.biruOIH254              GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.calcicolaOIH81          GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.durgaOIH84              GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.durgaOIH235             GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.graveolensOIH116        GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.hastaOIH80              GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.aff.klossiiOIH168       GTCGTTTTGA ---AACGA-- GTCCTCA--- -AGAGACCCT TGCGTGCG--
S.kunstleriAF478789       GTCGTTTTGA GACGATGA-- GTCCTCCTCA AAGAGACCC- ----TGTG--
S.kunstleriOIH161         GTCGTTTTGA GATGATGA-- GTCCTCCTCA AAGAGACCC- ----TGTG--
S.kunstleriOIH162         GTCGTTTTGA GATGATGA-- GTCCTCA--- -TGAGACCC- ----TGTG--
S.kunstleriOIH163         GTCGTTTTGA GATGATGA-- GTCCTCCTCA AAGAGACCC- ----TGTG--
S.lanjakensisOIH309       GTCGTTTTGA ---GATGA-- GTCCTCG--- -AGAGACCC- ----TGTG--
S.limianaOIH122           GTCGTTTTGA ---GATGA-- GTCCTCG--- -AGAGACCC- ----TGTG--
S.lucensOIH125            GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.malaccanaOIH159         GTCGTTTTGA ---AACGA-- GTCCTCA--- -AGAGACCC- ----TGCG--
S.multifoliaOIH111        GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTGTG
S.nigraOIH76              GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.cf.nigraOIH227          GTCGTTTTGA ---GACGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.penyamarOIH137          GTCGTTTTGA ---GACGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.petiolataOIH71          GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.picturataZI656          GTCGTTTTGA ---GCCGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.pseudoreticosaOIH83     GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.polyphyllaOIH119        GTCGTTTTGA ---AACGA-- GTCCTCG--- -AGAGACCCT TGCGTGCG--
S.polyphyllaOIH289        GTCGTTTTGA ---AACGA-- GTCCTCG--- -AGAGACCCT TGCGTGCG--
S.reticosaOIH79           GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.reticosaZI139           GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.scintillansOIH141       GTCGTTTTGA ---AACGA-- ATTCTCAAGA GAGAGACCC- ----TGTG--
S.stenophyllaOIH74        GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.stenophyllaOIH88        GTCGTTTTGA ---GATGA-- GTTCTCAAGA GAGAGACCC- ----TGTG--
S.cf.stenophylla2OIH93    GTCGTTT-GA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
S.uniflora0IH82           GTCGTTTCGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGCG--
H.uniflorumOIH113         GTCGTTTCGG ---GATGA-- GCCCTCAAGA GAGAGACCCC ----TGTG--
DistichochlamysspAF478745 GTCGTTTTGA ---GATGA-- GTTCTCA--- -AGAGACCC- ----TGTG--
B.pulcherrimaJX992748     GTCGTTTTTG ---GACGA-- GTCCTCA--- -AGAGACCC- ----TGTG--
Z.officinaleKC582866      GTCGTTTTTT ---GACGGAA TTCCTCA--- -ACAAGCCCC C---CGCG--
K.rotundaAF478767         GTCGTATTGG ---GATGAGT GTCCCCA--- -AGAGACCC- ----TGTG--
H.cyanescensJF825533      GTCGTTTTGG ---GATGA-- GTCCCCAAGA -AGAGACCC- ----TATT--
T.flagellarisAF478797     ATTTTGTTAG ---GATGA-- GTCCTCT--- GGTGGACCC- ----TGTG--
M.mullerensisAB245522     GTCGTTTTAA ---GATGA-- GTTCCCA--- -AGAGACCC- ----CGTG--
```

Appendix 1 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     655        665        675        685        695
S.argenteaOIH320                  --TGATTGCG GTGTCGGAC- ---------- GGAA--GGGC CG---TGCCC
S.bilobaAF478788                  --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---CGTCC
S.bilobaOIH326                    --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---TGTCC
S.bilobaOIH327                    --TGATTGCG GCGTCGAGC- ---------- GAAA--GTGC CG---TGTCC
S.biruOIH87                       --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.biruOIH254                      --TGATTGCG GTGCCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.calcicolaOIH81                  --CGATTGTG GCGCCGGAT- ---------- GAAA--GCGC CG---TGCCC
S.durgaOIH84                      --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.durgaOIH235                     --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.graveolensOIH116                --CGATTGCG GTGTCGGAT- ---------- GAAA--GGGC CG---TGCCC
S.hastaOIH80                      --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.aff.klossiiOIH168               --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---TGTCC
S.kunstleriAF478789               --CGATTGCG GCGTCGGAC- ---------- GAAA--GTGC CG---TGTCC
S.kunstleriOIH161                 --CGATTGCG GCGTCGGAC- ---------- GAAA--GTGC CG---TGTCC
S.kunstleriOIH162                 --CGATTGCG GCGTCGGAC- ---------- GAAA--GCGC CG---TGTCC
S.kunstleriOIH163                 --CGATTGCG GCGTCGGAC- ---------- GAAA--GTGC CG---TGTCC
S.lanjakensisOIH309               --TGATTGCG GTGCCGGAT- ---------- GAAA--GGGC CG---TGTCC
S.limianaOIH122                   --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---AGTCC
S.lucensOIH125                    --CGATTGCG GTGTCGGAT- ---------- GAAA--GGGC CG---TGCCC
S.malaccanaOIH159                 --CGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---TGTCC
S.multifoliaOIH111                ATTGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.nigraOIH76                      --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.cf.nigraOIH227                  --TGATGGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.penyamarOIH137                  --TGATTGCG GTGCCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.petiolataOIH71                  --TGATTGCG GCGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.picturataZI656                  --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGTCC
S.pseudoreticosaOIH83             --TGATTGCG GCGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.polyphyllaOIH119                --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---TGTCC
S.polyphyllaOIH289                --TGATTGCG GCGTCGGGC- ---------- GAAA--GTGC CG---TGTCC
S.reticosaOIH79                   --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.reticosaZI139                   --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.scintillansOIH141               --TGGTTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.stenophyllaOIH74                --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.stenophyllaOIH88                --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.cf.stenophylla2OIH93            --TGATTGCG GTGTCGGAC- ---------- GAAA--GGGC CG---TGCCC
S.uniflora0IH82                   --CGATTATG GTGTCGGAT- ---------- GAAA--TGGC CG---TGTCC
H.uniflorumOIH113                 --CGATCGCG GCATCGGAC- ---------- GAAA--GCGC CG---TGTCC
DistichochlamysspAF478745         --TGTTTTTG GCATCGGGC- ---------- GAAA--GTGC CG---TGTCC
B.pulcherrimaJX992748             --TGATTATG GCATCGGGT- ---------- GAAA--GTAC CG---TGCCC
Z.officinaleKC582866              -ATGACGGCG GCACCGGGCA GCGAATGAAA GAAAGCGCGC CGTGCTGCCC
K.rotundaAF478767                 --TGATTGTG GCGTCCGGT- ---------- GAAA--ATGC CG---CGTCG
H.cyanescensJF825533              --TGATTGTG GCGTCGGGT- ---------- GAAA--GTGC CG---TGTCC
T.flagellarisAF478797             ----ATAATG GTGTCGGTT- ---------- GAAA--GTGC CA---TGTGC
M.mullerensisAB245522             --TGATTGCG GCGTCGGGT- ---------- GAAA--GTCC CG---CGCCC
```

Appendix 1 continued

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                          ....|....| ....|....| ....|....|
                             705        715        725
S.argenteaOIH320          GTCA---ATC AACTTGTGGC CCCAAGTCAG
S.bilobaAF478788          GTCA---CCT AACTTGTGGC CCCAAGTCAG
S.bilobaOIH326            ATCA---CCT AACTTGTGGC CCCAAGTCAG
S.bilobaOIH327            ATCA---CCT AACTTGTGGC CCCAAGTCAG
S.biruOIH87               GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.biruOIH254              GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.calcicolaOIH81          ATCA---ATC AACTTGTGGC CCCAAGTCAG
S.durgaOIH84              GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.durgaOIH235             GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.graveolensOIH116        -------ATC AACTTGTGGC CCCAAGTCAG
S.hastaOIH80              GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.aff.klossiiOIH168       GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.kunstleriAF478789       GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.kunstleriOIH161         GTCA---ATT AACTTGTGGC CCCAAGTCAG
S.kunstleriOIH162         GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.kunstleriOIH163         GTCA---ATT AACTTGTGGC CCCAAGTCAG
S.lanjakensisOIH309       -------ATC AACCTGTGGC CCCAAGTCAG
S.limianaOIH122           ATCA---ACT AACTTGTGGC CCCAAGTCAG
S.lucensOIH125            -------ATC AACATGTGGC CCCAAGTCAG
S.malaccanaOIH159         GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.multifoliaOIH111        ACCAATCATC AACTTGTGGC CCCAAGTCAG
S.nigraOIH76              GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.cf.nigraOIH227          GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.penyamarOIH137          ATCA---ATC AACCTGTGGC CCCAAGTCAG
S.petiolataOIH71          GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.picturataZI656          -------ATC AACCTGTGGC CCCAAGTCAG
S.pseudoreticosaOIH83     GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.polyphyllaOIH119        GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.polyphyllaOIH289        GTCA---ACT AACTTGTGGC CCCAAGTCAG
S.reticosaOIH79           GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.reticosaZI139           GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.scintillansOIH141       -------ATC AACCTGTGGC CCCAAGTCAG
S.stenophyllaOIH74        GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.stenophyllaOIH88        GTCG---ATC AACTAGTGGC CCCAAGTCAG
S.cf.stenophylla2OIH93    GTCG---ATC AACTTGTGGC CCCAAGTCAG
S.unifloraOIH82           ATCA---ATC GACTTGTGGC CCCAAGTCAG
H.uniflorumOIH113         -------ATC TACTTGTGGC CCCAAGTCAG
DistichochlamysspAF478745 -------ATC AACTTGTGGC CCCAAGTCAG
B.pulcherrimaJX992748     -------ATA AACTTGTGGC CCCAAGTCAG
Z.officinaleKC582866      GTC----ATC AACTTGT-GC CCCAAGTCAG
K.rotundaAF478767         TCC----ATC AACTTGTGGC CCCAAGTCAG
H.cyanescensJF825533      -------ATC AACTTGTGGC CCCAAGTCAG
T.flagellarisAF478797     -------ATC AAATTGTGGC CCCATGTCAG
M.mullerensisAB245522     ATC----ATC AACTTGTGGC CCCAAGTCAG
```

Appendix 2: The aligned *trn*K-*mat*K region sequences of the taxa included in the phylogenetic analyses.

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                               5         15         25         35         45
S.argenteaOIH320          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.bilobaAF478889          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.bilobaOIH326            AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.bilobaOIH327            AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.biruOIH87               AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.biruOIH254              AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.calcicolaOIH81          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.durga1OIH84             AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.durgaOIH235             AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.graveolensOIH116        AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.hastaOIH80              AATTCGTCCA GACT----TT TGGTAGAAGT CTATAAGACC ACGACTGATC
S.aff.klossiiOIH168       AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.kunstleriAF478890       AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.kunstleriOIH161         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.kunstleriOIH162         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.kunstleriOIH163         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.lanjakensisOIH309       AATTCGTCCA GACT----TT TGGTAG-AGT TTATAAGACC ACGACTGATC
S.limianaOIH122           AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.lucensOIH125            AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.malaccanaOIH159         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.multifoliaOIH111        AATTCGTCCA GACTTTTTTT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.nigraOIH76              AATTCGTCCA GACT----TT TGGTAGAAGT CTATAAGACC ACGACTGATC
S.cf.nigraOIH227          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.penyamarOIH137          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.petiolataOIH71          AATTCGTCCA GACTTTTTTT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.picturataZI656          AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.pseudoreticosaOIH83     AATTCGTCCA GACTTTTTTT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.polyphyllaOIH119        AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.polyphyllaOIH289        AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.reticosaOIH79           AATTCGTCCA GACTTTTTTT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.reticosaZI139           AATTCGTCCA GACTTTTTTT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.scintillansOIH141       AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.stenophyllaOIH74        AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.stenophyllaOIH88        AATTCGTTCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.cf.stenophyllaOIH93     AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
S.unifloraOIH82           AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
B.pulcherrimaJX992809     AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
DisticochlamysspAF478844  AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
HaniffiacyanescensJF825538 AATTCGTCCA AACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
H.uniflorumOIH113         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
K.rotundaAF478868         AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     AATTCGTCCA GACT----AT TGGTAG-AGT CTATAAGACC ACGACTGATC
Z.officinaleAB047756      AATTCGTCCA GACT----TT TGGTAG-AGT CTATAAGACC ACGACTGATC
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                     55         65         75         85         95
S.argenteaOIH320                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.bilobaAF478889                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.bilobaOIH326                  CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.bilobaOIH327                  CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.biruOIH87                     CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.biruOIH254                    CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.calcicolaOIH81                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.durga1OIH84                   CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.durgaOIH235                   CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.graveolensOIH116              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.hastaOIH80                    CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.aff.klossiiOIH168             CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.kunstleriAF478890             CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.kunstleriOIH161               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.kunstleriOIH162               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.kunstleriOIH163               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.lanjakensisOIH309             CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.limianaOIH122                 CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.lucensOIH125                  CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.malaccanaOIH159               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.multifoliaOIH111              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.nigraOIH76                    CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.cf.nigraOIH227                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.penyamarOIH137                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.petiolataOIH71                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.picturataZI656                CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.pseudoreticosaOIH83           CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.polyphyllaOIH119              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.polyphyllaOIH289              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.reticosaOIH79                 CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.reticosaZI139                 CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.scintillansOIH141             CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.stenophyllaOIH74              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.stenophyllaOIH88              CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.cf.stenophyllaOIH93           CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
S.uniflaraOIH82                 CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
B.pulcherrimaJX992809           CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
DisticochlamysspAF478844        CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
HaniffiacyanescensJF825538      CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
H.uniflorumOIH113               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
K.rotundaAF478868               CTCAAAGGTA ATGAATGGAA AAAGCAGCAT GTCGTAATAC GTAATATAAT
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           CTCAAAGGTA ATGAATGGAA AAAGTAGCAT GTCGTAATAC GTAATATAAT
Z.officinaleAB047756            CTCAAGGGTA ATGAATGG-A AAAGCGGCAT GTCGTAATAC ATAATATAAT
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             105        115        125        135        145
S.argenteaOIH320          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.bilobaAF478889          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.bilobaOIH326            -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.bilobaOIH327            -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.biruOIH87               -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.biruOIH254              -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.calcicolaOIH81          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.durga1OIH84             -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.durgaOIH235             -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.graveolensOIH116        -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.hastaOIH80              -AAA-----A TAATAGATTT ATTATTTG-- ---------- -ATTTTCATT
S.aff.klossiiOIH168       -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.kunstleriAF478890       -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.kunstleriOIH161         -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.kunstleriOIH162         -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.kunstleriOIH163         -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.lanjakensisOIH309       -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.limianaOIH122           -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.lucensOIH125            -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.malaccanaOIH159         -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.multifoliaOIH111        -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.nigraOIH76              -AAA-----A TAATAGATTT ATTATTTG-- ---------- -ATTTTCATT
S.cf.nigraOIH227          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.penyamarOIH137          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.petiolataOIH71          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.picturataZI656          -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.pseudoreticosaOIH83     -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.polyphyllaOIH119        -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.polyphyllaOIH289        -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.reticosaOIH79           -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.reticosaZI139           -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.scintillansOIH141       -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.stenophyllaOIH74        -AAA-----A TAATAGATTT ATTATTTG-- ---------- -ATTTTCATT
S.stenophyllaOIH88        -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.cf.stenophyllaOIH93     -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
S.unifloraOIH82           -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
B.pulcherrimaJX992809     -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
DisticochlamysspAF478844  -AAA-----A TAATAAATCT ATTATTTT-- ---------- -ATTTTCATT
HaniffiacyanescensJF825538 -AAAATAATA TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
H.uniflorumOIH113         -AAA-----A TAATAGATTT ATTATTTT-- ---------- -ATTTTCATT
K.rotundaAF478868         -AAA-----A TAATAGATTT CTTATTTT-- ---------- -ATTTTCATT
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     -AAA-----A TAATAATTTT CTTATTTT-- ---TAATTGA TAATTGAATT
Z.officinaleAB047756      AAAAATAAAA TAATAAATCT ATTATTTT-- ---------- -ATTTTTATT
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   155        165        175        185        195
S.argenteaOIH320                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.bilobaAF478889                G--AAAAAA- --TTTAAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.bilobaOIH326                  G--AAAAAA- --TTTAAAAT GAAAATGAAA GTTAAATTAA GAATTTC---
S.bilobaOIH327                  G--AAAAAA- --TTTAAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.biruOIH87                     G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.biruOIH254                    G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.calcicolaOIH81                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.durga1OIH84                   G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.durgaOIH235                   G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.graveolensOIH116              G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.hastaOIH80                    G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.aff.klossiiOIH168             G--AAAAAA- --TTTAAAAT AAAAATGAAA GTTAAATTAA GAATTTC---
S.kunstleriAF478890             G--AAAAAA- --TTTAAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.kunstleriOIH161               G--AAAAAA- --TT------ -AAAATGAAA GTGAAATTAA GAATTTC---
S.kunstleriOIH162               G--AAAAAA- --TT------ -AAAATGAAA GTGAAATTAA GAATTTC---
S.kunstleriOIH163               G--AAAAAA- --TT------ -AAAATGAAA GTGAAATTAA GAATTTC---
S.lanjakensisOIH309             G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.limianaOIH122                 G--AAAAAA- --TTTAAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.lucensOIH125                  G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.malaccanaOIH159               GAAAAAAAA- --TTAAAAAT TAAAATGAAA GTGAAATTAA GAATTTA---
S.multifoliaOIH111              G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.nigraOIH76                    G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.cf.nigraOIH227                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.penyamarOIH137                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.petiolataOIH71                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.picturataZI656                G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTCA GAATTTC---
S.pseudoreticosaOIH83           G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.polyphyllaOIH119              G--AAAAAA- --TTTAAAAT TAAAATGAAA GTTAAATTAA GAATTTC---
S.polyphyllaOIH289              G--AAAAAA- --TTTAAAAT TAAAATGAAA GTTAAATTAA GAATTTC---
S.reticosaOIH79                 G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.reticosaZI139                 G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.scintillansOIH141             G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.stenophyllaOIH74              G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.stenophyllaOIH88              G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.cf.stenophyllaOIH93           G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
S.uniflaraOIH82                 G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTCTCC
B.pulcherrimaJX992809           G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
DisticochlamysspAF478844        G--AAAAAA- --TTTAAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
HaniffiacyanescensJF825538      G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
H.uniflorumOIH113               G--AAAAAA- --TTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
K.rotundaAF478868               G--AAAAAA- --TTTCTAAT TAAAATGAAA GTGAAATTAA GAATTTC---
M.mullerensisAB269791           ?--??????- --???????? ?????????? ?????????? ??????????
