Phylogenetic Classification of Seed Plants of Taiwan

Cheng-Tao Lin¹ and Kuo-Fang Chung²*

Abstract

Background: Biological classification, the hierarchical arrangement of scientific names of organisms, constitutes the core infrastructure of biological databases. For an efficient management of biological databases, adopting a stable and universal biological classification system is crucial. Currently in Taiwan Biodiversity Information Facility (TaiBIF; http://taibif.tw/), the national portal website that integrates Taiwan’s biodiversity information databases, angiosperms are arranged according to Cronquist’s System of Classification, which is not compatible with current trend of the Angiosperm Phylogeny Group (APG) classification. To consolidate the function and management of the database, TaiBIF is moving to adopt the APG IV classification and Christenhusz et al. (Phytotaxa 19:55–70, 2011)’s classification of gymnosperms, which we summarize as the Phylogenetic Classification of Seed Plants of Taiwan.

Results: The Phylogenetic Classification of Seed Plants of Taiwan places gymnosperms in five families [vs. eight families in the Flora of Taiwan (FOT)] and angiosperms in 210 families (vs. 193 families in FOT). Three FOT gymnosperm families are synonymized in current treatment. Of the 210 APG IV families, familial circumscriptions of 114 families are identical with FOT and 50 families are recircumscription of FOT, with 46 families newly added. Of the 29 FOT families not included in current classification, two families are excluded and 27 families are synonymized.

Conclusions: The adoption of the Phylogenetic Classification of Seed Plants of Taiwan in TaiBIF will provide better service and efficient management of the nation’s biodiversity information databases.

Keywords: Angiosperm Phylogeny Group classification, APG IV, Big new biology, Data cleaning, Flowering plants, Gymnosperms, Spermatophytina, TaiBIF, TaiCOL

Background

Biological classification, the hierarchical arrangement of scientific names of organisms, provides keywords and links to catalogue and organize biological information (Patterson et al. 2014). Biological classification constitutes the core infrastructure of biological databases (Patterson et al. 2010, 2014). Adopting a stable and universal biological classification system not only is crucial for the users but also fundamental for the efficient management of the databases.

TaiBIF (Taiwan Biodiversity Information Facility; http://taibif.tw/) is the national portal website that integrates Taiwan’s biodiversity information (Shao et al. 2013) through TaiCOL (Catalogue of Life in Taiwan; http://col.taibif.tw/), TaiEOL (Taiwan Encyclopedia of Life; http://eol.taibif.tw/), TaiBOL (Cryobanking Program for Wildlife Genetic Material in Taiwan; http://cryobank.museum.biodiv.tw/), and TELDAP (Taiwan e-Learning and Digital Archives Programs; http://core.teldap.tw/). As an associate participant of GBIF (Global Biodiversity Information Facility; http://www.gbif.org/), TaiBIF also functions as a national node of GBIF (Shao et al. 2013). The initiation of TaiBIF started in 2003 with the establishment of TaiBNET (Taiwan Biodiversity National Information Network; http://taibnet.sinica.edu.tw), providing “Taiwan species checklist” and the list of local taxonomic experts (Shao et al. 2013). Currently in TaiCOL, the successor of TaiBNET, the flowering plants are arranged according to Cronquist (1968)’s System of Classification (Shao et al. 2008), replacing A.
Engler’s Syllabus der Pflanzenfamilien that was adopted in the Flora of Taiwan (FOT), 2nd edition (Huang 1994). Although Cronquist’s System was highly influential and had been followed by several major floras such as Flora of North America (Reveal 1993) and Flora of Australia (Kanis et al. 1999), much of the content of Cronquist System is not compatible to the current trend of the APG classification.

The Angiosperm Phylogeny Group (APG) classification of the orders and families of flowering plants, now in its fourth edition (APG IV), is a collaborative effort of plant molecular systematic community worldwide (The Angiosperm Phylogeny Group 1998, 2003, 2009, 2016), providing the greatest stability and predictability regarding biodiversity information of flowering plants (Mayr 1981; Wearn et al. 2013). Although APG classification has not been adopted officially in Taiwan, families circumscribed by molecular phylogenetic studies and summarized by APG have been increasingly accepted by both academic (Hsu et al. 2011, 2016a, b; Wu et al. 2015) and citizen scientists (e.g., Nature Campus http://nc.biodiv.tw/bbs/index.php).

As an official provider of biodiversity information of the country, the classification systems followed by TaiCOL has deep and profound influences. In an effort to consolidate the function and management of TaiBIF that shall result in stable and better services of the websites, it is inevitable for TaiCOL to adopt classification systems that are constructed based on results of robust molecular phylogenetic analyses. This article outlines phylogenetic classification of families of the seed plants of Taiwan summarized based on Christenhusz et al. (2011)’s classification of gymnosperms, APG IV, and subsequent studies. To facilitate the transition toward APG IV, we also provide the spreadsheet of the classification schema for all seed plant genera that will be adopted by TaiCOL (Additional file 1: Appendix S1). This spreadsheet will be updated constantly and can be downloaded through TaiCOL. A brief note is provided for families of which circumscription has been changed between the treatment of FOT and APG IV classification.

Methods
The database of seed plants of Taiwan was compiled from “a checklist of the vascular plants of Taiwan” of the Flora of Taiwan (Boufford et al. 2003), “Illustrated Guide to Aquatic Plants of Taiwan” (Yang et al. 2001), Wu et al. (2010) that summarized naturalized and invasive flora, subsequently published native (e.g., Hsu et al. 2011; Wu et al. 2015) and naturalized (e.g., Liang et al. 2011; Wang et al. 2016) species, and the flora of Tongsha (Pratas) Island (Huang et al. 1994; Lin et al. 2005). The checklist was then imported into relational PostgreSQL database as a basis for migrating process. The migration process applied a ‘data cleaning framework’ to improve our data set quality through diagnosing, detecting, and correcting procedures. The data cleaning procedure included three major stages: (1) error type defining, (2) error instance identifying, and (3) error correcting (Maletic and Marcus 2000). Furthermore, we followed the data cleaning principles and methods suggested by Chapman (2005) when processing nomenclature data. In the initial stage of migration, instead of constructing a name-based database, a taxon-based database, which includes a unique taxonomy identifier (taxon ID) and several attributes such as family, genus, scientific names and vernacular names, etc., was constructed. In order to reduce the redundancy of the database and improve the data quality and integrity, we adopted relational database normalization to parse the raw data table into a second normal form schema. Through the normalization process, potential errors such as duplicate entries, misplaced taxa, etc., could be eliminated efficiently. In the second stage, we automated a python script to cross-validate our data base with Missouri Botanical Garden’s Tropicos (http://www.tropicos.org/) and International Plant Names Index (IPNI, http://ipni.org), identifying unmatched or unfound names for manual checking. In the third stage, three major possible errors or problems: (1) illegitimate or invalid names, (2) misspelled names, (3) different taxonomic treatment, were corrected after cross-validation.

We adopted Ruggiero et al. (2015) for the higher level classification of seed plants (Subphylum Spermatophyta and above). For gymnosperms (Superclass Gymnospermae), Christenhusz et al. (2011)’s classification was followed, though caution was taken for the uncertainty of the phylogenetic position of gnetophytes (Lu et al. 2014; Wang and Ran 2014). For angiosperms (Superclass Angiospermae), major clades recognized as superorders in Chase and Reveal (2009) and the classification of The Angiosperm Phylogeny Group (2016) was adopted, with the exception of Boraginales in which Luebert et al. (2016)’s new familial classification was followed. For orders and families of which vernacular names are lacking in the current literature of the flora of Taiwan, the names proposed by Liu et al. (2015) were followed.

