

Phylogeny of the eudicots: a nearly complete familial analysis based on *rbcL* gene sequences

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Summary. A phylogenetic analysis of 589 plastid *rbcL* gene sequences representing nearly all eudicot families (a total of 308 families; seven photosynthetic and four parasitic families are missing) was performed, and bootstrap re-sampling was used to assess support for clades. Based on these data, the ordinal classification of eudicots is revised following the previous classification of angiosperms by the Angiosperm Phylogeny Group (APG). Putative additional orders are discussed (e.g. *Dilleniales*, *Escalloniales*, *Vitales*), and several additional families are assigned to orders for future updates of the APG classification. The use of *rbcL* alone in such a large matrix was found to be practical in discovering and providing bootstrap support for most orders. Combination of these data with other matrices for the rest of the angiosperms should provide the framework for a complete phylogeny to be used in macro-evolutionary studies.

INTRODUCTION

The angiosperms are the first division of organisms to have been re-classified largely on the basis of molecular data analysed phylogenetically (APG 1998). Several large-scale molecular phylogenies have been produced for the angiosperms, based on both plastid *rbcL* (Chase *et al.* 1993, 1999, *in press*) and *atpB* (Savolainen *et al.* *in press*) genes, and on 18S rDNA from the nuclear genome (Soltis *et al.* 1997a; Soltis & Soltis 1998a). At higher taxonomic levels, these genes have also been combined in pairs (Bayer *et al.* 1999, Savolainen *et al.* *in press*, Nickrent & Soltis 1995, Soltis *et al.* 1997a) or the three altogether (Chase *et al.* 2000, Hoot *et al.* 1999, Soltis *et al.* 1999a, Soltis *et al.* *in press*). Combined analyses of these genes have always led to

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better resolution and higher bootstrap or jackknife percentages (Chase & Cox 1998, Savolainen *et al.* in press, Soltis *et al.* 1998, Soltis *et al.* 1999a, Soltis *et al.* in press). Recently, several studies focused on the palaeodicots (basal angiosperms with mostly uniaperturate pollen) have used even more genes, with up to five being combined to identify *Amborella* as the sister to all other angiosperms (Qiu *et al.* 1999). Despite the fact that these studies presented a comprehensive sampling of the angiosperms, few studies have included all families. Chase *et al.* (2000) sampled all but one monocot family (*Hydatellaceae*) and Hoot & Crane (1995), Hoot *et al.* (1999) and Qiu *et al.* (1993, 1998, 1999) included all lower dicot and palaeodicot families in their respective analyses. The APG classification (1998) lists 65 families not assigned to order. Unpublished results have also shown some families to be polyphyletic, and some of the synonymies presented in APG (1998) could be reconsidered. With improving use of herbarium specimens in DNA studies (Savolainen *et al.* 1995, Fay *et al.* 1998a) and because a DNA bank now holds over 10,000 extracts at Royal Botanic Gardens, Kew, it became both feasible and desirable to obtain molecular data for all angiosperm families. In this paper, we provide a nearly complete phylogeny of eudicot families, the bulk of the flowering plants (viz. angiosperms with triaperturate pollen, principally caryophyllids, rosids and asterids), based on an analysis of plastid *rbcL* gene sequences. The *rbcL* gene has proved useful at resolving interfamilial relationships (see review in Soltis & Soltis 1998b, Chase & Albert 1998); it is by far the most widely used gene in plant phylogenetics with over 4600 entries already available in the EMBL/GenBank/DDBJ databases (e.g. <http://www.ebi.ac.uk>). We present here a phylogenetic analysis of 589 eudicots representing 308 families (including 104 new *rbcL* sequences). Seven photosynthetic families are still missing since we could not obtain any usable material, and several of the parasitic plant families were not included since *rbcL* is either absent or only present as a pseudogene (Nickrent *et al.* 1998, see Table 1).

TABLE 1. Families of uncertain position according to APG (1998) for which DNA data are highly desirable, with indication of number of genera and species, as well as parasites (P, see text).

Family (No. genera/spp.)	Distribution
<i>Dipentodontaceae</i> (1/1)	Northeast India, Southern China, Burma
<i>Hoplestigmataceae</i> (1/2)	West equatorial Africa
<i>Medusandraceae</i> (1/1)	West tropical Africa
<i>Metteniusaceae</i> (1/3)	Northwest and South America
<i>Pottingeriaceae</i> (1/1)	Assam, northern Thailand
<i>Rhynchoscytaceae</i> (1/1)	Natal and Transkei, Southern Africa
<i>Tepuianthaceae</i> (1/5)	Guyana, Venezuela
<i>Balanophoraceae</i> (17/120/P)	Pantropical
<i>Cynomoriaceae</i> (1/2/P)	Mediterranean
<i>Cytinaceae</i> (1/7/P)	Mediterranean, Africa, Madagascar
<i>Mitragastromonaceae</i> (1/2/P)	Southeast Asia, Japan, Central America

MATERIALS AND METHODS

Taxa, voucher information for new sequences and accession numbers of all DNA sequences are listed in Appendix 1. Total DNA from fresh, silica gel-dried or herbarium specimens was extracted using the 2X CTAB method of Doyle & Doyle (1987) and subsequently purified through caesium chloride gradient. Some samples were further purified with silica columns (QIAquick™, Qiagen, according to manufacturer's protocol); this removes a degree of *Taq* inhibition, presumably from phenolic compounds not removed by gradient purification. For recently produced sequences, the *rbcL* exon was amplified by PCR (usually 28–30 cycles, 1 min denaturation at 95°C, 30 sec annealing at 50°C, 1 min extension at 72°C, 7 min final extension) using primers 1F (5'-ATGTCACCACAAACAGAAC-3') and 1460R (5'-TCCTTTAGTAAAGATTGGGCCGAG-3'; Olmstead *et al.* 1992, Fay *et al.* 1998a). Amplification products were then purified using QIAquick™ columns. Cycle sequencing (26 cycles, 10 sec denaturation at 96°C, 5 sec annealing at 50°C, 4 min extension at 60°C) with dye terminators was performed in 5 µl volumes on the cleaned PCR products and then purified by simple ethanol precipitation. The re-suspended samples were run on a PE Applied Biosystems Inc. 377 automated DNA sequencer following the manufacturer's protocols (PE Applied Biosystems Inc.). Both strands were sequenced using the amplification primers and additional internal primers 636F (5'-GCGTTGGAGAGATCGTTCT -3') and 724R (5'-TCGCATGTACCTGCAGTAGC -3'); these sequencing primers provided 80–90% overlapping and complementary pairs of sequences.

Not all DNAs were obtained according to the above protocol since we used sequences from various origins. The above protocol was also slightly modified when using herbarium specimens. For instance, bovine serum albumin (0.40% w/v) was added to the PCR mix because it is useful for recalcitrant DNA samples (Savolainen *et al.* 1995), and long DNA precipitation (>two weeks) was performed using isopropanol instead of ethanol prior to caesium gradients (Fay *et al.* 1998a). Double-PCR was performed, starting with an amplification using 20 cycles from which 1 µl after QIAquick purification was used in a second PCR amplification with 20 cycles using the same primers. Primer combinations 1F-724R or 636F-1460R were used to amplify *rbcL* in smaller fragments (Fay *et al.* 1998a), but PCR cycles were otherwise identical to those described above.

Sequences were aligned manually (1428 base pairs matrix) without indels (all raw data and matrices are available from VS and MWC; see also Appendix for details). Phylogenetic analysis was performed using PAUP*4.0b2a (Swofford 1998). Most-parsimonious trees were obtained from 1000 replicates of random taxon addition using equal weights and tree-bisection-reconnection (TBR) branch swapping, with only five trees held at each step (NCHUCK = 5). The variable positions in *rbcL* alone are insufficient to provide evidence for all branching patterns in such a complex phylogenetic tree. We also know that extensive swapping will indeed find shorter trees than the ones shown here, but these trees would be equally poor estimates of the true phylogeny (Chase & Cox 1998, Chase *et al.* in press). Therefore, our aim here was to provide a tree in which we can identify well-supported groups as estimated using the bootstrap (bootstrap

support, BS; Felsenstein 1985). One thousand bootstrap replicates were performed using the SPR swapping algorithm (which is faster than TBR) with simple addition of taxa and only 10 trees held at each step. The tree was rooted with *Ranunculales*, which are sister to all other eudicots according to numerous studies (Chase *et al.* 1993, Savolainen *et al.* in press, Soltis *et al.* 1998, in press, Soltis *et al.* 1999a, Hoot *et al.* 1999).

RESULTS AND DISCUSSION

The results of the phylogenetic analysis are presented in Figs 1–10 (one tree of 17401 steps, consistency index 0.12, retention index 0.58, ACCTRAN optimisation). Branch length (numbers above branches) and bootstrap support (numbers below branches) are also indicated. Phylogenetic relationships based solely on *rbcL* will misplace many taxa due to sampling error (i.e. too few variable positions), and groups without internal support greater than c. 75% are unreliable (they are subject to change with addition of either more taxa or more data). Identification of well-supported families, orders and supra-ordinal clades is the only reasonable task that can be achieved with the data at hand. Knowing which clades are consistent in all shortest trees is of little utility, so we illustrate only one tree with bootstrap percentages. Congruence with other data is of course more important than internal support as a mean of reliability, and this is mentioned in the text. For the remaining families unassigned to orders or for which aberrant placements are due to sampling error (Chase *et al.* in press), we need more data. Most results presented here are in agreement with previous large-scale phylogenetic analyses of angiosperms (Chase *et al.* 1993, Hoot *et al.* 1999, Qiu *et al.* 1999, Savolainen *et al.* in press, Soltis *et al.* 1997a, 1997b, 1998, in press, Soltis *et al.* 1999a, as well as the APG 1998 classification). In the following discussion we have cited these papers only when our results deviated from those studies, but we have provided additional and specific references for many smaller clades.

Early-Diverging Taxa

The early-diverging eudicot taxa (Fig. 1), or 'lower' eudicots, consist of the orders *Ranunculales* and *Proteales*, plus *Sabiaceae*, *Didymelaceae/Buxaceae* (BS 90%) and *Trochodendraceae* (including *Tetracentraceae*, BS 100%). *Ranunculales* consist of seven families (*Berberidaceae*, *Circaeasteraceae* (including *Kingdoniaceae*), *Eupteleaceae*, *Lardizabalaceae* (including *Sargentodoxaceae*), *Menispermaceae*, *Papaveraceae* (including *Fumariaceae* and *Pteridophyllaceae*), *Ranunculaceae*, BS 59% excluding *Papaveraceae*) whereas *Proteales* consist only of *Platanaceae/Proteaceae* (BS 69%) and *Nelumbonaceae* (APG 1998). The sister position of *Sabiaceae* to *Nelumbonaceae* in Fig. 1 could be due

Figs 1–10. One most parsimonious tree resulting from the exploratory phylogenetic analysis of *rbcL* for 589 taxa (see Material and Methods, length 17401 steps, consistency index 0.12, retention index 0.58, ACCTRAN optimisation). Number of steps are indicated above the branches, and bootstrap values over 50% are indicated below the branches. Note that any node that does not receive BS of at least 75% is unreliable (see text). Because of its size, the tree has been broken into ten parts: eudicots (1), *Caryophyllales* (2), rosids (3), *Malpighiales* (4), eurosids I *pro parte* (5), eurosid II (6), *Sapindales* (7), asterids (8), euasterids II (9), euasterids I (10).

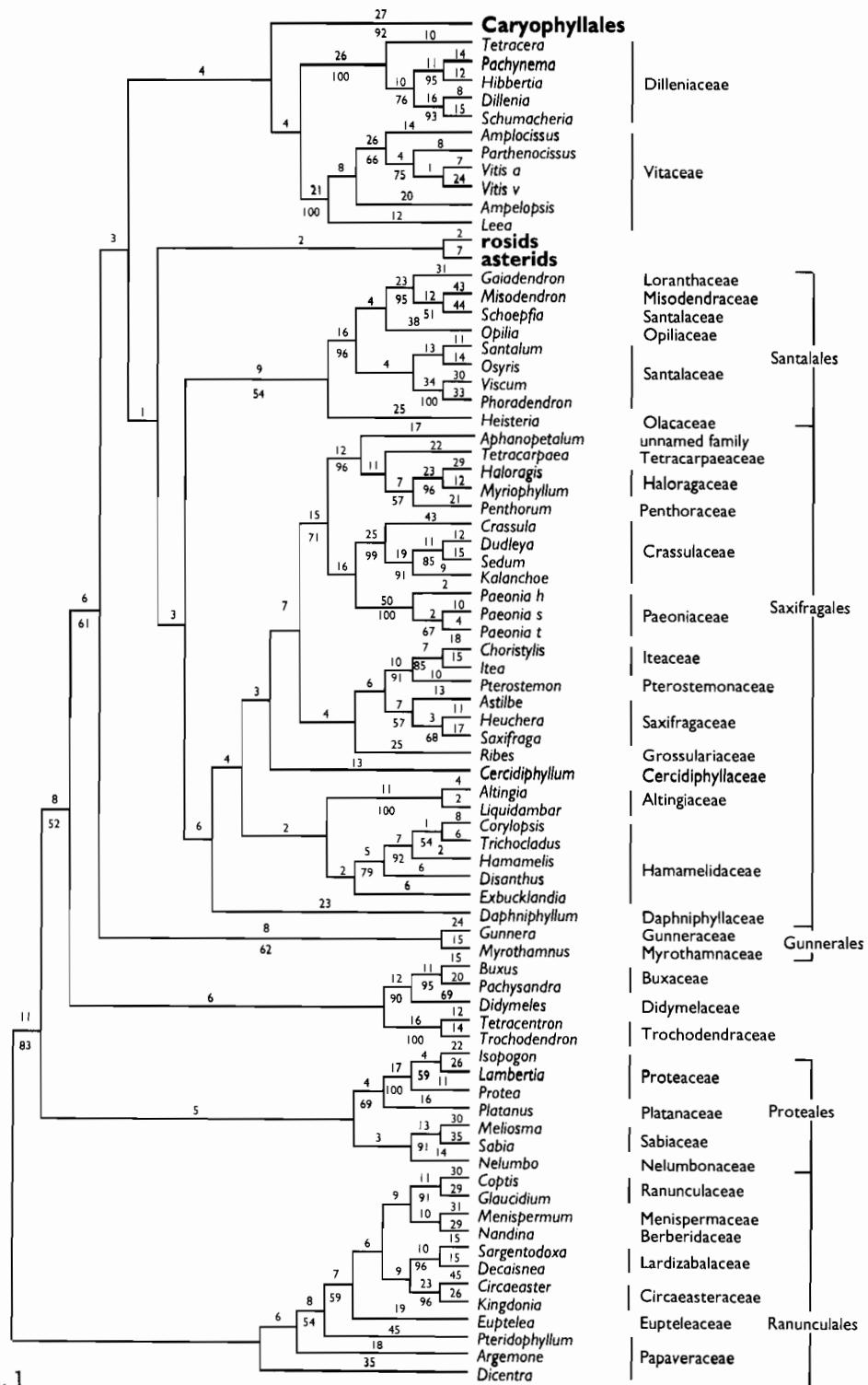


FIG. 1

to sampling error since Soltis *et al.* (in press) showed *Sabiaceae* to be unresolved with *Proteales* based on the combination of *atpB*, *rbcL* and 18S rDNA. The paraphyly of *Papaveraceae* in Fig. 1 is also probably due to sampling error. Affinities depicted here are mostly in agreement with previous publications from Hoot & Crane (1995), Hoot *et al.* (1995a, b, 1999) and Qiu *et al.* (1998).

Core Eudicots

The core eudicots according to APG (1998) consist of 23 orders, most of which (excluding *Caryophyllales*, *Santalales*, *Saxifragales*) have been included in two informal higher categories: rosids (including eurosids I and II, see Figs 3–7) and asterids (including euasterids I and II, see Figs 8–10). Rosids here include the order *Geraniales* unplaced in APG (1998), plus eurosids I (*Cucurbitales*, *Fabales*, *Fagales*, *Malpighiales*, *Oxalidales*, *Rosales*) and eurosids II (*Brassicaceles*, *Malvales*, *Myrtales*, *Sapindales*). Asterids included three orders unplaced in APG (1998), *Ericales*, *Cornales* and *Garryales*, plus euasterids I (*Gentianales*, *Lamiales*, *Solanaceles*) and euasterids II (*Apiales*, *Aquifoliaceles*, *Asterales*, *Dipsacales*). In addition, APG included in core eudicots 35 families not assigned to order: *Adoxaceae*, *Aextoxicaceae*, *Aphloiacae*, *Berberidopsidaceae*, *Boraginaceae*, *Bruniaceae*, *Carlemanniaceae*, *Celastraceae*, *Columelliaceae*, *Crossosomataceae*, *Desfontainiaceae*, *Dilleniaceae*, *Eremosynaceae*, *Escalloniaceae*, *Gunneraceae*, *Huaceae*, *Icacinaceae*, *Ixerbaceae*, *Krameriaceae*, *Myrothamnaceae*, *Parnassiaceae*, *Picramniaceae*, *Plocospermataceae*, *Podostemaceae*, *Polyosmaceae*, *Sphenostemonaceae*, *Stachyuraceae*, *Stackhousiaceae*, *Staphyleaceae*, *Tapisciaceae*, *Tribelaceae*, *Tristichaceae*, *Vahliaceae*, *Vitaceae* and *Zygophyllaceae*. In this analysis, eudicots (BS 61%) consist of all orders described above plus several additional orders and families. For descriptive purposes, we discuss below each order *sensu* APG (1998) and Soltis *et al.* (in press) in succession and their current familial composition. The previously unplaced families are discussed in each section with recommendations for their classification. Detailed familial descriptions can be found at <http://biodiversity.bio.uno.edu/delta/angio/index.htm> (Watson & Dallwitz 1992 and onwards), whereas discussions regarding morphological synapomorphies for most orders can be found in Nandi *et al.* (1998), Savolainen *et al.* (in press) and Soltis *et al.* (in press).

