Nomenclatural changes in Zingiberaceae:  
Caulokaempferia is a superfluous name for Monolophus and Jirawongsea is reduced to Boesenbergia

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ABSTRACT. Wallich published Monolophus Wall. (Zingiberaceae) in 1832 for two taxa he had described previously in 1820 as Kaempferia linearis Wall. and K. secunda Wall. He also mentioned M. ? elegans Wall., but the “?” indicates that he was not certain that this species belonged to this new genus. Consequently, Monolophus elegans, while validly published, cannot be the lectotype of the generic name. In 1964 Larsen argued against accepting Monolophus and established the alternative Caulokaempferia K.Larsen. Caulokaempferia, typified by the name C. linearis (Wall.) K.Larsen, is, however, superfluous. Monolophus is hereby reinstated with 22 new combinations. Its phylogenetic position is shown in relation to other genera. Based on comparative nuclear and chloroplast DNA sequence data analyses, Jirawongsea Picheans. (previously Caulokaempferia, pro parte) is reduced to Boesenbergia Kuntze with five new combinations.

Keywords. Kaempferia, molecular phylogeny, nomenclature, taxonomy

Introduction

Over the past several years the authors have been collecting molecular data from both the nuclear ITS and the chloroplast trnK intron to produce a phylogeny of the genus Boesenbergia Kuntze. In the process, other Zingiberaceae genera have been included as outgroups. Caulokaempferia K.Larsen is one of these genera. Until recently, this genus consisted of 29 species described from the Lao P.D.R., Northeast India and Thailand. In 2007, a molecular phylogeny of Caulokaempferia using samples of 23 taxa from Thailand and the Lao P.D.R. was completed (Chaiyoot, 2007). The results showed the genus to be polyphyletic with two distantly related clades. Since a sample of the type species, Caulokaempferia linearis, was not included, no definitive conclusion was
possible as to which clade should retain the name Caulokaempferia. Picheansoonthon et al. (2008) used these results in combination with the morphological characters of flower colour and capsule type (Larsen, 2003) to determine that the largest clade (18 species) represented true Caulokaempferia, while the smaller clade (five species) was better treated as a new genus, which was called Jirawongsea Picheans., despite the samples clustering within the Boesenbergia clade. Also, a morphological comparison of Jirawongsea to Boesenbergia was not included.

When conducting a brief historical review of Caulokaempferia as part of this study it was discovered that an earlier name, Monolophus Wallich (1832) appeared to have been validly published with two species, one of which is the type of Caulokaempferia. This intriguing information triggered an in-depth nomenclatural study to understand why Monolophus had not been used in lieu of Caulokaempferia.

This paper provides new insights into the nomenclature, phylogeny and morphology of Caulokaempferia and Jirawongsea.

While all four authors made significant contributions to the manuscript, JDM is the key investigator and general manager of this paper, JFV provided the historical research as a basis for nomenclatural decisions, SD was instrumental in making field observations, and LMP provided supporting molecular phylogenetic research.

Nomenclature

Wallich (1820) described two new species of Kaempferia L. (Zingiberaceae): K. linearis Wall. and K. secunda Wall. At the time he thought them to be atypical for this genus and gave a brief diagnosis for this “group”, but not a rank, nor a name: “Caulescent, with an entire crest”.

In 1829 he added Kaempferia elegans Wall. and stated, “[it] belongs to the section which I have long ago [1820] indicated … All three ought perhaps to be removed from Kaempferia, and formed into a distinct genus for which I would propose the name Monolophus [single, entire crest].” Monolophus is here a provisional name for both the section and the genus and is, therefore, invalid (McNeill et al., 2012 - Art. 36.1b) although there is, yet again, a diagnosis: “caulescent habit, absence of tubers and entire crest”.

The nomenclatural articles cited here are according to the International Code of Nomenclature (ICN) (McNeill et al. 2012).