Results and discussion
Based on Christenhusz et al. (2011), APG IV (2016), and Luebert et al. (2016)’s familial classification of Boraginales, the “Phylogenetic Classification of Seed Plants of Taiwan” is presented below. Of the four classes (I–IV), eight orders (A–H), and 12 families of gymnosperms in Christenhusz et al. (2011)’s classification, five families in four orders of two classes are naturally distributed in Taiwan. Compared to the treatment in FOT, current classification
includes Taxodiaceae in Cupressaceae and expands Taxaceae to include Amentotaxaceae and Cephalotaxaceae. Of the 16 superorders (A–S), 64 orders, and 427 families currently circumscribed (Luebert et al. 2016; APG IV 2016; Thulin et al. 2016), 210 families in 53 orders of 15 superorders are recorded in the flora of Taiwan (Fig. 1; Table 1).

The adoption of APG IV affects 79 (64 in dicotyledons and 15 in monocotyledons) of the 193 families (152 in dicotyledons and 41 in monocotyledons) recorded in FOT (Boufford et al. 2003), including changes in familial recircumscriptions in 50 families (41 in dicotyledons and 9 in monocotyledons), synonymization of 27 families (21 in dicotyledons and 6 in monocotyledons), and two families not present in Taiwan (i.e., Rafflesiaaceae and Hydrophyllaceae). Circumscriptions of 114 (59.1%) families [88 (57.9%) in dicotyledons and 26 (63.4%) in monocotyledons] of FOT remain unchanged. A total of 46 families are added under current classification. Table 1 summarizes current status of the families recorded in FOT (Boufford et al. 2003), newly added families (46), and frequently cultivated families not recorded in FOT (20).

The adoption of APG IV inevitably results in changes in statistics of the flora of Taiwan. For examples, Euphorbiaceae s.l. (89 species in 27 genera), Scrophulariaceae s.l. (73 species in 26 genera), and Liliaceae s.l. (48 species in 21 genera) were ranked as the 8th, 10th and 18th most species-rich families in FOT (Hsieh 2003); however, under APG IV classification, Euphorbiaceae reduces to ca. 60 species in 17 genera, Scrophulariaceae to only 4 species in 3 genera, and Liliaceae to ca. 8 species in 2 genera. Saxifragaceae is another case of drastic changes, reducing from 25 species in 13 genera to 7 species in 4 genera. On the other hand, families such as Malvaceae, Plantaginaceae, and Orobanchaceae expand greatly, increasing from eight, one, and four genera to 26, 16, and 14 genera, respectively.

In the Classification outlined below, codes composed of alphabet and number(s) are applied to each family to denote its ordinal (and superordinal) classification. For gymnosperms, Christenhusz et al. (2011)’s alphabetical (A–H) and numeric (1–12) codes for Orders and Families are adopted. For angiosperms, the numeric codes of APG IV families (1–416) are followed, with the addition of alphabetical (A–S) code for superorders and numerical (1–64) codes for orders modified from Chase and Reveal (2009). For example, “F14.60. Liliaceae 百合科” indicates Superorder Lilianae (F), Order Liliales (14), and Family Liliaceae (60). Code designations of superorders and orders are outlined in Fig. 1. The numeric family codes used in the Flora of Taiwan (Boufford et al. 2003) are also listed in parentheses after the Chinese vernacular family name to aid an easy comparison to families circumscribed in FOT. For examples, “(≡ IIA.1)” in Cycadaceae indicates Family 1 of Gymnosperma (IIA) in Boufford et al. (2003), “(≡ IIa.35)” of Nymphaeaceae denotes Family 35 of Dicotyledons (IIaB), and “(≡ IIb.7)” of Zosteraceae stands for Family 7 of Monocotyledons (IIb), while the sign “≡” indicates unchanged familial circumscription between FOT and current treatment. For those families of which circumscription has been changed, the number of genera in FOT and current treatment are also provided. For examples, “F14.60. Liliaceae 百合科 (IIb.9; 21/2)” indicates 21 genera included in Family 9 of Monocotyledons (IIb) in FOT, while only 2 genera are included in current classification. A statement is followed to denote newly added genera and/or genera excluded. For examples, current classification of “F18.89. Zingiberaceae 姜科 (IIb.35; 5/5)” includes the genus Curcuma 姜屬 based on Wu et al. (2010), while the genus Costus of FOT is moved to F18.88 Costaceae, resulting in a total of five genera as recorded in FOT (5/5). For newly added families, genera included are listed with references to previous classification. For newly recorded families, the number in parentheses after the Chinese vernacular name indicate the number of genera included. For families whose circumscription remain unchanged (e.g., Lauraceae, Asteraceae, Fabaceae, Orchidaceae, etc.), the full list of genera included is summarized in Additional file 1: Appendix S1. The Chinese vernacular names for all scientific names of taxa are adopted from FOT and/or names proposed when published (e.g., Chung et al. 2010b; Hsu et al. 2011). For newly added taxa not published by Taiwanese authors, the Chinese names proposed by Liu et al. (2015) are adopted. Although not officially recorded as parts of the flora, current treatments of 21 frequently cultivated plant families in Taiwan not recorded in FOT (marked with *) are also included.

Conclusions
Phylogenetic Classification of Seed Plants of Taiwan
Kingdom Plantae 植物界, Subkingdom Viridiplantae 綠色植物亞界, Infrakingdom Streptophyta 綠藻植物次界, Superphylum Embryophyta 有胚植物超門, Phylum Tracheophyta 維管束植物門, Subphylum Spermatophytina 種子植物亞門 (Ruggiero et al. 2015)

Superclass Gymnospermae 裸子植物超綱 (≡ gymnosperms in Chase and Reveal 2009 and Christenhusz et al. 2011)

Class I. Cycadopsida 蘇鐵綱, Subclass Cycadidae 蘇鐵亞綱
  A. Cycadales 蘇鐵目
    A.1. Cycadaceae 蘇鐵科 (≡ IIA.1)
    *A.2. Zamiaceae 藏米亞 (堅果鳳尾蕉) 科
Fig. 1 Ordinal phylogeny of angiosperms and APG IV classification, with notes on familial classification of angiosperm families of Taiwan
Table 1 Current taxonomic status of the families recorded in the Flora of Taiwan (FOT), 2nd ed. (Boufford et al. 2003) and newly added families to the flora of Taiwan based on APG IV