Santalales

Santalales (Fig. 1, BS 54%) consist of six families, mostly parasitic: *Loranthaceae*, *Misodendraceae*, *Olacaceae*, *Opiliaceae*, *Santalaceae* and *Viscaceae*. This delimitation of the order is roughly in agreement with APG (1998), Nickrent & Starr (1994) and Nickrent *et al.* (1994, 1998), but *Viscaceae* is here included in *Santalaceae* based on *rbcL* and 18S rDNA combined. According to the same studies and as also observed here, *Schoepfia* is not a member of *Olacaceae* but is instead sister to *Misodendraceae*.

Saxifragales

Saxifragales (Fig. 1) consist of 13 families that correspond to their circumscriptions in APG (1998): *Altingiaceae*, *Cercidiphyllaceae*, *Crassulaceae*, *Daphniphyllaceae*, *Grossulariaceae*, *Haloragaceae*, *Hamamelidaceae*, *Iteaceae*, *Paeoniaceae*, *Penthoraceae*, *Pterostemonaceae*, *Saxifragaceae* and *Tetracarpaeaceae* (*Aphanopetalum* is

kept here as a member of an un-named family). The order does not receive BS >50% in this analysis, but some subgroups received strong support (e.g. *Tetracarpaeaceae/Haloragaceae/Penthoraceae* BS 96%, *Pterostemonaceae/Iteaceae* BS 96%). *Choristylis* should be considered a member of *Iteaceae*. This delimitation is in agreement with Fishbein *et al.* (submitted), Soltis *et al.* (1990, 1993, 1996, 1997b), Morgan & Soltis (1993), Johnson & Soltis (1994, 1995) and Soltis & Soltis (1997).

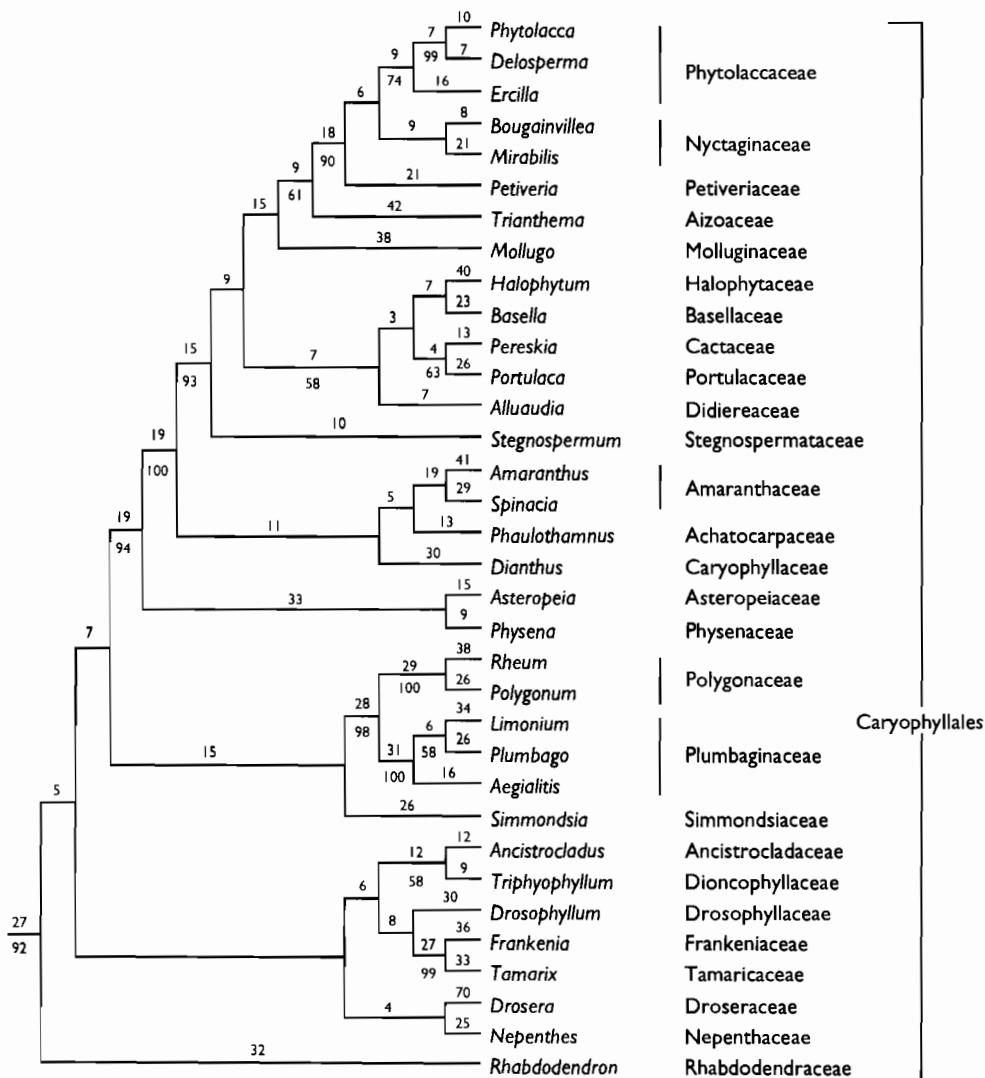


FIG. 2

Caryophyllales

Caryophyllales (Fig. 2, BS 92 %) include here 27 families for which several inter-familial relationships receive support: *Achatocarpaceae*, *Aizoaceae*, *Amaranthaceae*, *Ancistrocladaceae*, *Asteropeiaceae*, *Basellaceae*, *Cactaceae*, *Caryophyllaceae*, *Didiereaceae*, *Dioncophyllaceae*, *Droseraceae*, *Drosophyllaceae*, *Frankeniaceae*, *Halophytaceae*, *Molluginaceae*, *Nepenthaceae*, *Nyctaginaceae*, *Petiveriaceae*, *Physenaceae*, *Phytolaccaceae*, *Plumbaginaceae*, *Polygonaceae*, *Portulacaceae*, *Rhabdodendraceae*, *Simmondsiaceae*, *Stegnospermataceae*, *Tamaricaceae*. An expanded concept of *Caryophyllales* is in agreement with previous studies by Albert *et al.* (1992), Rettig *et al.* (1992), Downie *et al.* (1997), Fay *et al.* (1997a, b), Morton *et al.* (1997a), Lledó *et al.* (1998) and Clement & Mabry (in press), but none of these investigations sampled all families (see also caryophyllid families in Kubitzki *et al.* 1993). Many families of *Caryophyllales* are highly specialized (halophytes, carnivores, succulents etc.) and peculiar in various aspects. Several members have anomalous secondary growth or floral development (e.g. pseudodiplostemony, Ronse Decraene *et al.* 1998) and do not have the typical tricolpate pollen of the eudicots (Nandi *et al.* 1998, Savolainen *et al.* in press). Compared to APG (1998), our results indicate that *Halophytaceae* and *Petiveriaceae* should be added to the order *Caryophyllales*. We could not obtain material of *Sarcobataceae*, which APG included in this order (see also Downie *et al.* 1997). *Halophytaceae* consist of one succulent species from Patagonia, which has been included in *Amaranthaceae* [=*Chenopodiaceae*] by several authors (including APG 1998; see also Bittrich 1993) based on floral morphology, succulent leaves and exine structure of the pollen grains. In this analysis, *Halophytaceae* falls with *Basellaceae/Cactaceae/Didieraceae/Portulacaceae* (BS 58%), but not with *Amaranthaceae*; thus its present separate familial status should be maintained, pending further data. *Petiveriaceae* consist of one species from tropical and subtropical America (but sometimes also include more species from genera other than *Petiveria*); they have also been included in *Phytolaccaceae*. Our results indicate that they merit familial status since *Petiveria* is sister to *Nyctaginaceae/Phytolaccaceae* rather than being included in *Phytolaccaceae*, but additional data are necessary because BS is <50% for this result.

Oxalidales

Oxalidales (Fig. 3, BS 88%) consist of six families: *Brunelliaceae*, *Cephalotaceae*, *Connaraceae*, *Cunoniaceae* (including *Eucryphiaceae* and *Davidsoniaceae*), *Elaeocarpaceae* and *Oxalidaceae*. *Tremandraceae* (three genera and 45 species from Australia: *Platytheca*, *Tetratheca*, *Tremandra*) are embedded within *Elaeocarpaceae* (BS 65%). *Brunelliaceae*, a monogeneric family from tropical America, are also a member of *Oxalidales*. They were included in *Cunoniaceae* in APG (1998), but their position here sister to *Elaeocarpaceae/Cunoniaceae/Cephalotaceae* may justify continued familial status (Fig. 3).

Berberidopsidales

Berberidopsidales consist of two small families from Chile and Australia: *Berberidopsidaceae* and *Aextoxicaceae*. This assemblage (Fig. 3, BS 57%) could represent relicts of an ancient flora as noted previously (Savolainen *et al.* in press).

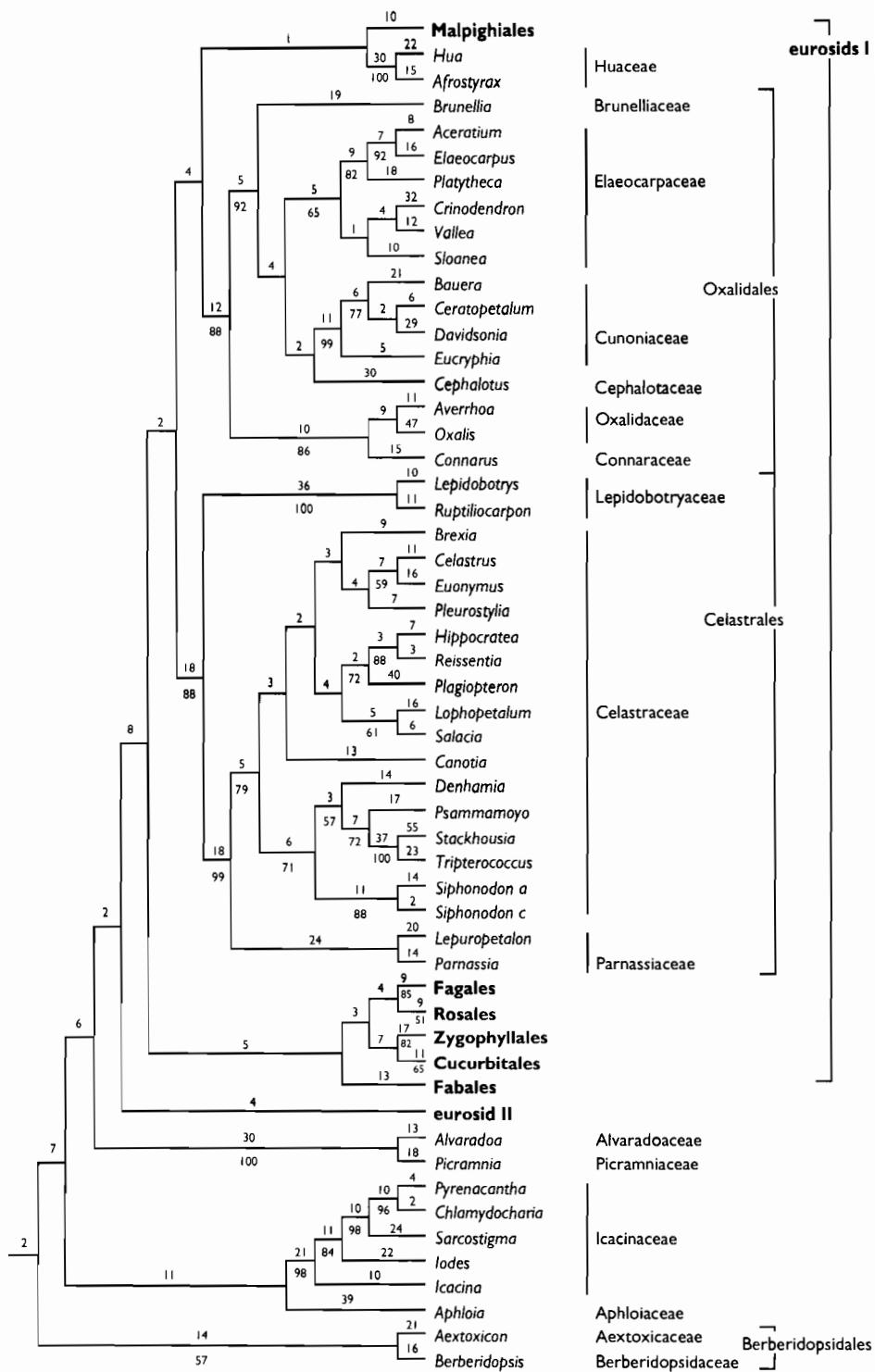


FIG. 3

Their placement relative to other orders remains unclear, even with a combined analysis of *atpB/rbcL* and 18S rDNA (Soltis *et al.* 1999a, Soltis *et al.* in press). This order was not defined in APG (1998).

Celastrales

Celastrales (Fig. 3, BS 88%) consist of three families: *Lepidobotryaceae*, *Parnassiaceae* (including *Lepuropetalaceae*) and *Celastraceae* (including *Brexiaceae*, *Hippocrateaceae*, *Stackhousiaceae* and *Plagiopteraceae*; see Baas *et al.* (1979), for details of *Plagiopteron*). The delimitation of this order has been variable with most of its previous members (viz. *sensu* Cronquist 1981) now being assigned to other orders (Savolainen *et al.* 1994, 1997). The order as recircumscribed here is reduced to its core family *Celastraceae* plus two rather peculiar small families: *Parnassiaceae* (*Lepuropetalon/Parnassia*; BS 100%) include the smallest terrestrial angiosperm (*Lepuropetalon*, see Chase *et al.* 1993), whereas *Lepidobotryaceae* show a geographical disjunction between Central America (*Ruptiliocarpon*) and tropical Africa (*Lepidobotrys*). It is also noteworthy that *Psammamoya* is sister to *Stackhousia/Tripterococcus* (BS 72%). These two latter genera were members of the *Stackhousiaceae*, but their inclusion in *Celastraceae* with *Psammamoya* as sister compares well with their geographical distribution (Australia) and their habit (xerophytic perennial rhizomes with reduced leaves and photosynthetic succulent stems). *Celastrales* were not recognised by APG (1998) with their families being unplaced under eurosids I; high BS (88%) justifies the resurrection of the order.

Malpighiales

Malpighiales are a large order including 36 families: *Balanopaceae*, *Bonnetiaceae*, *Caryocaraceae*, *Chrysobalanaceae*, *Clusiaceae*, *Ctenolophonaceae*, *Dichapetalaceae*, *Elatinaceae*, *Erythroxylaceae*, *Euphorbiaceae*, *Euphroniaceae*, *Goupiaceae*, *Hugoniaceae*, *Humiriaceae*, *Hypericaceae*, *Irvingiaceae*, *Ixonanthaceae*, *Kiggelariaceae* (including *Achariaceae*), *Lacistemaceae*, *Linaceae* (including *Hugoniaceae*), *Lophopyxidaceae*, *Malesherbiaceae*, *Malpighiaceae*, *Ochnaceae* *sensu lato* (including *Medusagynaceae* and *Quiinaceae*), *Pandaceae*, *Passifloraceae*, *Peridiscaceae*, *Phyllanthaceae*, *Podostemaceae* (including *Tristichaceae*), *Pseudanthaceae*, *Putranjivaceae*, *Rhizophoraceae*, *Salicaceae* (including *Flacourtiaceae pro parte* and *Syphostegiaceae*), *Trigoniaceae*, *Turneraceae* and *Violaceae*. The entire group of families received BS < 50%, but several sub-groups received high BS (see Fig. 4). This ordinal delimitation comprises all families *sensu* APG (1998), apart from *Achariaceae*, which are embedded within *Kiggelariaceae* (93% BS for *Acharia* sister to *Guthriea*; 100% for *Acharia/Guthriea* sister to *Kiggelaria/Gynocardia/Trichadenia*). In addition we have embedded *Medusagynaceae* and *Quiinaceae* in *Ochnaceae*, the entire clade receive 97% BS whereas there is no clear pattern for the separation of the three families. It is also in agreement with several studies in which the entire order received bootstrap or jackknife support (Savolainen *et al.* in press, Soltis *et al.* 1999a, Soltis *et al.* in press, Litt & Chase 1999). *Kiggelariaceae sensu stricto* (viz. one single species from tropical and South Africa, *Kiggelaria africana*) was included in *Flacourtiaceae* in APG (1998) whereas our results indicate that *Kiggelariaceae sensu lato* merit familial status (BS 100% excluding *Erythrospermum*). Apart from *Achariaceae*, *Kiggelariaceae* include *Gynocardia odorata*

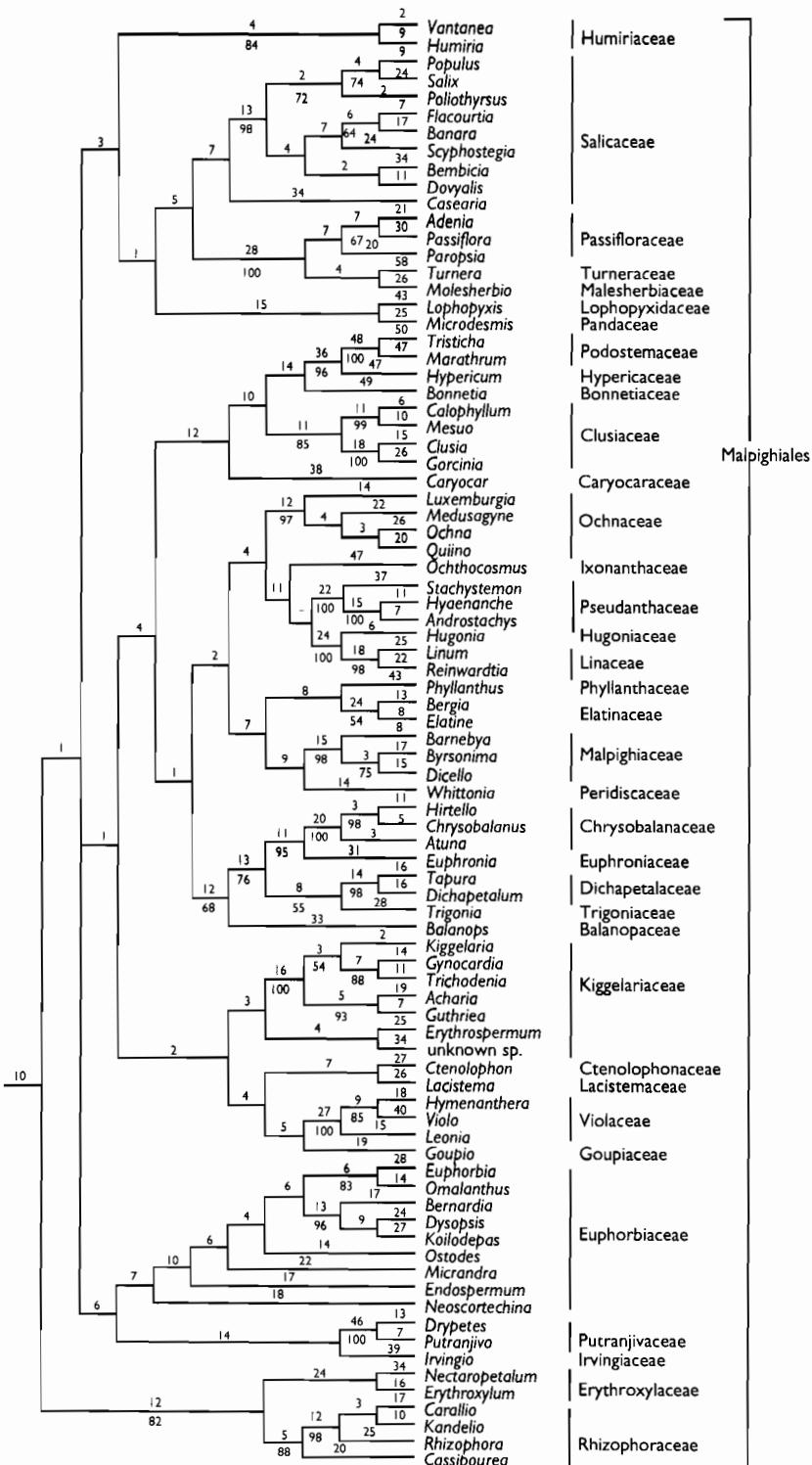


FIG. 4

from Assam and Burma and *Trichadenia* (two species from Sri Lanka and Malaysia). *Ochnaceae sensu stricto* do not appear monophyletic in this study, with *Medusagyne* falling between *Luxemburgia* and *Ochna*. Other studies resolved a monophyletic *Ochnaceae* (e.g. Fay *et al.* 1997b). However, relationships within the clade *Medusagyne/Ochnaceae/Quiinaceae* (BS 97%) remain unclear and lack BS >50%.