T.flagellarisAF478898           GAAAAAAAAA ATTTTCAAAT TAAAATGAAA GTGAAATTAA GAATTTC---
Z.officinaleAB047756            G--AAAAAA- --TT------ ---------- ---------- ----------
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                              205        215        225        235        245
S.argenteaOIH320          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.bilobaAF478889          --TCCTTACT CAATTCTTAC AATTTTTTCT GGTAGGGAAG TGGACAAAAC
S.bilobaOIH326            --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.bilobaOIH327            --TCCTTACT CAATTCTTAC AATTTTTTCT GGTAGGGAAG TGGACAAAAC
S.biruOIH87               --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.biruOIH254              --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.calcicolaOIH81          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.durga1OIH84             --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.durgaOIH235             --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.graveolensOIH116        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.hastaOIH80              --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.aff.klossiiOIH168       --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.kunstleriAF478890       --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.kunstleriOIH161         --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.kunstleriOIH162         --TCCTTATT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.kunstleriOIH163         --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.lanjakensisOIH309       --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.limianaOIH122           --TCCTTACT CAATTCTTAC AATTTTTTCT GGTAGGGAAG TGGACAAAAC
S.lucensOIH125            --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.malaccanaOIH159         --TCCTTACT CAATTCTTAC AATTTTTTCT GGTAGGGAAG TGGACAAAAC
S.multifoliaOIH111        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.nigraOIH76              --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.cf.nigraOIH227          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.penyamarOIH137          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.petiolataOIH71          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.picturataZI656          --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.pseudoreticosaOIH83     --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.polyphyllaOIH119        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.polyphyllaOIH289        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.reticosaOIH79           --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.reticosaZI139           --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.scintillansOIH141       --TCCTTATT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.stenophyllaOIH74        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.stenophyllaOIH88        --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.cf.stenophyllaOIH93     --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
S.uniflaraOIH82           TTTCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
B.pulcherrimaJX992809     --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGTAAG TGGACAAAAC
DisticochlamysspAF478844  --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
HaniffiacyanescensJF825538 --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
H.uniflorumOIH113         --TCCTTACT CAATTCTTAC AATTTTTTTT GGTAGGGAAG TGGACAAAAC
K.rotundaAF478868         --TCCTTACT CAATTCTTAC AATTTTTT-T GGTAGGGAAG TGGACAAAAC
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     --TCCTTACT CAATTCTTAC AATTGTTT-T GGTAGGGAAG TGGACAAAAC
Z.officinaleAB047756      ---------- ---------- ---------- ---------- ----------
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   255        265        275        285        295
S.argenteaOIH320                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.bilobaAF478889                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.bilobaOIH326                  AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.bilobaOIH327                  AAATTAAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.biruOIH87                     AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.biruOIH254                    AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.calcicolaOIH81                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.durga1OIH84                   AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.durgaOIH235                   AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.graveolensOIH116              AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.hastaOIH80                    AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.aff.klossiiOIH168             AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.kunstleriAF478890             AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.kunstleriOIH161               AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.kunstleriOIH162               AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.kunstleriOIH163               AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.lanjakensisOIH309             AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.limianaOIH122                 AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.lucensOIH125                  AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.malaccanaOIH159               AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.multifoliaOIH111              AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.nigraOIH76                    AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.cf.nigraOIH227                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.penyamarOIH137                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.petiolataOIH71                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.picturataZI656                AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.pseudoreticosaOIH83           AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.polyphyllaOIH119              AAATTAAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.polyphyllaOIH289              AAATTAAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.reticosaOIH79                 AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.reticosaZI139                 AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.scintillansOIH141             AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.stenophyllaOIH74              AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.stenophyllaOIH88              AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.cf.stenophyllaOIH93           AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
S.uniflaraOIH82                 AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
B.pulcherrimaJX992809           AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
DisticochlamysspAF478844        AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
HaniffiacyanescensJF825538      AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
H.uniflorumOIH113               AAATTCAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
K.rotundaAF478868               AAATTCAAAT TTATAGTTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           AAATTCAAAT ------TTTT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
Z.officinaleAB047756            -----CAAAT ------TTAT AGTTTGGTCT AGTGAATAAA TGGATAGAGC
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Appendix 2 continued

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                                ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                   305         315         325         335         345
S.argenteaOIH320                TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.bilobaAF478889                TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.bilobaOIH326                  TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.bilobaOIH327                  TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.biruOIH87                     TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.biruOIH254                    TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.calcicolaOIH81                TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.durga1OIH84                   TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.durgaOIH235                   TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.graveolensOIH116              TTCACGGC-- ----TCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.hastaOIH80                    TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.aff.klossiiOIH168             TTCATGGCTC CAATTCTAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.kunstleriAF478890             TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.kunstleriOIH16                TTCATGGCTC CAATTCCAAT TCTAATAAAA CAAAAAGCAA CGAGCTTATG
S.kunstleriOIH162               TTCATGGCTC CAATTCCAAT TCTAATAAAA CAAAAAGCAA CGAGCTTATG
S.kunstleriOIH163               TTCATGGCTC CAATTCCAAT TCTAATAAAA CAAAAAGCAA CGAGCTTATG
S.lanjakensisOIH309             TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.limianaOIH122                 TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.lucensOIH125                  TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.malaccanaOIH159               TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.multifoliaOIH111              TTCACGGCTC CAATTCCAAT TCTAATAAAT CAAAAAGCAA CGAGCTTATG
S.nigraOIH76                    TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.cf.nigraOIH227                TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.penyamarOIH137                TTCACGGCTC TAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.petiolataOIH71                TTCACGGCTC CAATTCCAAT TCTAATAAAT CAAAAAGCAA CGAGCTTATG
S.picturataZI656                TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.pseudoreticosaOIH83           TTCACGGCTC CAATTCCAAT TCTAATAAAT CAAAAAGCAA CGAGCTTATG
S.polyphyllaOIH119              TTCATGGCTC CAATTCTAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.polyphyllaOIH289              TTCATGGCTC CAATTCTAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.reticosaOIH79                 TTCACGGCTC CAATTCCAAT TCTAATAAAT CAAAAAGCAA CGAGCTTATG
S.reticosaZI139                 TTCACGGCTC CAATTCCAAT TCTAATAAAT CAAAAAGCAA CGAGCTTATG
S.scintillansOIH141             TTCACGGCTC TAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.stenophyllaOIH74              TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.stenophyllaOIH88              TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.cf.stenophyllaOIH93           TTCACGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
S.unifloraOIH82                 TTCATGGCTC CAATTCCAAT TCTAATAAAC CAAAAAGCAA CGAGCTTATG
B.pulcherrimaJX992809           TTCATGGCTC CAATTCCAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
DisticochlamysspAF478844        TTCATGGCTC CAATTCCAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
HaniffiacyanescensJF825538      TTCATGGCTC CAATTCTAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
H.uniflorumOIH113               TTCATGGCTC CAATTCCAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
K.rotundaAF478868               TTCATGGCTC CAATTCCAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           TTCATGGC-- ----TCCAAT TCTGATAAAC AAAAAAGCAA CGAGCTTATG
Z.officinaleAB047756            TTCATGGCTC CAATTCCAAT TCTGATAAAC CAAAAAGCAA CGAGCTTATG
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             355        365        375        385        395
S.argenteaOIH320          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.bilobaAF478889          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.bilobaOIH326            TTCTTAATTT GAATTAAATG ATTACCCGAT CTAA--TTAG ACGTTAAAAA
S.bilobaOIH327            TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.biruOIH87               TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.biruOIH254              TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.calcicolaOIH81          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.durga1OIH84             TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.durgaOIH235             TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.graveolensOIH116        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.hastaOIH80              TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.aff.klossiiOIH168       TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.kunstleriAF478890       TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.kunstleriOIH161         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.kunstleriOIH162         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.kunstleriOIH163         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.lanjakensisOIH309       TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.limianaOIH122           TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.lucensOIH125            TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.malaccanaOIH159         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.multifoliaOIH111        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.nigraOIH76              TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.cf.nigraOIH227          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.penyamarOIH137          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.petiolataOIH71          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.picturataZI656          TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.pseudoreticosaOIH83     TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.polyphyllaOIH119        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.polyphyllaOIH289        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.reticosaOIH79           TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.reticosaZI139           TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.scintillansOIH141       TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.stenophyllaOIH74        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.stenophyllaOIH88        TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.cf.stenophyllaOIH93     TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
S.uniflaraOIH82           TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
B.pulcherrimaJX992809     TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
DisticochlamysspAF478844  TTCTTAATTT GAATTAAATG ATTACCCGAT CTAR--TTAG ACGTTTAAAA
HaniffiacyanescensJF825538 TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
H.uniflorumOIH113         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
K.rotundaAF478868         TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     TTCTTAATTT GAATTAAATG ATTACCCGAT CTAG--TTAG ACGTTAAAAA
Z.officinaleAB047756      TTCTTAATTT GAATTAAATG ATTACCCGAT CTAGTTTTAG ACGTTAAAAA
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Appendix 2 continued

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                                 ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     405         415         425         435         445
S.argenteaOIH320                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.bilobaAF478889                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAAGAGACCA
S.bilobaOIH326                   TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.bilobaOIH327                   TGGATTAGTG CCTGATACGG GAAAGGATGG GGTCTCCCGT GAAGAGACCA
S.biruOIH87                      TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.biruOIH254                     TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.calcicolaOIH81                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.durga1OIH84                    TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.durgaOIH235                    TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.graveolensOIH116               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.hastaOIH80                     TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.aff.klossiiOIH168              TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.kunstleriAF478890              TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.kunstleriOIH161                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.kunstleriOIH162                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.kunstleriOIH163                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.lanjakensisOIH309              TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.limianaOIH122                  TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAAGAGACCA
S.lucensOIH125                   TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.malaccanaOIH159                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.multifoliaOIH111               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.nigraOIH76                     TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.cf.nigraOIH227                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.penyamarOIH137                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.petiolataOIH71                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.picturataZI656                 TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.pseudoreticosaOIH83            TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.polyphyllaOIH119               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.polyphyllaOIH289               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
S.reticosaOIH79                  TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.reticosaZI139                  TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.scintillansOIH141              TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.stenophyllaOIH74               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.stenophyllaOIH88               TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.cf.stenophyllaOIH93            TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCG
S.uniflora0IH82                  TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCCCCCGT GAGGAGACCA
B.pulcherrimaJX992809            TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
DisticochlamysspAF478844         TGGATTAGTG CCTGGTACAG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
HaniffiacyanescensJF825538       TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
H.uniflorumOIH113                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
K.rotundaAF478868                TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
M.mullerensisAB269791            ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898            TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
Z.officinaleAB047756             TGGATTAGTG CCTGGTACGG GAAAGGATGG GGTCTCCCGT GAGGAGACCA
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Appendix 2 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     455         465         475         485         495
S.argenteaOIH320                  TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.bilobaAF478889                  TTGATTCTTT  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.bilobaOIH326                    TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.bilobaOIH327                    TTGATTC--T  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.biruOIH87                       TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.biruOIH254                      TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.calcicolaOIH81                  TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.durga1OIH84                     TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.durgaOIH235                     TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.graveolensOIH116                TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.hastaOIH80                      TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.aff.klossiiOIH168               TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.kunstleriAF478890               TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.kunstleriOIH16                  TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.kunstleriOIH162                 TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.kunstleriOIH163                 TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.lanjakensisOIH309               TTGATTC---  -----TTTTT  TTTTATGAAT  C---------  ------CTAA
S.limianaOIH122                   TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.lucensOIH125                    TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.malaccanaOIH159                 TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.multifoliaOIH111                TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.nigraOIH76                      TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.cf.nigraOIH227                  TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.penyamarOIH137                  TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
S.petiolataOIH71                  TTGATTC--T  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.picturataZI656                  TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.pseudoreticosaOIH83             TTGATTC---  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.polyphyllaOIH119                TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.polyphyllaOIH289                TTGATTC---  -TTTTTTTTT  TTTTATGAAT  CCTAAATATT  GATTATCTAA
S.reticosaOIH79                   TTGATTC---  -TTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.reticosaZI139                   TTGATTC---  -TTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.scintillansOIH141               TTGATTC---  -----TTTTT  TTTTATGAAT  C---------  ------CTAA
S.stenophyllaOIH74                TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.stenophyllaOIH88                TTGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.cf.stenophyllaOIH93             TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
S.unifloraOIH82                   TTGATTC---  ---TTTTTTT  TTTTATGAAT  C---------  ------CTAA
B.pulcherrimaJX992809             TCGATTC---  --TTTTTTTT  TTTTATGAAT  C---------  ------CTAA
DisticochlamysspAF478844          TTGATTC-TT  TTTTTTTTTT  TTTTATCACT  C---------  ------CTAA
HaniffiacyanescensJF825538        TTGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
H.uniflorumOIH113                 TCGATTC---  ----TTTTTT  TTTTATGAAT  C---------  ------CTAA
K.rotundaAF478868                 TTGATTC---  -TTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
M.mullerensisAB269791             ??????????  ??????????  ??????????  ??????????  ??????????