| Category | Families |
|----------|----------|
| FOT families excluded (2) | IlIa.43 Rafflesiaeae and IlIa.125 Hydrophyllaceae |
| FOT families synonymized (27) | IlIa.7A Cecropia, IlIa.20 Chenopodiaceae, IlIa.26 Illiciaceae, IlIa.48A Fumariaceae, IlIa.70 Aceraceae, IlIa.71A Bresceniaceae, IlIa.81 Leitaceae, IlIa.83 Tiliaceae, IlIa.85 Bombacaceae, IlIa.86 Sterculiaceae, IlIa.89 Flacourtia, IlIa.101A Trapaceae, IlIa.103 Theogonaceae, IlIa.104 Anagraceae, IlIa.109 Pyrolaceae, IlIa.111 Myrsinaceae, IlIa.122 Ascelpiaceae, IlIa.128 Callitrinaceae, IlIa.137 Myoporaceae, IlIa.140 Valerianaceae, IlIa.141 Dipsacaceae, IlIa.6 Zannichelliaceae, IlIa.8 Najadaceae, IlIb.11 Agavaceae, IlIb.28(A) Taccaceae, IlIb.30 Lemnaceae, and IlIb.33 Sparganaceae |
| FOT families circumscription unchanged (114) | IlIa.3 Salicaceae, IlIa.6 Ulmaceae, IlIa.7 Moraceae, IlIa.8 Urticaceae, IlIa.9A Olacaceae, IlIa.10 Santalaceae, IlIa.11 Loranthaceae, IlIa.14 Phytolaccaceae, IlIa.18 Portulacaceae, IlIa.21 Amaranthaceae, IlIa.25 Schisandraceae, IlIa.45 Theaceae, IlIa.46 Clusiaceae (≡ Gutierrezaceae), IlIa.48 Papaveraceae, IlIa.49 Capparaceae, IlIa.51 Hamamelidaceae, IlIa.53 Saxifragaceae, IlIa.61 Euphorbiaceae, IlIa.71 Sapindaceae, IlIa.75 Celastraceae, IlIa.78 Icacinaceae, IlIa.80 Vitaceae, IlIa.84 Malvaceae, IlIa.95 Lythraceae, IlIa.105 Cornaceae, IlIa.106 Araliaceae, IlIa.107 Apocynaceae (≡ Urtellitaceae), IlIa.110 Eriaceae, IlIa.112 Primulaceae, IlIa.119 Loganiaceae, IlIa.120 Gentianaceae, IlIa.121 Apocynaceae, IlIa.123 Rubiaceae, IlIa.126 Boraginaceae, IlIa.127 Verbenaceae, IlIa.128 Callitrichaceae, IlIa.129 Lamiaceae (≡ Labiatae), IlIa.131 Scrophulariaceae, IlIa.133 Acanthaceae, IlIa.135 Orobanchaceae, IlIa.138 Plantaginaceae, IlIa.139 Caprifoliaceae, IlIb.1 Alismataceae, IlIb.2 Hydrocharitaceae, IlIb.4 Potamogetonaceae, IlIb.9 Lilieaeae, IlIb.12 Amaryllidaceae, IlIb.14 Dioscoreaceae, IlIb.29 Araceae, IlIb.33 Typhaceae, and IlIb.35 Zingiberaceae |
| FOT families circumscription changed (50) | IlIa.1 Myricaceae, IlIa.2 Juglandaceae, IlIa.4 Betulaceae, IlIa.5 Fagaceae, IlIa.10 Acauceae, IlIa.11 Betulaceae, IlIa.128 Callitrinaceae, IlIa.137 Myoporaceae, IlIa.140 Valerianaceae, IlIa.141 Dipsacaceae, IlIa.6 Zannichelliaceae, IlIa.8 Najadaceae, IlIb.11 Agavaceae, IlIb.28(A) Taccaceae, IlIb.30 Lemnaceae, and IlIb.33 Sparganaceae |
| FOT families synonymized (27) | IlIa.3 Salicaceae, IlIa.6 Ulmaceae, IlIa.7 Moraceae, IlIa.8 Urticaceae, IlIa.9A Olacaceae, IlIa.10 Santalaceae, IlIa.11 Loranthaceae, IlIa.14 Phytolaccaceae, IlIa.18 Portulacaceae, IlIa.21 Amaranthaceae, IlIa.25 Schisandraceae, IlIa.45 Theaceae, IlIa.46 Clusiaceae (≡ Gutierrezaceae), IlIa.48 Papaveraceae, IlIa.49 Capparaceae, IlIa.51 Hamamelidaceae, IlIa.53 Saxifragaceae, IlIa.61 Euphorbiaceae, IlIa.71 Sapindaceae, IlIa.75 Celastraceae, IlIa.78 Icacinaceae, IlIa.80 Vitaceae, IlIa.84 Malvaceae, IlIa.95 Lythraceae, IlIa.105 Cornaceae, IlIa.106 Araliaceae, IlIa.107 Apocynaceae (≡ Urtellitaceae), IlIa.110 Eriaceae, IlIa.112 Primulaceae, IlIa.119 Loganiaceae, IlIa.120 Gentianaceae, IlIa.121 Apocynaceae, IlIa.123 Rubiaceae, IlIa.126 Boraginaceae, IlIa.127 Verbenaceae, IlIa.128 Callitrichaceae, IlIa.129 Lamiaceae (≡ Labiatae), IlIa.131 Scrophulariaceae, IlIa.133 Acanthaceae, IlIa.135 Orobanchaceae, IlIa.138 Plantaginaceae, IlIa.139 Caprifoliaceae, IlIb.1 Alismataceae, IlIb.2 Hydrocharitaceae, IlIb.4 Potamogetonaceae, IlIb.9 Lilieaeae, IlIb.12 Amaryllidaceae, IlIb.14 Dioscoreaceae, IlIb.29 Araceae, IlIb.33 Typhaceae, and IlIb.35 Zingiberaceae |
| Newly added families (46) | F9.27 Acoraceae, F10.41 Cymodoceae, F12.43 Nartheciaceae, F14.53 Melanthiaceae, F14.56 Cluchiaceae, F15.72 Asphodelaceae, F15.74 Asparagaceae, F18.88 Costaceae, N27.123 Altingiaceae, N27.127 Theaceae, N27.128 Grossulariaceae, O30.141 Surianaceae, O31.149 Campanulaceae, O36.184 Calophyllaceae, and O36.186 Hydrangeaceae, O36.189 Puttoniaceae, O36.208 Linaceae, O36.211 Phyllanthaceae, O41.234 Dipentodontaceae, O43.245 Muntingiaceae, O44.254 Akanaceae, O44.257 Caricaceae, O44.269 Cleomaceae, O46.278 Schoenophyliceae, R47.314 Talinaceae, R47.317 Cactaceae, S54.357 Ehretiaceae, S54.357F Heliconiaceae, S56.363 Hydrangeaceae, S57.373 Linderniaceae, S57.384 Mazaceae, S57.385 Phrymaceae, S58.388 Stemomuraceae, S58.389 Cardiopodaceae, S58.391 Helwingiaceae, S59.400 Menyanthaceae, and S63.408 Adoxaceae |
| Additional cultivated families (20) | A2.7 Zamiaceae, B.8 Achariaceae, F14.55 Asterothriaceae, F18.82 Strelitziaceae, F18.84 Heliconiaceae, F19.91 Bromeliaceae, M26.120 Dilleniaceae, O32.156 Casuarinaceae, O36.181 Ochnaceae, O36.197 Chrysobalanaceae, O42.238 Burseraceae, O43.250 Bixaceae, O44.253 Dipterocarpaceae, O44.255 Trochoiacaceae, R47.311 Didieraceae, S48.318 Nyssaceae, S49.329 Polemoniaceae, S52.350 Eucommiaceae, and S57.376 Pedaliaceae |
Class II. Ginkgoopsida 銀杏綱, Subclass Ginkgoidae 銀杏亞綱
B. Ginkgoales 銀杏目
  *B3. Ginkgoaceae 銀杏科

Class III. Gnetopsida 買麻藤綱, Subclass Gnetidae 買麻藤亞綱
C. Welwitschiales 二葉樹目
D. Gnetales 買麻藤目
E. Ephedrales 麻黃目

Class IV. Pinopsida 檜綱, Subclass Pinidae 檜亞綱
F. Pinales 檜目
  F7. Pinaceae 檜科 (≡ IIA.6)
G. Araucariales 南洋杉目
  *G8. Araucariaceae 南洋杉科
  G9. Podocarpaceae 羅漢杉科 (≡ IIA.5)
H. Cupressales 柏目
  H11. Cupressaceae 柏科 (IIA.8; 3/5)
  Including IIA.7 Taxodiaceae (Cryptomeria 柳杉屬, Cunninghamia 杉木屬 and Taiwania 臺灣杉屬).
  H12. Taxaceae 紅豆杉科 (IIA.2; 1/3)
  Including IIA.3 Amentotaxaceae (Amentotaxus 穗花杉屬) and IIA.4 Cephalotaxaceae (Cephalotaxus 麻黃科).

Superclass “Angiospermae” 被子植物超綱, Class Magnoliopsida 木蘭植物綱, Subclass Magnoliidae 木蘭植物亞綱 (≡ angiosperms in Chase and Reveal 2009; APG IV 2016)

Amborellanae 無油樟超目
A1. Amborellales 無油樟目

B. Nymphaeanae 睡蓮超目
B2. Nymphaeales 睡蓮目
  B2.3. Cabombaceae 燕藻科 (≡ IIBa.36; 1/2)
  Adding Cabomba 燕藻屬 (Yang et al. 2001).
  B2.4. Nymphaeaceae 睡蓮科 (≡ IIBa.35)

C. Austrobaileyanae 木蘭藤 (昆士蘭梓) 超目
C3. Austrobaileyales 木蘭藤 (昆士蘭梓) 目
  C3.7. Schisandraceae 五味子科 (IIBa.25; 2/3)
  Including IIBa.26 Illiciaceae (Illicium 八角屬).