Compared to APG (1998), our results also indicate that five additional families are members of *Malpighiales*: *Bonnetiaceae*, *Ctenolophonaceae*, *Lophopyxidaceae*, *Peridiscaceae* and *Podostemaceae* (including *Tristichaceae*). *Bonnetiaceae* (excluding *Ploiarium* from Southeast Asia which is related to *Thymelaeaceae*; see *Malvales* below) include 30 species from tropical America and were included in *Theales* by Dahlgren (1980) and Cronquist (1981). *Ctenolophonaceae* comprise three species from tropical Africa and western Malaysia; their pollen type already indicated a close relationship with *Malpighiaceae* (Saad 1962). *Lophopyxidaceae* were originally included in *Celastrales* by Cronquist (1981); they include a single species from Malaysia and the western Pacific, *Lophopyxis maingayi*. *Peridiscaceae* comprise *Peridiscus* and *Whittonia* from South America; they were of uncertain position in APG (1998), but our results indicate that they are sister to *Malpighiaceae*. *Phyllanthaceae* were included in *Euphorbiaceae* at a subfamily level, but those results and others indicate that *Phyllanthoideae* warrant familial status; the same applies to *Oldfieldioideae*, elevated here to family *Pseudanthaceae*. *Podostemaceae*, a pantropical aquatic family comprising c. 200 species, appear to be members of *Malpighiales*. Based on molecular data, Les *et al.* (1997) included *Podostemaceae* in *Saxifragales* but this study did not include any *Malpighiales*. *Tristichaceae* (two pantropical species) should be included in *Podostemaceae* (BS 100%, see Soltis *et al.* 1999b), whereas they were unassigned to order in rosids by APG (1998).

Nitrogen-fixing orders

Several families of the closely related orders *Cucurbitales*, *Fabales*, *Fagales* and *Rosales* (Fig. 5) form associations with nitrogen-fixing bacteria, suggesting a single origin for the predisposition for this key physiological process (Soltis *et al.* 1995). *Cucurbitales* (BS 65%) consist here of seven families: *Anisophylleaceae*, *Begoniaceae*, *Coriariaceae*, *Corynocarpaceae*, *Cucurbitaceae*, *Datiscaceae* and *Tetramelaceae*. *Fabales* (BS 82 %) consist of four families: *Fabaceae*, *Polygalaceae* (including *Xanthophyllaceae*), *Quillajaceae* and *Surianaceae*. *Fagales* (BS 85%) consist of eight families: *Betulaceae*, *Casuarinaceae*, *Fagaceae*, *Juglandaceae*, *Myricaceae*, *Nothofagaceae*, *Rhoipteleaceae* and *Ticodendraceae*. In this study, *Casuarinaceae* are embedded in *Betulaceae*, but with greater sampling the two families are separated (Sytsma *et al.* unpubl.). *Rosales* (BS 51%) consist of 11 families: *Barbeyaceae*, *Cannabaceae*, *Cecropiaceae*, *Celtidaceae*, *Dirachmaceae*, *Elaeagnaceae*, *Moraceae*, *Rhamnaceae*, *Rosaceae*, *Ulmaceae* and *Urticaceae*. All the above sets of relationships are in agreement with APG (1998). However, contrary to what seems to be indicated for *Rhamnaceae*, this family includes both *Rhamnus* and *Zizyphus*. These two genera do not form a monophyletic group based on *rbcL*, and *Elaeagnaceae* appear embedded within *Rhamnaceae*. However, this is a well-known problem that has been addressed by Thulin *et al.* (1998) and Richardson *et al.* (in press), and addition of data from other sources resolved the monophyly of *Rhamnaceae*.

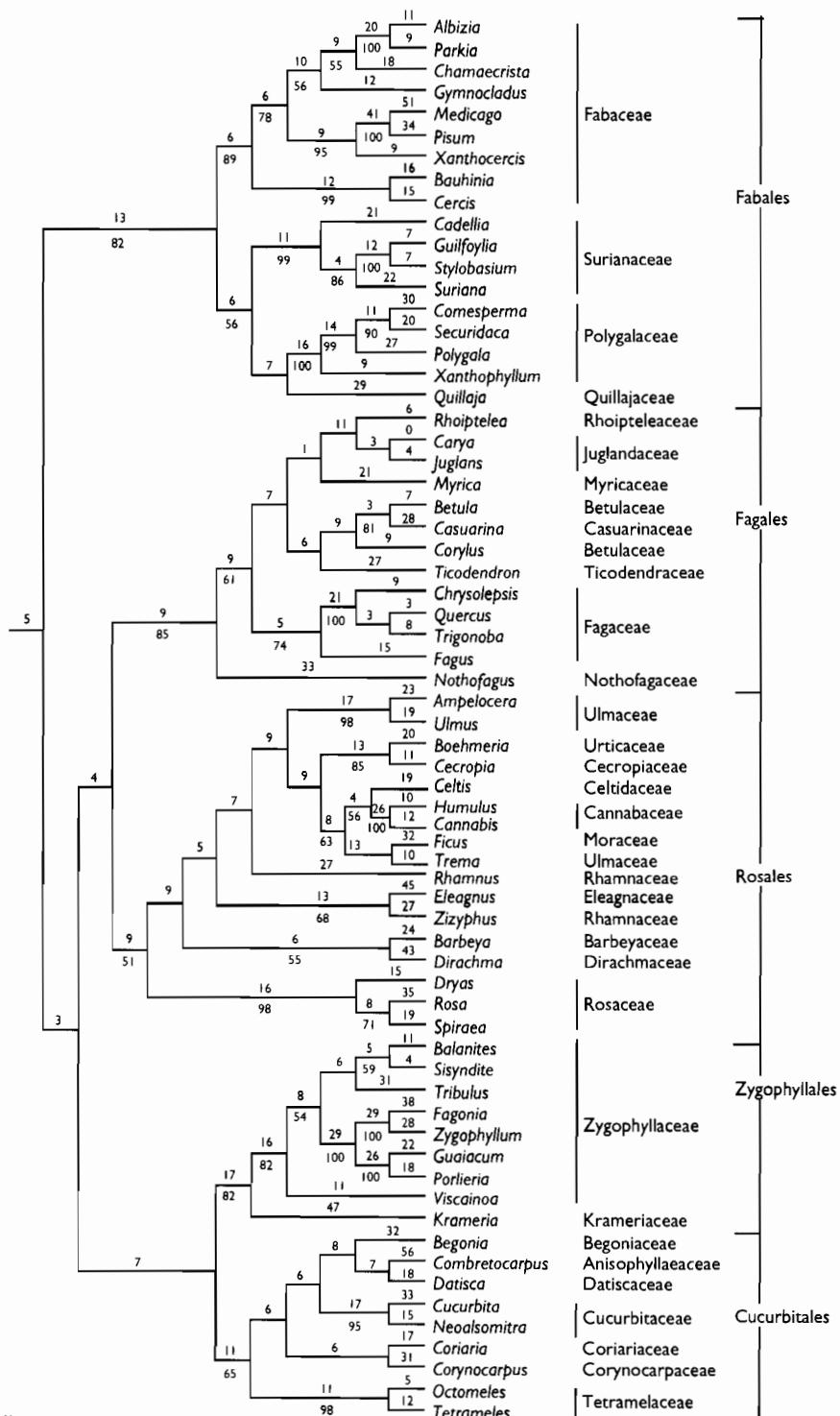


FIG. 5

Zygophyllales

Zygophyllales (Fig. 5, BS 82%) include two families: *Zygophyllaceae* and *Krameriaceae*. They are included in eurosids I as previously reported by Soltis *et al.* (1999a) and Soltis *et al.* (in press) based on *atpB*, *rbcL* and 18S rDNA. This order was not used by APG (1998) with their families being included under rosids (see also Sheahan & Chase 1996 & in press, for a detailed analysis based on molecular data and anatomy/morphology). Their exclusion from all of the rosid orders indicates that recognition of *Zygophyllales* is appropriate.

Geriales

Geriales (Fig. 6) consist of three families: *Geraniaceae* (including *Hypsecharitaceae*), *Melianthaceae* (including *Francoaceae* and *Greyiaceae*) and *Vivianaceae* (including *Ledocarpaceae*), thus reducing by half the number of families in this order compared to APG (1998, see also Price & Palmer 1993). *Melianthaceae*, including *Francoaceae* and *Greyiaceae*, share pinnately veined leaves, gamosepaly, tendency to tetramerous, anatropous ovules, outer integument contributing to the micropyle, embryo-sac development of *Polygonum*-type, basal to axile placentation and a small embryo with copious endosperm. In addition, *Greyiaceae* and *Melianthaceae* have calcium oxalate crystals in wood parenchyma, multilacunar nodes and similar wood anatomy; Cronquist (1981) also reports that the pollen of *Greyia* is very similar to that of *Bersama*.

Brassicales

Brassicales (Fig. 6, BS 88%) consist of 14 families: *Akaniaceae*, *Bataceae*, *Brassicaceae*, *Caricaceae*, *Gyrostemonaceae*, *Koeberliniaceae*, *Limnanthaceae*, *Moringaceae*, *Pentadiplandraceae*, *Resedaceae*, *Salvadoraceae*, *Setchellanthaceae*, *Tovariaceae* and *Tropaeolaceae*. As previously reported (Gadek *et al.* 1992, Rodman *et al.* 1993, 1998), this order includes all families producing mustard oils (glucosinolates) except *Drypetes* (*Putranjivaceae*), which is a member of *Malpighiales*. *Brassicales* as circumscribed here are congruent with APG (1998) except for the exclusion of *Emblingiaceae*. Placement of *Emblingiaceae* (a monotypic family from Western Australia) within *Brassicales* was probably due to misidentified material. The original sequence is potentially from a member of *Gyrostemonaceae*, which are common in the same localities after fires and have a similar habit to *Emblingia* (the voucher for this material cannot be found; C. Quinn, UNSW, pers. comm.). We have used here an independent, properly vouchered and verified collection of *Emblingia*, and *Emblingiaceae* are embedded in *Gentianaceae* (BS 100%), correlating well with their fused sepals and petals. *Tapisci* (one species from China) is sister to *Brassicales* (BS <50%) but is not included in this order with additional genes in all shortest trees (*Tapisciaceae* fall as sister to the whole eurosids II in Soltis *et al.* in press, but they were without assignment to order in APG 1998).

Malvales

Malvales (Fig. 6) consist of 11 families: *Bixaceae*, *Cistaceae*, *Cochlospermaceae*, *Diegodendraceae*, *Dipterocarpaceae*, *Malvaceae* (including *Bombacaceae*, *Tiliaceae* and *Sterculiaceae*), *Muntingiaceae*, *Neuradaceae*, *Sarcolaenaceae*, *Sphaerosepalaceae* and *Thymelaeaceae*. Despite receiving BS<50%, *Malvales* as circumscribed are in

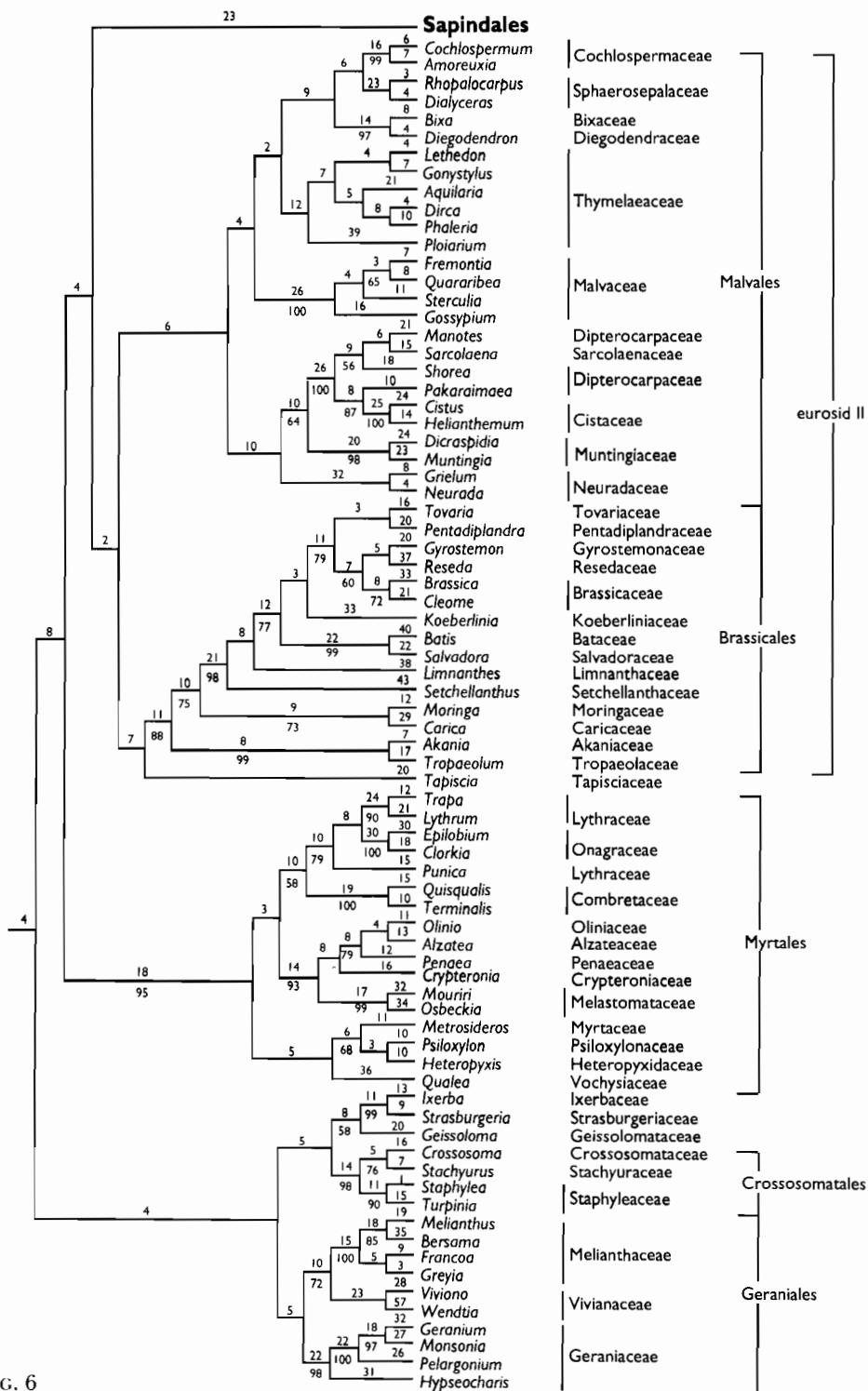


FIG. 6

agreement with APG (1998) and studies from Alverson *et al.* (1998), Bayer *et al.* (1998, 1999), Fay *et al.* (1997a) and Dayanandan *et al.* (1999). *Ploiarium* (the only Old World *Bonnetiaceae*, ranging from Southeast Asia to Papua New Guinea) is a member of *Thymelaeaceae*.

Myrtales

Myrtales (Fig. 6, BS 95%) here consist of 13 families: *Alzateaceae*, *Combretaceae*, *Crypteroniaceae*, *Heteropyxidaceae*, *Lythraceae* (including *Punicaceae* and *Trapaceae*), *Memecylaceae*, *Melastomataceae*, *Myrtaceae*, *Oliniaceae*, *Onagraceae*, *Penaeaceae*, *Psiloxylaceae* and *Vochysiaceae*. *Myrtales* as circumscribed here agree with APG (1998) except that we have not been able to get material of *Rhynchocalycaceae* (Table 1). *Rhynchocalycaceae* are a monospecific family from Natal and Transkei (southern Africa); they have also been considered to be related to *Myrtales* by Dahlgren (1980) and Cronquist (1981). With greater sampling, Conti *et al.* (1996) showed *Punicaceae* and *Trapaceae* to be embedded within *Lythraceae*.