T.flagellarisAF478898             TTGATTC-TT  TTTTTTTTTT  TTTTATGAAT  C---------  ------CTAA
Z.officinaleAB047756              TTGATTC---  ----TTTTTC  TTTTATGAAT  C---------  ------CTAA
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                    505        515        525        535        545
S.argenteaOIH320                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.bilobaAF478889                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.bilobaOIH326                  ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.bilobaOIH327                  ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAAAA ACAGTATACT
S.biruOIH87                     ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.biruOIH254                    ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.calcicolaOIH81                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.durga1OIH84                   ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.durgaOIH235                   ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.graveolensOIH116              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.hastaOIH80                    ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.aff.klossiiOIH168             ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.kunstleriAF478890             ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.kunstleriOIH161               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.kunstleriOIH162               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.kunstleriOIH163               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.lanjakensisOIH309             ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.limianaOIH122                 ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.lucensOIH125                  ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.malaccanaOIH159               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.multifoliaOIH111              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.nigraOIH76                    ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.cf.nigraOIH227                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.penyamarOIH137                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.petiolataOIH71                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.picturataZI656                ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.pseudoreticosaOIH83           ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.polyphyllaOIH119              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.polyphyllaOIH289              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.reticosaOIH79                 ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.reticosaZI139                 ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.scintillansOIH141             ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.stenophyllaOIH74              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.stenophyllaOIH88              ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.cf.stenophyllaOIH93           ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
S.uniflora0IH82                 ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
B.pulcherrimaJX992809           ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATATT
DisticochlamysspAF478844        ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
HaniffiacyanescensJF825538      ATATTTATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
H.uniflorumOIH113               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
K.rotundaAF478868               ATATTGATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           ATATTGATTA TTATGGGTTA GAGACAAATG TGTAAAAGAA ACAGTATACT
Z.officinaleAB047756            ATATTTATTA TTATGGGTTA GAGACGAATG TGTAAAAGAA ACAGTATACT
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             555        565        575        585        595
S.argenteaOIH320          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.bilobaAF478889          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.bilobaOIH326            GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.bilobaOIH327            GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.biruOIH87               GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.biruOIH254              GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.calcicolaOIH81          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.durga1OIH84             GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.durgaOIH235             GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.graveolensOIH116        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.hastaOIH80              GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.aff.klossiiOIH168       GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.kunstleriAF478890       GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.kunstleriOIH161         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.kunstleriOIH162         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.kunstleriOIH163         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.lanjakensisOIH309       GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.limianaOIH122           GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.lucensOIH125            GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.malaccanaOIH159         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.multifoliaOIH111        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.nigraOIH76              GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.cf.nigraOIH227          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.penyamarOIH137          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.petiolataOIH71          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCGGGTTGC
S.picturataZI656          GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.pseudoreticosaOIH83     GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.polyphyllaOIH119        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.polyphyllaOIH289        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.reticosaOIH79           GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.reticosaZI139           GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.scintillansOIH141       GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.stenophyllaOIH74        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.stenophyllaOIH88        GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.cf.stenophyllaOIH93     GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
S.unifloraOIH82           GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
B.pulcherrimaJX992809     GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
DisticochlamysspAF478844  GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
HaniffiacyanescensJF825538 GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
H.uniflorumOIH113         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
K.rotundaAF478868         GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     GATAAAGATA ATTAATTCCA ATTCCAAAAT CAAAAGAGCA ATCCGGTTGT
Z.officinaleAB047756      GATAAAGATA ATT------A ATTCCAAAAT CAAAAGAGCA ATCAGGTTGC
```

Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                    605      615      625      635      645
S.argenteaOIH320                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.bilobaAF478889                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.bilobaOIH326                  AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.bilobaOIH327                  AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.biruOIH87                     AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.biruOIH254                    AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.calcicolaOIH81                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.durga1OIH84                   AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.durgaOIH235                   AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.graveolensOIH116              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.hastaOIH80                    AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.aff.klossiiOIH168             AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.kunstleriAF478890             AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.kunstleriOIH161               AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.kunstleriOIH162               AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.kunstleriOIH163               AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.lanjakensisOIH309             AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.limianaOIH122                 AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.lucensOIH125                  AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.malaccanaOIH159               AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.multifoliaOIH111              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.nigraOIH76                    AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.cf.nigraOIH227                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.penyamarOIH137                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.petiolataOIH71                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.picturataZI656                AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.pseudoreticosaOIH83           AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.polyphyllaOIH119              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.polyphyllaOIH289              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.reticosaOIH79                 AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.reticosaZI139                 AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.scintillansOIH141             AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.stenophyllaOIH74              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.stenophyllaOIH88              AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.cf.stenophyllaOIH93           AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
S.unifloraOIH82                 AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
B.pulcherrimaJX992809           AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
DisticochlamysspAF478844        AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
HaniffiacyanescensJF825538      AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
H.uniflorumOIH113               AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
K.rotundaAF478868               AAAAATAAAG GGTCATTATC CTCTTGTAAT GTCATTATCC TCTTGTAATT
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           AAAAATAAAG G--------- ---------- GTCATTATCC TATTGTAATT
Z.officinaleAB047756            AAAAATAAAG G--------- ---------- GTCATTATCC TCTTGTAATT
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    655        665        675        685        695
S.argenteaOIH320                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.bilobaAF478889                 ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.bilobaOIH326                   ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.bilobaOIH327                   ATAACGAAAA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.biruOIH87                      ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.biruOIH254                     ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.calcicolaOIH81                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.durga1OIH84                    ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.durgaOIH235                    ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.graveolensOIH116               ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.hastaOIH80                     ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.aff.klossiiOIH168              ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.kunstleriAF478890              ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.kunstleriOIH161                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.kunstleriOIH162                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.kunstleriOIH163                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.lanjakensisOIH309              ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.limianaOIH122                  ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.lucensOIH125                   ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.malaccanaOIH159                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.multifoliaOIH111               ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.nigraOIH76                     ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.cf.nigraOIH227                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.penyamarOIH137                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.petiolataOIH71                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.picturataZI656                 ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.pseudoreticosaOIH83            ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.polyphyllaOIH119               ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.polyphyllaOIH289               ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGAAGTA AAAAAACCTA
S.reticosaOIH79                  ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.reticosaZI139                  ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.scintillansOIH141              ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.stenophyllaOIH74               ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.stenophyllaOIH88               ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.cf.stenophyllaOIH93            ATAATGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
S.uniflaraOIH82                  ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
B.pulcherrimaJX992809            ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
DisticochlamysspAF478844         ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
HaniffiacyanescensJF825538       ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
H.uniflorumOIH113                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
K.rotundaAF478868                ATAACGAAGA TAAACCATTT TTGATAGAAA AAGGGGAGTA AAAAAACCTA
M.mullerensisAB269791            ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898            ATAACGAAGA TAAACCA-TT TTGATAGAAA ---GGGGGTA AAAAAACTTG
Z.officinaleAB047756             ATAACGAAGA TAAACCATTT TTGCTAGAAA AAGGGGAGTA AAAAAACCTA
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Appendix 2 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     705         715         725         735         745
S.argenteaOIH320                  TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.bilobaAF478889                  TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.bilobaOIH326                    TTGATTGGAT TTACTCTTTC CTTTACAGGT ------TTAT T-------AT
S.bilobaOIH327                    TTGATTGGAT TTCCCCTTTC CTTTACAGGT ------TTAT T-------AT
S.biruOIH87                       TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.biruOIH254                      TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.calcicolaOIH81                  TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.durga1OIH84                     TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.durgaOIH235                     TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.graveolensOIH116                TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT TATTATTAAT
S.hastaOIH80                      TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.aff.klossiiOIH168               TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.kunstleriAF478890               TTGATTGGAT TTCCTCTTTC CTTTACAGGT TTATTATTAT T-------AT
S.kunstleriOIH161                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.kunstleriOIH162                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.kunstleriOIH163                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.lanjakensisOIH309               TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.limianaOIH122                   TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.lucensOIH125                    TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.malaccanaOIH159                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.multifoliaOIH111                TTGATTAGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------AT
S.nigraOIH76                      TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.cf.nigraOIH227                  TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.penyamarOIH137                  TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.petiolataOIH71                  TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.picturataZI656                  TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.pseudoreticosaOIH83             TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.polyphyllaOIH119                TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.polyphyllaOIH289                TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.reticosaOIH79                   TTGATTGGAT TTCCTCCTTC CTTTACAGAT ------TTAT T-------A-
S.reticosaZI139                   TTGATTGGAT TTCCTCCTTC CTTTACAGAT ------TTAT T-------A-
S.scintillansOIH141               TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
S.stenophyllaOIH74                TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.stenophyllaOIH88                TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.cf.stenophyllaOIH93             TTGATTGGAT TTCCTCCTTC CTTTACAGGT ------TTAT T-------A-
S.uniflaraOIH82                   TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
B.pulcherrimaJX992809             TTGATTGGAT TTCCTCTTTC CTTTAYAGGT ------TTAT T-------AT
DisticochlamysspAF478844          TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
HaniffiacyanescensJF825538        TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
H.uniflorumOIH113                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------AT
K.rotundaAF478868                 TTGATTGGAT TTCCTCTTTC CTTTACAGGT ------TTAT T-------A-
M.mullerensisAB269791             ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898             TTGATTGGAC TCCCTCTTTC CTTTACAGGG TATCCTTTTT T-------AT
Z.officinaleAB047756              TTGATTGGAT TTCCTCTTTC CTTTACAGGT TTATTATTAT T-------AT
```

Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     755        765        775        785        795
S.argenteaOIH320                  --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.bilobaAF478889                  --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.bilobaOIH326                    --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.bilobaOIH327                    --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.biruOIH87                       ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.biruOIH254                      ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.calcicolaOIH81                  --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.durga1OIH84                     ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.durgaOIH235                     ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.graveolensOIH116                --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.hastaOIH80                      ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.aff.klossiiOIH168               --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.kunstleriAF478890               --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.kunstleriOIH161                 --------TA ---TTATTGT A---TATATA CATAATCCTC TTTTCTTTAT
S.kunstleriOIH162                 --------TA ---TTATTGT A---TATATA CATAATCC-- ---TCTTTAT
S.kunstleriOIH163                 --------TA ---TTATTGT A---TATATA CATAATCCTC TTTTCTTTAT
S.lanjakensisOIH309               --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.limianaOIH122                   --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.lucensOIH125                    --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.malaccanaOIH159                 --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.multifoliaOIH111                --------TA TTGTTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.nigraOIH76                      ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.cf.nigraOIH227                  ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.penyamarOIH137                  --------TA ---TTATTGT A---TATATA CATAATCT-- ---TTTTTAT
S.petiolataOIH71                  ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.picturataZI656                  --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.pseudoreticosaOIH83             ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.polyphyllaOIH119                --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.polyphyllaOIH289                --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.reticosaOIH79                   ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.reticosaZI139                   ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.scintillansOIH141               --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.stenophyllaOIH74                ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.stenophyllaOIH88                ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.cf.stenophyllaOIH93             ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
S.uniflaraOIH82                   --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
B.pulcherrimaJX992809             --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
DisticochlamysspAF478844          --------TA ---TTATTGT ATTGTATATA TATAATCT-- ---TCTTTAT
HaniffiacyanescensJF825538        --------TA ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
H.uniflorumOIH113                 --------TA ---TTATTGT A---TATATA CATAATCT-- ---TATTTAT
K.rotundaAF478868                 ---------- ---TTATTGT A---TATATA CATAATCT-- ---TCTTTAT
M.mullerensisAB269791             ?????????? ?????????? ?????????? ????????-- ---???????
T.flagellarisAF478898             TACTATTGTA TTTTTATTGT A---TATATA CATAATAT-- ---TCTTTAT
Z.officinaleAB047756              --------TG ---TAATTGT A---TATATA CATAATCT-- ---TCTTTAT
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     805      815       825       835       845
S.argenteaOIH320                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.bilobaAF478889                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.bilobaOIH326                    TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.bilobaOIH327                    TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.biruOIH87                       TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.biruOIH254                      TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.calcicolaOIH81                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.durga1OIH84                     TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.durgaOIH235                     TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.graveolensOIH116                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.hastaOIH80                      TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.aff.klossiiOIH168               TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.kunstleriAF478890               TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.kunstleriOIH161                 TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.kunstleriOIH162                 TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.kunstleriOIH163                 TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.lanjakensisOIH309               TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.limianaOIH122                   TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.lucensOIH125                    TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.malaccanaOIH159                 TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.multifoliaOIH111                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.nigraOIH76                      TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.cf.nigraOIH227                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.penyamarOIH137                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.petiolataOIH71                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.picturataZI656                  TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.pseudoreticosaOIH83             TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.polyphyllaOIH119                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.polyphyllaOIH289                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.reticosaOIH79                   TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.reticosaZI139                   TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.scintillansOIH141               TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.stenophyllaOIH74                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.stenophyllaOIH88                TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.cf.stenophyllaOIH93             TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
S.unifloraOIH82                   TATACATAAT ACTC------ TACTCTGTTT TGACCATATT GCACTAT---
B.pulcherrimaJX992809             TATACATAA- ---------- TACTCTGTTT TGACCATATT GCACTAT---
DisticochlamysspAF478844          TATACATAA- ---------- TACTCTGTTT TGACCATATT GCACTAT---
HaniffiacyanescensJF825538        TATACATAA- ---------- TACTCTGTTT TGACCATATT GCACTAT---
H.uniflorumOIH113                 TATACATAA- ---------- TACTCTGTTT TGACCATATT GCACTAT---
K.rotundaAF478868                 TATACATAAT ACTCTCATAA TACTCTGTTT TGACCATATT GCACTAT---
M.mullerensisAB269791             ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898             TATGCATAA- ---------- TACTCTGTTT TGACCATATT GCACTATGTA
Z.officinaleAB047756              TATACATAAT ATACATAA-- TACTCTGTTT TGACCATATT GCACTAT---
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             855        865        875        885        895
S.argenteaOIH320          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.bilobaAF478889          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.bilobaOIH326            ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.bilobaOIH327            ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.biruOIH87               ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.biruOIH254              ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.calcicolaOIH81          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.durga1OIH84             ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.durgaOIH235             ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.graveolensOIH116        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.hastaOIH80              ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.aff.klossiiOIH168       ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.kunstleriAF478890       ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.kunstleriOIH161         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTTTGCTTCA
S.kunstleriOIH162         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.kunstleriOIH163         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTTTGCTTCA
S.lanjakensisOIH309       ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.limianaOIH122           ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.lucensOIH125            ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.malaccanaOIH159         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.multifoliaOIH111        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.nigraOIH76              ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.cf.nigraOIH227          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.penyamarOIH137          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.petiolataOIH71          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.picturataZI656          ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.pseudoreticosaOIH83     ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.polyphyllaOIH119        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.polyphyllaOIH289        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.reticosaOIH79           ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.reticosaZI139           ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.scintillansOIH141       ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.stenophyllaOIH74        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.stenophyllaOIH88        ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.cf.stenophyllaOIH93     ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
S.uniflaraOIH82           ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
B.pulcherrimaJX992809     ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
DisticochlamysspAF478844  ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
HaniffiacyanescensJF825538 ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCCAC CTTTGCTTCA
H.uniflorumOIH113         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
K.rotundaAF478868         ---GTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTAC CTCTGCTTCA
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     TCAGTATCAG TTATTTTATA ACTCAAGAAG TTCCTTCTTC CTCTGCTTCA
Z.officinaleAB047756      ---GTATCAG TTATTTTATA ACTCAAGAAA TTCTTTCTAC CTTTGCTTCA
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                              905        915        925        935        945
S.argenteaOIH320          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.bilobaAF478889          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.bilobaOIH326            CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.bilobaOIH327            CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.biruOIH87               CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.biruOIH254              CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.calcicolaOIH81          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.durga1OIH84             CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.durgaOIH235             CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.graveolensOIH116        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.hastaOIH80              CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.aff.klossiiOIH168       CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.kunstleriAF478890       CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.kunstleriOIH161         CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.kunstleriOIH162         CGTGAAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.kunstleriOIH163         CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.lanjakensisOIH309       CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.limianaOIH122           CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.lucensOIH125            CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.malaccanaOIH159         CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.multifoliaOIH111        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.nigraOIH76              CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.cf.nigraOIH227          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.penyamarOIH137          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.petiolataOIH71          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.picturataZI656          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.pseudoreticosaOIH83     CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.polyphyllaOIH119        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.polyphyllaOIH289        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.reticosaOIH79           CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.reticosaZI139           CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.scintillansOIH141       CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.stenophyllaOIH74        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.stenophyllaOIH88        CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.cf.stenophyllaOIH93     CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
S.uniflouraOIH82          CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
B.pulcherrimaJX992809     CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
DisticochlamysspAF478844  CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
HaniffiacyanescensJF825538 TGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAAAT
H.uniflorumOIH113         CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
K.rotundaAF478868         CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
M.mullerensisAB269791     ?????????? ???ATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
T.flagellarisAF478898     CGTGGAAATG TAAATGGAAG AATTACAAGG ATATTTAGAA GAATATAGAT