D. Magnolianae 木蘭超目
D4. Canellales 白桂 (白桂皮) 目
D5. Piperales 胡椒目
  D5.10. Saururaceae 三白草科 (≡ IIBa.39)
  D5.11. Piperaceae 胡椒科 (≡ IIBa.40)
  D5.12. Aristolochiaceae 馬兜鈴科 (≡ IIBa.42)

D6. Magnoliidae 木蘭目
  D6.13. Myristicaceae 肉荳蔻科 (≡ IIBa.24)
  D6.14. Magnoliaceae 木蘭科 (≡ IIBa.22)
  D6.18. Annonaceae 香荔枝科 (≡ IIBa.23)

D7. Laurales 樟目
  D7.23. Hernandiaceae 蓮葉桐科 (≡ IIBa.28)
  D7.25. Lauraceae 樟科 (≡ IIBa.27)

E. Chloranthanae 金粟蘭超目
E8. Chloranthales 金粟蘭目
  E8.26. Chloranthaceae 金粟蘭科

F. Lilianae 百合超目 (Trias-Blasi et al. 2015)
  F9. Acorales 藜科
    F9.27. Acoraceae 藜科

F10. Alismatales 澤瀉科 (IIBa.1; 3/5)
  F10.28. Araceae 留蘭花科
   F10.30. Araceae 留蘭花科 (including IIBb.8 Najadaceae (Najas) and IIBb.6 Zannichelliaceae (Zannichelia) as Halodule (Lin et al. 2005).
   Adding Stuckenia (≡ Potamogeton pectinatus) as Limnocharitaceae (Hydrocleys 黃花屬; Yang et al. 2001).

F10.32. Hydrocharitaceae 水蓮科 (IIBa.2; 7/10)
  Adding Egeria 水蓮科 (including IIBb.8 Najadaceae (Najas) and IIBb.6 Zannichelliaceae (Zannichelia) as Halodule (Lin et al. 2005). Based on Ko (2004), the photographs of Lin et al. 2005 (Fig. 5a, b) identified as Thalassodendron ciliatum are likely misidentification of Cymodocea serrulata.}

F10.34. Aponogetonaceae 水蓮科 (IIBa.3)
F10.37. Zosteraceae 甘蔗科 (≡ IIBa.7)
F10.38. Potamogetonaceae 眼子菜科 (IIBa.4; 1/3)
  Adding Stuckenia (≡ Potamogeton pectinatus) as Limnocharitaceae (Hydrocleys 黃花屬; Yang et al. 2001).

F10.40. Ruppiaceae 流蘇科 (≡ IIBa.5)
F10.41. Cymodoceaceae 絲粉藻科 (3)
  IIBa.4 Potamogetonaceae pro parte (Cymodoceaceae 絲粉藻屬 and Syringodium 針葉藻屬; Lin et al. 2005) and IIBa.6 Zannichelliaceae pro parte (Halodule 二葉藻屬). Based on Ko (2004), the photographs of Lin et al. 2005 (Fig. 5a, b) identified as Thalassodendron ciliatum are likely misidentification of Cymodocea serrulata.
F11. Petrosoviales 櫻井草 (無葉蓮) 目
  F11.42. Petrosoviaceae 櫻井草 (無葉蓮) 科 (≡ IIB.9A)

F12. Dioscoreales 薯蕷目
  F12.43. Nartheciaceae 沼金花 (納茜菜) 科 (1)
  *F12.44. Burmanniaceae 水玉簪科 (≡ IIBb.18)
  F12.45. Dioscoreaceae 薯蕷科 (IIB.14; 1/2)
    Including IIBb.28(A) Taccaceae (Tecca 薯蕷科).

F13. Pandanales 露兜樹目
  F13.46. Triuridaceae 頂草科 (≡ IIBb.39)
  F13.48. Stemonaceae 百部科 (≡ IIBb.10)
  F13.49. Cyclanthaceae 巴拿馬草科 (≡ IIBb.28)
  F13.50. Pandanaceae 露兜樹科 (≡ IIBb.31)

F14. Liliales 百合目
  F14.53. Melanthiaceae 黑蒟蒻花科 (5)
    Ypsilandra (蒟蒻花屬; Hsu et al. 2011) and
    IIBb.9 Liliaeae pro. parte (Helonias 萱蕷屬, Paris 七葉—枝花屬, Trillium 延齡草屬, and
    Veratrum 藥薑屬).
  *F14.55. Alstroemeriaceae 百合水仙 (六出花) 科
  F14.56. Colchicaceae 秋水仙科 (1)
    Disporum 寶雛花屬 (IIBb.9 Liliaeae).
  F14.59. Smilacaceae 蓂蔥科 (≡ IIBb.15)
  F14.60. Liliaeae 百合科 (IIBb.9; 21/2)
    Lilium (百合屬) and Tricyrtis (油點草屬); excluding
    F14.53 Melanthiaceae (Helonias, Paris, Trillium, and Veratrum), F14.56 Colchicaceae (Disporum), F15.72 Asphodelaceae (Dianella and Hemerocallis), F15.73 Amaryllidaceae pro parte (Allium), and F15.74 Asparagaceae pro parte [Asparagus, Aspidistra, Disporopsis, Liriopoe, Ophiopogon, Peliosanthes, Polygonatum, Rohdea (= Campylandra), Scilla (= Barnardi), Smilacina (= Maianthemum), and Thysanotus].

F15. Asparagales 天門冬目
  F15.61. Orchidaceae 蘭科 (≡ IIBb.38)
  F15.66. Hypoxiaceae 仙茅科 (≡ IIBb.13)
  F15.70. Iridaceae 薔薇科 (≡ IIBb.17)
  F15.72. Asphodelaceae 阿福花 (獨尾草) 科 (2)
    IIBb.9 Liliaeae pro parte (Dianella 柄根蘭屬 and
    Hemerocallis 豈草屬).
  F15.73. Amaryllidaceae 石蒜科 (IIBb.12; 2/3)
    Including Allium 薔薇屬 (IIBb.9 Liliaeae).
  F15.74. Asparagaceae 天門冬科 (16)
    Including IIBb.11 Agavaceae (Agave 龍舌蘭屬, Cordyline 朱蕉屬, Dracaena 龍血樹屬, and Yucca 金棒蘭屬) and IIBb.9 Liliaeae pro. parte [Asparagus 天門冬屬, Aspidistra 蜘蛛抱蛋屬, Barnardia (= Scilla sinensis) 棉絨屬, Disporopsis 假寶雛花屬, Heteropolygonatum 黃精屬 (Chao et al. 2013), Liriopoe 天門冬屬, Maianthemum 龍舌蘭屬 (舞鶴草) 屬, Ophiopogon 沿階草屬, Peliosanthes 球子草屬, Polygonatum 黃精屬, Rohdea (= Campylandra) 萬年青屬 (Yamashita and Tamura 2004), and Thysanotus 藥薑草屬].

F16. Arecales 棕櫚目
  F16.76. Arecaceae (= Palmae) 棕櫚科 (≡ IIBb.27)

F17. Commelinales 鴨跖草目
  F17.78. Commelinaceae 鴨跖草科 (≡ IIBb.21)
  F17.79. Philhyraceae 田蔘科 (≡ IIBb.19)
  F17.80. Pontederiaceae 雨久花科 (≡ IIBb.16)

F18. Zingiberales 薑目
  *F18.82. Strelitziaceae 旅人蕉科
  *F18.84. Heliconiaceae 鳳凰蕉 (赫蕉) 科
  F18.85. Musaceae 芭蕉科 (≡ IIBb.34)
  F18.86. Cannaceae 美人蕉科 (≡ IIBb.36)
  F18.87. Marantaceae 竹芋科 (≡ IIBb.37)
  F18.88. Costaceae 非洲罌粟科 (1)
    Costus 非洲罌粟屬 (IIBb.35 Zingiberales).
  F18.89. Zingiberales 薑科 (IIBb.35; 5/5)
    Including Curcuma 薑黃屬 (Wu et al. 2010); excluding F18.88. Costaceae (Costus).