Crossosomatales

Crossosomatales include three families (Fig. 6): *Crossosomataceae*, *Stachyuraceae* and *Staphyleaceae* (excluding *Tapisciaceae*, see *Brassicales*). *Crossosomataceae* are microphyllous xerophytic shrubs from North America; *Stachyuraceae* include five species from Himalaya to Japan whereas *Staphyleaceae* comprise c. 60 species from southwestern Europe, eastern Asia and the Americas. *Crossosomatales* were not recognised by APG (1998) with their families being unplaced under rosids; high BS (98%) justify the recognition of Takhtajan's order. In addition, *Aphloiaceae* received BS<50% for their placement, but they are sister to *Iacinaeae* in Fig. 3 (see below for comments on what we view as an aberrant placement). However, based on combined *atpB*, *rbcL* and 18S rDNA (Soltis *et al.* 1999a; Soltis *et al.* in press) *Aphloia* is sister to *Ixerba* with 73% jackknife support, and *Ixerba/Aphloia* are then sister to *Crossosomatales* (56% jackknife support); with *rbcL* alone (this paper) *Ixerba* is sister to *Strasburgeria* (BS 99%), and these two are sister to *Geissoloma* (BS 58%). Thus, if these relationships are confirmed (especially using additional data for *Geissoloma* and *Strasburgeria*), then *Crossosomatales* could be expanded to include *Geissolomataceae* (one species in South Africa), *Ierbaceae* (one species in New Zealand), *Strasburgeriaceae* (one species in New Caledonia) and perhaps *Aphloiaceae* (one species in East Africa, Madagascar and the Mascarenes).

Sapindales

Sapindales (Fig. 7, BS 74%) consist of ten families: *Anacardiaceae*, *Biebersteiniaceae*, *Burseraceae*, *Kirkiaceae*, *Meliaceae*, *Nitrariaceae*, *Peganaceae*, *Rutaceae*, *Sapindaceae* (including *Aceraceae* and *Hippocastanaceae*) and *Simaroubaceae*. This definition of *Sapindales* is in agreement with APG (1998) and previous studies based on molecular data (Bakker *et al.* 1998, Gadek *et al.* 1996). *Beiselia* is sister to and distant from the rest of *Burseraceae* and has distinct features, for example in pollen structure (Clarkson *et al.* in prep.). *Lissocarpa* falls within *Rutaceae* (BS 72%); because the *rbcL* sequence was obtained from degraded herbarium DNA, this rather peculiar placement needs confirmation. However the sequence was unique and should be

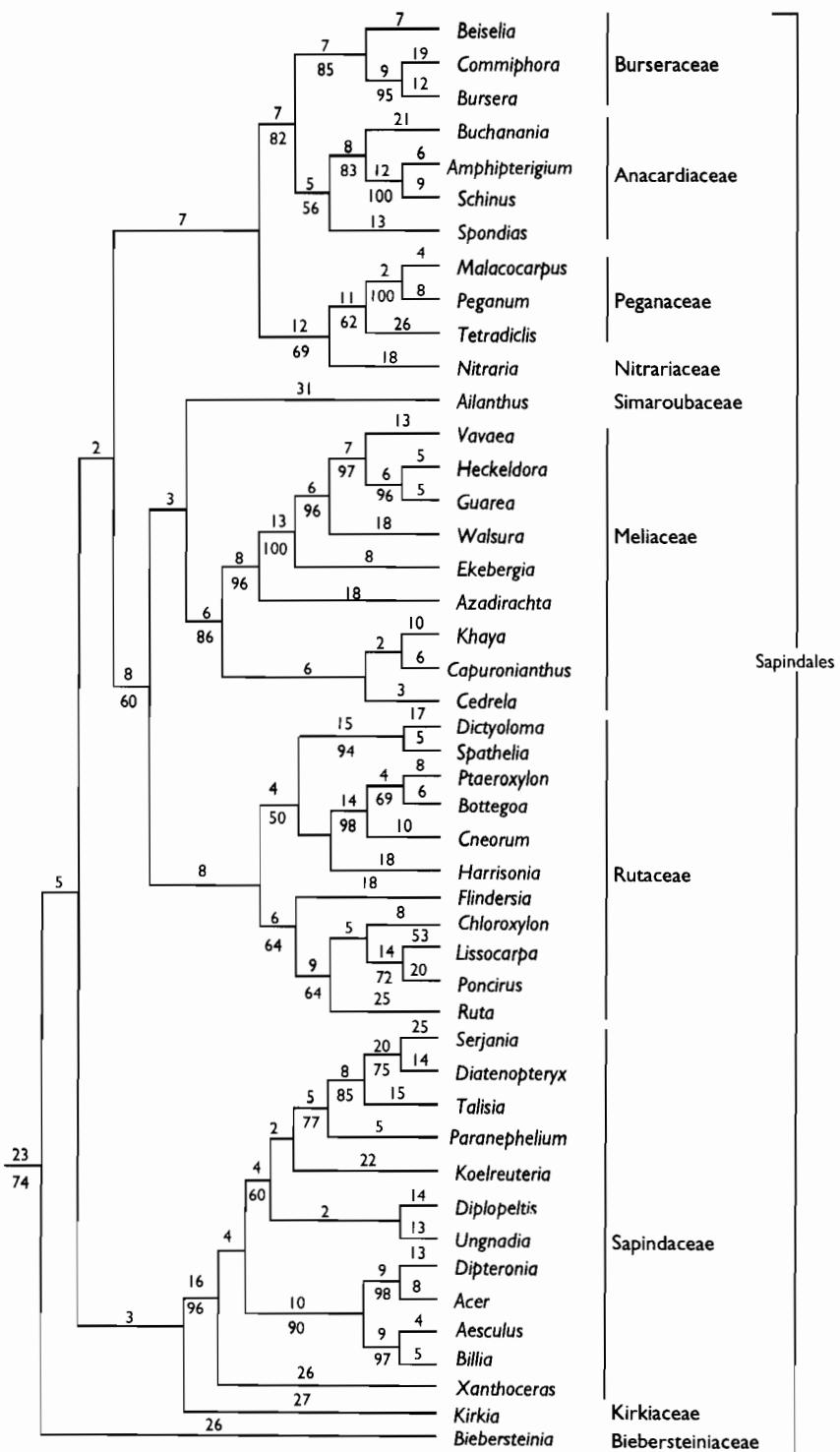


FIG. 7

considered seriously. *Tetradiclis* falls into *Peganaceae* whereas it was previously included in *Zygophyllaceae* (Sheahan & Chase 1996).

Cornales

Cornales (Fig. 8) consist of six families: *Cornaceae*, *Grubbiaceae*, *Hydrangeaceae*, *Hydrostachydaceae*, *Loasaceae* and *Nyssaceae*. In Soltis *et al.* (in press), this order received 98% jackknife support (apart from *Grubbiaceae* which were not included), but *rbcL* alone does not provide BS >50% except for *Hydrangeaceae*/*Loasaceae* (62%, Fig. 8). *Loasaceae* appear paraphyletic (Fig. 8), but this could be due to sampling error (see Hempel *et al.* 1995).

Ericales

Ericales (Fig. 8, BS 73%) consist of 24 families: *Actinidiaceae*, *Balsaminaceae*, *Clethraceae*, *Cyrillaceae*, *Diapensiaceae*, *Ebenaceae*, *Ericaceae*, *Fouquieriaceae*, *Lecythidaceae* (including *Scytopetalaceae*), *Marcgraviaceae*, *Myrsinaceae*, *Pellicieraceae*, *Polemoniaceae*, *Primulaceae*, *Roridulaceae*, *Sapotaceae*, *Sarraceniaceae*, *Sladeniaceae*, *Styracaceae* (including *Halesiaceae*), *Symplocaceae*, *Ternstroemiaceae*, *Tetrameristaceae*, *Theaceae* and *Theophrastaceae*. This corresponds to *Ericales* *sensu* APG (1998) and is in agreement with previous molecular studies from Anderberg *et al.* (1998), Johnson & Soltis (1995), Johnson *et al.* (1996, 1999), Kron (1996, 1997), Kron & Chase (1993) and Morton *et al.* (1997b), except that *Sladeniaceae* are added here. *Sladeniaceae* are a monospecific family from Burma, Yunnan and Thailand that were classified under ‘families of uncertain position’ in APG (1998). Their position in *Ericales* compares well with previous views from Dahlgren (1980) and Cronquist (1981) that placed *Sladeniaceae* in *Theales/Theaceae*; they could be considered as part of *Ternstroemiaceae*. We were only able to amplify half a sequence for *rbcL* so this position needs confirmation. *Halesiaceae* were recognized by APG (1998) as distinct, but because *Halesia* falls here as sister to *Styrax*, a broader circumscription of *Styraceae* is more appropriate.

Garryales

Garryales (Fig. 9) consist of four families: *Aucubaceae*, *Eucommiaceae*, *Garryaceae* and *Oncothecaceae*. This order received BS<50% (only *Aucuba/Garrya* received 98% BS). *Aucubaceae* (*Aucuba*) consist of three species from Himalaya to Japan. *Garryaceae* (*Garrya*) contain 18–20 species from southeastern USA, Central America and the West Indies. *Eucommiaceae* contain only one species from China, and *Oncothecaceae* (*Oncotheca*) contain only two species from New Caledonia. The assemblage *Garrya/Aucuba/Eucommia* is in agreement with APG (1998). The inclusion of *Oncothecaceae* in *Garryales* needs confirmation because with three genes (Soltis *et al.* in press) *Oncotheca* falls with other asterids (jackknife support <50%).

Apiales

Apiales (Fig. 9, BS 76%) consist of seven families: *Apiaceae*, *Araliaceae*, *Aralidiaceae*, *Griselinaceae*, *Melanophyllaceae*, *Pittosporaceae* and *Torriliaceae* (see also Plunkett *et al.* 1997a, b). It is noteworthy that this order contains mostly polypetalous flowers whereas the vast majority of euasterids are characterized by gamopetalry; however, Erbar & Leins (1996) showed that members of *Apiales* exhibit early sympetalry.

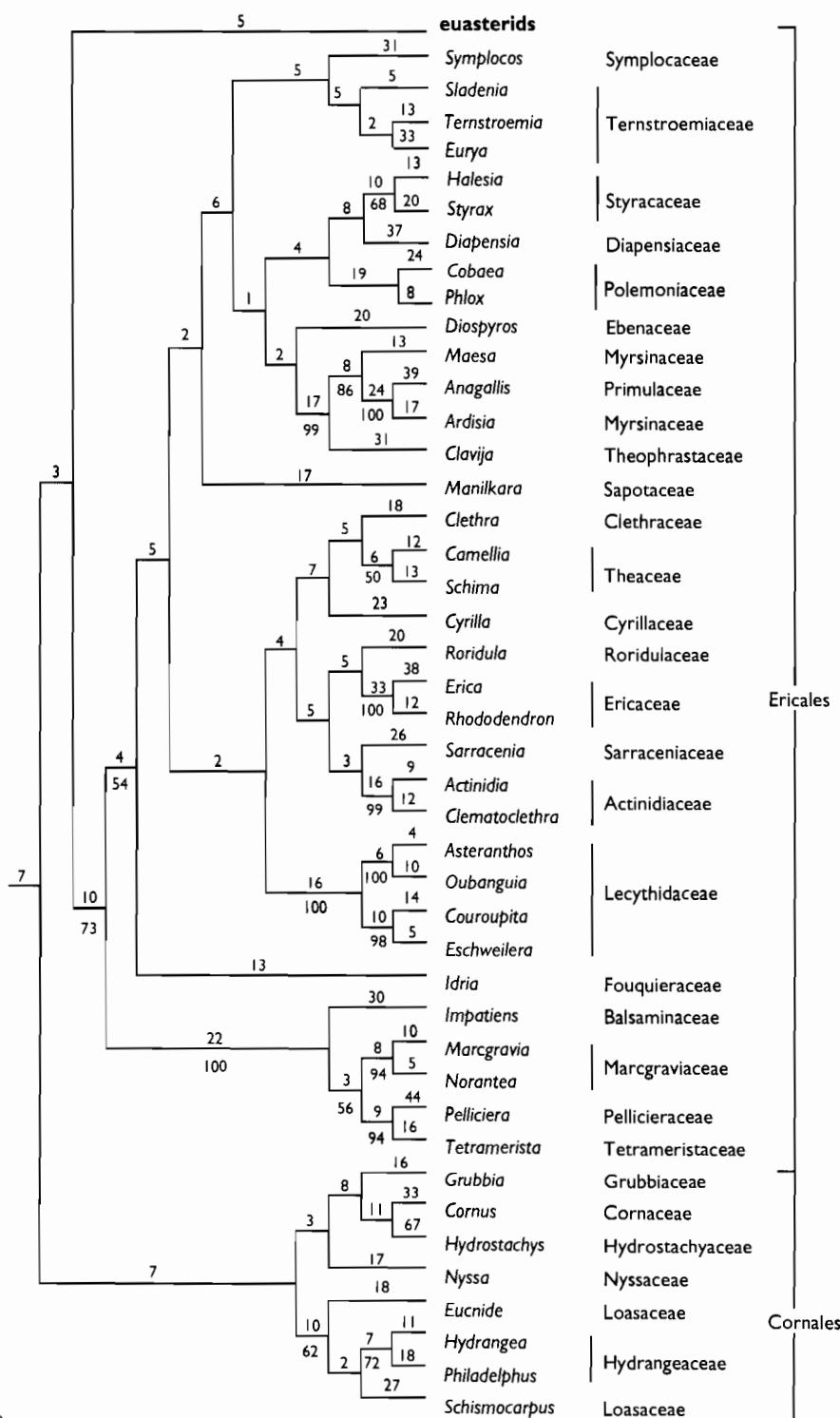


FIG. 8

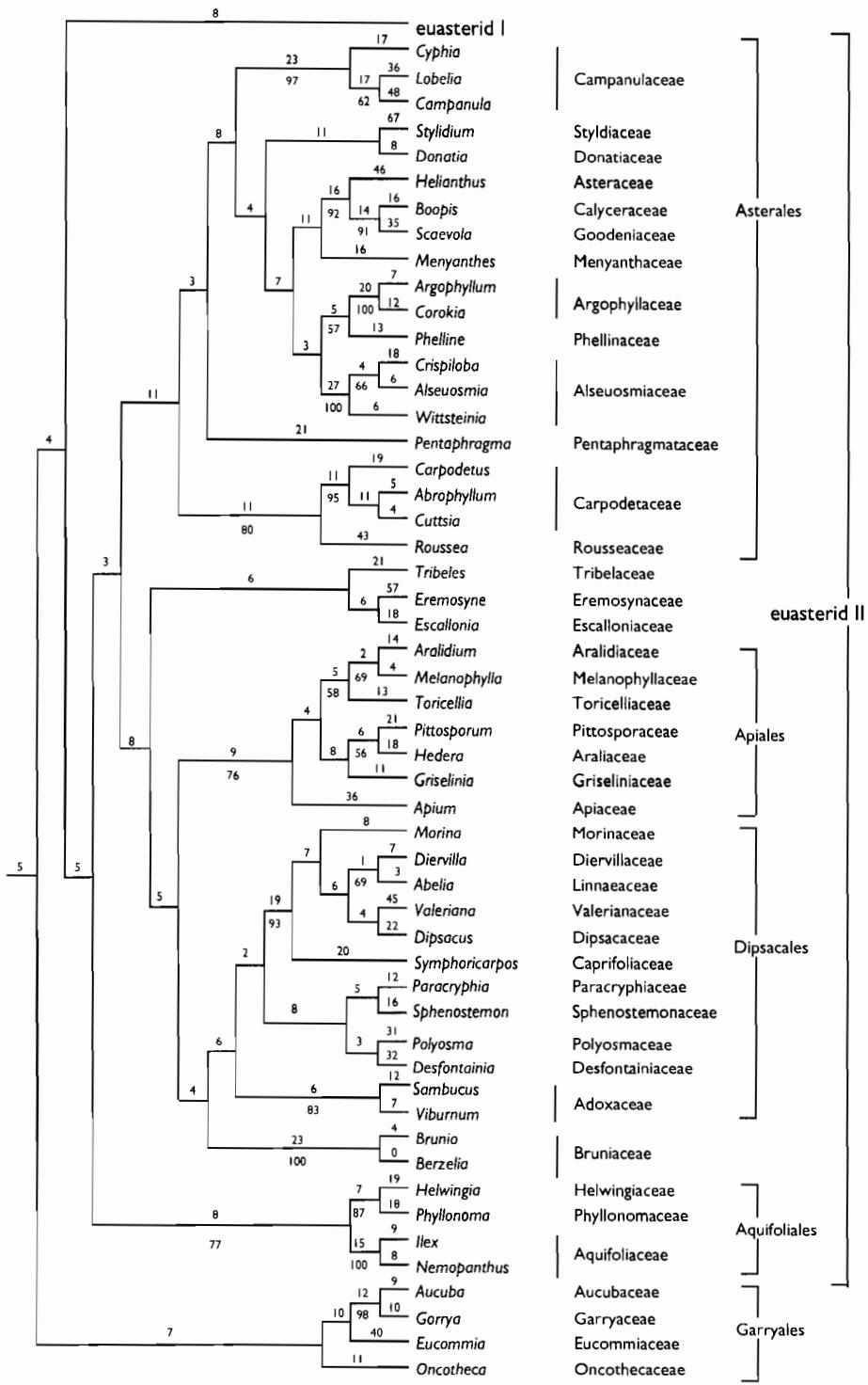


FIG. 9

Aquifoliales

Aquifoliales (Fig. 9, BS 77%) consist of three families: *Aquifoliaceae*, *Helwingiaceae* and *Phyllonomaceae*. *Aquifoliaceae* have over 300 species and one genus (*Ilex*, including *Nemopanthus*; Powell *et al.* 2000) mainly from South America and Southeast Asia, *Helwingiaceae* (*Helwingia*) have five species from eastern Himalaya to Japan and Taiwan, whereas *Phyllonomaceae* (*Phyllonoma*) have four species from Mexico to northwestern Bolivia. This alliance is rather peculiar with the two last families having epiphyllous inflorescences as previously noted by Chase *et al.* (1993). Reduction to a single family might be appropriate.