Z.officinaleAB047756      CGTGGAAATA TAAATGGAAG AATTACAAGG ATATTTAGAA GAAGATAGAT
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Appendix 2 continued

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                                ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                   955         965         975         985         995
S.argenteaOIH320                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.bilobaAF478889                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.bilobaOIH326                  CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.bilobaOIH327                  CTCGGCAACA ACAGTTTCTA TATCCACTTT CTCTTTCAAG AATATATTTA
S.biruOIH87                     CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.biruOIH254                    CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.calcicolaOIH81                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.durga1OIH84                   CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.durgaOIH235                   CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.graveolensOIH116              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.hastaOIH80                    CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.aff.klossiiOIH168             CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.kunstleriAF478890             CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.kunstleriOIH161               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.kunstleriOIH162               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.kunstleriOIH163               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.lanjakensisOIH309             CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.limianaOIH122                 CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.lucensOIH125                  CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.malaccanaOIH159               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.multifoliaOIH111              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.nigraOIH76                    CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.cf.nigraOIH227                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.penyamarOIH137                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.petiolataOIH71                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.picturataZI656                CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.pseudoreticosaOIH83           CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.polyphyllaOIH119              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.polyphyllaOIH289              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.reticosaOIH79                 CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.reticosaZI139                 CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.scintillansOIH141             CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.stenophyllaOIH74              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.stenophyllaOIH88              CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.cf.stenophyllaOIH93           CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
S.unifloraOIH82                 CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
B.pulcherrimaJX992809           CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
DisticochlamysspAF478844        CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
HaniffiacyanescensJF825538      CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
H.uniflorumOIH113               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
K.rotundaAF478868               CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
M.mullerensisAB269791           CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
T.flagellarisAF478898           CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
Z.officinaleAB047756            CTCGGCAACA ACAGTTTCTA TATCCAC-TT CTCTTTCAAG AATATATTTA
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             1005       1015       1025       1035       1045
S.argenteaOIH320          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.bilobaAF478889          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.bilobaOIH326            CGTATTTGCT TATGATCATG GGTT-AAAAA GTTCCAATTT T------TTA
S.bilobaOIH327            TGTATTTGCT TATGATCATG GGTTAAAAAA GTT-AACTTT T------TTA
S.biruOIH87               CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.biruOIH254              CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.calcicolaOIH81          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.durga1OIH84             CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.durgaOIH235             CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.graveolensOIH116        CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.hastaOIH80              CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.aff.klossiiOIH168       TGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.kunstleriAF478890       CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.kunstleriOIH161         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT TTTATGATTA
S.kunstleriOIH162         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.kunstleriOIH163         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT TTTATGATTA
S.lanjakensisOIH309       CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.limianaOIH122           CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.lucensOIH125            CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.malaccanaOIH159         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.multifoliaOIH111        CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.nigraOIH76              CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.cf.nigraOIH227          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.penyamarOIH137          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.petiolataOIH71          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.picturataZI656          CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.pseudoreticosaOIH83     CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.polyphyllaOIH119        TGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.polyphyllaOIH289        TGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.reticosaOIH79           CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.reticosaZI139           CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.scintillansOIH141       CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.stenophyllaOIH74        CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.stenophyllaOIH88        CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.cf.stenophyllaOIH93     CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
S.uniflaraOIH82           CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
B.pulcherrimaJX992809     CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
DisticochlamysspAF478844  CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
HaniffiacyanescensJF825538 CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
H.uniflorumOIH113         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
K.rotundaAF478868         CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
M.mullerensisAB269791     CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
T.flagellarisAF478898     CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CGATTT T------TTA
Z.officinaleAB047756      CGTATTTGCT TATGATCATG GGTT-AAATA GTT-CAATTT T------TTA
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    1055       1065       1075       1085       1095
S.argenteaOIH320                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.bilobaAF478889                 TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.bilobaOIH326                   TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.bilobaOIH327                   TGAACCCCCA AAACTCCTTG GAGTTATGAC AATAAATTTA GTTCAGTACT
S.biruOIH87                      TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.biruOIH254                     TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.calcicolaOIH81                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.durga1OIH84                    TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.durgaOIH235                    TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.graveolensOIH116               TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.hastaOIH80                     TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.aff.klossiiOIH168              TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.kunstleriAF478890              TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.kunstleriOIH161                TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.kunstleriOIH162                TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.kunstleriOIH163                TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.lanjakensisOIH309              TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.limianaOIH122                  TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.lucensOIH125                   TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.malaccanaOIH159                TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.multifoliaOIH111               TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.nigraOIH76                     TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.cf.nigraOIH227                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.penyamarOIH137                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAATACT
S.petiolataOIH71                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.picturataZI656                 TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.pseudoreticosaOIH83            TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.polyphyllaOIH119               TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.polyphyllaOIH289               TGAA-CCCCA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.reticosaOIH79                  TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.reticosaZI139                  TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.scintillansOIH141              TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.stenophyllaOIH74               TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.stenophyllaOIH88               TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.cf.stenophyllaOIH93            TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
S.uniflaraOIH82                  TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
B.pulcherrimaJX992809            TGAA-CCCCA AAACTCCTC- AGGTTATGAC AATAAATTTA GTTCAGTACT
DisticochlamysspAF478844         TGAA-CCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
HaniffiacyanescensJF825538       TGAA-TCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
H.uniflorumOIH113                TGAA-CCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
K.rotundaAF478868                TGAA-CCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
M.mullerensisAB269791            TGAA-CCACA AAACTCCTT- GAGTTATGAC AATAAATTTA GTTCAGTACT
T.flagellarisAF478898            TGAA-CCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
Z.officinaleAB047756             TGAA-CCCCA AAACTCCTT- GGGTTATGAC AATAAATTTA GTTCAGTACT
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1105       1115       1125       1135       1145
S.argenteaOIH320                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.bilobaAF478889                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.bilobaOIH326                  TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.bilobaOIH327                  TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.biruOIH87                     TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.biruOIH254                    TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.calcicolaOIH81                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.durga1OIH84                   TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.durgaOIH235                   TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.graveolensOIH116              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.hastaOIH80                    TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.aff.klossiiOIH168             TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.kunstleriAF478890             TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.kunstleriOIH161               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.kunstleriOIH162               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.kunstleriOIH163               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.lanjakensisOIH309             TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.limianaOIH122                 TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.lucensOIH125                  TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.malaccanaOIH159               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.multifoliaOIH111              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.nigraOIH76                    TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.cf.nigraOIH227                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.penyamarOIH137                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.petiolataOIH71                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.picturataZI656                TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.pseudoreticosaOIH83           TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.polyphyllaOIH119              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.polyphyllaOIH289              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.reticosaOIH79                 TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.reticosaZI139                 TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.scintillansOIH141             TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.stenophyllaOIH74              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.stenophyllaOIH88              TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.cf.stenophyllaOIH93           TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
S.unifloraOIH82                 TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
B.pulcherrimaJX992809           TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
DisticochlamysspAF478844        TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
HaniffiacyanescensJF825538      TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
H.uniflorumOIH113               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
K.rotundaAF478868               TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
M.mullerensisAB269791           TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTTATTTATT
T.flagellarisAF478898           TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
Z.officinaleAB047756            TGTGAAACGT TTAATTATTC GAATGTATCA AAAAAATTAT TTGATTTATT
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             1155       1165       1175       1185       1195
S.argenteaOIH320          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.bilobaAF478889          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.bilobaOIH326            CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.bilobaOIH327            CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.biruOIH87               CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.biruOIH254              CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.calcicolaOIH81          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.durga1OIH84             CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.durgaOIH235             CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.graveolensOIH116        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAA------T
S.hastaOIH80              CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.aff.klossiiOIH168       CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.kunstleriAF478890       CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.kunstleriOIH161         CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.kunstleriOIH162         CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAA------T
S.kunstleriOIH163         CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.lanjakensisOIH309       CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.limianaOIH122           CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.lucensOIH125            CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.malaccanaOIH159         CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.multifoliaOIH111        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.nigraOIH76              CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.cf.nigraOIH227          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.penyamarOIH137          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.petiolataOIH71          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.picturataZI656          CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.pseudoreticosaOIH83     CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.polyphyllaOIH119        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.polyphyllaOIH289        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.reticosaOIH79           CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.reticosaZI139           CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.scintillansOIH141       CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.stenophyllaOIH74        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.stenophyllaOIH88        CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.cf.stenophyllaOIH93     CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
S.uniflaraOIH82           CAGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
B.pulcherrimaJX992809     CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAA------T
DisticochlamysspAF478844  CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
HaniffiacyanescensJF825538 CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAA------T
H.uniflorumOIH113         CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
K.rotundaAF478868         CGGTTAATGA TATTTACCAA AATATATTTA TTGGGCATAA CAATTATTTT
M.mullerensisAB269791     CGGTTAATGA TATTTACCAA AATATATTTG TTGGGCATAA CAATTATTTT
T.flagellarisAF478898     CGGTTAATTC TTTTTACCAA AATATATTTG TTGGGCATAA CATTTATTTT
Z.officinaleAB047756      CGGTTAATGA TATTTACCAA AATATATTTG TCGGGCATAA CAATTATTTT
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                     1205       1215       1225       1235       1245
S.argenteaOIH320                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.bilobaAF478889                 TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.bilobaOIH326                   TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.bilobaOIH327                   TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.biruOIH87                      TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.biruOIH254                     TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.calcicolaOIH81                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.durga1OIH84                    TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.durgaOIH235                    TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.graveolensOIH116               TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.hastaOIH80                     TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.aff.klossiiOIH168              TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.kunstleriAF478890              TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.kunstleriOIH161                TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.kunstleriOIH162                TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.kunstleriOIH163                TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.lanjakensisOIH309              TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.limianaOIH122                  TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.lucensOIH125                   TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.malaccanaOIH159                TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.multifoliaOIH111               TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.nigraOIH76                     TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.cf.nigraOIH227                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.penyamarOIH137                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.petiolataOIH71                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.picturataZI656                 TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.pseudoreticosaOIH83            TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.polyphyllaOIH119               TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.polyphyllaOIH289               TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.reticosaOIH79                  TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.reticosaZI139                  TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.scintillansOIH141              TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.stenophyllaOIH74               TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.stenophyllaOIH88               TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.cf.stenophyllaOIH93            TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
S.uniflaraOIH82                  TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
B.pulcherrimaJX992809            TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
DisticochlamysspAF478844         T------ATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
HaniffiacyanescensJF825538       TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
H.uniflorumOIH113                TATTTAAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
K.rotundaAF478868                TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
M.mullerensisAB269791            TATTTTCATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
T.flagellarisAF478898            TTTTT---TT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
Z.officinaleAB047756             TATTTTAATT TTTTTTCTCA GATTCTATCT GAAGGTTTTG CAGTCATTGT
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    1255       1265       1275       1285       1295
S.argenteaOIH320                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.bilobaAF478889                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.bilobaOIH326                   AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.bilobaOIH327                   AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.biruOIH87                      AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.biruOIH254                     AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.calcicolaOIH81                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.durga1OIH84                    AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.durgaOIH235                    AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.graveolensOIH116               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.hastaOIH80                     AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.aff.klossiiOIH168              AGAAATTCCA TTTTTGCTGC AGTTAATATC TTTCCTTGAA GAAAAAGAAA
S.kunstleriAF478890              AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTCGAA GAAAAAGAAA
S.kunstleriOIH161                AGAAACTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.kunstleriOIH162                AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.kunstleriOIH163                AGAAACTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.lanjakensisOIH309              AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCTCTTGAA GAAAAAGAAA
S.limianaOIH122                  AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.lucensOIH125                   AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.malaccanaOIH159                AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.multifoliaOIH111               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.nigraOIH76                     AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.cf.nigraOIH227                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.penyamarOIH137                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCTCTTGAA GAAAAAGAAA
S.petiolataOIH71                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.picturataZI656                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.pseudoreticosaOIH83            AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.polyphyllaOIH119               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.polyphyllaOIH289               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
S.reticosaOIH79                  AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.reticosaZI139                  AGAAATTCCA TTTTTGCAGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.scintillansOIH141              AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCTCTTGAA GAAAAAGAAA
S.stenophyllaOIH74               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.stenophyllaOIH88               AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.cf.stenophyllaOIH93            AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTAAA GAAAAAGAAA
S.uniflouraOIH82                 AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCTCTTGAA GAAAAAGAAA
B.pulcherrimaJX992809            AGAAATTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
DisticochlamysspAF478844         AGAAATTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
HaniffiacyanescensJF825538       AGAAATTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
H.uniflorumOIH113                AGAAATTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
K.rotundaAF478868                AGAAACTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
M.mullerensisAB269791            AGAAATTCCA TTTTTGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
T.flagellarisAF478898            AGAAATTCCA TTTTCGCTGC AGTTAATTTA TTCCCTTGAA GAAAAAGAAA
Z.officinaleAB047756             AGAAATTCCA TTTTCGCTGC AGTTAATATC TTCCCTTGAA GAAAAAGAAA
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     1305       1315       1325       1335       1345
S.argenteaOIH320                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.bilobaAF478889                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.bilobaOIH326                    TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.bilobaOIH327                    TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.biruOIH87                       TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.biruOIH254                      TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.calcicolaOIH81                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.durga1OIH84                     TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.durgaOIH235                     TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.graveolensOIH116                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.hastaOIH80                      TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.aff.klossiiOIH168               TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.kunstleriAF478890               TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.kunstleriOIH161                 TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.kunstleriOIH162                 TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.kunstleriOIH163                 TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.lanjakensisOIH309               TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.limianaOIH122                   TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.lucensOIH125                    TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.malaccanaOIH159                 TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.multifoliaOIH111                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.nigraOIH76                      TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.cf.nigraOIH227                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.penyamarOIH137                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.petiolataOIH71                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.picturataZI656                  TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.pseudoreticosaOIH83             TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.polyphyllaOIH119                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.polyphyllaOIH289                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.reticosaOIH79                   TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.reticosaZI139                   TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.scintillansOIH141               TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.stenophyllaOIH74                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.stenophyllaOIH88                TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.cf.stenophyllaOIH93             TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
S.uniflaraOIH82                   TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
B.pulcherrimaJX992809             TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
DisticochlamysspAF478844          TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
HaniffiacyanescensJF825538        TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
H.uniflorumOIH113                 TACCAAAATC TTACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
K.rotundaAF478868                 TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
M.mullerensisAB269791             TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
T.flagellarisAF478898             TACCAAAATC TAACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
Z.officinaleAB047756              TACCAAAATC TCACAATTTA CAATCTAGTC ATTCAATATT TCCTTTTTTA
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1355       1365       1375       1385       1395
S.argenteaOIH320                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.bilobaAF478889                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.bilobaOIH326                  GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.bilobaOIH327                  GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.biruOIH87                     GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.biruOIH254                    GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.calcicolaOIH81                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.durga1OIH84                   GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.durgaOIH235                   GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.graveolensOIH116              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.hastaOIH80                    GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.aff.klossiiOIH168             GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.kunstleriAF478890             GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.kunstleriOIH161               GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.kunstleriOIH162               GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.kunstleriOIH163               GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.lanjakensisOIH309             GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.limianaOIH122                 GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.lucensOIH125                  GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.malaccanaOIH159               GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.multifoliaOIH111              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.nigraOIH76                    GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.cf.nigraOIH227                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.penyamarOIH137                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.petiolataOIH71                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.picturataZI656                GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.pseudoreticosaOIH83           GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.polyphyllaOIH119              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.polyphyllaOIH289              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.reticosaOIH79                 GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.reticosaZI139                 GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.scintillansOIH141             GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.stenophyllaOIH74              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.stenophyllaOIH88              GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.cf.stenophyllaOIH93           GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