F19. Poales 禾本科
  F19.90. Typhaceae 香蒲科 (IIBb.33; 1/2)
    Including IIBb.33 Sparganiaceae (Sparganium 紫菫屬).
  *F19.91. Bromeliaceae 鳳梨科
  F19.93. Xyridaceae 護膚科 (≡ IIBb.22)
  F19.94. Erionacaceae 殺精科 (≡ IIBb.23)
  F19.97. Juncaceae 燈心草科 (≡ IIBb.20)
  F19.98. Cyperaceae 莖科 (≡ IIBb.25)
  F19.100. Flagellariaceae 鎮藤科 (≡ IIBb.24)
  F19.103. Poaceae (≡ Gramineae) 禾本科 (≡ IIBb.26)

G. Ceratophyllanae 金魚藻超目
  G20. Ceratophylalles 金魚藻目
  G20.104. Ceratophyllaceae 金魚藻科 (≡ IIBb.38)

H. Ranunculanae 毛茛超目
  H21.106. Papaveraceae 紫堇科 (IIBb.48; 3/5)
    Including IIBb.48A Fumariaceae (Corydalis 紫堇屬 and Fumaria 紫堇屬).
H21.108. Lardizabalaceae 木通科 (≡ IIBa.32)
H21.109. Menispermaceae 防己科 (≡ IIBa.33)
H21.110. Berberidaceae 小檗科 (≡ IIBa.31)
H21.111. Ranunculaceae 毛茛科 (≡ IIBa.30)

I. Proteanae 山龍眼超目
   I22. Proteales 山龍眼目
      I22.112. Sabiaceae 清風藤科 (≡ IIBa.72)
      I22.113. Nelumbonaceae 蓮科 (≡ IIBa.34)
      I22.115. Proteaceae 山龍眼科 (≡ IIBa.9)

J. Trochodendranae 昆欄樹超目
   J23. Trochodendrales 昆欄樹目
      J23.116. Trochodendraceae 昆欄樹科 (≡ IIBa.29)

K. Buxanae 黃楊超目
   K24. Buxales 黃楊目
      K24.117. Buxaceae 黃楊目 (≡ IIBa.77)

L. Myrothamnanae 摺扇葉超目
   L25. Gunnerales 大葉草 (洋二仙草) 目

M. Dillenianae 第倫桃超目
   M26. Dilleniales 第倫桃目
      *M26.120. Dilleniaceae 第倫桃科

N. Saxifraganae 虎耳草超目
   N27. Saxifragales 虎耳草目
      N27.123. Altingiaceae 萱樹 (楓香) 科 (1)
      *N27.124. Hamamelidaceae 金縷梅科 (IIBa.51; 6/5)
      Excluding Liquidambar (N27.123).
      N27.126. Daphniphyllaceae 虎皮楠科 (≡ IIBa.62)
      N27.127. Iteaceae 鼠刺科 (1)
      *Itea 鼠刺屬 (IIBa.53 Saxifragaceae).
      N27.128. Grossulariaceae 茶藨子科 (1)
      *Ribes 茶藨子屬 (IIBa.53 Saxifragaceae).
      N27.129. Saxifragaceae 虎耳草科 (IIBa.53; 13/5)
      *Astilbe 落新婦屬, Chrysanthemum 蝴蝶眼鏡草属, Mitella 噴吐草屬, Saxifraga 虎耳草屬, and Tiarella 黃水枝屬; excluding S48.320
      Hydrangeaceae (Cardiandra, Deutzia, Hydrangea, Pileostegia, and Schizophragma), N27.127 Iteaceae (*Itea), N27.128 Grossulariaceae (*Ribes), and Parnassia (O34.168).
      N27.130. Crassulaceae 景天科 (≡ IIBa.52)
      N27.134. Haloragaceae 小二仙草科 (≡ IIBa.102)

O. Rosanae 薔薇超目
   O28. Vitales 蘑菇目
      O28.136. Vitaceae 葡萄科 (IIBa.80; 6/7)
      Including IIBa.81 Leeaceae (Leea 火筒樹屬).

O29. Zygophyllales 茭藜目
   O29.138. Zygophyllales 茭藜目 (≡ IIBa.60)

O30. Fabales 豆目
   O30.140. Fabaceae (≡ Leguminosae 豆科 (IIBa.57)
   O30.141. Surianaceae 海人樹科 (1)
      Suriana 海人樹屬 (Huang et al. 1994).
   O30.142. Polygalaceae 遠志科 (≡ IIBa.67)

O31. Rosales 薔薇目
   O31.143. Rosaceae 薔薇科 (≡ IIBa.55)
   O31.146. Elaeagnaceae 胡蘆巴科 (≡ IIBa.88)
   O31.147. Rhamnaceae 糸李科 (≡ IIBa.79)
   O31.148. Ulmaceae 榆科 (IIBa.6; 5/2)
      *Ulmus 榆屬 and Zelkova 榕屬; excluding O31.149 Cannabaceae pro parte (Apinanthe, Celtis, and Trema).
   O31.149. Cannabaceae 大麻科 (4)
      *Humulus 啄草屬 (IIBa.7 Moraceae) and IIBa.6 Ulmaceae pro parte (Apinanthe) 啄葉樹属, Celtis 朴屬, and Trema 山黃麻屬).
   O31.150. Moraceae 桑科 (IIBa.7; 8/7)
      Excluding Hummulus (O31.149).
   O31.151. Urticaceae 荨麻科 (IIBa.8; 21/22)
      Including IIBa.7A Cecropiaceae (Poikilosperma 雞頭麻屬).

O32. Fagales 榆科目
   O32.153. Fagaceae 榆科 (≡ IIBa.5)
   O32.154. Myricaceae 楊梅科 (≡ IIBa.1)
      *Morella (≡ Myrica) 楊梅屬 (Herbert 2005; Huguet et al. 2005).
   O32.155. Juglandaceae 椿科 (≡ IIBa.2)
      *O32.156. Casuarinaceae 木麻黃科
      O32.158. Betulaceae 椿科 (≡ IIBa.4)

O33. Cucurbitales 葫蘆科 (瓜) 目
   O33.162. Coriariaceae 馬桑科 (≡ IIBa.68)
   O33.163. Cucurbitaceae 葫蘆科 (瓜) 科 (≡ IIBa.94)
   O33.166. Begoniaceae 秋海棠科 (≡ IIBa.93)

O34. Celastrales 衛矛目
   O34.168. Celastraceae 衛矛科 (IIBa.75; 6/6)
      Including Parnassia 梅花草屬 (IIBa.53 Saxifragaceae); excluding Perrottetia (O41.234).

O35. Oxalidales 酢漿草目
   O35.170. Connaraceae 牛栓藤科 (≡ IIBa.56)
   O35.171. Oxalidaceae 酢漿草科 (≡ IIBa.58)
   O35.173. Elaeocarpaceae 木英科 (≡ IIBa.82)
O36. Malpighiales 酹科 (金虎尾) 目
O36.179. Rhizophoraceae 紅樹科 (≡ IIBa.99)
*O36.181. Ochnaceae 金蓮木科
O36.183. Clusiaceae (≡ Guttiferae) 藥科 (IIBa.46; 4/1)
Garcinia 福木屬; excluding O36.184 Calophyllaceae (Calophyllium) and O36.186 Hypericaceae (Hypericum and Triadenum).