Asterales

Asterales (Fig. 9, BS 75%) consist of 13 families for which several inter-familial relationships receive support: *Alseuosmiaceae*, *Argophyllaceae*, *Asteraceae*, *Calyceraceae*, *Campanulaceae* (including *Lobeliaceae*), *Carpodetaceae*, *Donatiaceae*, *Goodeniaceae*, *Menyanthaceae*, *Pentaphragmataceae*, *Phellinaceae*, *Rousseaceae* and *Styliadiaceae*. This circumscription is in agreement with APG (1998).

Dipsacales

Dipsacales (Fig. 9) consist of eleven families: *Adoxaceae*, *Caprifoliaceae*, *Desfontainiaceae*, *Diervillaceae*, *Dipsacaceae*, *Linnaeaceae*, *Morinaceae*, *Paracryphiaceae*, *Polyosmaceae*, *Sphenostemonaceae* and *Valerianaceae*. Core *Dipsacales* include only *Caprifoliaceae*, *Diervillaceae*, *Dipsacaceae*, *Linnaeaceae*, *Morinaceae* and *Valerianaceae*, they received 93% BS. *Adoxaceae* should be included in *Dipsacales* despite the fact that *rbcL* alone does not provide support for this placement. A combined analysis of *atpB*, *rbcL* and 18S rDNA provided 86% jackknife support for this circumscription (Soltis *et al.* 1999a, Soltis *et al.* in press, see also Donoghue *et al.* 1992, Backlund & Bremer 1997). Finally, *Polyosmaceae* (60 species from Himalaya to tropical Australia) are sister to *Desfontainiaceae* (one species in the Andes) whereas Gustafsson *et al.* (1996) and Backlund & Bremer (1997) found *Desfontainia* to be sister of *Columellia* with BS>50%. *Columellia* is here sister to *Gentianales/Solanales/Lamiales* but with no BS>50% (Fig. 10). *Sphenostemonaceae* (seven species from eastern Malaysia, Queensland and New Caledonia) are sister to *Paracryphiaceae* (one species in New Caledonia) but with no BS>50%. For details on *Dipsacales* see also Backlund (1996) and Backlund *et al.* (in press).

Gentianales

Gentianales (Fig. 10, BS 75%) consist of five families: *Apocynaceae*, *Gelsemiaceae*, *Gentianaceae*, *Loganiaceae* and *Rubiaceae*, in agreement with APG (1998), Civeyrel *et al.* (1998) and Manen *et al.* (1994). *Emblingiaceae* are included in *Gentianaceae*, contrary to the APG placement (1998, viz. *Brassicales* due to a misidentification, see above). *Dialypetalanthaceae*, consisting of one species in eastern Brazil, should be included in *Rubiaceae* (Fay *et al.* in press).

Lamiales

Lamiales (Fig. 10) consist of 23 families (BS 56%, BS 67 % excluding *Plocospermum*): *Acanthaceae*, *Antirrhinaceae* (including *Plantaginaceae*), *Avicenniaceae*,

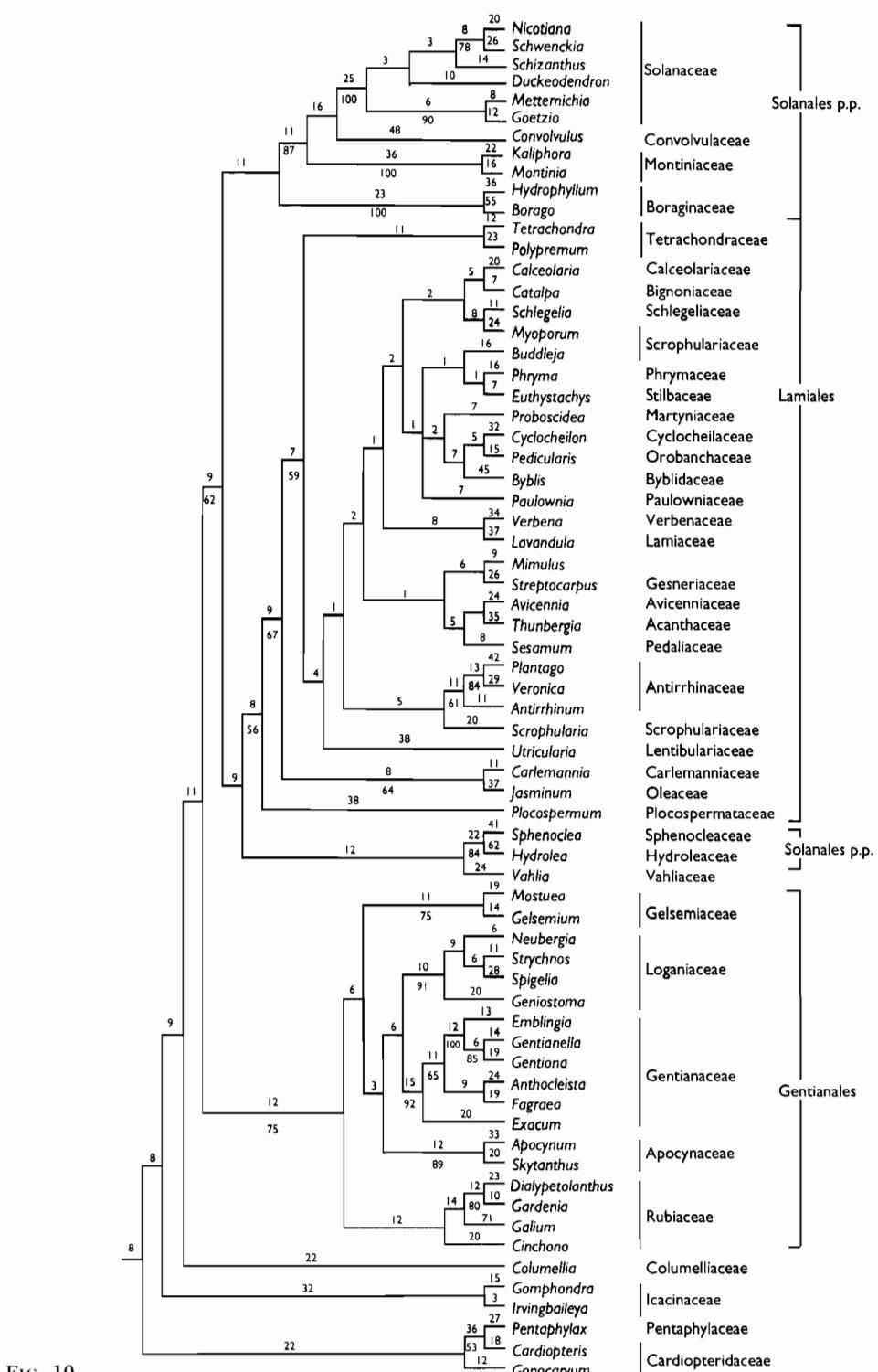


FIG. 10

Bignoniaceae, *Byblidaceae*, *Calceolariaceae*, *Carlemanniaceae*, *Cyclocheilaceae*, *Gesneriaceae*, *Lamiaceae*, *Lentibulariaceae*, *Martyniaceae*, *Oleaceae*, *Orobanchaceae*, *Paulowniaceae*, *Pedaliaceae*, *Phrymaceae*, *Plocospermataceae*, *Schlegeliaceae*, *Scrophulariaceae* (including *Buddlejaceae* and *Myoporaceae*), *Stilbaceae*, *Tetrachondraceae* and *Verbenaceae*. Compared to APG (1998), we have added here *Antirrhinaceae*, *Calceolariaceae*, *Carlemanniaceae*, *Martyniaceae*, *Plocospermataceae* and *Tetrachondraceae*, we have also included *Buddlejaceae* and *Myoporaceae* in *Scrophulariaceae* according to Olmstead *et al.* (1992, 1999, submitted, Oxelman *et al.* 1999), as well as *Plantaginaceae* in *Antirrhinaceae* according to Reveal *et al.* (1999). *Antirrhinaceae* (BS 61%) have been resurrected because *Scrophulariaceae* have been shown to be polyphyletic (Olmstead & Reeves 1995, Olmstead *et al.* 1999, pers. comm.). *Calceolariaceae* (slipper flowers) are new and distinct from *Scrophulariaceae sensu stricto* and include *Calceolaria* (250 species from South America), *Jovellana* (six species from New Zealand and Chile) and *Porodittia* (= *Stemotria*) from Peru (Olmstead *et al.* 1999, pers. comm.). *Carlemanniaceae* consist of five species and two genera (*Carlemannia* and *Silvianthus*) from Southeast Asia to Sumatra; they were included in *Caprifoliaceae/Dipsacales* by Cronquist (1981), but their connivent anthers compare well with their placement in *Lamiales* (BS 64% for *Carlemannia* sister to *Jasminum*). *Martyniaceae* comprise 13 species and four genera (*Proboscidea* included here) from tropical and subtropical America; they were included in *Pedaliaceae* in APG (1998) but our results as well as those of Olmstead *et al.* (1999, pers. comm.) indicate that their familial status should be maintained.

Plocospermataceae are a monogeneric family comprising three species from Central America; they were included in *Loganiaceae* by Cronquist (1981) and not assigned to order in APG (1998). *Tetrachondraceae* are a new family with two species and one genus (*Tetrachondra*) from Patagonia and New Zealand and *Polypteron procumbens* from tropical America (Oxelman *et al.* 1999, Olmstead *et al.* pers. comm.). Several other genera of the *Lamiales sensu* Olmstead *et al.* (pers. comm.) should receive familial status when additional information is available (e.g., *Mimulus* possibly to be assigned to family *Mimulaceae*). *Vahlia* could also be included in *Lamiales* (Olmstead *et al.* pers. comm.) despite the fact that they are sister to *Sphenocleaceae/Hydroleaceae* in this study (Fig. 10). *Vahlia* contain five species in the genus *Vahlia* (= *Bistella*) from tropical and South Africa (Cape) to northwestern India. *Vahlia* was included in *Saxifragaceae* (*Saxifragales*, Dahlgren 1980 or *Rosales*, Cronquist 1981) because of their free sepals/petals and were unassigned to order in APG (1998); the presence of iridoids and tenuinucellate ovules compare well with their placement within the asterids and *Lamiales*.

Although not likely to be popular with specialists, a more practical solution for family circumscription in *Lamiales* would be to recognise *Scrophulariaceae sensu lato*, including all these families except *Carlemanniaceae*, *Oleaceae* and *Plocospermataceae*. These families are morphologically and chemically coherent, and the low levels of sequence divergence are similar to many other large families. We find the emerging narrow family limits based on subtle morphological differences difficult to justify.

Solanales

According to APG (1998), *Solanales* (Fig. 10) consist of five families: *Convolvulaceae*, *Hydroleaceae*, *Montiniaceae* (including *Kaliphora*), *Solanaceae* (including

Duckeodendraceae and *Goetziaceae*) and *Sphenocleaceae*. In this study, however, these families do not form a monophyletic group making *Solanales* paraphyletic to *Lamiales* (Fig. 10). This is probably due to sampling error (*rbcL* by itself does not provide enough information). Based on a combined *atpB/rbcL/18S* rDNA analysis, *Solanales* received 96% jackknife support (Soltis *et al.* 1999a, Soltis *et al.* in press).

Families to be assigned to orders

Boraginaceae (including *Hydrophyllaceae*) remain unassigned to order in euasterid I (within *Lamiales/Gentianales/Solanales*, BS 62%), but based on *ndhF* they could be included in *Solanales* (Olmstead *et al.* 1999). Even using a combined analysis of *atpB*, *rbcL* and 18S rDNA (Soltis *et al.* 1999a, Soltis *et al.* in press) support for the inclusion of *Boraginaceae* within any order was lacking.

Bruniaceae include *Berzeliaeae* (BS 100%); this South African clade remains unassigned to order within euasterid II (APG 1998, Soltis *et al.* 1999a, Soltis *et al.* in press). *Icacinaceae* are at least diphyletic (Savolainen *et al.* in press, Soltis *et al.* 1999a, Soltis *et al.* in press). The true *Icacinaceae* are represented here by *Chlamydocharia*, *Iacina*, *Iodes*, *Pyrenacantha* and *Sarcostigma* (see below), but *Gonocaryum*, *Irvingbaileya* and *Gomphandra* (formerly in *Icacinaceae*) fall outside this family (see Fig. 10). These latter three genera are close to *Pentaphylax* (one species from southern China to Malay Peninsula) and *Cardiopteris* (three species from southeastern Asia and Australia). Therefore, *Cardiopteridaceae* could be expanded to include *Pentaphylaceae* and some genera previously referred to *Icacinaceae* (at least *Gonocaryum*, *Irvingbaileya* and *Gomphandra*); however, more data are needed to confirm this view. *Icacinaceae sensu stricto* (Fig. 3) form a well-supported clade (BS 98%), but their position within core eudicots is not yet clear. Contrary to what is shown in Fig. 3, *Icacinaceae* are undoubtedly better placed among asterids because of their tenuinucellate ovules and gamopetalous flowers, but *rbcL* alone does not provide support for such a relationship. *Icacinaceae sensu stricto* are members of *Garryales* (jackknife support 55%) based on a combined analysis of *rbcL/atpB/18S* rDNA (Soltis *et al.* 1999a, Soltis *et al.* in press), whereas *Irvingbaileya/Gonocaryum* were included in *Aquifoliales* in the same study (jackknife support 96%).

Columelliaceae (Fig. 10) received support <50%, and they remain unassigned to order within euasterids (APG 1998). Based on pairwise absolute distance calculations, *Columellia* is equally close to *Gonocaryum* (*Cardiopteridaceae sensu lato*) and *Melanophylla* (*Apiales*), but distance alone can be misleading.

Dilleniaceae and *Vitaceae* (including *Leea*) are together sister to *Caryophyllales* (Fig. 1). Based on the combined *atpB/rbcL/18S* rDNA analyses (Soltis *et al.* 1999a, Soltis *et al.* in press), *Dilleniaceae* are also sister to *Caryophyllales* (jackknife support 60%) whereas *Vitaceae* are sister to rosids (jackknife support 70%). Both families could be elevated to the ordinal level in updates of the APG classification if additional molecular data provide support for these placements; familial circumscriptions are well supported with *rbcL* alone (BS 100% in both cases).

Eremosynaceae, *Escalloniaceae* and *Tribelaceae* form a clade within euasterids II (Fig. 9), but with BS<50% provided by *rbcL* alone. However, *Escallonia/Eremosyne* received 90% jackknife support based on the combined analysis of *atpB/rbcL/18S* rDNA

(Soltis *et al.* 1999a, Soltis *et al.* in press, see also Hibscher-Jetter *et al.* 1997). Therefore we could perhaps define the order *Escalloniales* and include the three families mentioned above. *Escalloniaceae* are from South America and Australasia with 150 species; *Eremosynaceae* and *Tribelaceae* are both monotypic and occur in southwestern Australia and South America, respectively. Alternatively and more reasonably, the two last families could be included in an expanded family *Escalloniaceae*.

Gunneraceae (50 species, tropical and southern temperate) are sister (BS 62%) to *Myrothamnaceae* (two species from southern tropical Africa and Madagascar), as previously reported based on the combined *atpB/rbcL/18S* rDNA analysis (jackknife support 75%; Soltis *et al.* 1999a, Soltis *et al.* in press). However, the placement of *Gunneraceae/Myrothamnaceae* relative to asterids/rosids remains unclear and requires additional data; we would however suggest including both families in *Gunnerales* in further updates of the APG classification (see Soltis *et al.* 1999a).

Huaceae remain unassigned to order within eurosids I. The use of *rbcL* alone provided BS<50% for the placement of *Huaceae*, but in combination with *atpB/18S* rDNA, sister status to *Celastrales* was supported (jackknife support 62%; Soltis *et al.* in press). *Picramniaceae* are sister to *Alvadoraceae* (BS 100%, alternatively *Alvadora* could be included in the former), but they remain unassigned to order within rosids. They comprise 50 species from central and tropical America. Based on a combined *atpB/rbcL* analysis, *Picramniaceae* were sister to *Krameriaceae/Zygophyllaceae* among eurosids I, but with BS<50% (Savolainen *et al.* in press). Additional molecular data are required for a well-supported placement of these families.

CONCLUSIONS

As exemplified at the last International Botanical Congress (St. Louis, USA, 1999), recent progress in plant systematics has been the basis of many discoveries (e.g. Gura 1999, Mathews & Donoghue 1999, Qiu *et al.* 1999, Soltis *et al.* 1999a). Most botanists now wish to know the phylogeny of the model taxa they are studying, and this is now as true for physiologists and geneticists as for evolutionary biologists. Understanding the evolutionary history for the traits being investigated can provide important insights into this operation. Classifying all angiosperm families based on phylogenetic analyses as initiated by APG (1998) is thus highly desirable because it provides the framework for more thorough and varied analyses to take place at lower taxonomic levels (Soltis *et al.* 1999a).

In this analysis, we have sampled nearly all eudicot families. More importantly, the large number of phylogenetic studies published in the last five years has guided our sampling strategy, making this study the most encyclopaedic of any published thus far. Soltis *et al.* (in press) observed that what APG called families and orders based on molecular data were uniformly characterised by relatively long branches associated with bootstrap support. Despite the fact that *rbcL* alone does not provide support for several of the interordinal relationships, it is noteworthy that the information in a single gene can identify as monophyletic nearly all families and orders with BS >50%. It is also noteworthy that none of the more important clades identified in the *rbcL* study by Chase *et al.* in 1993 has been seriously questioned. Since then, the addition of taxa has refined the definition of many orders whereas

the placement of more problematic taxa (e.g. *Vitaceae* or *Zygophyllaceae*) remains uncertain and we await further data. Therefore, this analysis permits two main conclusions to be drawn.