S.unifloraOIH82                 GAGGATAAAT TATTGCATTT AAATTATCTG TGCGATATAC TAATACCCTA
B.pulcherrimaJX992809           GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
DisticochlamysspAF478844        GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
HaniffiacyanescensJF825538      GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
H.uniflorumOIH113               GAGAATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
K.rotundaAF478868               GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
M.mullerensisAB269791           GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
T.flagellarisAF478898           GAGGATAAAT TATTGCATTT AAATTATCTG TCCAATATAC TAATACCCTA
Z.officinaleAB047756            GAGGATAAAT TATTGCATTT AAATTATCTG TCCGATATAC TAATACCCTA
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    1405       1415       1425       1435       1445
S.argenteaOIH320                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.bilobaAF478889                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.bilobaOIH326                   TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.bilobaOIH327                   TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.biruOIH87                      TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.biruOIH254                     TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.calcicolaOIH81                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.durga1OIH84                    TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.durgaOIH235                    TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.graveolensOIH116               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.hastaOIH80                     TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.aff.klossiiOIH168              TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.kunstleriAF478890              TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.kunstleriOIH161                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.kunstleriOIH162                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.kunstleriOIH163                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.lanjakensisOIH309              TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.limianaOIH122                  TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.lucensOIH125                   TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.malaccanaOIH159                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.multifoliaOIH111               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.nigraOIH76                     TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.cf.nigraOIH227                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.penyamarOIH137                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.petiolataOIH71                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.picturataZI656                 TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.pseudoreticosaOIH83            TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.polyphyllaOIH119               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.polyphyllaOIH289               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.reticosaOIH79                  TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.reticosaZI139                  TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.scintillansOIH141              TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.stenophyllaOIH74               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.stenophyllaOIH88               TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.cf.stenophyllaOIH93            TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
S.uniflaraOIH82                  TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
B.pulcherrimaJX992809            TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
DisticochlamysspAF478844         TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
HaniffiacyanescensJF825538       TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
H.uniflorumOIH113                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
K.rotundaAF478868                TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
M.mullerensisAB269791            TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
T.flagellarisAF478898            TCCCGTCCAT ATGGAAATCT TGGTCCAAAT GCTTCAATCC TGGATCCAGG
Z.officinaleAB047756             TCCCGTCCAT ATGGAAATCT TGGTCCAAAT ACTTCAATCC TGGATCCAGG
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     1455       1465       1475       1485       1495
S.argenteaOIH320                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.bilobaAF478889                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.bilobaOIH326                    ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.bilobaOIH327                    ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.biruOIH87                       ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.biruOIH254                      ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.calcicolaOIH81                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTTCACGA ATATTATAAT
S.durga1OIH84                     ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.durgaOIH235                     ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.graveolensOIH116                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.hastaOIH80                      ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.aff.klossiiOIH168               ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.kunstleriAF478890               ACGTTTTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.kunstleriOIH161                 ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.kunstleriOIH162                 ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.kunstleriOIH163                 ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.lanjakensisOIH309               ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.limianaOIH122                   ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.lucensOIH125                    ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTTCACGA ATATTATAAT
S.malaccanaOIH159                 ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.multifoliaOIH111                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.nigraOIH76                      ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.cf.nigraOIH227                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.penyamarOIH137                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.petiolataOIH71                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.picturataZI656                  ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.pseudoreticosaOIH83             ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.polyphyllaOIH119                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.polyphyllaOIH289                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
S.reticosaOIH79                   ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.reticosaZI139                   ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.scintillansOIH141               ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.stenophyllaOIH74                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.stenophyllaOIH88                ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.cf.stenophyllaOIH93             ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
S.unifloraOIH82                   ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
B.pulcherrimaJX992809             ATGTTCTCTT TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
DisticochlamysspAF478844          ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
HaniffiacyanescensJF825538        ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
H.uniflorumOIH113                 ATATTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
K.rotundaAF478868                 ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCTACGA ATATTATAAT
M.mullerensisAB269791             ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
T.flagellarisAF478898             ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTTTCCACGA ATATTATAAT
Z.officinaleAB047756              ATGTTCTCTC TTTACATTTA TTGCAGTTCC TTCTCCACGA ATATTATAAT
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Appendix 2 continued

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                                ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                   1505       1515       1525       1535       1545
S.argenteaOIH320                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.bilobaAF478889                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.bilobaOIH326                  TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.bilobaOIH327                  TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.biruOIH87                     TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.biruOIH254                    TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.calcicolaOIH81                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.durga1OIH84                   TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.durgaOIH235                   TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.graveolensOIH116              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.hastaOIH80                    TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.aff.klossiiOIH168             TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.kunstleriAF478890             TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.kunstleriOIH161               TGGAATAGTC TCATTATTCC GAAAAAATAT ATTTACGTAC TTTCAAAAGA
S.kunstleriOIH162               TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.kunstleriOIH163               TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAC TTTCAAAAGA
S.lanjakensisOIH309             TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.limianaOIH122                 TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.lucensOIH125                  TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.malaccanaOIH159               TGGAATAGTC TCATTATTCC GAAAAAATAT ATTTACGTAT TTTCAAAAGA
S.multifoliaOIH111              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.nigraOIH76                    TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.cf.nigraOIH227                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.penyamarOIH137                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.petiolataOIH71                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.picturataZI656                TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.pseudoreticosaOIH83           TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.polyphyllaOIH119              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.polyphyllaOIH289              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.reticosaOIH79                 TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.reticosaZI139                 TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.scintillansOIH141             TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.stenophyllaOIH74              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.stenophyllaOIH88              TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.cf.stenophyllaOIH93           TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
S.unifloraOIH82                 TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
B.pulcherrimaJX992809           TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
DisticochlamysspAF478844        TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
HaniffiacyanescensJF825538      TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
H.uniflorumOIH113               TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
K.rotundaAF478868               TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
M.mullerensisAB269791           TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
T.flagellarisAF478898           TGGAATAGTC TCATTATTCC GAAAAAAGAT ATTTATATAT TTTCAAAAGA
Z.officinaleAB047756            TGGAATAGTC TCATTATTCC GAAAAAATCT ATTTACGTAT TTTCAAAAGA
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             1555       1565       1575       1585       1595
S.argenteaOIH320          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.bilobaAF478889          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.bilobaOIH326            AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.bilobaOIH327            AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.biruOIH87               AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.biruOIH254              AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.calcicolaOIH81          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.durga1OIH84             AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.durgaOIH235             AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.graveolensOIH116        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.hastaOIH80              AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.aff.klossiiOIH168       AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.kunstleriAF478890       AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.kunstleriOIH161         AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.kunstleriOIH162         AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.kunstleriOIH163         AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.lanjakensisOIH309       AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.limianaOIH122           AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.lucensOIH125            AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.malaccanaOIH159         AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.multifoliaOIH111        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.nigraOIH76              AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.cf.nigraOIH227          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.penyamarOIH137          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.petiolataOIH71          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.picturataZI656          AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.pseudoreticosaOIH83     AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.polyphyllaOIH119        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.polyphyllaOIH289        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
S.reticosaOIH79           AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.reticosaZI139           AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.scintillansOIH141       AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.stenophyllaOIH74        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.stenophyllaOIH88        AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.cf.stenophyllaOIH93     AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
S.uniflaraOIH82           AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
B.pulcherrimaJX992809     AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
DisticochlamysspAF478844  AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
HaniffiacyanescensJF825538 AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
H.uniflorumOIH113         AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
K.rotundaAF478868         AAATAAAAGA TTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
M.mullerensisAB269791     AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATATG
T.flagellarisAF478898     AAATAAAAGA CTATTTTGGT TCTTATATAA TATATATATA TATGAATACG
Z.officinaleAB047756      AAATAAAAGA CTATTTTGGT TCTTATATAA TTTATATATA TATGAATACG
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1605       1615       1625       1635       1645
S.argenteaOIH320                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.bilobaAF478889                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.bilobaOIH326                  AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.bilobaOIH327                  AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.biruOIH87                     AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.biruOIH254                    AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.calcicolaOIH81                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.durga1OIH84                   AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.durgaOIH235                   AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.graveolensOIH116              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.hastaOIH80                    AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.aff.klossiiOIH168             AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.kunstleriAF478890             AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.kunstleriOIH161               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.kunstleriOIH162               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.kunstleriOIH163               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.lanjakensisOIH309             AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.limianaOIH122                 AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.lucensOIH125                  AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.malaccanaOIH159               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.multifoliaOIH111              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.nigraOIH76                    AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.cf.nigraOIH227                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.penyamarOIH137                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.petiolataOIH71                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.picturataZI656                AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.pseudoreticosaOIH83           AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.polyphyllaOIH119              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.polyphyllaOIH289              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.reticosaOIH79                 AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.reticosaZI139                 AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.scintillansOIH141             AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.stenophyllaOIH74              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.stenophyllaOIH88              AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.cf.stenophyllaOIH93           AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
S.uniflaraOIH82                 AATTTCTATT AATGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
B.pulcherrimaJX992809           AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
DisticochlamysspAF478844        AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
HaniffiacyanescensJF825538      AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
H.uniflorumOIH113               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
K.rotundaAF478868               AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
M.mullerensisAB269791           AATTTCTATT AGTGTTTTCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
T.flagellarisAF478898           AATTTCTATT AGTGTTTCCT CGTAAACAAT CCTCTTTTTT ACGATTAATA
Z.officinaleAB047756            AATTTCTATT AGTGTTTCCT TGTAAACAAT CCTCTTTTTT ACGATTAATA
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    1655       1665       1675       1685       1695
S.argenteaOIH320                 TCTTCTGGAG TCCTTCTTGA GCGAATATAT TTTTATATAA AAATAGAACA
S.bilobaAF478889                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.bilobaOIH326                   TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.bilobaOIH327                   TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.biruOIH87                      TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.biruOIH254                     TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.calcicolaOIH81                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.durga1OIH84                    TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.durgaOIH235                    TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.graveolensOIH116               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.hastaOIH80                     TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.aff.klossiiOIH168              TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.kunstleriAF478890              TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.kunstleriOIH161                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.kunstleriOIH162                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATCGAACA
S.kunstleriOIH163                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.lanjakensisOIH309              TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.limianaOIH122                  TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.lucensOIH125                   TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.malaccanaOIH159                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.multifoliaOIH111               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.nigraOIH76                     TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.cf.nigraOIH227                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.penyamarOIH137                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.petiolataOIH71                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.picturataZI656                 TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.pseudoreticosaOIH83            TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.polyphyllaOIH119               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.polyphyllaOIH289               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
S.reticosaOIH79                  TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.reticosaZI139                  TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.scintillansOIH141              TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.stenophyllaOIH74               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.stenophyllaOIH88               TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.cf.stenophyllaOIH93            TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATATAA AAATAGAACA
S.uniflora0IH82                  TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
B.pulcherrimaJX992809            TCTTCTGGAG TCCTTTTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
DisticochlamysspAF478844         TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
HaniffiacyanescensJF825538       TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
H.uniflorumOIH113                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
K.rotundaAF478868                TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
M.mullerensisAB269791            TCTTCTGGAG TCCTTATTGA GCGAATACAT TTTTATATAA AAATAGAACA
T.flagellarisAF478898            TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
Z.officinaleAB047756             TCTTCTGGAG TCCTTCTTGA GCGAATACAT TTTTATGTAA AAATAGAACA
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             1705       1715       1725       1735       1745
S.argenteaOIH320          TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.bilobaAF478889          TCTTGGAGTG TGCCGAATTT TTTTTCAGAA GACTCTATGG ATTTTTAAGG
S.bilobaOIH326            TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.bilobaOIH327            TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTTAAGG
S.biruOIH87               TCTTAGAGTG TGCCAAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.biruOIH254              TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.calcicolaOIH81          TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.durga1OIH84             TCTTAGAGTG TGCCAAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.durgaOIH235             TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.graveolensOIH116        TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.hastaOIH80              TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.aff.klossiiOIH168       TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.kunstleriAF478890       TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.kunstleriOIH161         TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.kunstleriOIH162         TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.kunstleriOIH163         TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.lanjakensisOIH309       TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.limianaOIH122           TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.lucensOIH125            TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.malaccanaOIH159         TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.multifoliaOIH111        TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.nigraOIH76              TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.cf.nigraOIH227          TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.penyamarOIH137          TCTTGGAGTA TGCCGAATTT TTTGTCAAAA GACTCTATGG ATTTTGAAGG
S.petiolataOIH71          TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.picturataZI656          TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.pseudoreticosaOIH83     TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.polyphyllaOIH119        TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.polyphyllaOIH289        TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
S.reticosaOIH79           TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.reticosaZI139           TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.scintillansOIH141       TCTTGGAGTA TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.stenophyllaOIH74        TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.stenophyllaOIH88        TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.cf.stenophyllaOIH93     TCTTAGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTGAAGG
S.uniflaraOIH82           TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCCATGG ATTTTGAAGG
B.pulcherrimaJX992809     TCTTGGGGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
DisticochlamysspAF478844  TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
HaniffiacyanescensJF825538 TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
H.uniflorumOIH113         TCTTGGAGTG TGTCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
K.rotundaAF478868         TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
M.mullerensisAB269791     TCTTGGAGTG TGCCGAATTT TTTGTCAGAA GACTTTATGG ATTTTGAAGG
T.flagellarisAF478898     TCTTGGAGTG TGTCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
Z.officinaleAB047756      TCTTGGAGTG TACCGAATTT TTTGTCAGAA GACTCTATGG ATTTTCAAGG
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1755       1765       1775       1785       1795
S.argenteaOIH320                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.bilobaAF478889                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.bilobaOIH326                  ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.bilobaOIH327                  ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.biruOIH87                     ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.biruOIH254                    ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.calcicolaOIH81                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.durga1OIH84                   ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.durgaOIH235                   ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.graveolensOIH116              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.hastaOIH80                    ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.aff.klossiiOIH168             ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.kunstleriAF478890             ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.kunstleriOIH161               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.kunstleriOIH162               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.kunstleriOIH163               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.lanjakensisOIH309             ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.limianaOIH122                 ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.lucensOIH125                  ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.malaccanaOIH159               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.multifoliaOIH111              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.nigraOIH76                    ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.cf.nigraOIH227                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.penyamarOIH137                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.petiolataOIH71                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.picturataZI656                ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.pseudoreticosaOIH83           ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.polyphyllaOIH119              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.polyphyllaOIH289              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.reticosaOIH79                 ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.reticosaZI139                 ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.scintillansOIH141             ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.stenophyllaOIH74              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.stenophyllaOIH88              ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.cf.stenophyllaOIH93           ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
S.uniflaraOIH82                 ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
B.pulcherrimaJX992809           ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
DisticochlamysspAF478844        ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
HaniffiacyanescensJF825538      ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
H.uniflorumOIH113               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
K.rotundaAF478868               ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
M.mullerensisAB269791           ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
T.flagellarisAF478898           ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCG
Z.officinaleAB047756            ATCCTTTCAT ACATTATATT CGATATCAAG GAAAATCGAT TCTGGGTTCA
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1805       1815       1825       1835       1845
S.argenteaOIH320                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.bilobaAF478889                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.bilobaOIH326                  AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.bilobaOIH327                  AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.biruOIH87                     AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.biruOIH254                    AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.calcicolaOIH81                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.durga1OIH84                   AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.durgaOIH235                   AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.graveolensOIH116              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.hastaOIH80                    AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.aff.klossiiOIH168             AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.kunstleriAF478890             AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.kunstleriOIH161               AAAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.kunstleriOIH162               AAAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.kunstleriOIH163               AAAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.lanjakensisOIH309             AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.limianaOIH122                 AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.lucensOIH125                  AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.malaccanaOIH159               AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.multifoliaOIH111              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.nigraOIH76                    AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.cf.nigraOIH227                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.penyamarOIH137                AGAGGGACTC ATTTTTTGAT GAAAAAATGG AAATACCACC TTGTTAATTT