O36.184. Calophyllaceae 胡桐 (紅厚殼) 科 (1)
Calophyllum 胡桐屬 (IIBa.46 Guttiferae).
O36.186. Hypericaceae 金絲桃科 (2)
IIBa.46 Guttiferae pro parte (Hypericum 金絲桃屬 and Triadenum 三腺金絲桃屬).
O36.189. Putranjivaceae 非洲核果木 (核酸木) 科 (1)
Drypetes (including Liodendron) 鐵色屬 (IIBa.61 Euphorbiaceae).
O36.191. Elatinaceae 溝繁縷科 (≡ IIBa.92)
O36.192. Malpighiaceae 黃褥花 (金虎尾) 科 (≡ IIBa.66)
*O36.197. Chrysobalanaceae 可可李 (金殼果) 科
O36.200. Violaceae 金紫薇科 (≡ IIBa.90)
O36.202. Passifloraceae 西番蓮科 (≡ IIBa.91A)
O36.204. Salicaceae 楊柳科 (IIBa.3) (1/7)
Salix 柳屬; including IIBa.89 Flacourtiaceae (Casearia 嘉賜木屬, Flacourtia 羅庚果屬, Homalium 天料木屬, Idesia 山桐子屬, Scolopia 魯花樹屬, and Xylomia 作木屬).
O36.207. Euphorbiaceae 大戟科 (IIBa.61; 27/17)
Acalypha 鐵莧屬, Alchornea 山麻桿屬, Claoxylon 假鐵莧屬, Croton 巴豆屬, Euphorbia (including Chamaesyce) 大戟屬, Excoecaria 土沉香屬, Homonoia 水楊梅屬, Maer- ranga 血桐屬, Mallotus 野桐屬, Melanolepis 蟲尾屬, Mercurialis 山靛屬, Homalanthus (≡ Omalanthus) 圓葉血桐屬, Ricinus 茄屬, Sapium 烏桕屬, and Suregada (including Gelonium) 白楊屬; adding Manihot 木薯屬 and Vernicia (including Aleurites montana; Wu et al. 2010) 油桐屬; excluding O36.189 Putranjivaceae (Drypetes and Liodendron) and O36.211 Phyllanthaceae (Antidesma, Bischofia, Breynia, Bridelia, Flueggea, Glochidion, Margaritaria, Phyllanthus, and Synnostenon).
O36.208. Linaceae 亞麻科 (1)
Linum 亞麻屬 (Chao et al. 2017).
O36.211. Phyllanthaceae 葡萄科 (8)
IIBa.61 Euphorbiaceae pro parte (Antidesma 五月茶屬, Bischofia 重陽木屬, Breynia (including Synnostenon) 山漆苧屬, Bridelia 土密樹屬, Flueggea 白飯樹屬, Glochidion 香頭果, Margaritaria 紫黃屬, and Phyllanthus 油柑屬).
O37. Geraniaceae 銀牛兒苗科
O37.212. Geraniaceae 銀牛兒苗科 (≡ IIBa.59)
O38. Myrtales 桃金孃目
O38.214. Combretaceae 使君子科 (≡ IIBa.100)
O38.215. Lythraceae 桃金孃科 (IIBa.95; 5/6)
Including IIBa.101A Trapaceae (Trapa 菓屬) and *Punicaceae.
O38.216. Onagraceae 柳葉科 (≡ IIBa.101)
O38.218. Myrtaceae 桃金孃科 (≡ IIBa.96)
O38.219. Melastomataceae 野牡丹科 (≡ IIBa.98)
O39. Crososomatales 溼蘇子 (濕子木) 目
O39.226. Staphyleaceae 眶節花科 (≡ IIBa.76)
O39.228. Stachyuraceae 眾節花科 (≡ IIBa.91)
O40. Picramniales 美洲木目
O41. Huerteales 棉柚樹 (十齒花) 目
O41.234. Dipentodontaceae 十齒花科 (1)
Perrottetia 核子木屬 (IIBa.75 Celastraceae).
O42. Sapindales 無患子目
*O42.238. Burseraceae 橄欖科
O42.239. Anacardiaceae 漿樹科 (≡ IIBa.69)
O42.240. Sapindaceae 無患子科 (IIBa.71; 9/10)
Including IIBa.70 Aceraceae (Acer 橄欖屬).
O42.241. Rutaceae 芸香科 (≡ IIBa.63)
O42.242. Simaroubaceae 苦木科 (≡ IIBa.64)
O42.243. Meliaceae 檀科 (≡ IIBa.65)
O43. Malvales 錦葵目
O43.245. Muntingiaceae 文定果 (西印度欒欖) 科 (1)
Muntingia 西印度欒欖屬 (IIBa.83 Tiliaceae).
O43.247. Malvacae 紅花木科 (IIBa.84; 8/26)
Abelmoschus 秋葵屬, Abutilon 茉莉屬, Hibiscus 木槿屬, Malachia 玄葵屬, Malva 錦葵屬, Malvastrum 賽葵屬, Sida 金午時花屬, Thespesia 傳楊屬, and Urena 野棉花屬; adding Anoda 銀棉屬 (Li and Wang 2012) and Modiola 銀棉屬 (Wu et al. 2010); including IIBa.85 Bombacaceae (Bombax 木棉屬 and Pachira 馬拉巴栗屬; Wu et al. 2010), IIBa.86 Sterculiaceae (Firmiana 柏桐屬, Helicteres 山芝麻屬, Heritiera 錦菜屬, Kleinhovia 克蘭樹屬, Melochia 野路葵屬, Pterospermum 櫻子樹屬, Reevesia 捲樹屬, Sterculia 藥婆屬, and Waltheria 平桃樹屬) and IIBa.83 Tiliaceae pro parte (Berrya 六翅木屬, Corchorus 黃麻
null
Camellia 山茶属，Gordonia 大头茶属，Pyrenaria 烈木茶属，和 Schima 木荷属；excluding S49.332 Pentaphylacaceae（Adinandra, Annesleia, Cleveryra, Eurya, and Ternstroemia）
S49.337. Symplocaceae 茶木科（IIBa.117）
S49.338. Diapensiaceae 岩羊草科（IIBa.108）
S49.339. Styracaceae 安息香科（IIBa.116）
S49.342. Actinidiaceae 鸡爪槭科（IIBa.44）
S49.345. Mitrastemonaceae 柿花科（IIBa.43；Rafflesiaaceae）。
S49.346. Ericaceae 杜鹃花科（IIBa.110；6/11）
Including IIBa.109 Pyrolaceae（IIBa.43；Rafflesiaaceae）。

S50. Icacinaceae 芸香花科（IIBa.78；3/1）
Nothapodytes 㭣紫花属；excluding Gomphandra（S58.388）and Gonocaryum（S58.389）。

S51. Metteniusiaceae 水螅花目

S52. Garryales 番薯花目
*S52.350. Eucommiaceae 杜仲科（IIBa.337）
S52.351. Garryaceae 番薯花科（I）
Aucuba 桃叶珊瑚属（IIBa.105 Cornaceae）。