First, it is a straightforward task to reclassify angiosperms based on molecular data. Because the rate of evolution and the spectrum of evolutionary constraints acting on the plastid genome make it an ideal tool to be used by plant systematists, the phylogenetic signal is clear and easily detected when the sampling is thorough enough (Hillis 1998, Källersjö *et al.* 1998, Soltis *et al.* 1998). The main difficulty has been in obtaining material from geographically restricted and rare key taxa, and a few families have yet to be sampled and investigated (Table 1). Obtaining DNA sequences from herbarium samples is not yet a routine task; we tried for all of the remaining unsampled families, but although we obtained DNA in each case we have been unable to amplify *rbcL* from these degraded samples.

Second, the use of time-consuming exhaustive tree-search methods in the hope of finding a reasonably short tree is not necessary; faster and simple tree-building methods perform equally well in recovering accurate estimates of the true phylogeny in simulations (Nei *et al.* 1998, Chase *et al.* in press). Thus when large data sets are used to build a family/order tree for the angiosperms, only well-supported groups are of interest (no matter how many taxa are included), and these are found easily with simple and fast methods. Obtaining an optimal tree with single genes and hundreds of taxa is not only impossible, it is also unnecessary; shorter trees are not only underestimates of the true phylogeny (Chase & Cox 1998, Chase *et al.* in press), but they also do not uniformly contain more accurate clades than trees produced with faster methods (Chase *et al.* in press). As stated, most angiosperm families and orders received BS even using one single gene like *rbcL* (c. 60% of the branches received BS>50%), and all analyses performed here required less than one week (using a Power Macintosh G3, 300 Mhz, 256 MB RAM). However, some families and clades of several families still remained unassigned to order. In these cases, we simply need to add more data, as demonstrated in combined analyses of three genes (*atpB*, *rbcL*, 18S rDNA) that have clearly increased support for all clades (Soltis *et al.* 1998, Soltis *et al.* 1999a, Soltis *et al.* in press). For more problematic branching patterns such as the earliest angiosperms, five genes were required to provide a clear pattern for these ancient lineages (Qiu *et al.* 1999), and these findings have been corroborated by several independent lines of evidence (e.g. gene duplication; Mathews & Donoghue 1999). Here for the eudicots as well, we need to add more genes, especially faster-evolving ones to provide support for recent or rapid cladogenesis.

Soon, large data sets for all angiosperms families will be available, the analysis of which will provide clear pattern and support for all clades above the generic level. In the meantime, our data could be combined with other data sets for angiosperms, e.g. those for basal angiosperms in Qiu *et al.* (1999), monocots in Chase *et al.* (2000), parasites in Nickrent *et al.* (1998) or data sets for general patterns in Chase *et al.* (1993), Savolainen *et al.* (in press), Soltis *et al.* (1997a, b, in press) and Soltis *et al.* (1999a). These could be used to produce a complete super-tree for the families of angiosperms (see Sanderson *et al.* 1998), as has already been produced for all extant species of primates and carnivores (Purvis *et al.* 1995, Bininda-Emonds *et al.*

1999). However, prior to such achievements, *rbcL* alone has proved to be useful in depicting interfamilial relationships in eudicots. The APG study (1998) was the beginning of a new way to classify flowering plants, and we hope this analysis will aid in this process and that it will also become a starting point for addressing questions of patterns and processes of angiosperm evolution (e.g. Barraclough *et al.* 1996, 1998, Savolainen & Goudet 1998, Pagel 1999).

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REFERENCES

- Albert, V. A., Williams, S. E. & Chase, M. W. (1992). Carnivorous plants: phylogeny and structural evolution. *Science* 257: 1491 – 1495.
- Alverson, W. S., Karol, K. G., Baum, D. A., Chase, M. W., Swensen, S. M., McCourt, R. & Sytsma, K. J. (1998). Circumscription of the *Malvales* and relationships to other *Rosidae*: evidence from *rbcL* sequence data. *Amer. J. Bot.* 85: 876 – 887.
- Anderberg, A. A., Stahl, B. & Källersjö, M. (1998). Phylogenetic relationships in the *Primulales* inferred from *rbcL* sequence data. *Pl. Syst. Evol.* 211: 93 – 102.
- APG (1998). An ordinal classification for the families of flowering plants. *Ann. Missouri Bot. Gard.* 85: 531 – 553.
- Baas, P., Geesink, R., van Heel, W. A. & Muller, H. J. (1979). The affinities of *Plagiopteron suaveolens* Griff. (*Plagiopteraceae*). *Grana* 18: 69 – 89.
- Backlund, A. (1996). Phylogeny of the *Dipsacales*. Doctoral Thesis. Acta University Uppsala 243.
- & Bremer, B. (1997). Phylogeny of the *Asteridae* s.str. based on *rbcL* sequences, with particular reference to the *Dipsacales*. *Pl. Syst. Evol.* 207: 225 – 254.
- & Bremer, K. (1998). To be or not to be — Principles of classification and monotypic plant families. *Taxon* 47: 391 – 400.
- , Oxelman, B. & Bremer, B. (in press). Phylogenetic relationships within *Gentianales* based on *ndhF* and *rbcL* sequences, with particular references to the *Loganiaceae*. *Amer. J. Bot.*
- Bakker, F. T., Vassiliades, D. D., Morton, C. M. & Savolainen, V. (1998). Phylogenetic relationships of *Biebersteinia* Stephan (*Geraniaceae*) inferred from *rbcL* and *atpB* sequence comparison. *Bot. J. Linn. Soc.* 127: 149 – 158.
- Barraclough, T. G., Harvey, P. H. & Nee, S. (1996). Rate of *rbcL* gene sequence evolution and species diversification in flowering plants (angiosperms). *Proc. Roy. Soc. B* 263: 589 – 591.
- , Vogler, A. & Harvey, P. (1998). Revealing the factors that promote speciation. *Phil. Trans. Roy. Soc. B* 353: 241 – 249.
- Bayer, C., Chase, M. W. & Fay, M. F. (1998). *Muntingiaceae*, a new family of dicotyledons with malvaceous affinities. *Taxon* 47: 37 – 42.

- , Fay, M. F., de Brujin, A. Y., Savolainen, V., Morton, C. M., Kubitzki, K. & Chase, M. W. (1999). Support for an expanded family concept of *Malvaceae* within a recircumscribed order *Malvales*: a combined analysis of plastid *atpB* and *rbcL* sequences. *Bot. J. Linn. Soc.* 129: 267 – 303.
- Bininda-Emonds, O. R. P., Gittleman, J. L. & Purvis, A. (1999). Building large trees by combining phylogenetic information: a complete phylogeny of the extant *Carnivora* (*Mammalia*). *Biol. Rev.* 74: 143 – 175.
- Bittrich, V. (1993). *Halophytaceae* In: K. Kubitzki, J. G. Rohwer & V. Bittrich (eds.), *The families and genera of vascular plants. Flowering plants, dicotyledons. Magnoliid, hamamelid and caryophyllid families*, pp. 320 – 321. Springer Verlag, Berlin.
- Bousquet, J., Strauss, S. H., Doerksen, A. D. & Price, R. A. (1992). Extensive variation in evolutionary rate of *rbcL* gene sequences among seed plants. *Proc. Natl. Acad. Sci. USA* 89: 7844 – 7848.
- Bremer, B. & Thulin, M. (1998). Collapse of *Isertiaeae*, re-establishment of *Mussaendeae*, and a new genus of *Sabiceeae* (*Rubiaceae*); phylogenetic relationships based on *rbcL* data. *Pl. Syst. Evol.* 211: 71 – 92.
- Bremer, K., Olmstead, R. G., Struwe, L. & Sweere, J. A. (1994). *rbcL* sequences support exclusion of *Retzia*, *Desfontainia* and *Nicodemia* from the *Gentianales*. *Pl. Syst. Evol.* 190: 213 – 230.
- , Andreasen, K. & Olsson, D. (1995). Subfamilial and tribal relationships in the *Rubiaceae* based on *rbcL* sequence data. *Ann. Missouri Bot. Gard.* 82: 383 – 397.
- & Gustafsson, M. H. (1997). East Gondwanan ancestry of the sunflower alliance of families. *Proc. Natl. Acad. Sci. USA*: 9188 – 9190.
- Chase, M. W. & 42 others (1993). Phylogenetics of seed plants: an analysis of nucleotide sequences from the plastid gene *rbcL*. *Ann. Missouri Bot. Gard.* 80: 528 – 580.
- & Albert, V. A. (1998). A perspective on the contribution of plastid *rbcL* DNA sequences to angiosperm phylogenetics In: D. E. Soltis, P. S. Soltis & J. J. Doyle (eds.), *Molecular Systematics of plants II: DNA sequencing*, pp 488 – 507. Kluwer Academic, Dordrecht.
- & Cox, A. V. (1998). Gene sequences, collaboration, and analysis of large data sets. *Austral. Syst. Bot.* 11: 215 – 229.
- , Morton, C. M. & Kallunki, J. A. (1999). Phylogenetic relationships of *Rutaceae*: a cladistic analysis of the subfamilies using evidence from *rbcL* and *atpB* sequence variation. *Amer. J. Bot.* 86: 1191 – 1199.
- , Savolainen, V., Takahashi, K., Fay, M. F., Soltis, D. E., Soltis, P. S. (in press). Simple tree search methods work better for complex phylogenies. *Abstract. Amer. J. Bot. Suppl.* 87.
- , Soltis, D. E., Soltis, P. S., Rudall, P. J., Fay, M. F., Hahn, W. H., Sullivan, S., Joseph, J., Molvray, M., Kores, P. J., Givnish, T. J., Sytsma, K. J. & Pires, J. C. (2000). Higher-level systematics of the monocotyledons: an assessment of current knowledge and a new classification. In: K. L. Wilson & D. A. Morrison (eds), *Monocots: Systematics and Evolution*, pp. 3 – 16. CSIRO Press, Sydney.
- Chen, Z. D., Wang, X. Q., Sun, H. Y. & Han, Y. (1998). Systematic position of the *Rhoipteleaceae*: evidence from *rbcL* sequences. *Acta Phytotax. Sin.*, Addit. 36: 1 – 5.

- Civeyrel, L., Le Thomas, A., Ferguson, K. & Chase, M. W. (1998). Critical reexamination of palynological characters used to delimit *Asclepiadaceae* in comparison to the molecular phylogeny obtained from plastid *matK* sequences. *Molec. Phylogen. Evol.* 9: 517 – 527.
- Clarkson, J., Chase, M. W. & Harley, M. M. (in prep.). Phylogenetic relationships in the *Burseraceae* based on plastid *rps16* intron.
- Clement, J. S. & Mabry, T. J. (in press). *rbcL* sequence data and pigment evolution in the *Caryophyllales*: non-monophyly of the betalain-producing plants. *Amer. J. Bot.*
- Conti, E., Fischbach, A. & Sytsma, K. J. (1993). Tribal relationships in *Onagraceae*: implications from *rbcL* sequence data. *Ann. Missouri Bot. Gard.* 80: 672 – 685.
- , Litt, A. & Sytsma, K. J. (1996). Circumscription of *Myrtales* and their relationships to other rosids: evidence from *rbcL* sequence data. *Amer. J. Bot.* 83: 221 – 233.
- Cosner, M. E., Jansen, R. K. & Lammers, T. G. (1994). Phylogenetic relationships in the *Campanulales* based on *rbcL* sequences. *Pl. Syst. Evol.* 190: 79 – 95.
- Cronquist, A. (1981). An integrated system of classification of flowering plants. Columbia University Press, New York.
- Dahlgren, R. M. T. (1980). A revised system of classification of the angiosperms. *Bot. J. Linn. Soc.* 80: 91 – 124.
- Dayanandan, S., Ashton, P. S. & Primack, R. B. (1999). Phylogeny of the tropical tree family *Dipterocarpaceae* based on nucleotide sequences of the chloroplast *rbcL* gene. *Amer. J. Bot.* 86: 1182 – 1190.
- Donoghue, M. J., Olmstead, R. G., Smith, J. F. & Palme, J. D. (1992). Phylogenetic relationships of *Dipsacales* based on *rbcL* sequences. *Ann. Missouri Bot. Gard.* 79: 333 – 345.
- Downie, S. R., Katz-Downie, D. S. & Cho, K.-J. (1997). Relationships in the *Caryophyllales* as suggested by phylogenetic analyses of partial chloroplast DNA ORF2280 homolog sequences. *Amer. J. Bot.* 84: 253 – 273.
- Doyle, J. J. & Doyle, J. L. (1987). A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochem. Bull. Bot. Soc. Amer.* 19: 11 – 15.
- , —, Ballenger, J. A., Dickson, E. E., Kajita, T. & Ohashi, H. (1997). A phylogeny of the chloroplast gene *rbcL* in the *Leguminosae*: taxonomic correlations and insights into the evolution of nodulation. *Amer. J. Bot.* 84: 541 – 554.
- Endress, M. E., Sennblad, B., Nilsson, S., Civeyrel, L., Chase, M. W., Huysmans, S., Grafstroem, E. & Bremer, B. (1996). A phylogenetic analysis of *Apocynaceae* s. str. and some related taxa in *Gentianales*. A multidisciplinary approach. *Opera Bot. Belg.* 7: 59 – 102.
- Erbar, C. & Leins, P. (1996). Distribution of the character state “early sympetal” and “late sympetal” within the “sympetalae tetracycliae” and presumably allied groups. *Bot. Acta* 109: 427 – 440.
- Fay, M. F., Cameron, K. M., Prance, G. T., Lledo, M. D. & Chase, M. W. (1997a). Familial relationships of *Rhabdodendron* (*Rhabdodendraceae*): plastid *rbcL* sequences indicate a caryophyllid placement. *Kew Bull.* 52: 923 – 932.
- , Swensen, S. M. & Chase, M. W. (1997b). Taxonomic affinities of *Medusagyne oppositifolia* (*Medusagynaceae*). *Kew Bull.* 52: 111 – 120.

- , Bayer, C., Alverson, W., de Brujin, A. Y., Swensen, S. M. & Chase, M. W. (1998a). Plastid *rbcL* sequences indicate a close affinity between *Diegodendron* and *Bixa*. *Taxon* 47: 43 – 50.
- , Olmstead, R. G., Richardson, J. E., Santiago, E., Prance, G. T. & Chase, M. W. (1998b). Molecular data support the inclusion of *Duckeodendron celastroides* in *Solanaceae*. *Kew Bull.* 53: 203 – 212.
- , Bremer, B., Prance, G. T., van der Bank, M., Bridson, D. & Chase, M. W. (in press). Plastid *rbcL* sequence data show *Dialypetalanthus* to be a member of *Rubiaceae*. *Kew Bull.*
- Felsenstein, J. (1985). Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* 39: 783 – 791.
- Fernando, E. S., Gadek, P. A., Crayn, D. M. & Quinn, C. J. (1993). Rosid affinities of *Surianaceae*: molecular evidence. *Molec. Phylogenetic Evol.* 2: 344 – 350.
- Fishbein, M., Hibscher-Jetter, C., Soltis, D. E. & Hufford, L. (submitted). Phylogeny of *Saxifragales* (Angiosperms, Eudicots): analysis of a rapid, ancient radiation. *Syst. Biol.*
- Gadek, P. A., Quinn, C. J., Rodman, J. E., Karol, K. G., Conti, E., Price, R. A. & Fernando, E. S. (1992). Affinities of the Australian endemic *Akaniaceae*: new evidence from *rbcL* sequences. *Austral. Syst. Bot.* 5: 717 – 734.
- , Fernando, E. S., Quinn, C. J., Hoot, S. B., Terrazas, T., Sheahan, M. C. & Chase, M. W. (1996). *Sapindales*: molecular delimitation and infraordinal groups. *Amer. J. Bot.* 83: 802 – 811.
- Giannasi, D. E., Zurawski, G. R., Learn, G. H. & Clegg, M. T. (1992). Evolutionary relationships of the *Caryophyllidae* based on comparative *rbcL* sequences. *Syst. Bot.* 17: 1 – 15.
- Gunter, L. E., Kochert, G. & Giannasi, D. E. (1994). Phylogenetic relationships of the *Juglandaceae*. *Pl. Syst. Evol.* 192: 11 – 29.
- Gura, T. (1999). International Botanical Congress Meeting: new ways to glean medicines from plants. *Science* 285: 1347 – 1349.
- Gustafsson, M. H. G., Backlund, A. & Bremer, B. (1996). Phylogeny of the *Asterales* sensu lato based on *rbcL* sequences with particular reference to the *Goodeniaceae*. *Pl. Syst. Evol.* 199: 217 – 242.
- Hempel, A. L., Reeves, P. A., Olmstead, R. G. & Jansen, R. K. (1995). Implications of *rbcL* sequence data for higher order relationships of *Loasaceae* and the anomalous aquatic plant *Hydrostachys* (*Hydrostachyaceae*). *Pl. Syst. Evol.* 194: 25 – 37.
- Hibscher-Jetter, C., Soltis, D. E. & MacFarlane, T. D. (1997). Phylogenetic analysis of *Eremosyne pectinata* (*Saxifragaceae* s. l.) based on *rbcL* sequence data. *Pl. Syst. Evol.* 204: 225 – 232.
- Hillis, D. M. (1998). Taxonomic sampling, phylogenetic accuracy, and investigator bias. *Syst. Biol.* 47: 3 – 8.
- Hoot, S. B., Culham, A. & Crane, P. R. (1995a). The utility of *atpB* gene sequences in resolving phylogenetic relationships: comparison with *rbcL* and 18S ribosomal DNA sequences in the *Lardizabalaceae*. *Ann. Missouri Bot. Gard.* 82: 194 – 208.
- , — & — (1995b). Phylogenetic relationships of the *Lardizabalaceae* and *Sargentodoxaceae*: chloroplast and nuclear DNA sequence evidence. *Pl. Syst. Evol.* 9: 195 – 199.