S.petiolataOIH71                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.picturataZI656                AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.pseudoreticosaOIH83           AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.polyphyllaOIH119              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.polyphyllaOIH289              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.reticosaOIH79                 AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.reticosaZI139                 AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.scintillansOIH141             AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.stenophyllaOIH74              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.stenophyllaOIH88              AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.cf.stenophyllaOIH93           AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
S.uniflora0IH82                 AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
B.pulcherrimaJX992809           AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACTACC TTGTTAATTT
DisticochlamysspAF478844        AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
HaniffiacyanescensJF825538      AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
H.uniflorumOIH113               AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
K.rotundaAF478868               AGAGGGACTA ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
M.mullerensisAB269791           AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
T.flagellarisAF478898           AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
Z.officinaleAB047756            AGAGGGACTC ATTTTTTGAT GAAGAAATGG AAATACCACC TTGTTAATTT
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Appendix 2 continued

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                                 ....|....| ....|....| ....|....| ....|....| ....|....|
                                    1855       1865       1875       1885       1895
S.argenteaOIH320                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ATCATATAGG ATTGATATAA
S.bilobaAF478889                 TTGGCAATAT TATTTTAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.bilobaOIH326                   TTGGCAATAT TATTTTAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.bilobaOIH327                   TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.biruOIH87                      TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.biruOIH254                     TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.calcicolaOIH81                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.durga1OIH84                    TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.durgaOIH235                    TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.graveolensOIH116               TTGGCAATAT TATTTTCATT TTTGGTCTCA AGCATATAGG ATTGATATAA
S.hastaOIH80                     TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.aff.klossiiOIH168              TTGGCAATAT TATTTTAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.kunstleriAF478890              TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.kunstleriOIH161                TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.kunstleriOIH162                TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.kunstleriOIH163                TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.lanjakensisOIH309              TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.limianaOIH122                  TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.lucensOIH125                   TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.malaccanaOIH159                TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.multifoliaOIH111               TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.nigraOIH76                     TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.cf.nigraOIH227                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.penyamarOIH137                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.petiolataOIH71                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.picturataZI656                 TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.pseudoreticosaOIH83            TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.polyphyllaOIH119               TTGGCAATAT TATTTTAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.polyphyllaOIH289               TTGGCAATAT TATTTTAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.reticosaOIH79                  TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.reticosaZI139                  TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.scintillansOIH141              TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.stenophyllaOIH74               TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.stenophyllaOIH88               TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.cf.stenophyllaOIH93            TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
S.unifloraOIH82                  TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
B.pulcherrimaJX992809            TTGGCAATAT TATTTTCATT TTTGGTCTCG ACCATATAGG ATTGATATAA
DisticochlamysspAF478844         TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
HaniffiacyanescensJF825538       TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
H.uniflorumOIH113                TTGGCAATAT TATTTTCATT TTTGGTCTAG ACCATATAGG ATTGATATAA
K.rotundaAF478868                TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
M.mullerensisAB269791            TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
T.flagellarisAF478898            TTGGCAATAT TATTTGAATT TTTGGTCTCA ACCATATAGG ATTGATATAA
Z.officinaleAB047756             TTGGCAATAT TATTTTCATT TTTGGTCTCA ACCATATAGG ATTGATATAA
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   1905       1915       1925       1935       1945
S.argenteaOIH320                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.bilobaAF478889                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.bilobaOIH326                  AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.bilobaOIH327                  AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.biruOIH87                     AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.biruOIH254                    AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.calcicolaOIH81                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.durga1OIH84                   AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.durgaOIH235                   AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.graveolensOIH116              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.hastaOIH80                    AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.aff.klossiiOIH168             AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.kunstleriAF478890             AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.kunstleriOIH161               AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.kunstleriOIH162               AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.kunstleriOIH163               AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.lanjakensisOIH309             AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.limianaOIH122                 AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.lucensOIH125                  AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.malaccanaOIH159               AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.multifoliaOIH111              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.nigraOIH76                    AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.cf.nigraOIH227                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.penyamarOIH137                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.petiolataOIH71                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.picturataZI656                AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.pseudoreticosaOIH83           AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.polyphyllaOIH119              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.polyphyllaOIH289              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.reticosaOIH79                 AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.reticosaZI139                 AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.scintillansOIH141             AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.stenophyllaOIH74              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.stenophyllaOIH88              AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.cf.stenophyllaOIH93           AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
S.unifloraOIH82                 AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
B.pulcherrimaJX992809           AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
DisticochlamysspAF478844        AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
HaniffiacyanescensJF825538      AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
H.uniflorumOIH113               AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
K.rotundaAF478868               AGAAATTATC AAACTATTCT TTTTTTTTTG CGGGATATTT TTCAAGTGAA
M.mullerensisAB269791           AGAAATTCTC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
T.flagellarisAF478898           AGAAATTATC AAACTATTAT TTTTTTTTTC TGGGTTATTT TTCAAGTGTA
Z.officinaleAB047756            AGAAATTATC AAACTATTCT TTTTATTTTC TGGGTTATTT TTCAAGTGTA
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Appendix 2 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     1955        1965        1975        1985        1995
S.argenteaOIH320                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.bilobaAF478889                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.bilobaOIH326                    CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.bilobaOIH327                    CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.biruOIH87                       CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.biruOIH254                      CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.calcicolaOIH81                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.durga1OIH84                     CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.durgaOIH235                     CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.graveolensOIH116                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.hastaOIH80                      CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.aff.klossiiOIH168               CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.kunstleriAF478890               CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.kunstleriOIH161                 CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.kunstleriOIH162                 CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.kunstleriOIH163                 CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.lanjakensisOIH309               CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.limianaOIH122                   CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.lucensOIH125                    CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.malaccanaOIH159                 CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.multifoliaOIH111                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.nigraOIH76                      CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.cf.nigraOIH227                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.penyamarOIH137                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.petiolataOIH71                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.picturataZI656                  CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.pseudoreticosaOIH83             CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.polyphyllaOIH119                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.polyphyllaOIH289                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.reticosaOIH79                   CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.reticosaZI139                   CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.scintillansOIH141               CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.stenophyllaOIH74                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.stenophyllaOIH88                CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.cf.stenophyllaOIH93             CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
S.uniflaraOIH82                   CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
B.pulcherrimaJX992809             CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
DisticochlamysspAF478844          CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
HaniffiacyanescensJF825538        CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
H.uniflorumOIH113                 CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
K.rotundaAF478868                 CAAAATAATT CTTTGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
M.mullerensisAB269791             CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
T.flagellarisAF478898             CAAATTAATT CTTTGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
Z.officinaleAB047756              CAAATTAATT CTTCGATGGT AAGGAATCAA ATGCTAGAGA ATTCATTTCT
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                      2005       2015       2025       2035       2045
S.argenteaOIH320                  AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.bilobaAF478889                  AATGGATACT CTTGCTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.bilobaOIH326                    AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.bilobaOIH327                    AATGGATACT CTTGCTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.biruOIH87                       AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.biruOIH254                      AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.calcicolaOIH81                  AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.durga1OIH84                     AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.durgaOIH235                     AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.graveolensOIH116                AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.hastaOIH80                      AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.aff.klossiiOIH168               AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.kunstleriAF478890               AATGGATACT TTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.kunstleriOIH161                 AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.kunstleriOIH162                 AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.kunstleriOIH163                 AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.lanjakensisOIH309               AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.limianaOIH122                   AATGGATACT CTTGCTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.lucensOIH125                    AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.malaccanaOIH159                 AATGGATACT CTTGCTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.multifoliaOIH111                AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.nigraOIH76                      AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.cf.nigraOIH227                  AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.penyamarOIH137                  AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.petiolataOIH71                  AATGGATACT CTTACTAATA AATTTTATAC TATAATCCCA ATTATTCCTC
S.picturataZI656                  AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.pseudoreticosaOIH83             AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.polyphyllaOIH119                AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.polyphyllaOIH289                AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
S.reticosaOIH79                   AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.reticosaZI139                   AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.scintillansOIH141               AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.stenophyllaOIH74                AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.stenophyllaOIH88                AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.cf.stenophyllaOIH93             AATGGATACT CTTACTAATA AATTTGATAC TATAATCCCA ATTATTCCTC
S.uniflaraOIH82                   AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
B.pulcherrimaJX992809             AATGGATACT CTTACTAAGA AATTTTATAC TATAATCCCA ATTATTCCTC
DisticochlamysspAF478844          AATGGATACT TTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
HaniffiacyanescensJF825538        AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
H.uniflorumOIH113                 AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
K.rotundaAF478868                 AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
M.mullerensisAB269791             AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCA ATTATTCCTC
T.flagellarisAF478898             AATGGATACT CTTACTAAGA AATTTGATAC CATAATCCCA ATAATTCCTC
Z.officinaleAB047756              AATGGATACT CTTACTAAGA AATTTGATAC TATAATCCCG ATTATTCCTC
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   2055       2065       2075       2085       2095
S.argenteaOIH320                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.bilobaAF478889                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.bilobaOIH326                  TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.bilobaOIH327                  TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.biruOIH87                     TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.biruOIH254                    TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.calcicolaOIH81                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.durga1OIH84                   TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.durgaOIH235                   TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.graveolensOIH116              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.hastaOIH80                    TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.aff.klossiiOIH168             TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.kunstleriAF478890             TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.kunstleriOIH161               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.kunstleriOIH162               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.kunstleriOIH163               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.lanjakensisOIH309             TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.limianaOIH122                 TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.lucensOIH125                  TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.malaccanaOIH159               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.multifoliaOIH111              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.nigraOIH76                    TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.cf.nigraOIH227                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.penyamarOIH137                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGATATCCT
S.petiolataOIH71                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.picturataZI656                TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.pseudoreticosaOIH83           TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.polyphyllaOIH119              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.polyphyllaOIH289              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.reticosaOIH79                 TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.reticosaZI139                 TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.scintillansOIH141             TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.stenophyllaOIH74              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.stenophyllaOIH88              TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.cf.stenophyllaOIH93           TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
S.uniflaraOIH82                 TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
B.pulcherrimaJX992809           TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
DisticochlamysspAF478844        TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
HaniffiacyanescensJF825538      TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
H.uniflorumOIH113               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
K.rotundaAF478868               TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
M.mullerensisAB269791           TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
T.flagellarisAF478898           TTATTCGATC ATTGTCTAAA GCTCAATTTT GTACCGTATC TGGATATCCT
Z.officinaleAB047756            TTATTCGATC ATTGTTTAAA GCTCAATTTT GTACCGTATC TGGGTATCCT
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     2105       2115       2125       2135       2145
S.argenteaOIH320                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.bilobaAF478889                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.bilobaOIH326                    ATTAGTAAAT CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.bilobaOIH327                    ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.biruOIH87                       ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.biruOIH254                      ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.calcicolaOIH81                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.durga1OIH84                     ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.durgaOIH235                     ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.graveolensOIH116                ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.hastaOIH80                      ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.aff.klossiiOIH168               ATTAGTAAAC CAATTTGGAC CGATTTAACG GATTGTGATA TTATTAATAG
S.kunstleriAF478890               ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.kunstleriOIH161                 ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.kunstleriOIH162                 ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.kunstleriOIH163                 ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.lanjakensisOIH309               ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.limianaOIH122                   ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.lucensOIH125                    ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.malaccanaOIH159                 ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.multifoliaOIH111                ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.nigraOIH76                      ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.cf.nigraOIH227                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.penyamarOIH137                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.petiolataOIH71                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TCATTAATAG
S.picturataZI656                  ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.pseudoreticosaOIH83             ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.polyphyllaOIH119                ATTAGTAAAC CAATTTGGAC CGATTTAACG GATTGTGATA TTATTAATAG
S.polyphyllaOIH289                ATTAGTAAAC CAATTTGGAC CGATTTAACG GATTGTGATA TTATTAATAG
S.reticosaOIH79                   ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.reticosaZI139                   ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.scintillansOIH141               ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.stenophyllaOIH74                ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.stenophyllaOIH88                ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.cf.stenophyllaOIH93             ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
S.unifloraOIH82                   ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
B.pulcherrimaJX992809             ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
DisticochlamysspAF478844          ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
HaniffiacyanescensJF825538        ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
H.uniflorumOIH113                 ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
K.rotundaAF478868                 ATTAGTAAAC CAATTTGGAC CAATTTAGCG GATTGTGATA TTATTAATAG
M.mullerensisAB269791             ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
T.flagellarisAF478898             ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
Z.officinaleAB047756              ATTAGTAAAC CAATTTGGAC CGATTTAGCG GATTGTGATA TTATTAATAG
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     2155       2165       2175       2185       2195
S.argenteaOIH320                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.bilobaAF478889                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.bilobaOIH326                    ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.bilobaOIH327                    ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.biruOIH87                       ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.biruOIH254                      ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.calcicolaOIH81                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.durga1OIH84                     ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.durgaOIH235                     ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.graveolensOIH116                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.hastaOIH80                      ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.aff.klossiiOIH168               ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.kunstleriAF478890               ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.kunstleriOIH161                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.kunstleriOIH162                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.kunstleriOIH163                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.lanjakensisOIH309               ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.limianaOIH122                   ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.lucensOIH125                    ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.malaccanaOIH159                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.multifoliaOIH111                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.nigraOIH76                      ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.cf.nigraOIH227                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.penyamarOIH137                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.petiolataOIH71                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.picturataZI656                  ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.pseudoreticosaOIH83             ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.polyphyllaOIH119                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.polyphyllaOIH289                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.reticosaOIH79                   ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.reticosaZI139                   ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.scintillansOIH141               ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.stenophyllaOIH74                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.stenophyllaOIH88                ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.cf.stenophyllaOIH93             ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
S.uniflaraOIH82                   ATTTGGTCGA ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
B.pulcherrimaJX992809             ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
DisticochlamysspAF478844          ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
HaniffiacyanescensJF825538        ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
H.uniflorumOIH113                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
K.rotundaAF478868                 ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
M.mullerensisAB269791             ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
T.flagellarisAF478898             ATTTGGTCGG ATATGTAGAA AGCTTTCTCA CTATCACAGT GGATCCTCAA
Z.officinaleAB047756              ATTTGGTCGG ATATGTAGAA AGCTTACTCA CTATCACAGT GGATCCTCAA
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Appendix 2 continued

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                                ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                   2205        2215        2225        2235        2245
S.argenteaOIH320                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.bilobaAF478889                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.bilobaOIH326                  AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.bilobaOIH327                  AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.biruOIH87                     AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.biruOIH254                    AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.calcicolaOIH81                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.durga1OIH84                   AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.durgaOIH235                   AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.graveolensOIH116              AAAAACAGAA TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.hastaOIH80                    AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.aff.klossiiOIH168             AAAAACAGAG TTTGTATCGA ATAAAGTATA TACTTCGACT TTCATGTGCC
S.kunstleriAF478890             AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.kunstleriOIH161               AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTAGACT TTCATGTGCC
S.kunstleriOIH162               AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTAGACT TTCATGTGCC
S.kunstleriOIH163               AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTAGACT TTCATGTGCC
S.lanjakensisOIH309             AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.limianaOIH122                 AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.lucensOIH125                  AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.malaccanaOIH159               AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.multifoliaOIH111              AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.nigraOIH76                    AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.cf.nigraOIH227                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.penyamarOIH137                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.petiolataOIH71                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.picturataZI656                AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.pseudoreticosaOIH83           AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.polyphyllaOIH119              AAAAACAGAG TTTGTATCGA ATAAAGTATA TACTTCGACT TTCATGTGCC
S.polyphyllaOIH289              AAAAACAGAG TTTGTATCGA ATAAAGTATA TACTTCGACT TTCATGTGCC
S.reticosaOIH79                 AAAAACAGAG TTTGTATCAA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.reticosaZI139                 AAAAACAGAG TTTGTATCAA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.scintillansOIH141             AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.stenophyllaOIH74              AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.stenophyllaOIH88              AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.cf.stenophyllaOIH93           AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
S.unifloraOIH82                 AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
B.pulcherrimaJX992809           AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCGTGTGTC
DisticochlamysspAF478844        AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
HaniffiacyanescensJF825538      AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
H.uniflorumOIH113               AAAAACAGAG TTTGTATCAA ATGAAGTATA TACTTCGACT TTCATGTGCC
K.rotundaAF478868               AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
M.mullerensisAB269791           AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
T.flagellarisAF478898           AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCG
Z.officinaleAB047756            AAAAACAGAG TTTGTATCGA ATGAAGTATA TACTTCGACT TTCATGTGCC
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Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             2255       2265       2275       2285       2295