S53. Gentianales 茜草科
S53.352. Rubiaceae 茜草科（IIBa.123；38/46）
Argostemma 水冠草属，Canthium 朴叶乌头属，Cephalanthus 风箱草属，Coptosapelta 风箱藤属，Dammacanthus 伏牛花属，Dentella 小牙草属，Diodia 钓丝草属，Galium 赤道乌头属，Gardenia 黄栀属，Geophila 花花属，Guettarda 菊花木属，Hedyotis 茜草属，Ixora 仙丹花属，Knoxia 韩氏草属，Lasianthus 麦角素属，Litosanthes 伞冠木属，Mitchella 茜草属，Mitracarpus 覆被果属（Ling and Chen 2013），Morinda 羊角藤属，Mussaenda 玉叶金花属，Neantotis 新耳草属，Neonauclea 桂仁藤属，Nortera 深柱夢草属，Oldenlandiopsis 微耳草属（Jung et al. 2011），Opphiorrhiza 蚓根草属（including Hayataella；Nakamura et al. 2006），Paederia 药用藤属，Pavetta 朴叶乌头属，Psychotria 九叶木属，Randia 朴叶藤属，Richardia 拟鸭舌单属，Rubia 赤道草属，Serissa 漫天星属（Wu et al. 2010），Shevarda 雪亚迪木属（Wu et al. 2010），Sinodina 水冬瓜属，Spermacoce 拟鸭舌单属（including Hemidonia in Wu et al. 2010），Tarenna 玉心花属，Timonius 牡丹属，Tricyrtis 獐牙单属，Uncaria 闍糅属，and Wendlandia 水蹄藤属；including IIBa.103
Theligonaceae（Theligonum 茜草花属）。Based on Neupane et al.（2015），the genera Dimetia 深旋转草属（新拟），Exallage 金毛耳草属（新拟），Leptopetalum 赤耳草属（新拟），Oldelandia 龙吐珠属（新拟），and Scleromitrion 蛇舌草属 are segregated from the Taiwanese species of Hedyotis（Hsu and Chen 2017）。
S53.353. Gentianaceae 龙胆科（IIBa.120；7/7）
Including Fagavia 灰莓科（IIBa.119 Loganiaceae）；excluding Nymphoides（S59.400）。
S53.354. Loganiaceae 马钱科（IIBa.119；6/4）
Excluding Fagraea（S53.353）and Buddelea（S57.371）。
S53.356. Apocynaceae 夹竹桃科（IIBa.121；10/24）
Alyxia 念珠藤属，Anandronan 铁线属，Cerbera 椰果属，Holarhena 止涕木属，Melolinus 山橙属，Parsonia 爬藤属，Rauvolfia 萝芙木属，Tabernaemontana 马蹄花属，Trachelospermum 绵石属，Urceola（including Edysanthera）水壶藤属；adding Alstonia 黑板树属（Wu et al. 2010）and Catharanthus 长春花属（Vinca in Wu et al. 2010）；including IIBa.122 Asclepiadaceae（Asclepias 尖尾藤属，Cryptolepis 隐鳞藤属，Cynanchum 牛皮消属，Dischidia 风不動属，Dregae 華他卡藤属，Gymnema 武靴藤属，Heterostemma 布朗藤属，Hoya 吟兰属，Jasminanthes 舌濕花属，Marsdenia 牛弭菜属，Telosma 夜香花属，and Tylophora 鸡勐属）。

S54. Boraginales 紫草目（sensu Luebert et al. 2016）
S54.357. Boraginaceae 紫草科（IIBa.126；12/8）
Bothriopsernum 紫穗子草属，Cynoglossum 琉璃草属，Lithospermum 紫草属，Thyrocarpus 术草属，Trichodesma 碧草属，and Trigonotis 附地草属；adding Myosotis 忘忘草属（Wu et al. 2010）and Symphytum 聚合草属（Wu et al. 2010）；excluding S54.357B Coldeniaeae（Coldenia），S54.357C Cordiaceae（Cordia），S54.357D Ehretiaceae（Carmona and Ehretia），and S54.357E Heliotropiaceae（Heliotropium and Tournefortia）。

S54.357B. Coldeniaeae 生草果科（1）
Coldenia 生草果属（IIBa.126 Boraginaceae）。
S54.357C. Cordiaceae 花布子科（1）
Cordia 花布子属（IIBa.126 Boraginaceae）。
S54.357D. Ehretiaceae 厚殼樹科（1）
Ehretia（including Carmona）厚殼樹属（IIBa.126 Boraginaceae）。
S54.357E. Heliotropiaceae 天芹菜科（1）
Heliotropium（including Tournefortia）天芹菜属（IIBa.126 Boraginaceae）。
S55. Vahliales 黃漆姑目

S56. Solanales 茄目
S56.359. Convolvulacesae 旋花科 (≡ IIBa.124)
S56.360. Solanaceae 茄科 (≡ IIBa.130)
S56.362. Sphenocleaceae 密穗桔梗（尖瓣花）科 (≡ IIBa.142A)
S56.363. Hydroleaceae 田基麻科 (1)
Hydrolea 探芹草属 (IIBa.125 Hydrophyllaceae)

S57. Lamiales 唇形目
S57.366. Oleaceae 木犀科 (≡ IIBa.118)
S57.369. Gesneriaceae 苦苣苔科 (≡ IIBa.134)
S57.370. Plantaginaceae 车前科 (IIBa.138; 1/16)
Plantago 车前属; including IIBa.128 Callitrichaceae (Callitriche 水马齿属) and IIBa.131 Scrophulariaceae pro parte [Antirrhinum] 金鱼草属 (Chen and Wang 2014), Bacopa 遇长沙属, Deinostemma 柽柳根属, Digitalis 毛地黄属, Dopratinum 虹眼草属, Ellisiophyllum 海嫁菊属, Hemiphragma 腰果花属, Limnophila 石龍尾属, Mecardonia 遇长沙属, Microcarpaea 微果草属, Scoparia 野甘草属, Stemodia (学生花属; Liang et al. 2011), Veronica 娘婆纳属, and Veronicastrum 腹水草属).
S57.371. Scrophulariaceae 花荵科 (IIBa.131; 26/3)
Scrophularia 花荵属 (花荵属); including Buddleia 揭波属 (IIBa.119 Loganiaceae) and IIBa.137 Myoporaceae (Myoporum 苦蓝盘属); excluding S57.370 Plantaginaceae pro parte (Bacopa, Deinostema, Digitalis, Dopratinum, Ellisiophyllum, Hemiphragma, Limnophila, Mecardonia, Microcarpaea, Scoparia, Veronica, and Veronicastrum), S57.373 Linderniaceae (Legazpia, Lindernia, and Torenia), S57.384 Mazaceae (Mazus), S57.385 Phrymaceae (Mimulus), S57.386 Paulowniaceae (Paulownia), and S57.387 Orobancheae pro parte (Alectra, Centranthera, Euphrasia, Pedicularis, Phtheirospermum, Siphonostegia, and Striga).

S57.373. Linderniaceae 母草科 (4)
IIBa.131 Scrophulariaceae pro parte [Legazpia 三翅草属, Lindernia 母草属, Micranthemum 珍珠草属 (Hsu et al. 2016a), and Torenia 倒地蜈蚣属].

*S57.376. Pedaliaceae 胡麻 (芝麻) 科
S57.377. Acanthaceae 爵床科 (IIBa.133; 15/20)
Adding Asystasia 十萬錯属 (Wu et al. 2010), Nelsonia 滴子草属 (Wang et al. 2016), and Thunbergia 鄧伯花属 (Wu et al. 2010); including Avicennia 海茄苳属 (IIBa.127 Verbenaceae).

S57.378. Bignoniaceae 紫葳科 (≡ IIBa.132)
S57.379. Lentibulariaceae 獭蒞科 (≡ IIBa.136)
S57.382. Verbenaceae 馬鞭草科 (IIBa.127; 11/5)
Lantana 馬鞭草属, Phyla 鴨舌碗屬, Stachytarpheta 木馬鞭草属, Verbenca 馬鞭草属; adding Duranta 假鐵觀屬 (Wu et al. 2010); excluding Avicennia (S57.377) and S57.383 Lamiaeae pro parte (Callicarpa, Caryopteris, Clerodendrum, Premna, Sphenodesme, and Vitex).
S57.383. Lamiaeae (≡ Labiatae) 唇形科
Including IIBa.127 Verbenaceae pro parte [Callicarpa 紫珠屬, Caryopteris 藥屬, Clerodendrum 海州常山屬, Premna 魚臭木屬, Sphenodesme 檀翅藤屬, Tectona 柚木屬 (Wu et al. 2010), and Vitex 牡荊屬].
S57.384. Mazaceae 泉草科 (1)
Mazus 泉草属 (IIBa.131 Scrophulariaceae)
S57.385. Phrymaceae 獴毒草（透骨草）科 (3)
Erythranthe (Mimusulus; Barker et al. 2012) 溝酸漿屬 (IIBa.131 Scrophulariaceae), Pelipedium 罵鳥屬 (Hsu et al. 2016b), and Phryma 獴毒草屬 (Jung et al. 2005).
S57.386. Paulowniaceae 泡桐科 (1)
Paulownia 泡桐屬 (IIBa.131 Scrophulariaceae).
S57.387. Orobancheae 列當科 (IIBa.135; 4/14)
Aeginetia 野菰屬, Boschniakia 草蓴盒屬, Christisonia 假野菰屬, Orobanche 列當屬; adding Phacellanthus 黃花珍珠屬 (Chung et al. 2010b); including IIBa.131 Scrophulariaceae pro parte [Alectra 碎骨屬, Centranthera 鉢蕊花屬, Euphrasia 珊瑚草屬, Lathraea 齒麟草屬 (Chung et al. 2010a), Melampyrum山蓮花屬 (Chen and Wang 2009), Pedicularis 馬先蒿屬, Phtheirospermum 松果屬, Siphonostegia 陰行草屬, and Striga 獴腳金屬].