- & Crane, P. R. (1995). Inter-familial relationships in the *Ranunculidae* based on molecular systematics. *Pl. Syst. Evol.* 9: 119 – 131.
- , Kadereit, J. W., Blattner, F. R., Jork, K. B., Schwarzbach, A. E. & Crane, P. R. (1997). Data congruency and phylogeny of the *Papaveraceae s. l.* based on four data sets: *atpB*, *rbcL* and 18S nuclear ribosomal DNA sequences. *Syst. Bot.* 22: 575 – 590.
- , Megallon-Puebla, S. & Crane, P. R. (1999). Phylogeny of basal eudicots based on three molecular data sets: *atpB* and *rbcL* sequences, *trnK* restriction sites and morphological characters. *Ann. Missouri Bot. Gard.* 86: 119 – 131.
- Johnson, L. A., Schultz, J. L., Soltis, D. E. & Soltis, P. S. (1996). Monophyly and generic relationships of *Polemoniaceae* based on *matK* sequences. *Amer. J. Bot.* 83: 1207 – 1224.
- & Soltis, D. E. (1994). *matK* DNA sequences and phylogenetic reconstruction in *Saxifragaceae* s.s. *Syst. Bot.* 19: 143 – 156.
- & Soltis, D. E. (1995). Phylogenetic inference in *Saxifragaceae sensu stricto* and *Gilia* (*Polemoniaceae*) using *matK* sequences. *Ann. Missouri Bot. Gard.* 82: 149 – 75.
- , — & Soltis, P. S. (1999). Phylogenetic relationships of *Polemoniaceae* inferred from 18S ribosomal DNA sequences. *Pl. Syst. Evol.* 214: 65 – 89.
- Källersjö, M., Farris, J. S., Chase, M. W., Bremer, B., Fay, M. F., Humphries, C. J., Petersen, G., Seberg, O. & Bremer, K. (1998). Simultaneous parsimony jackknife analysis of 2538 *rbcL* DNA sequences reveals support for major clades of green plants, land plants, seed plants and flowering plants. *Pl. Syst. Evol.* 213: 259 – 287.
- Käss, E. & Wink, M. (1995). Molecular phylogeny of the *Papilioideae* (Family *Leguminosae*): *rbcL* sequences versus chemical taxonomy. *Bot. Acta* 108: 149 – 162.
- Kaufmann, M. & Wink, M. (1994). Molecular systematics of the *Nepetoideae* (family *Labiatae*): Phylogenetic implications from *rbcL* gene sequences. *Biosci. Rep.* 49: 635 – 645.
- Kim, K.-J., Jansen, R. K., Wallace, R. S., Michaels, H. J. & Palme R. J. D. (1992). Phylogenetic implications of *rbcL* sequence variation in the *Asteraceae*. *Ann. Missouri Bot. Gard.* 79: 428 – 445.
- Koontz, J. A. & Soltis, D. E. (1999). DNA sequence data reveal polyphyly of *Brexioidae* (*Brexiaceae*; *Saxifragaceae* *sensu lato*). *Pl. Syst. Evol.* 219: 199 – 208.
- Kron, K. (1996). Phylogenetic relationships of *Empetraceae*, *Epacridaceae*, and *Ericaceae*: evidence from nuclear ribosomal 18S sequence data. *Ann. Bot.* 77: 293 – 303.
- (1997). Phylogenetic relationships of *Rhododendroideae* (*Ericaceae*). *Amer. J. Bot.* 84: 973 – 980.
- & Chase, M. W. (1993). Systematics of the *Ericaceae*, *Empetraceae*, *Epacridaceae* and related taxa based upon *rbcL* sequence data. *Ann. Missouri Bot. Gard.* 80: 735 – 741.
- Kubitzki, K., Rohwer, J. G. & Bittrich, V. (1993). The families and genera of vascular plants. Flowering plants, dicotyledons. Magnoliid, hamamelid and caryophyllid families. Springer Verlag, Berlin.
- Les, D. H., Garvin, D. K. & Wimpee, C. F. (1991). Molecular evolutionary history of ancient aquatic angiosperms. *Proc. Natl. Acad. Sci. USA*: 10119 – 10123.

- , Philbrick, C. T. & Novelo, R. A. (1997). The phylogenetic position of riverweeds (*Podostemaceae*): insights from *rbcL* sequence data. *Aquatic Bot.* 57: 5 – 27.
- Lin, D. M., Liu, Z. Q. & King, S. D. (1986). *Nicotiana* chloroplast genome: X. Correlation between the DNA sequences and the isoelectric focusing pattern of the LS of rubisco. *Pl. Molec. Biol.* 6: 81 – 87.
- Litt, A. & Chase, M. W. (1999). The systematic position of *Euphronia*, with comments on the position of *Balanops*: an analysis based on *rbcL* sequence data. *Syst. Bot.* 23: 401 – 409.
- Lledó, M. D., Crespo, M. B., Cameron, K. M., Fay, M. F. & Chase, M. W. (1998). Systematics of *Plumbaginaceae* based upon cladistic analysis of *rbcL* sequence data. *Syst. Bot.* 23: 21 – 29.
- Manen, J.-F., Natali, A. & Ehrendorfer, F. (1994). Phylogeny of *Rubiaceae* & *Rubieae* inferred from the sequence of a cpDNA intergene region. *Pl. Syst. Evol.* 190: 195 – 211.
- & — (1995). Comparison of the evolution of ribulose-1,5-bisphosphate carboxylase (*rbcL*) and *atpB-rbcL* noncoding spacer sequences in a recent plant group, the tribe *Rubieae* (*Rubiaceae*). *J. Molec. Evol.* 41: 920 – 927.
- Martin, P. G. & Dowd, J. M. (1993). Using sequences of *rbcL* to study phylogeny and biogeography of *Nothofagus* species. *Austral. Syst. Bot.* 6: 441 – 447.
- Mathews, S. & Donoghue, M. J. (1999). The root of angiosperm phylogeny inferred from duplicate phytochrome genes. *Science* 286: 947 – 950.
- Michaels, H. J., Scott, K. M., Olmstead, R. G., Szaro, T., Jansen, R. K. & Palmer, J. D. (1993). Interfamilial relationships of the *Asteraceae*: insights from *rbcL* sequence variation. *Ann. Missouri Bot. Gard.* 80: 742 – 751.
- Morgan, D. R. & Soltis, D. E. (1993). Phylogenetic relationships among *Saxifragaceae sensu lato* based on *rbcL* sequence data. *Ann. Missouri Bot. Gard.* 80: 631 – 660.
- , — & Robertson, K. R. (1994). Systematic and Evolutionary Implications of *rbcL* Sequence Variation in *Rosaceae*. *Amer. J. Bot.* 81: 890 – 903.
- Morton, C. M., Chase, M. W. & Karol, K. G. (1997a). Phylogenetic relationships of two anomalous dicot genera, *Physena* and *Asteropeia*: evidence from *rbcL* plastid DNA sequences. *Bot. Rev.* 63: 231 – 239.
- , —, Kron, K. A. & Swensen, S. M. (1997b). A molecular evaluation of the monophyly of the order *Ebenales* based upon *rbcL* sequence data. *Syst. Bot.* 21: 577 – 586.
- , Mori, S. A., Prance, G. T., Karol, K. G. & Chase, M. W. (1997c). Phylogenetic relationships of *Lecythidaceae*: A cladistic analysis using *rbcL* sequence and morphological data. *Amer. J. Bot.* 84: 530 – 540.
- Nandi, O. I., Chase, M. W. & Endress, P. K. (1998). A combined cladistic analysis of angiosperms using *rbcL* and non-molecular data sets. *Ann. Missouri Bot. Gard.* 85: 137 – 212.
- Nei, M., Kumar, S. & Takahashi, K. (1998). The optimization principle in phylogenetic analysis tends to give incorrect topologies when the number of nucleotides or amino acids used is small. *Proc. Natl. Acad. Sci. USA* 95: 12390 – 12397.
- Nickrent, D. L., Schuette, K. & Starr, E. (1994). A molecular phylogeny of *Arceuthobium* (*Viscaceae*) based on nuclear ribosomal DNA internal transcribed spacer sequences. *Amer. J. Bot.* 81: 1149 – 60.

- , Duff, R. J., Colwell, A. E., Wolfe, A. D., Young, N. D., Steiner, K. E. & dePamphilis, C. W. (1998). Molecular phylogenetics and evolutionary studies of parasitic plants In: D. E. Soltis, P. S. Soltis & J. J. Doyle (eds.), *Molecular Systematics of plants II: DNA sequencing*, pp. 211 – 241. Kluwer Academic, Dordrecht.
- & Soltis, D. E. (1995). A comparison of angiosperm phylogenies based upon complete 18S rDNA and *rbcL* sequences. *Ann. Missouri Bot. Gard.* 82: 208 – 234.
- & Starr, E. M. (1994). High rates of nucleotide substitution in nuclear small-subunit (18S) rDNA from holoparasitic flowering plants. *J. Molec. Evol.* 39: 62 – 70.
- Olmstead, R. G., Michaels, H. J., Scott, K. M. & Palmer, J. D. (1992). Monophyly of the *Asteridae* and identification of their major lineages inferred from DNA sequences of *rbcL*. *Ann. Missouri Bot. Gard.* 79: 249 – 65.
- , Bremer, B., Scott, K. M. & Palmer, J. D. (1993). A parsimony analysis of the *Asteridae sensu lato* based on *rbcL* sequences. *Ann. Missouri Bot. Gard.* 80: 700 – 722.
- & Reeves, P. A. (1995). Evidence for the polyphyly of the *Scrophulariaceae* based on chloroplast *rbcL* and *ndhF* sequences. *Ann. Missouri Bot. Gard.* 82: 176 – 93.
- , Sweere, J. A., Spangler, R. E., Bohs, L. & Palmer, J. D. (1999). Phylogeny and provisional classification of the *Solanaceae* based on chloroplast DNA In: M. Nee & D. Symon (eds.), *Solanaceae IV, Advances in biology and utilization*, Royal Botanic Gardens, Kew.
- , Kim, K.-J., Jansen, R. K. & Wagstaff, S. J. (submitted). The phylogeny of the *Asteridae sensu lato* based on chloroplast *ndhF* gene sequences. *Syst. Bot.*
- Oxelman, B., Backlund, M. & Bremer, B. (1999). Relationships of the *Buddlejaceae* investigated using parsimony jackknife and branch support analysis of *ndhF* and *rbcL* sequence data. *Syst. Bot.* 24(2): 164 – 182.
- Pagel, M. (1999). Inferring historical patterns of biological evolution. *Nature* 401: 877 – 884.
- Plunkett, G. M., Soltis, D. E. & Soltis, P. S. (1997a). Evolutionary patterns in *Apiaceae*: inferences based on *matK* sequence data. *Syst. Bot.* 21: 477 – 495.
- , — & — (1997b). Clarification of the relationship between *Apiaceae* and *Araliaceae* based on *matK* and *rbcL* sequence data. *Amer. J. Bot.* 84: 565 – 580.
- Powell, M., Savolainen, V., Cuenoud, P., Manen, J.-F. & Andrews, S. (2000). The mountain holly (*Nemopanthus mucronatus*) revisited with molecular data. *Kew Bull.* 55: 341 – 347.
- Price, R. A. & Palmer, J. D. (1993). Phylogenetic relationships of the *Geraniaceae* and *Geraniales* from *rbcL* sequence comparison. *Ann. Missouri Bot. Gard.* 80: 661 – 671.
- Purvis, A., Nee, S. & Harvey, P. H. (1995). Macroevolutionary inferences from primate phylogeny. *Proc. Roy. Soc. B* 260: 329 – 333.
- Qiu, Y.-L., Chase, M. W., Les, D. H. & Parks, C. R. (1993). Molecular phylogenetics of the *Magnoliidae*: cladistic analyses of nucleotide sequences of the plastid gene *rbcL*. *Ann. Missouri Bot. Gard.* 80: 587 – 606.
- , Chase, M. W., Hoot, S. B., Conti, E., Crane, P. R., Sytsma, K. J. & Parks, C. R. (1998). Phylogenetics of the *Hamamelidae* and their allies: parsimony analysis of nucleotide sequences of the plastid gene *rbcL*. *Int. J. Pl. Sci.* 159: 891 – 905.
- , Lee, J., Bernasconi-Quadroni, F., Soltis, D. E., Soltis, P. S., Zanis, M., Chen, Z., Savolainen, V. & Chase, M. W. (1999). The earliest angiosperms: evidence from mitochondrial, plastid and nuclear genomes. *Nature* 402: 404 – 407.

- Rettig, J. H., Wilson, H. D. & Manhart, J. M. (1992). Phylogeny of the *Caryophyllales* — gene sequence data. *Taxon* 41: 201 – 209.
- Reveal, J. L., Judd, W. S. & Olmstead, R. G. (1999). Proposal to conserve the name *Antirrhinaceae* against *Plantaginaceae* (*Magnoliophyta*). *Taxon* 48: 182.
- Richardson, J., Fay, M. F., Cronk, Q. C., Bowman, D. & Chase, M. W. (in press). A molecular analysis of *Rhamnaceae* using *rbcL* and *trnL-F* plastid DNA sequences. *Amer. J. Bot.*
- Rodman, J. E., Price, R. A., Karol, K., Conti, E., Sytsma, K. J. & Palmer, J. D. (1993). Nucleotide sequences of the *rbcL* gene indicate monophyly of mustard oil plants. *Ann. Missouri Bot. Gard.* 80: 686 – 699.
- , Karol, K. G., Price, R. A., Conti, E. & Sytsma, K. J. (1994). Nucleotide sequences of *rbcL* confirm the capparalean affinity of the Australian endemic *Gyrostemonaceae*. *Austral. Syst. Bot.* 7: 57 – 69.
- , —, — & Sytsma, K. J. (1996). Molecules, morphology and Dahlgren's expanded order *Capparales*. *Syst. Bot.* 21: 289 – 307.
- , Soltis, P. S., Soltis, D. E., Sytsma, K. J. & Karol, K. G. (1998). Parallel evolution of glucosinolate biosynthesis inferred from congruent nuclear and plastid gene phylogenies. *Amer. J. Bot.* 87: 997 – 1006.
- Ronse Decraene, P. L., Smets, E. F. & Vanvinckenroye, P. (1998). Pseudo diplostemony, and its implication for the evolution of the androecium in the *Caryophyllaceae*. *J. Pl. Res.* 111: 25 – 43.
- Saad, S. I. (1962). Pollen morphology of *Ctenolophon*. *Bot. Not.* 115: 49 – 57.
- Sanderson, M. J., Purvis, A. & Henze, C. (1998). Phylogenetic supertrees: assembling the trees of life. *Trends Ecol. Evol.* 13: 105 – 109.
- Savolainen, V., Manen, J. F., Douzery, E. & Spichiger, R. (1994). Molecular phylogeny of families related to *Celastrales* based on *rbcL* 5' flanking sequences. *Molec. Phylogenет. Evol.* 3: 27 – 37.
- , Cuenoud, P., Spichiger, R., Martinez, M. D. P., Crevecoeur, M. & Manen, J.-F. (1995). The use of herbarium specimens in DNA phylogenetics: evaluation and improvement. *Pl. Syst. Evol.* 197: 87 – 98.
- , Spichiger, R. & Manen, J.-F. (1997). Polyphyletism of *Celastrales* deduced from a noncoding chloroplast DNA region. *Molec. Phylogenet. Evol.* 7: 145 – 157.
- & Goudet, J. (1998). Rate of gene sequence evolution and species diversification in flowering plants: a re-evaluation. *Proc. Roy. Soc. B* 265: 603 – 607.
- , Chase, M. W., Morton, C. M., Hoot, S. B., Soltis, D. E., Bayer, C., Fay, M. F., de Brujin, A., Sullivan, S. & Qiu, Y.-L. (in press). Phylogenetics of flowering plants based upon a combined analysis of plastid *atpB* and *rbcL* gene sequences. *Syst. Biol.*
- Sennblad, B. & Bremer, B. (1996). The familial and subfamilial relationships of *Apocynaceae* and *Asclepiadaceae* evaluated with *rbcL* data. *Pl. Syst. Evol.* 202: 153 – 175.
- Sheahan, M. C. & Chase, M. W. (1996). A phylogenetic analysis of *Zygophyllaceae* R. Br. based on morphological, anatomical, and *rbcL* DNA sequence data. *Bot. J. Linn. Soc.* 122: 279 – 300.
- & — (in press). Phylogenetic relationships within *Zygophyllaceae* based on DNA sequences of three plastid regions, with special emphasis on *Zygophylloideae*. *Syst. Bot.*

- Soltis, D. E., Soltis, P. S., Clegg, M. T. & Durbin, M. (1990). *rbcL* sequence divergence and phylogenetic relationships in *Saxifragaceae sensu lato*. Proc. Natl. Acad. Sci. USA 87: 4640 – 4644.
- , Morgan, D. R., Grable, A., Soltis, P. S. & Kuzoff, R. (1993). Molecular systematics of *Saxifragaceae sensu stricto*. Amer. J. Bot. 80: 1056 – 1081.
- , Soltis, P. S., Morgan, D. R., Swensen, S. M., Mullin, B. C., Dowd, J. M. & Martin, P. G. (1995). Chloroplast gene sequence data suggest a single origin of the predisposition for symbiotic nitrogen fixation in angiosperms. Proc. Natl. Acad. Sci. USA 92: 2647 – 2651.
- , Kuzoff, R. K., Conti, E., Gornall, R. & Ferguson, K. (1996). matK and *rbcL* gene sequence data indicate that *Saxifraga* (*Saxifragaceae*) is polyphyletic. Amer. J. Bot. 83: 371 – 382.
- & Soltis, P. S. (1997). Phylogenetic relationships in the *Saxifragaceae sensu lato*: a comparison of topologies based on 18S rDNA and *rbcL* sequences. Amer. J. Bot. 84: 504 – 522.
- , Soltis, P. S., Nickrent, D. L., Johnson, L. A., Hahn, W. J., Hoot, S. B., Sweere, J. A., Kuzoff, R. K., Kron, K. A. & Chase, M. W. (1997a). Angiosperm phylogeny inferred from 18S ribosomal DNA sequences. Ann. Missouri Bot. Gard. 84: 1 – 49.
- , Hibsch-Jetter, C., Soltis, P. S., Chase, M. W. & Farris, J. S. (1997b) Molecular phylogenetic relationships among angiosperms: an overview based on *rbcL* and 18S rDNA sequences In: K. Iwatsuki & P. H. Raven (eds.), Evolution and diversification of land plants, pp. 157 – 178. Springer, Tokyo.
- , Soltis, P. S., Mort, M. E., Chase, M. W., Savolainen, V., Hoot, S. B. & Morton, C. M. (1998). Inferring complex phylogenies using parsimony: an empirical approach using three large DNA data sets for angiosperms. Syst. Biol. 47: 32 – 42.
- & Soltis, P. S. (1998b) Choosing an approach and an appropriate gene for phylogenetic analysis In: D. E. Soltis, P. S. Soltis & J. J. Doyle (eds.), Molecular Systematics of plants II: DNA sequencing, pp. 1 – 42. Kluwer Academic, Dordrecht.
- , Mort, M. E., Soltis, P. S., Hibsch-Jetter, C., Zimmer, E. A. & Morgan, D. (1999b). Phylogenetic relationships of the enigmatic angiosperm family *Podostemaceae* inferred from 18S rDNA and *rbcL* sequence data. Molec. Phylogenetic Evol. 261 – 272.
- , Soltis, P. S., Chase, M. W., Mort, M. E., Albach, D. C., Zanis, M., Savolainen, V., Hahn, W. H., Hoot, S. B., Fay, M. F., Axtell, M., Swensen, S. M., Nixon, K. C. & Farris, J. S. (in press). Angiosperm phylogeny inferred from a combined data set of 18S rDNA, *rbcL*, and *atpB* sequences. Bot. J. Linn. Soc.
- Soltis, P. S. & Soltis, D. E. (1998a) Molecular evolution of 18S rDNA in angiosperms: implications for character weighting in phylogenetic analysis In: D. E. Soltis, P. S. Soltis & J. J. Doyle, (eds.), Molecular Systematics of plants II: DNA sequencing, pp. 188 – 210. Kluwer Academic, Dordrecht.
- , Soltis, D. E. & Chase, M. W. (1999a). Angiosperm phylogeny inferred from multiple genes as a tool for comparative biology. Nature 402: 402 – 404.
- Swensen, S. M. (1996). The evolution of actinorhizal symbioses: evidence for multiple origins of the symbiotic association. Amer. J. Bot. 83: 1503 – 1512.