S.argenteaOIH320          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.bilobaAF478889          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.bilobaOIH326            AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.bilobaOIH327            AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.biruOIH87               AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.biruOIH254              AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.calcicolaOIH81          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.durga1OIH84             AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.durgaOIH235             AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.graveolensOIH116        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.hastaOIH80              AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.aff.klossiiOIH168       AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.kunstleriAF478890       AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.kunstleriOIH161         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.kunstleriOIH162         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.kunstleriOIH163         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.lanjakensisOIH309       AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.limianaOIH122           AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.lucensOIH125            AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.malaccanaOIH159         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.multifoliaOIH111        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.nigraOIH76              AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.cf.nigraOIH227          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.penyamarOIH137          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.petiolataOIH71          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.picturataZI656          AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.pseudoreticosaOIH83     AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.polyphyllaOIH119        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.polyphyllaOIH289        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.reticosaOIH79           AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.reticosaZI139           AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.scintillansOIH141       AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.stenophyllaOIH74        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.stenophyllaOIH88        AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.cf.stenophyllaOIH93     AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
S.unifloraOIH82           AAAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
B.pulcherrimaJX992809     AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
DisticochlamysspAF478844  AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
HaniffiacyanescensJF825538 AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
H.uniflorumOIH113         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GTACGCAGTT TTTTGCAAAG
K.rotundaAF478868         AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
M.mullerensisAB269791     AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
T.flagellarisAF478898     AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
Z.officinaleAB047756      AGAACTTTGG CCCGTAAACA TAAAAGTTCA GCACGCAGTT TTTTGCAAAG
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     2305       2315       2325       2335       2345
S.argenteaOIH320                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.bilobaAF478889                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.bilobaOIH326                    ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.bilobaOIH327                    ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.biruOIH87                       ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.biruOIH254                      ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.calcicolaOIH81                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.durga1OIH84                     ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.durgaOIH235                     ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.graveolensOIH116                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.hastaOIH80                      ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.aff.klossiiOIH168               ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.kunstleriAF478890               ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.kunstleriOIH161                 ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.kunstleriOIH162                 ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.kunstleriOIH163                 ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.lanjakensisOIH309               ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.limianaOIH122                   ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.lucensOIH125                    ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.malaccanaOIH159                 ATTAAGTTCG GGATTATTAG AAGAATTTTT TACGGAAGAA GAACAAGTTA
S.multifoliaOIH111                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.nigraOIH76                      ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.cf.nigraOIH227                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.penyamarOIH137                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.petiolataOIH71                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.picturataZI656                  ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.pseudoreticosaOIH83             ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.polyphyllaOIH119                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.polyphyllaOIH289                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.reticosaOIH79                   ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.reticosaZI139                   ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.scintillansOIH141               ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
S.stenophyllaOIH74                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.stenophyllaOIH88                ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.cf.stenophyllaOIH93             ATTAAGTTCG GGATTATTAG AAGAATTCTT TACAGAAGAA GAACAAGTTA
S.unifloraOIH82                   ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
B.pulcherrimaJX992809             ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
DisticochlamysspAF478844          ATTAAGTTCG GTATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
HaniffiacyanescensJF825538        ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAAAA GAACAAGTTA
H.uniflorumOIH113                 ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
K.rotundaAF478868                 ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
M.mullerensisAB269791             ATTAAGTTCG GGATTATTAG AAGAATTTTT TACGGAAGAA GAACAAGTTA
T.flagellarisAF478898             ATTAAGTTCG GGATTATTAG AAGAATTCTT TATGGAAGAA GAACAAGTTA
Z.officinaleAB047756              ATTAAGTTCG GGATTATTAG AAGAATTCTT TACGGAAGAA GAACAAGTTA
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Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   2355       2365       2375       2385       2395
S.argenteaOIH320                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.bilobaAF478889                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.bilobaOIH326                  TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.bilobaOIH327                  TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.biruOIH87                     TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.biruOIH254                    TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.calcicolaOIH81                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.durga1OIH84                   TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.durgaOIH235                   TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.graveolensOIH116              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.hastaOIH80                    TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.aff.klossiiOIH168             TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.kunstleriAF478890             TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.kunstleriOIH161               TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.kunstleriOIH162               TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.kunstleriOIH163               TTTTTTTGAT CTTTCCAAAA ATAATTTATT TTTA------ ----------
S.lanjakensisOIH309             TTTTTTTGAT CTTTCCAAAA AGAATTTCTT TTTA------ ----------
S.limianaOIH122                 TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.lucensOIH125                  TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.malaccanaOIH159               TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.multifoliaOIH111              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.nigraOIH76                    TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.cf.nigraOIH227                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.penyamarOIH137                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.petiolataOIH71                TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.picturataZI656                TTTTTTTTAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.pseudoreticosaOIH83           TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.polyphyllaOIH119              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.polyphyllaOIH289              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.reticosaOIH79                 TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.reticosaZI139                 TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.scintillansOIH141             TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.stenophyllaOIH74              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.stenophyllaOIH88              TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.cf.stenophyllaOIH93           TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
S.uniflora0IH82                 TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
B.pulcherrimaJX992809           TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
DisticochlamysspAF478844        TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
HaniffiacyanescensJF825538      TTTTTTTTAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
H.uniflorumOIH113               TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
K.rotundaAF478868               TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
M.mullerensisAB269791           TTTTTTTGAT CTTTCCAAAA ATAATTTCTT TTTA------ ----------
T.flagellarisAF478898           TTTCTTTGAT CTTTCCAAAA ATAACTTCTT TTTATTTATA TGGATCATAT
Z.officinaleAB047756            TTTTTTTGAT CTTTCCTAAA ATAATTTCTT TTTA------ ----------
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                      2405       2415       2425       2435       2445
S.argenteaOIH320                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.bilobaAF478889                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.bilobaOIH326                    ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
S.bilobaOIH327                    ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.biruOIH87                       ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.biruOIH254                      ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.calcicolaOIH81                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.durga1OIH84                     ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.durgaOIH235                     ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.graveolensOIH116                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.hastaOIH80                      ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.aff.klossiiOIH168               ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
S.kunstleriAF478890               ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.kunstleriOIH161                 ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.kunstleriOIH162                 ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.kunstleriOIH163                 ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.lanjakensisOIH309               ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.limianaOIH122                   ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.lucensOIH125                    ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.malaccanaOIH159                 ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.multifoliaOIH111                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.nigraOIH76                      ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.cf.nigraOIH227                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.penyamarOIH137                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.petiolataOIH71                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.picturataZI656                  ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.pseudoreticosaOIH83             ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.polyphyllaOIH119                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
S.polyphyllaOIH289                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
S.reticosaOIH79                   ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.reticosaZI139                   ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.scintillansOIH141               ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCATTTGGA
S.stenophyllaOIH74                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.stenophyllaOIH88                ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.cf.stenophyllaOIH93             ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
S.unifloraOIH82                   ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
B.pulcherrimaJX992809             ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
DisticochlamysspAF478844          ---------- -TTTATGTGG ATCATATAGA GAACGTATTT GGTAT-----
HaniffiacyanescensJF825538        ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
H.uniflorumOIH113                 ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
K.rotundaAF478868                 ---------- -TTTATACGG ATCATATAGA GAACGTATTT GGTAT-----
M.mullerensisAB269791             ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGCAT-----
T.flagellarisAF478898             GGAGAACGTA TTTTATATGG ATCATATGGA GAACGTATTT GGTAT-----
Z.officinaleAB047756              ---------- -TTTATATGG ATCATATAGA GAACGTATTT GGTAT-----
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Appendix 2 continued

	2455	2465	2475	2485	2495
S.argenteaOIH320	----------	----------	----------	----------	----------
S.bilobaAF478889	----------	----------	----------	----------	----------
S.bilobaOIH326	----------	----------	----------	----------	----------
S.bilobaOIH327	----------	----------	----------	----------	----------
S.biruOIH87	----------	----------	----------	----------	----------
S.biruOIH254	----------	----------	----------	----------	----------
S.calcicolaOIH81	----------	----------	----------	----------	----------
S.durga1OIH84	----------	----------	----------	----------	----------
S.durgaOIH235	----------	----------	----------	----------	----------
S.graveolensOIH116	----------	----------	----------	----------	----------
S.hastaOIH80	----------	----------	----------	----------	----------
S.aff.klossiiOIH168	----------	----------	----------	----------	----------
S.kunstleriAF478890	----------	----------	----------	----------	----------
S.kunstleriOIH161	----------	----------	----------	----------	----------
S.kunstleriOIH162	----------	----------	----------	----------	----------
S.kunstleriOIH163	----------	----------	----------	----------	----------
S.lanjakensisOIH309	----------	----------	----------	----------	----------
S.limianaOIH122	----------	----------	----------	----------	----------
S.lucensOIH125	----------	----------	----------	----------	----------
S.malaccanaOIH159	----------	----------	----------	----------	----------
S.multifoliaOIH111	----------	----------	----------	----------	----------
S.nigraOIH76	----------	----------	----------	----------	----------
S.cf.nigraOIH227	----------	----------	----------	----------	----------
S.penyamarOIH137	----------	----------	----------	----------	----------
S.petiolataOIH71	----------	----------	----------	----------	----------
S.picturataZI656	----------	----------	----------	----------	----------
S.pseudoreticosaOIH83	----------	----------	----------	----------	----------
S.polyphyllaOIH119	----------	----------	----------	----------	----------
S.polyphyllaOIH289	----------	----------	----------	----------	----------
S.reticosaOIH79	----------	----------	----------	----------	----------
S.reticosaZI139	----------	----------	----------	----------	----------
S.scintillansOIH141	TATTATCCGT	ATCAATGACC	TGGTAATTGG	ATATTATCCG	TATCAATGAC
S.stenophyllaOIH74	----------	----------	----------	----------	----------
S.stenophyllaOIH88	----------	----------	----------	----------	----------
S.cf.stenophyllaOIH93	----------	----------	----------	----------	----------
S.unifloraOIH82	----------	----------	----------	----------	----------
B.pulcherrimaJX992809	----------	----------	----------	----------	----------
DisticochlamysspAF478844	----------	----------	----------	----------	----------
HaniffiacyanescensJF825538	----------	----------	----------	----------	----------
H.uniflorumOIH113	----------	----------	----------	----------	----------
K.rotundaAF478868	----------	----------	----------	----------	----------
M.mullerensisAB269791	----------	----------	----------	----------	----------
T.flagellarisAF478898	----------	----------	----------	----------	----------
Z.officinaleAB047756	----------	----------	----------	----------	----------

Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     2505       2515       2525       2535       2545
S.argenteaOIH320                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.bilobaAF478889                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.bilobaOIH326                    -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.bilobaOIH327                    -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.biruOIH87                       -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.biruOIH254                      -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.calcicolaOIH81                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.durga1OIH84                     -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.durgaOIH235                     -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.graveolensOIH116                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.hastaOIH80                      -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.aff.klossiiOIH168               -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.kunstleriAF478890               -------TTG GATATTATCC GTGTCAATGA CCTGGTAAAT TGTTTATTAG
S.kunstleriOIH161                 -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.kunstleriOIH162                 -------TTG GATATTATCC GTATCAATGA CCCGGTAAAT TGTTTATTAG
S.kunstleriOIH163                 -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.lanjakensisOIH309               -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.limianaOIH122                   -------TTA GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.lucensOIH125                    -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.malaccanaOIH159                 -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.multifoliaOIH111                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.nigraOIH76                      -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.cf.nigraOIH227                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.penyamarOIH137                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.petiolataOIH71                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.picturataZI656                  -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.pseudoreticosaOIH83             -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.polyphyllaOIH119                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.polyphyllaOIH289                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.reticosaOIH79                   -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.reticosaZI139                   -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.scintillansOIH141               CTGGTAATTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.stenophyllaOIH74                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.stenophyllaOIH88                -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.cf.stenophyllaOIH93             -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
S.uniflaraOIH82                   -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
B.pulcherrimaJX992809             -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
DisticochlamysspAF478844          -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
HaniffiacyanescensJF825538        -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
H.uniflorumOIH113                 -------TTG GATATTATCC GTATCAATGA CCCGGTAAAT TGTTTATTAG
K.rotundaAF478868                 -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
M.mullerensisAB269791             -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
T.flagellarisAF478898             -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT AGTGTATTAG
Z.officinaleAB047756              -------TTG GATATTATCC GTATCAATGA CCTGGTAAAT TGTTTATTAG
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Appendix 2 continued

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                                  ....|....| ....|....| ....|....| ....|....| ....|....|
                                     2555       2565       2575       2585       2595
S.argenteaOIH320                  TCACGACATA ATAC------ ---------- ---------- ----------
S.bilobaAF478889                  TCACGACAT- ---------- ---------- ---------- ----------
S.bilobaOIH326                    TCACGACATA ATAC------ ---------- ---------- ----------
S.bilobaOIH327                    TCACGACATA ATAC------ ---------- ---------- ----------
S.biruOIH87                       TCACGACATA ATAC------ ---------- ---------- ----------
S.biruOIH254                      TCACGACATA ATAC------ ---------- ---------- ----------
S.calcicolaOIH81                  TCACGACATA ATAC------ ---------- ---------- ----------
S.durga1OIH84                     TCACGACATA ATAC------ ---------- ---------- ----------
S.durgaOIH235                     TCACGACATA ATAC------ ---------- ---------- ----------
S.graveolensOIH116                TCACGACATA ATAC------ ---------- ---------- ----------
S.hastaOIH80                      TCACGACATA ATAC------ ---------- ---------- ----------
S.aff.klossiiOIH168               TCACGACATA ATAC------ ---------- ---------- ----------
S.kunstleriAF478890               TCACGACATA ATACAATACA ATATAAATAT AAGAATACAA TATAAATATA
S.kunstleriOIH161                 TCACGACATA ATAC------ ---------- ---------- ----------
S.kunstleriOIH162                 TCACGATATA ATAC------ ---------- ---------- ----------
S.kunstleriOIH163                 TCACGACATA ATAC------ ---------- ---------- ----------
S.lanjakensisOIH309               TCACGACATA ATAC------ ---------- ---------- ----------
S.limianaOIH122                   TCACGACATA ATAC------ ---------- ---------- ----------
S.lucensOIH125                    TCACGACATA ATAC------ ---------- ---------- ----------
S.malaccanaOIH159                 TCACGACATA ATACAATACA ATATAAATAT AAG------- ----------
S.multifoliaOIH111                TCACGACATA ATAC------ ---------- ---------- ----------
S.nigraOIH76                      TCACGACATA ATAC------ ---------- ---------- ----------
S.cf.nigraOIH227                  TCACGACATA ATAC------ ---------- ---------- ----------
S.penyamarOIH137                  TCACGACATA ATAC------ ---------- ---------- ----------
S.petiolataOIH71                  TCACGACATA ATAC------ ---------- ---------- ----------
S.picturataZI656                  TCACGACATA ATAC------ ---------- ---------- ----------
S.pseudoreticosaOIH83             TCACGACATA ATAC------ ---------- ---------- ----------
S.polyphyllaOIH119                TCACGACATA ATAC------ ---------- ---------- ----------
S.polyphyllaOIH289                TCACGACATA ATAC------ ---------- ---------- ----------
S.reticosaOIH79                   TCACGACATA ATAC------ ---------- ---------- ----------
S.reticosaZI139                   TCACGACATA ATAC------ ---------- ---------- ----------
S.scintillansOIH141               TCACGACATA ATAC------ ---------- ---------- ----------
S.stenophyllaOIH74                TCACGACATA ATAC------ ---------- ---------- ----------
S.stenophyllaOIH88                TCACGACATA ATAC------ ---------- ---------- ----------
S.cf.stenophyllaOIH93             TCACGACATA ATAC------ ---------- ---------- ----------
S.uniflaraOIH82                   TCACGACAT- ---------- ---------- ---------- ----------
B.pulcherrimaJX992809             TCACGACATA ATAC------ ---------- ---------- ----------
DisticochlamysspAF478844          TCACGACATA ATAC------ ---------- ---------- ----------
HaniffiacyanescensJF825538        TCACGACATA ATAC------ ---------- ---------- ----------
H.uniflorumOIH113                 TCACGACATA ATAC------ ---------- ---------- ----------
K.rotundaAF478868                 TCACGACATA ATAC------ ---------- ---------- ----------
M.mullerensisAB269791             TCACGACATA A????????? ?????????? ?????????? ??????????
T.flagellarisAF478898             TCCCGACAT- ---------- ---------- ---------- ----------
Z.officinaleAB047756              TCACGACATA ATAC------ ---------- ---------- ----------
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Appendix 2 continued

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                                  ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                     2605        2615        2625        2635        2645
S.argenteaOIH320                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.bilobaAF478889                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.bilobaOIH326                    --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.bilobaOIH327                    --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.biruOIH87                       --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.biruOIH254                      --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.calcicolaOIH81                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.durga1OIH84                     --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.durgaOIH235                     --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.graveolensOIH116                --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.hastaOIH80                      --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.aff.klossiiOIH168               --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.kunstleriAF478890               AGAATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.kunstleriOIH161                 --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.kunstleriOIH162                 --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.kunstleriOIH163                 --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.lanjakensisOIH309               --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.limianaOIH122                   --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.lucensOIH125                    --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.malaccanaOIH159                 ATAATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.multifoliaOIH111                --AATACAAT ATAAATATAA GATCCATACA AG-------- ---ATGTACA
S.nigraOIH76                      --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.cf.nigraOIH227                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.penyamarOIH137                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.petiolataOIH71                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.picturataZI656                  --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.pseudoreticosaOIH83             --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.polyphyllaOIH119                --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.polyphyllaOIH289                --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.reticosaOIH79                   --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.reticosaZI139                   --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.scintillansOIH141               --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.stenophyllaOIH74                --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.stenophyllaOIH88                --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.cf.stenophyllaOIH93             --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
S.unifloraOIH82                   --AATACAAT ATAAATATAA GATCCATATA AG-------- ---ATGTACA
B.pulcherrimaJX992809             --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
DisticochlamysspAF478844          --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
HaniffiacyanescensJF825538        --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
H.uniflorumOIH113                 --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
K.rotundaAF478868                 --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
M.mullerensisAB269791             ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898             --AATATAAT ATAAATAGAA AATCCATAGA AGATCTAATG GAAATGTAAA
Z.officinaleAB047756              --AATACAAT ATAAATATAA GATCCATAGA AG-------- ---ATGTACA
```

Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   2655       2665       2675       2685       2695
S.argenteaOIH320                AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.bilobaAF478889                AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGATAAAAAA
S.bilobaOIH326                  AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.bilobaOIH327                  AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGATAAAAAA
S.biruOIH87                     AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.biruOIH254                    AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.calcicolaOIH81                AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.durga1OIH84                   AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.durgaOIH235                   AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.graveolensOIH116              AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.hastaOIH80                    AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.aff.klossiiOIH168             AATGATCTAT ATTTATAA-- ---T------ --ATAGATCA AGAGAAAAAA
S.kunstleriAF478890             AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.kunstleriOIH161               AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.kunstleriOIH162               AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.kunstleriOIH163               AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.lanjakensisOIH309             AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.limianaOIH122                 AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGATAAAAAA
S.lucensOIH125                  AATGATCTAT ATTTATAC-- ---TATAGAT CAATAGATCA AGAGAAAAAA
S.malaccanaOIH159               AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.multifoliaOIH111              AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.nigraOIH76                    AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.cf.nigraOIH227                AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.penyamarOIH137                AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.petiolataOIH71                AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.picturataZI656                AATGATCTAT ATTTATAC-- ---T------ --ATAAATCA AGAGAAAAAA
S.pseudoreticosaOIH83           AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.polyphyllaOIH119              AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.polyphyllaOIH289              AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.reticosaOIH79                 AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.reticosaZI139                 AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.scintillansOIH141             AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
S.stenophyllaOIH74              AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.stenophyllaOIH88              AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.cf.stenophyllaOIH93           AATGATCTAT ATTTATACTA TAGT------ --ATAGATCA AGAGAAAAAA
S.uniflaraOIH82                 AATGATCTAT ATTTATAC-- ---T------ --ATGGATCA AGAGAAAAAA
B.pulcherrimaJX992809           AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
DisticochlamysspAF478844        AATGATCTAT ATTTATAC-- ---T------ --ACAGATCA AGAGAAAAAA
HaniffiacyanescensJF825538      AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
H.uniflorumOIH113               AATGGTCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
K.rotundaAF478868               AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
M.mullerensisAB269791           ?????????? ?????????? ????-----? ?????????? ??????????