Wallich (1832) published Monolophus and included three species with references to earlier publications. Although Monolophus as a genus is not separately mentioned, Art. 35.1 and Ex. 1 on Suaeda Forssk. do not apply because the name of the genus and its three species are validly published through direct reference to previous diagnoses and descriptions (Art. 38.1). Monolophus linearis and M. secunda are clearly syntypes while M. elegans is not, as it was cited with a query and was not part of the original concept in 1820.
As Wallich (1829) so beautifully illustrated *Kaempferia elegans* it became the best known species of the assemblage, thus causing later problems in lectotypification (e.g. supposedly by Endlicher (1837)).

*Monolophus* was recognised by Endlicher (1837), followed by Steudel (1841), Horaninov (1862), Pfeiffer (1874), and more recently by Wu & Chen (1978). Endlicher’s citation of *Kaempferia elegans* is not to be regarded as a lectotypification, but as a representative of the genus. As *Kaempferia elegans* is not a syntype this cannot be a lectotype, yet it was erroneously accepted by Larsen (1964: 165), followed by Burtt & Smith (1972: 216), Wu & Chen (1981), and Newman et al. (2004: 118), and thus apparently by the *Index Nominum Genericorum* (Farr, 2013).

Horaninov (1862) is sometimes cited as the validating author of *Monolophus* but from the text it is clear that he was not, as he refers to Endlicher (1837), Roxburgh (1820) and Wallich (1832).

Bentham (1883) regarded *Monolophus* as connecting *Kaempferia* L. sections *Stachyanthesis* Benth. and *Soncorus* Rumph. ex Horan. The latter is an invalid name for *Kaempferia* sect. *Kaempferia* as an autonym is required. He included only *Kaempferia linearis* and *K. secunda* and did not mention *K. elegans*.

Baker (1892) accepted *Monolophus* as a subgenus of *Kaempferia* and included seven species, some of which are now placed elsewhere, e.g. in *Boesenbergia* Kuntze, *Camptandra* Ridl., *Kaempferia* and *Stahlianthus* Kuntze. He was more or less followed by Schumann (1904: 73) who created a later isonym, as he erroneously thought that Baker had regarded it as a section.

Larsen (1964) transferred *Kaempferia linearis* and *K. secunda* to a new genus, *Caulokaempferia* with *C. linearis* as the type. This transfer was supported by then new morphological findings and cytological data.

As was argued above, Larsen (1964) was incorrect in regarding *Kaempferia elegans* as the type of *Monolophus*, which he saw as more related to *K. galanga* L., the lectotype of *Kaempferia*. He, therefore, rejected *Monolophus* because 1) the type species would be a *Kaempferia* and 2) “the name refers to a character widely distributed also in neighbouring genera”. The first argument is to be rejected as *Kaempferia elegans* is not a candidate for lectotypification. The second is a taxonomic, not a nomenclatural, argument and also contravenes Art. 51.1 (a name is not to be rejected because it would be inappropriate).

Because *Kaempferia linearis* and *K. secunda* are the syntypes of *Monolophus*, Larsen (1964) created a superfluous name. The fact that, in 1964, *Monolophus* had not yet been lectotypified is irrelevant (Art. 52.2a). *Monolophus linearis* Wall. was later designated as the lectotype by Wu & Chen (1978: 28).

Even though Wu & Chen (1978) recognised the validity of *Monolophus* they later (Wu & Chen, 1981) changed their opinion on the validity of *Monolophus* and reverted to the name *Caulokaempferia* which has been in general usage to the present day.

Here we reinstate *Monolophus* as the valid name for this genus and provide 22 new combinations (Appendix 1).
Materials and Methods

Molecular phylogeny. *Caulokaempferia* and *Jirawongsea* leaf tissue samples were obtained from living plants (where available) and dried in silica gel. Supplemental ingroup data were obtained from GenBank, as were additional sequences which provided the scaffold for the taxa sampled here. A complete list of samples and GenBank accession numbers are provided in Appendix 4. The *Caulokaempferia* nucleotide data produced by Chaiyoot (2007) have not yet been deposited into any of the four international sequence repositories BOLD, DDBJ, EMBL, GenBank, thus they could not be included here.