S58. Aquifoliales 冬青目
S58.388. Stemonuraceae 金檀木（粗榧木）科 (1)
Gomphandra 毛蕊木屬 (IIBa.78 Icacinaceae)
S58.389. Cardiopteridaceae 心翼果科 (1)
Conocarpium 瑪欖屬 (IIBa.78 Icacinaceae)
S58.391. Helwingiaceae 青莢葉目 (1)
Helwingia 青莢葉屬 (IIBa.105 Cornaceae)
S58.392. Aquifoliaceae 冬青科 (≡ IIBa.74)

S59. Asterales 菊目
S59.394. Campanulaceae 桔梗科 (≡ IIBa.142)
S59.400. Menyanthaceae 睡菜科 (1)
Nymphoides 荊葉屬 (IIBa.120 Gentianaceae)
S59.401. Goodeniaceae 草海桐科 (≡ IIBa.143)
S59.403. Asteraceae (≡ Compositae) 菊科 (≡ IIBa.144)
S60. Escalloniales 南鼠刺 (吊片果) 目

S61. Bruniales 絨球花目

S62. Paracaryphiales 盔被花 (盔瓣花) 目

S63. Dipsaccales 川續断目

S63.408. Adoxaceae 五福花科 (2)

IIBa.139 Caprifoliaceae pro parte (Sambucus 接骨木属 and Viburnum 英莲属).

S63.409. Caprifoliaceae 忍冬科 (IIBa.139; 4/6) Abelia 六道木属 and Lonicera 忍冬属; including II Ba.141 Dipsacaceae (Scabiosa 山薔薇屬) and II Ba.140 Valerianaceae (Patrinia 故醬屬, Triplotegia 雙參屬, and Valeriana 畚草屬); excluding S63.408 Adoxaceae (Sambucus and Viburnum).

S64. Apiaceae 纖形目

S64.413. Pittosporaceae海桐科 (≡ II Ba.54)

S64.414. Araliaceae五加科 (IIBa.106; 10/11) Including Hydrocotyle 天胡荽属 (II Ba.107 Umbelliferae).

S64.416. Apiaceae (≡ Umbelliferae) 纖形科 (II Ba.107; 18/18)

Adding Foeniculum 香香屬 (Wu et al. 2010); excluding Hydrocotyle (S64.414).

Additional file

Additional file 1: Appendix S1. List of seed plant genera of Taiwan and their familial classification under the Phylogenetic Classification of Seed Plants of Taiwan.

Abbreviations

APG: Angiosperm Phylogeny Group; FOT: Flora of Taiwan; TaBiBF: Taiwan Biodiversity Information Facility; TaCIL: Catalogue of Life in Taiwan; TaEOL: Taiwan Encyclopedia of Life; TaEOL: Cryobanking Program for Wildlife Genetic Material in Taiwan; TELDAP: Taiwan e-Learning and Digital Archives Programs; GBIF: Global Biodiversity Information Facility; TaBiNET: Taiwan Biodiversity National Information Network.

Authors' contributions

C-TL and K-FC conceived the idea, designed the project, and wrote the manuscript. C-TL conducted data cleaning and data analysis. Both authors read and approved the final manuscript.

Author details

1 Department of Biological Resources, National Chiayi University, Chiayi 60004, Taiwan. 2 Research Museum and Herbarium (HAST), Biodiversity Research Center, Academia Sinica, Taipei 11529, Taiwan.

Acknowledgements

This work is supported by Forestry Bureau, Council of Agriculture [106AS-11.9.6-FB-e2 (to C-TL), 106-08.1-S8-17(3) (to K-FC), and 106AS-11.8.1-FB-e4 (to K-FC)] and Ministry of Science and Technology (MOST105-2621-B-001-002-MY3) (to K-FC).

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Not applicable.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Funding

Supported by Forestry Bureau, Council of Agriculture [106AS-11.9.6-FB-e2 (to C-TL), 106-08.1-S8-17(3) (to K-FC), and 106AS-11.8.1-FB-e4 (to K-FC)] and Ministry of Science and Technology (MOST105-2621-B-001-002-MY3) (to K-FC).

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 6 September 2017 Accepted: 10 November 2017

Published online: 21 November 2017

References

Barker WR, Nesom GL, Beardsley PM, Fragia NS (2012) A taxonomic conspectus of Phrymaceae: a narrowed circumscription for Mimulus, new and resurrected genera, and new names and combinations. Phytoneuron 39:1–60

Boufford DE, Ohashi H, Huang T-C, Hsieh C-F, Tsai J-L, Yang K-C, Peng C-I, Kuoh C-S, Hsiao A (2003) A checklist of the vascular plants of Taiwan. In: Editorial Committee of the Flora of Taiwan (ed) Flora of Taiwan, vol 6, 2nd edn. Department of Botany, National Taiwan University, Taipei, pp 15–139

Chao C-T, Tseng Y-H, Tseng H-Y (2013) Heteropyronatum altelobatum (Asparagaceae), comb. nov. Ann Bot Fennici 50:91–94. https://doi.org/10.1111/j.1095-8339.2009.00996.x

Chao C-T, Chen P-H, Tseng H-Y (2017) Linum usitatissimum L. (Linaceae), a newly naturalized species in Taiwan. Quart J For Res 39:107–111

Chapman AD (2005) Principles of data quality, version 10. Global Biodiversity Information Facility, Copenhagen

Chase MW, Reveal JL (2009) A phylogenetic classification of the land plants to accompany APG III. Bot J Lin Soc 161:122–127. https://doi.org/10.1111/j.1095-8339.2009.00996.x

Chen C-H, Wang C-M (2009) Melampyrum roseum Maxim. (Scrophulariaceae), a newly recorded genus and species in Taiwan. Taiwania 54:183–186

Chen C-H, Wang C-M (2014) Antirrhinum orontium L. (Scrophulariaceae), a newly naturalized genus and species in Taiwan. Coll Res 27:71–75

Christenhusz MJM, Reveal JL, Farjon A, Garden MF, Mill RR, Chase MW (2012) A taxonomic conspectus of the seed plants to accompany APG III. Bot J Lin Soc 161:122–127. https://doi.org/10.1111/j.1095-8339.2009.00996.x

Chung S-W, Hsu T-C, Jung M-I, Hsiao S-C, Fang W-U (2010a) Lathraea purpurea (Scrophulariaceae): a new generic record in Taiwan. Taiwan J For Sci 25:265–269

Chung S-W, Hsu T-C, Peng C-I (2010b) Phacellanthus (Orobanchaceae), a newly recorded genus in Taiwan. Bot Stud 51:531–536

Cronquist A (1968) The evolution and classification of flowering plants. Houghton Mifflin, Boston

De Smet Y, Granados Mendoza C, Wanke S, Goetghobeur P, Samain M-S (2015) Molecular phylogenetics and new (infra) generic classification to alleviate polyphyly in tribe Hydrangeeae (Cornales: Hydrangeaceae). Taxon 64:741–753. https://doi.org/10.12705/644.6

Herbert J (2005) New combinations and a new species in Morella (Myricaceae). Novon 15:293–295

Hsieh C-F (2003) Composition, endemism and phytogeographical affinities of the Taiwan Flora. In: Editorial Committee of the Flora of Taiwan (ed) Flora of Taiwan, vol 6, 2nd edn. Department of Botany, National Taiwan University, Taipei, pp 1–14