T.flagellarisAF478898           AATGATCTAT ATTTATAC-- ---T------ --ATAGAT-- --AAAAAAAA
Z.officinaleAB047756            AATGATCTAT ATTTATAC-- ---T------ --ATAGATCA AGAGAAAAAA
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Appendix 2 continued

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                                ....|....|  ....|....|  ....|....|  ....|....|  ....|....|
                                   2705        2715        2725        2735        2745
S.argenteaOIH320                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.bilobaAF478889                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.bilobaOIH326                  TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.bilobaOIH327                  TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.biruOIH87                     TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.biruOIH254                    TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.calcicolaOIH81                TATCCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.durga1OIH84                   TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.durgaOIH235                   TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.graveolensOIH116              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.hastaOIH80                    TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.aff.klossiiOIH168             TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.kunstleriAF478890             TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.kunstleriOIH161               TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.kunstleriOIH162               TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.kunstleriOIH163               TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.lanjakensisOIH309             TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.limianaOIH122                 TATTCATAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.lucensOIH125                  TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.malaccanaOIH159               TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTTATGTAGT
S.multifoliaOIH111              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.nigraOIH76                    TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.cf.nigraOIH227                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.penyamarOIH137                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.petiolataOIH71                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.picturataZI656                TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.pseudoreticosaOIH83           TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.polyphyllaOIH119              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.polyphyllaOIH289              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.reticosaOIH79                 TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.reticosaZI139                 TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.scintillansOIH141             TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.stenophyllaOIH74              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.stenophyllaOIH88              TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.cf.stenophyllaOIH93           TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
S.uniflaraOIH82                 TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
B.pulcherrimaJX992809           TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
DisticochlamysspAF478844        TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
HaniffiacyanescensJF825538      TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
H.uniflorumOIH113               TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
K.rotundaAF478868               TATTCAGAGA ATTATCATTC TGAAATGCTC ATCTGAAATG CTCATGTAGT
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           AATTAAGAGA ATTAGCAT-- ---------- -TATGAAATG CTCATGTAGT
Z.officinaleAB047756            TATTCAGAGA ATTATCAT-- ---------- -TCTGAAATG CTCATGTAGT
```

Appendix 2 continued

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                                ....|....| ....|....| ....|....| ....|....| ....|....|
                                   2755       2765       2775       2785       2795
S.argenteaOIH320                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.bilobaAF478889                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTTTTAT TTGCACTTTA
S.bilobaOIH326                  ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTATTAT TTGCACTTTA
S.bilobaOIH327                  ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTTTTAT TTGCACTTTA
S.biruOIH87                     ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.biruOIH254                    ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.calcicolaOIH81                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTTTTAT TTGCACTTTA
S.durga1OIH84                   ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.durgaOIH235                   ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.graveolensOIH116              ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.hastaOIH80                    ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.aff.klossiiOIH168             ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.kunstleriAF478890             ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.kunstleriOIH161               ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTATTAT TTGCACTTTA
S.kunstleriOIH162               ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.kunstleriOIH163               ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTATTAT TTGCACTTTA
S.lanjakensisOIH309             ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.limianaOIH122                 ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTTTTAT TTGCACTTTA
S.lucensOIH125                  ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.malaccanaOIH159               ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.multifoliaOIH111              ACTGTACTGC TTGAATCAAC TGAATAGTCA AAATTCTTAT TTGCACTTTA
S.nigraOIH76                    ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.cf.nigraOIH227                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.penyamarOIH137                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.petiolataOIH71                ACTGTACTGC TTGAATCAAC TGAATAGTCA AAATTCTTAT TTGCACTTTA
S.picturataZI656                ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.pseudoreticosaOIH83           ACTGTACTGC TTGAATCAAC TGAATAGTCA AAATTCTTAT TTGCACTTTA
S.polyphyllaOIH119              ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.polyphyllaOIH289              ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.reticosaOIH79                 ACTGTACTGC TTGAATCAAC TGAATAGTCA AAATTCTTAT TTGCACTTTA
S.reticosaZI139                 ACTGTACTGC TTGAATCAAC TGAATAGTCA AAATTCTTAT TTGCACTTTA
S.scintillansOIH141             ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.stenophyllaOIH74              ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.stenophyllaOIH88              ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
S.cf.stenophyllaOIH93           ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTTTTAT TTGCACTTTA
S.uniflora0IH82                 ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
B.pulcherrimaJX992809           ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
DisticochlamysspAF478844        ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
HaniffiacyanescensJF825538      ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
H.uniflorumOIH113               ACTGTACTGC TTGAATCAAC CGAGTAGTCA AAATTCTTAT TTGCACTTTA
K.rotundaAF478868               ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
M.mullerensisAB269791           ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898           ACTGTACTGC TTGAATCAAC TGAGTAGTCC AAATTCTTAT TTGC-----A
Z.officinaleAB047756            ACTGTACTGC TTGAATCAAC TGAGTAGTCA AAATTCTTAT TTGCACTTTA
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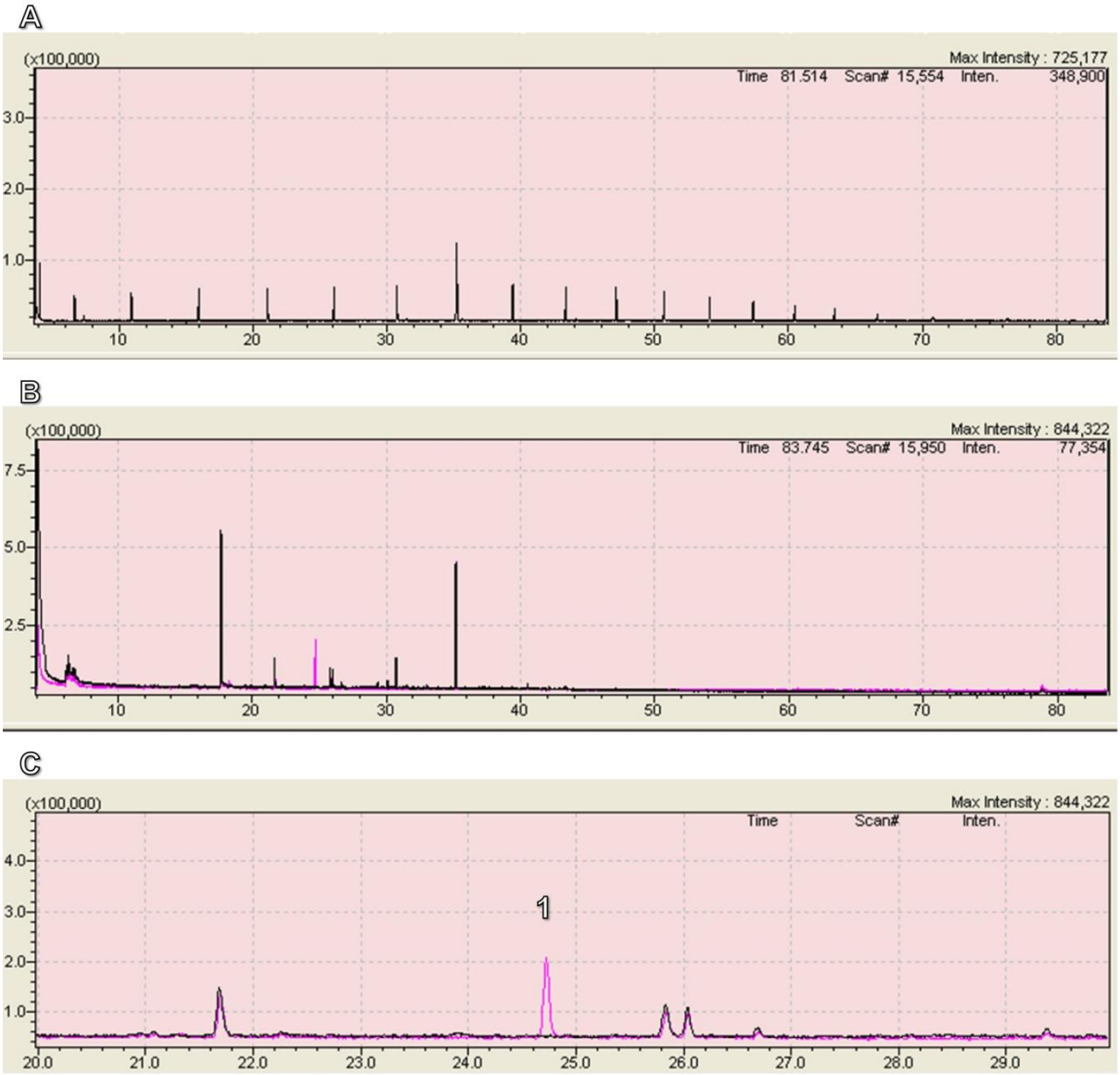
Appendix 2 continued

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                          ....|....| ....|....| ....|....| ....|....| ....|....|
                             2805       2815       2825       2835       2845
S.argenteaOIH320          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.bilobaAF478889          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.bilobaOIH326            CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.bilobaOIH327            CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.biruOIH87               CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.biruOIH254              CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.calcicolaOIH81          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.durga1OIH84             CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.durgaOIH235             CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.graveolensOIH116        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.hastaOIH80              CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.aff.klossiiOIH168       CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.kunstleriAF478890       CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.kunstleriOIH161         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.kunstleriOIH162         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.kunstleriOIH163         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.lanjakensisOIH309       CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.limianaOIH122           CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.lucensOIH125            CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.malaccanaOIH159         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.multifoliaOIH111        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.nigraOIH76              CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.cf.nigraOIH227          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.penyamarOIH137          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.petiolataOIH71          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.picturataZI656          CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.pseudoreticosaOIH83     CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.polyphyllaOIH119        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.polyphyllaOIH289        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.reticosaOIH79           CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.reticosaZI139           CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.scintillansOIH141       CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.stenophyllaOIH74        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.stenophyllaOIH88        CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.cf.stenophyllaOIH93     CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
S.uniflaraOIH82           CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
B.pulcherrimaJX992809     CTTTCTTCTC GGGGTGTTTT TTA-TAATAT GTATACATAG GGAAAGTCGT
DisticochlamysspAF478844  CTTTCTTCTC GGTATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
HaniffiacyanescensJF825538 CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
H.uniflorumOIH113         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
K.rotundaAF478868         CTTTCTTCTC GGGATGTTTT TT----ATAT GTATACATAG GGAAAGTCGT
M.mullerensisAB269791     ?????????? ?????????? ?????????? ?????????? ??????????
T.flagellarisAF478898     CTTTCTTATC GGGATGTTTT TT----ATAT GTATACATAG AGAAAGTCGT
Z.officinaleAB047756      CTTTCTTCTC GGGATGTTTT TTATTTATAT GTATACATAG GGAAAGTCGT
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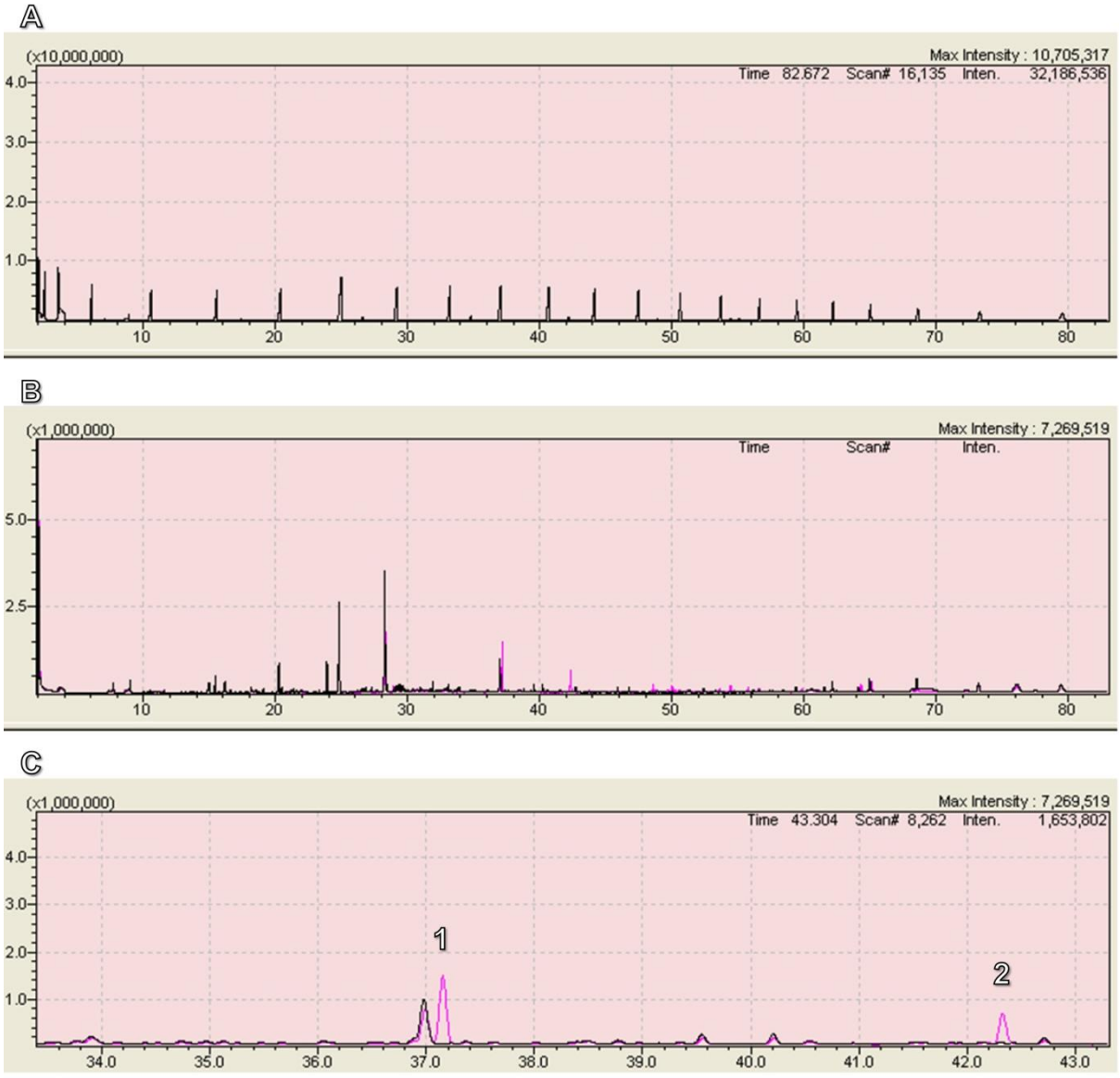
Appendix 2 continued

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                                ....|....| ....|....| ....
                                   2855       2865
S.argenteaOIH320                GTGCAATGAA AAATGCAAGC ACGT
S.bilobaAF478889                GTGCAATGAA AAATGCAAGC ACGT
S.bilobaOIH326                  GTGCAATGAA AAATGCAAGC ACGT
S.bilobaOIH327                  GTGCAATGAA AAATGCAAGC ACGT
S.biruOIH87                     GTGCAATGAA AAATGCAAGC ACGT
S.biruOIH254                    GTGCAATGAA AAATGCAAGC ACGT
S.calcicolaOIH81                GTGCAATGAA AAATGCAAGC ACGT
S.durga1OIH84                   GTGCAATGAA AAATGCAAGC ACGT
S.durgaOIH235                   GTGCAATGAA AAATGCAAGC ACGT
S.graveolensOIH116              GTGCAATGAA AAATGCAAGC ACGT
S.hastaOIH80                    GTGCAATGAA AAATGCAAGC ACGT
S.aff.klossiiOIH168             GTGCAATGAA AAATGCAAGC ACGT
S.kunstleriAF478890             GTGCAATGAA AAATGCAAGC ACGT
S.kunstleriOIH161               GTGCAATGAA AAATGCAAGC ACGT
S.kunstleriOIH162               GTGCAATGAA AAATGCAAGC ACGT
S.kunstleriOIH163               GTGCAATGAA AAATGCAAGC ACGT
S.lanjakensisOIH309             GTGCAATGAA AAATGCAAGC ACGT
S.limianaOIH122                 GTGCAATGAA AAATGCAAGC ACGT
S.lucensOIH125                  GTGCAATGAA AAATGCAAGC ACGT
S.malaccanaOIH159               GTGCAATGAA AAATGCAAGC ACGT
S.multifoliaOIH111              GTGCAATGAA AAATGCAAGC ACGT
S.nigraOIH76                    GTGCAATGAA AAATGCAAGC ACGT
S.cf.nigraOIH227                GTGCAATGAA AAATGCAAGC ACGT
S.penyamarOIH137                GTGCAATGAA AAATGCAAGC ACGT
S.petiolataOIH71                GTGCAATGAA AAATGCAAGC ACGT
S.picturataZI656                GTGCAATGAA AAATGCAAGC ACGT
S.pseudoreticosaOIH83           GTGCAATGAA AAATGCAAGC ACGT
S.polyphyllaOIH119              GTGCAATGAA AAATGCAAGC ACGT
S.polyphyllaOIH289              GTGCAATGAA AAATGCAAGC ACGT
S.reticosaOIH79                 GTGCAATGAA AAATGCAAGC ACGT
S.reticosaZI139                 GTGCAATGAA AAATGCAAGC ACGT
S.scintillansOIH141             GTGCAATGAA AAATGCAAGC ACGT
S.stenophyllaOIH74              GTGCAATGAA AAATGCAAGC ACGT
S.stenophyllaOIH88              GTGCAATGAA AAATGCAAGC ACGT
S.cf.stenophyllaOIH93           GTGCAATGAA AAATGCAAGC ACGT
S.unifloraOIH82                 GTGCAATGAA AAATGCAAGC ACGT
B.pulcherrimaJX992809           GTGCAATGAA AAGTGCAAGC ACGT
DisticochlamysspAF478844        GTGCAATGAA AAATGCAAGC ACGT
HaniffiacyanescensJF825538      GTGCAATGAA AAATGCAAGC ACGT
H.uniflorumOIH113               GTGCAATGAA AAATGCAAGC ACGT
K.rotundaAF478868               GTGCAATGAA AAATGCAAGC ACGT
M.mullerensisAB269791           ?????????? ?????????? ????
T.flagellarisAF478898           GTGCAATGAA AAATGCAAGC ACGT
Z.officinaleAB047756            GTGCAATGAA AAATGCAAGC ACGT
```

Appendix 3: Representative chromatogram of the *S. malaccana* (OIH302) flowers analysed by BPX5 intermediate polar column in splitless mode is shown with the compound peak – A: external standard; B: chromatograms of the *S. malaccana* OIH302 sample and control; C: enlarged partial chromatogram showing the compound peak, 1= benzyl acetate.



Appendix 4: Representative chromatogram of the *S. malaccana* (OIH302) flowers analyzed by BP20 polar column in splitless mode is shown with the two major compound peaks – A: external standard; B: chromatograms of the *S. malaccana* OIH302 sample and control; C: enlarged partial chromatogram showing the compound peaks, 1=benzyl acetate, 2=benzyl alcohol.



Appendix 5: List of Publications

Journal articles:

Ooi I.H., Meekiong, K. & Wong S.Y. (2017). A Review of *Scaphochlamys* (Zingiberaceae) from Borneo, with Description of Eleven New Species. *Phytotaxa*, *317*: 231-279.

Ooi I.H. & Wong S.Y. (2014). *Scaphochlamys stenophylla* (Zingiberaceae): a New Species from Sarawak, Malaysian Borneo. *Willdenowia*, *44*:241-245.

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