DNA extraction follows Kress et al. (2002) while amplification and analytical methods follow Mood et al. (2013). Only minimal detail is provided here. The nuclear ribosomal ITS (nrITS) region was amplified using the 18S-F and 26S-R primers (Prince, 2010). The plastid *trnK* region was amplified in two parts, the first using 1F and 1235R primers and the second using m1F and 2R. Data were collected on an ABI Genetic Analyzer and sequences of each specimen were edited and a consensus sequence was generated in Sequencher v4.9 (Gene Codes Corporation, Ann Arbor, Michigan, USA). Sequences were aligned manually in Se-al (Rambaut, 1996) and areas of ambiguous alignment identified. Data were analysed under parsimony criteria by genomic data partition, firstly independently and later in combination. Data were also analysed including and excluding ambiguously aligned regions to determine if this altered the resulting tree topologies. Maximum parsimony analyses were conducted in PAUP* (version 4.0b10; Swofford, 2002). Heuristic search methods were conducted in each case with 1000 random addition replicates. Branch support was estimated using parsimony bootstrap (BS) in PAUP*.

Results

Both the individual and combined data analyses agreed in topology. All trees from all analyses agreed (or did not conflict) with a monophyletic *Caulokaempferia (Monolophus)* and *Boesenbergia*. Additionally, both phylogenies placed all samples of *Jirawongsea* within *Boesenbergia*. For brevity, only the results of the combined data analyses are shown and discussed below. The combined ITS and *trnK* data analysis (ambiguously aligned regions excluded) produced 64 shortest parsimony trees, one of which is shown in Figure 1. All samples of *Jirawongsea* (labelled *Boesenbergia* in Fig. 1) are part of a strongly supported (BS=100%) clade that includes *B. rotunda* (L.) Mansf. and *B. curtisii* (Baker) Schltr., which is nested within a monophyletic *Boesenbergia* (BS=56%). These findings are consistent, whether ambiguously aligned data are included or excluded from the analyses. Analyses of just the *trnK* or the ITS data partitions recover similar tree topologies. The only differences in topology generally involve minor changes in sister taxon relationships (with low support) among genera of Zingibereae. Branch support is generally lower in the separate analyses.
Discussion

Larsen (1964) described *Caulokaempferia* with eight species that he considered to be yellow-flowered. Larsen & Smith (1972) added *Caulokaempferia alba* (white-flowered) and the yellow-flowered, *C. yunnanensis* (Gagnep.) R.M.Sm. (See Appendix 2). The inclusion of these taxa was problematic, as they were quite different from each other and the type. The authors discussed the diversity of *Caulokaempferia* and *Boesenbergia* and suggested, on balance, that these species belonged in *Caulokaempferia* but conceded that characters such as the “large concave bracts ... [with a] lamina-like extension of the apex.” in *C. yunnanensis* were more complex and required extending the generic limits. Recent sampling of this taxon in molecular studies by Kress et al. (2002), Záveská et al. (2012) and here (Fig. 1), has shown it to have close affinity to *Curcuma* L., but we maintain it in *Pyrgophyllum* (Gagnep.) T.L.Wu & Z.Y. Chen. Larsen & Smith (1972) considered the flower of *Caulokaempferia alba* to be similar in appearance to other species in *Caulokaempferia*, but its vegetative form, trilocular capsule and flowering sequence required considerable accommodation. In this species the flowers open sequentially, top to bottom, whereas in the type species, they open bottom to top. Obviously, this was a disconcerting fact, as Larsen & Smith (1972) stated...
“Such a mode of flowering has not been previously observed in Caulokaempferia, and the possibility of affinity to at least some Boesenbergia cannot be discarded.”

Based on the first author’s study of Boesenbergia across their range, it appears that all of the species presently described can be distinguished from all other Zingibereae (except Haplochorema K.Schum.) by their basipetalous flowering. This is defined here as a flowering sequence where the first flower to open is at or near the apex and subsequent flowers open sequentially down the rachis from single-flowered bracts. In contrast, Caulokaempferia species are acropetalous with the flower-opening sequence from bottom to top. It should be noted that some Caulokaempferia have circinni of 2–4 flowers per bract, and in this case, the flowering sequence in the circinni in relation to the overall sequence is undocumented.

Larsen & Smith (1972) mentioned several characters in Caulokaempferia alba which they thought were atypical of Boesenbergia—a non-saccate labellum, a crested anther and no [androecial] tube at the base of the labellum. In fact, these three characters have been documented in Boesenbergia descriptions (Valetor, 1918; Holttum, 1950). For example, Boesenbergia rotunda (Fig. 3C), a well-known ginger of ethnobotanical importance, and B. curtisii (Fig. 3D) have these “atypical” characters. Perhaps Larsen & Smith were referring to Boesenbergia species similar to the type, B. pulcherrima (Wall.) Kuntze, which have a saccate labellum, an uncrested anther and an androecial tube (Holttum, 1950).

Wallich (1820) did not note flower colour in the original description of Kaempferia linearis and nor is a colour shown in the drawing received by Kew (K) on October 17, 1828 (annotated as “Wallich 1828 East Ind. Co. #25”). The first mention of the flower colour was by Baker (1892) who noted “flowers white ... tinged with yellow at the throat”, but it is unknown where this information originated. Contrary to Baker’s colour description, Parry 281 (K) from Assam (1927) was annotated “flowers yellow”. Larsen (1964) cited this specimen as representative of Caulokaempferia linearis, but in its description he stated “ [flower] tinged with yellow at the throat”.

By 2003, five more Caulokaempferia species had been published by Larsen (1973, 2003). Two of these, Caulokaempferia thailandica and C. violacea had characters very similar to C. alba. It became apparent to Larsen that the accommodation of these latter taxa [and Caulokaempferia alba] within Caulokaempferia was becoming more problematic. To preclude moving these species to another genus, he taxonomically grouped them into either yellow-flowered with unilocular capsules (to include the type) or into “the whitish- to violet-flowered species” with trilocular capsules. He further stated, “Until the relationships between these groups have been satisfactorily elucidated through molecular studies, [I have] chosen to keep the two groups united in the genus Caulokaempferia” (Larsen, 2003).

The first phylogenetic study to sample Caulokaempferia was by Kress et al. (2002). Only three species from the yellow-flowered group were included. The results showed affinity to Haniffia albiflora K.Larsen & Mood. Ngamriabsakul et al. (2004) and Thong-a-ram et al. (2005) sampled Caulokaempferia violacea, showing it to be closely allied to Boesenbergia. Chaiyoot (2007) sampled both Caulokaempferia colour groups, but without the type, C. linearis. His results showed the genus to be comprised of
two unrelated clades. The five taxa of Larsen’s white-flowered group clustered within a strongly supported monophyletic *Boesenbergia* (BS=100%). This finding brought full circle the observation of Larsen & Smith (1972) concerning the flowering sequence of *Caulokaempferia alba* being the same as in *Boesenbergia*. Picheansoonthon et al. (2008) proposed that these five taxa represented a new genus and named them *Jirawongsea*, despite the findings of the molecular data analyses. Since the type, *Caulokaempferia*
linearis had not been included by Chaiyoot (2007), no direct determination could be made as to which clade actually represented Caulokaempferia. In lieu of this, Picheansoonthon et al. (2008) followed the floral colour grouping of Larsen (2003) and selected the yellow-flowered group as representative of Caulokaempferia. To support their generic proposal, the taxonomic discussion was confined to the morphological dissimilarities between Caulokaempferia and Jirawongsea with no mention of the morphological similarities or phylogenetic affinity of the latter to Boesenbergia.

Figure 1 shows that Caulokaempferia linearis (as Monolophus linearis) does indeed group with the other species of Monolophus which are predominantly yellow-flowered. Surprisingly, as can be seen from a photograph of Monolophus linearis taken near the type locality in Meghalaya, India, the flower is not yellow, but white (Fig. 2B) as was stated by Baker (1892). In fact, none of the Indian species are yellow-flowered: Caulokaempferia secunda flowers are dark pink to violet (Fig. 2D) and those of C. sikkimensis are white. Consequently, taxonomic grouping by flower colour was an imperfect fit.

Based on phylogenetic and taxonomic investigations, Jirawongsea is reduced to Boesenbergia with five new combinations (Appendix 3).

Since the most recent circumscription of Caulokaempferia (Larsen & Smith, 1972) included characters of taxa that are no longer in this genus, an updated description of the genus is provided here under the name Monolophus.


Perennial herbs up to 45 cm; stems with 2–4 bladeless sheaths at the base. Leaves 3–10, sessile or petiolate, ligule small, bilobed to entire. Inflorescence terminal, acropetalous, flowers opening singly (?). Bracts 1–10, distichous, lanceolate, acuminate, the margins quite free to the base; 1–4 flowered. Bracteoles membranous, often not associated with the first flower in those species with single-flowered bracts. Calyx tubular, often 2–3 dentate, not deeply split unilaterally. Floral tube long, narrow, widening at the mouth; lobes 3, the dorsal broader and a little longer than the laterals. Lateral staminodes petaloid, normally small in relation to the labellum. Labellum large, orbicular, entire or bilobed, slightly concave. Stamen usually with a very short filament (occasionally up to 5 mm long) or sessile on the floral tube; anther thecae mostly parallel, dehiscing longitudinally; anther crest conspicuous, entire or dentate, often reflexed. Epigynous glands short, mostly linear, free from each other. Ovary unilocular; placentation free central. Fruit a unilocular capsule with a lateral suture. Seeds numerous, small, ellipsoid, glabrous or with a dense indumentum, aril white.
ACKNOWLEDGEMENTS. We would like to thank Poonsak Vatcharakorn (Chanthaburi, Thailand) for assistance in the field; R. Pooma (BKF) and L. Pashirajan, Botanical Survey India (CAL) for botanical assistance; J. Leong-Škorničkova (SING) for photography; P.C. Boyce (UNIMAS, Malaysia) for helpful comments; S.H. Chen (TAIE) for the translation of Chinese texts; the reviewers for their time and diligence; and the Field Museum (F), Chicago, USA, for use of laboratory facilities. Colour plates were created by T.D. Shafto (Hawaii, USA).

Fig. 2. A. Boesenbergia alba (K.Larsen & R.M. Smith) Mood & L.M.Prince. B. Monolophus linearis (Wall.) Wall. C. Monolophus saxicola (K.Larsen) Veldk. & Mood. D. Monolophus secundus (Wall.) Wall. (Photos: A & C, J. Mood; B & D, S. Dey)

References


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### Appendix 1. Enumeration of Monolophus species


TYPE: India, Silhet, F.D. & W.G. (Da Silva and Gomez) in Wallich 6591 (holotype K; isotypes C, CAL, P, IDC microfiche 7394).


Appendix 2. Taxa excluded from Monolophus (name in bold is currently accepted name).


Note – Included in Kaempferia L. sect. Stachyanthesis Benth. (1883). According to Leong-Škorničková et al. (2007) Hedychium scaposum Nimmo is the basionym of Monolophus scaposus even though the name was not mentioned by Dalzell (1850). Later, Dalzell & Gibson (1861) described Hedychium scaposum Nimmo with M. scaposus Dalz. in synonymy. Under Art 41.4 of the ICN, even though there is no reference to a basionym, Dalzell’s intention is obvious and Nimmo is to be accepted as the author of the basionym. As no Graham nor Nimmo material apparently exists Leong-Škorničková et al. (2007) designated a neotype.


Appendix 4: GenBank accession numbers for Zingiberaceae used in this study. Format: identification, plant sample number [for newly sequenced samples] (collector and voucher number, herbarium), ITS GenBank number/trnK GenBank number.
Boesenbergia alba (K.Larsen & R.M.Sm.) Mood & L.M.Prince: M3253 (Mood 3253, BISH) KF982792/KF982801.

Boesenbergia alba (K.Larsen & R.M.Sm.) Mood & L.M.Prince: M12C30 (Funakoshi s.n., MBK) KF982793/KF982802.

Boesenbergia buttii (K.Larsen & Jenjitt.) Mood & L.M.Prince: M12C32 (Funakoshi s.n., MBK) KF982794/KF982803.

Boesenbergia curtisii (Baker) Schltr.: M1739 (Mood 1739, BISH) KF982795/KF982804.

Boesenbergia hamiltonii Mood, S. Dey & L.M.Prince: M3017 (Mood 3017, BISH) JX992754/JX992815.

Boesenbergia plicata var. lurida Holttum: M3120 (Mood & Vatcharakorn 3120, BK) JX992808/JX992839.

Boesenbergia pulcherrima (Wall.) Kuntze: M08P276 (Mood 08P276, BISH) X992809/JX992748.

Boesenbergia rotunda (L.) Mansf.: (Kress 00-6737, US) AF478726/AF478726.

Boesenbergia thailandica (K.Larsen) Mood & L.M.Prince: (Ngamriabsakul 61, BKF) AY424748/--.

Boesenbergia violacea (K.Larsen & Triboun) Mood & L.M.Prince: M12C31 (Funakoshi s.n., MBK) KF982796/KF982805.

Camptandra parvula (King ex Baker) Ridley: (Kress 99-6328, US) AF478730/AF478830.

Cornucaempferia aurantiiflora Mood & K.Larsen: (Kress 01-6983, US) AF478736/AF478835.

Distichochlamys rubrostriata W.J.Kress & Rhese: (Kress 01-6848, US) AF478745/AF478844.

Globba curtisii Holttum: (Kress 99-6347, US) AF478754/AF478853.

Haniffia albiflora K.Larsen & Mood: (Kress 99-6370, US) AF478756/AF478855.


Hemiorchis rhodorrhachis K.Schum.: (Newman 861, E) AF478763/AF478863.

Hitchenia glauca Wall.: (Kress 00-6743 US) AF478765/AF478864.

Hornstedtia hainanensis T.L.Wu & S.J.Chen: (Kress 97-5769, US) AF478766/AF478865.

Kaempferia rotunda L.: (Kress 99-6304, US) AF478767/AF478868.

Monolophus coenobialis Hance: (unknown) HM236121/--.

Monolophus limianus (Mokkamul & Picheans.) Veldk. & Mood.: M3246 (Mood 3246, BISH) KF982797/KF982806.

Monolophus linearis (Wall.) Wall.: M12C193 (Dey NU198, CAL) KF982798/KF982807.

Monolophus saxicola (K.Larsen) Veldk. & Mood: M12C29 (Funakoshi s.n., MBK) KF982799/KF982808.

Monolophus sikkimensis (King ex Baker) Veldk. & Mood: New2458 (Newman 2458, spirit, E) KF982800/KF982809.

Pommereschea lackneri Witt.: (Kress 00-6739, US) AF478776/AF478877.

Pyrgophyllum yunnanense (Gagnep.) T.L.Wu & Z.Y.Chen: (Kress 00-6596, US) AF478777/AF478878.

Siliquamomum tonkinense Baill.: (Kress 00-6802, US) AF478791/AF478892.

Siphonochilus kirkii (Hook.f.) B.L.Burtt: (Kress 94-3692, US) AF478794/AF478895.

Tamijia flagellaris S.Sakai & Nagam.: (Kazuyuki S55, KYOTO) AF478797/AF478898.

Zingiber gramineum Noronha ex Blume: (Kress 96-5739, US) AF478800/AF478902.