- Swofford, D. L. (1998). PAUP*: Phylogenetic analysis using parsimony (* and other methods), Version 4.0. Sinauer Associates, Sunderland, Massachusetts.
- Thulin, M., Bremer, B., Richardson, J., Niklasson, J., Fay, M. F. & Chase, M. W. (1998). Family relationships of the enigmatic rosid genera *Barbeya* and *Dirachma* from the Horn of Africa region. *Pl. Syst. Evol.* 213: 103 – 119.
- Ueda, K., Kosuge, K. & Tobe, H. (1997). A molecular phylogeny of *Celtidaceae* and *Ulmaceae* (*Urticales*) based on *rbcL* nucleotide sequences. *J. Pl. Res.* 110: 171 – 178.
- Wolfe, A. D. & dePamphilis, C. W. (1998). The effect of relaxed functional constraints on the photosynthetic gene *rbcL* in photosynthetic and nonphotosynthetic parasitic plants. *Molec. Biol. Evol.* 15: 1243 – 1258.
- Xiang, Q.-Y., Soltis, D. E., Morgan, D. R. & Soltis, P. E. (1993). Phylogenetic relationships of *Cornus* L. *sensu lato* and putative relatives inferred from *rbcL* sequence data. *Ann. Missouri Bot. Gard.* 80: 723 – 734.
- & Soltis, D. E. (1998). *rbcL* sequence data define a cornaceous clade and clarify relationships of *Cornus* L. *sensu lato*. In: D. E. Boufford & H. Ohba (eds.), *Sino-Japanese florista: its characteristics and diversification*, pp. 125 – 137. University of Tokyo Press, Tokyo.
- Zurawski, G., Perrot, B., Bottomley, W. & Whitfield, P. R. (1981). The structure of the gene for the large subunit of ribulose 1,5 bisphosphate carboxylase from spinach chloroplast DNA. *Nucl. Acids Res.* 9: 3251 – 3270.
- , Whitfield, P. R. & Bottomley, W. (1986). Sequence of the gene for the large subunit of ribulose-1,5-bisphosphate-carboxylase from pea chloroplasts. *Nucl. Acids Res.* 14: 3975.

APPENDIX 1.

Family	Species	Accession number	Citation (voucher)
Acanthaceae	<i>Thunbergia coccinea</i> Wall.	L12956	Chase <i>et al.</i> 1993
Achariaceae	<i>Acharia tragodes</i> Thunb.	AF206728	Soltis <i>et al.</i> in press
Achatocarpaceae	<i>Phaulothamnus spinescens</i> A. Gray	M97887	Manhart & Rettig unpubl.
Actinidiaceae	<i>Actinidia chinensis</i> Planch.	L01882	Albert <i>et al.</i> 1992
Actinidiaceae	<i>Clematolettha lasioclada</i> Maxim.	Z80172	Morton <i>et al.</i> 1997b
Adoxaceae	<i>Sambucus nigra</i> L.	L14066	Donoghue <i>et al.</i> 1992
Adoxaceae	<i>Viburnum acerifolia</i> L.	L01959	Olmstead <i>et al.</i> 1992
Aextoxicaceae	<i>Aextoxicum punctatum</i> Ruiz & Pav.	X83986	Savolainen <i>et al.</i> 1997
Aizoaceae	<i>Delosperma echinatum</i> (Lam.) Schwantes	AJ235778	Savolainen <i>et al.</i> in press
Aizoaceae	<i>Trianthema portulacastrum</i> L.	M62572	Rettig <i>et al.</i> unpubl.
Akaniaceae	<i>Akania bidwillii</i> (R. Hogg) Mabb.	L12568	Gadek <i>et al.</i> 1992
Alseuomiaceae	<i>Crispiloba disperma</i> (S. Moore) Steenis	X87382	Gustafsson <i>et al.</i> 1996
Alseuomiaceae	<i>Wittsteinia vacciniacea</i> F. Muell.	X87399	Gustafsson <i>et al.</i> 1996
Alseuosmiaceae	<i>Alseuosmia macrophylla</i> A. Cunn.	X87377	Soltis <i>et al.</i> in press
Altingiaceae	<i>Altingia excelsa</i> Noronha	AJ131769	Chase <i>et al.</i> 1993
Altingiaceae	<i>Liquidambar formosana</i> Hance	M58394	Chase <i>et al.</i> 1993
Alzateaceae	<i>Alzatea verticillata</i> Ruiz & Pav.	U26316	Conti <i>et al.</i> 1996
Amaranthaceae	<i>Amaranthus tricolor</i> L.	X53980	Rettig <i>et al.</i> 1992
Amaranthaceae	<i>Spinacia oleracea</i> L.	J01443	Zurawski <i>et al.</i> 1981
Anacardiaceae	<i>Amphipterygium adstringens</i> (Schltdl.) Schiede ex Standl.	AJ402921	this paper (<i>Manzanero</i> 1150 NY)
Anacardiaceae	<i>Buchanania latifolia</i> Roxb.	U39275	Gadek <i>et al.</i> 1996
Anacardiaceae	<i>Schinus molle</i> L.	U39270	Gadek <i>et al.</i> 1996
Anacardiaceae	<i>Spondias cytherea</i> Tussac	U39274	Gadek <i>et al.</i> 1996
Ancistrocladaceae	<i>Ancistrocladus korupensis</i> D. W. Thomas & Gereau	AF206733	Soltis <i>et al.</i> in press
Anisophyllaceae	<i>Combretocarpus rotundatus</i> Danser	AF006763	Setoguchi <i>et al.</i> unpubl.
Anrtirrhinaceae	<i>Plantago lanceolata</i> Hook.	L36454	Olmstead & Reeves 1995
Aphloiaceae	<i>Aphloia theiformis</i> (Vahl) Benn.	AF206735	Soltis <i>et al.</i> in press
Apiaceae	<i>Apium graveolens</i> L.	L01885	Albert <i>et al.</i> 1992
Apiaceae	<i>Melanophylla alnifolia</i> Baker	U50254	Plunkett <i>et al.</i> 1997b
Apocynaceae	<i>Apocynum cannabinum</i> L.	X91761	Sennblad & Bremer 1996
Apocynaceae	<i>Skylanthus acutus</i> Meyen	AJ403003	this paper (<i>Endress</i> s.n. Z)

Family	Species	Accession number	Citation (voucher)
Aquifoliaceae	<i>Ilex crenata</i> Thunb.	L01928	Albert <i>et al.</i> 1992
Aquifoliaceae	<i>Nemopanthus mucronatus</i> (L.) Trel.	X69747	Savolainen <i>et al.</i> 1994
Araliaceae	<i>Hedera helix</i> L.	L01924	Xiang <i>et al.</i> 1993
Aralidiaceae	<i>Aralidium pinnatifidum</i> (Jungh. & de Vriese) Miq.	U58627	Xiang & Soltis 1998
Argophyllaceae	<i>Argophyllum</i> sp.	X87379	Gustafsson <i>et al.</i> 1996
Argophyllaceae	<i>Corokia cotoneaster</i> Raoul	L11221	Xiang <i>et al.</i> 1993
Asteraceae	<i>Helianthus annuus</i> L.	L13929	Kim <i>et al.</i> 1992
Asteropeiaceae	<i>Asteropeia micraster</i> Hallier f.	Z80150	Morton <i>et al.</i> 1997b
Aucubaceae	<i>Aucuba japonica</i> Thunb.	L11210	Xiang <i>et al.</i> 1993
Avicenniaceae	<i>Avicennia germinans</i> (Humb., Bonpl. & Kunth) Moldenke	U28868	Wagstaff & Olmstead unpubl.
Balanopaceae	<i>Balanops viellardii</i> Baill.	AF089760	Litt & Chase 1999
Balsaminaceae	<i>Impatiens capensis</i> Meerb.	Z83142	Chase <i>et al.</i> 1993
Barbeyaceae	<i>Barbeya oleoides</i> Schwein.	U60314	Qiu <i>et al.</i> 1998
Basellaceae	<i>Basella alba</i> L.	M62564	Rettig <i>et al.</i> 1992
Bataceae	<i>Batis maritima</i> L.	M88341	Chase <i>et al.</i> 1993
Begoniaceae	<i>Begonia metallica</i> ♀ <i>sanguinea</i>	L01888	Chase <i>et al.</i> 1993
Berberidaceae	<i>Nandina domestica</i> Thunb.	L37920	Hoot <i>et al.</i> 1995
Berberidopsidaceae	<i>Berberidopsis corallina</i> Hook.	AJ235773	Savolainen <i>et al.</i> in press
Betulaceae	<i>Betula nigra</i> L.	L01889	Albert <i>et al.</i> 1992
Betulaceae	<i>Corylus cornuta</i> Marshall	X56619	Bousquet <i>et al.</i> 1992
Biebersteiniaceae	<i>Biebersteinia orphanidis</i> Boiss.	AF035920	Bakker <i>et al.</i> 1998
Bignoniaceae	<i>Catalpa bignonioides</i> Walter	L11679	Olmstead <i>et al.</i> 1992
Bixaceae	<i>Bixa orellana</i> L.	Y15139	Fay <i>et al.</i> 1998a
Bonnetiaceae	<i>Bonnetia roraimae</i> Oliv.	AJ402930	this paper (Weitzman <i>et al.</i> 402 US)
Boraginaceae	<i>Borago officinalis</i> L.	L11680	Olmstead <i>et al.</i> 1992
Boraginaceae	<i>Hydrophyllum virginianum</i> L.	L01927	Olmstead <i>et al.</i> 1992
Brassicaceae	<i>Brassica oleracea</i> L.	M88342	Rodman <i>et al.</i> 1993
Brassicaceae	<i>Cleome hassleriana</i> Chodat	M95755	Chase <i>et al.</i> 1993
Brunelliaceae	<i>Brunellia</i> sp.	AJ402932	this paper (Lewis 3366 K)
Bruniaceae	<i>Berzelia lanuginosa</i> Brongn.	L14391	Olmstead <i>et al.</i> 1993
Bruniaceae	<i>Brunia albiflora</i> E. Phillips	Y10674	Backlund & Bremer 1998
Buddlejaceae	<i>Buddleja</i> sp.	AJ001757	Oxelman <i>et al.</i> unpubl.
Buddlejaceae	<i>Polyptimum procumbens</i> L.	AJ011989	Oxelman <i>et al.</i> 1999

<i>Burseraceae</i>	<i>Beiselia mexicana</i> Forman	AJ402925	this paper (<i>Chase</i> 639 K)
<i>Burseraceae</i>	<i>Bursera inaguensis</i> Britton	L01890	Albert <i>et al.</i> 1992
<i>Burseraceae</i>	<i>Commiphora abyssinica</i> Engl.	U39276	Gadek <i>et al.</i> 1996
<i>Buxaceae</i>	<i>Buxus sempervirens</i> L.	AF093717	Hoot <i>et al.</i> 1999
<i>Buxaceae</i>	<i>Pachysandra procumbens</i> Michx.	AF093718	Chase <i>et al.</i> 1993
<i>Byblidaceae</i>	<i>Byblis liniflora</i> Salish.	L01891	Albert <i>et al.</i> 1992
<i>Cactaceae</i>	<i>Pereskia aculeata</i> Mill.	M97888	Rettig <i>et al.</i> 1992
<i>Calyceraceae</i>	<i>Boopis anthemoides</i> Juss.	L13860	Olmstead <i>et al.</i> 1992
<i>Campanulaceae</i>	<i>Campanula ramulosa</i> Wall.	L13861	Olmstead <i>et al.</i> 1992
<i>Campanulaceae</i>	<i>Cyphia elata</i> Harv.	L18796	Cosner <i>et al.</i> 1994
<i>Campanulaceae</i>	<i>Lobelia erinus</i> L.	L01931	Albert <i>et al.</i> 1992
<i>Cannabaceae</i>	<i>Cannabis sativa</i> L.	AJ402933	this paper (<i>Chase</i> 2992 K)
<i>Cannabaceae</i>	<i>Humulus lupulus</i> L.	AF061992	Qiu <i>et al.</i> 1998
<i>Caprifoliaceae</i>	<i>Symphoricarpos albus</i> (L.) S. F. Blake	L11682	Olmstead <i>et al.</i> 1992
<i>Cardiopteridaceae</i>	<i>Gomphandra javanica</i> Valeton	AJ402954	this paper (<i>Chase</i> 1293 K)
<i>Cardiopteridaceae</i>	<i>Gonocaryum litorale</i> Sleumer	AJ235779	Savolainen <i>et al.</i> in press
<i>Cardiopteridaceae</i>	<i>Irvingbaileya</i> sp.	AF156733	Soltis <i>et al.</i> in press
<i>Cardipteridaceae</i>	<i>Cardipteris quinqueloba</i> Hassk.	AJ402936	this paper (<i>Van Bensekom</i> 3836 K)
<i>Caricaceae</i>	<i>Carica papaya</i> L.	M95671	Rodman <i>et al.</i> 1993
<i>Carlemanniaceae</i>	<i>Carlemannia griffithii</i>	AJ402937	this paper (<i>Grierson & Long</i> 3027 K)
<i>Carpodetaceae</i>	<i>Abrophyllum ornans</i> Hook. f.	X87375	Gustafsson <i>et al.</i> 1996
<i>Carpodetaceae</i>	<i>Carpodetus serratus</i> J. R. Forst. & G. Forst.	Y08461	Bremer & Gustafsson 1997
<i>Carpodetaceae</i>	<i>Cuttisia viburnea</i> F. Muell.	Y08462	Bremer & Gustafsson 1997
<i>Caryocaraceae</i>	<i>Caryocar glabrum</i> Pers.	Z75671	Fay <i>et al.</i> 1997b
<i>Caryophyllaceae</i>	<i>Dianthus caryophyllus</i> L.	M77699	Giannasi <i>et al.</i> 1992
<i>Casuarinaceae</i>	<i>Casuarina litorea</i> L.	L01893	Albert <i>et al.</i> 1992
<i>Cecropiaceae</i>	<i>Cecropia palmata</i> Willd.	AF061196	Qiu <i>et al.</i> 1998
<i>Celastraceae</i>	<i>Brexia madagascariensis</i> Thouars	L11176	Soltis <i>et al.</i> 1990
<i>Celastraceae</i>	<i>Canotia holoranthus</i> Torr.	AJ402934	this paper (<i>Ramsden & Hodgson</i> 6336 NY)
<i>Celastraceae</i>	<i>Celastrus orbiculatus</i> Humb. & Bonpl.	AJ235775	Savolainen <i>et al.</i> in press
<i>Celastraceae</i>	<i>Denhamia celastroides</i> (F. Muell.) Jessup	AJ402941	this paper (<i>Chase</i> 2050 K)
<i>Celastraceae</i>	<i>Euonymus alatus</i> Siebold	L13184	Chase <i>et al.</i> 1993
<i>Celastraceae</i>	<i>Hippocratea richardiana</i> Cambess.	X69740	Savolainen <i>et al.</i> in press
<i>Celastraceae</i>	<i>Lophopetalum sessilifolium</i> Ridl.	AJ402969	this paper (<i>Chase</i> 1214 K)
<i>Celastraceae</i>	<i>Plagiopteron suaveolens</i> Griff.	AJ235787	Savolainen <i>et al.</i> in press
<i>Celastraceae</i>	<i>Pleurostylia wightii</i> Pierre	AJ402989	this paper (<i>Chase</i> 2093 K)
<i>Celastraceae</i>	<i>Psammomoya choretroides</i> Diels & Loes.	AJ402994	this paper (<i>Chase</i> 2160 K)

Family	Species	Accession number	Citation (voucher)
<i>Celastraceae</i>	<i>Reissantia</i> sp.	AJ402996	this paper (<i>Chase</i> 2471 K)
<i>Celastraceae</i>	<i>Salacia undulata</i> Cambess.	AJ402998	this paper (<i>Chase</i> 2096 K)
<i>Celastraceae</i>	<i>Siphonodon australis</i> Benth.	AJ403002/AJ403033	this paper (<i>Savolainen</i> saul G)
<i>Celastraceae</i>	<i>Siphonodon celastrineus</i> Griff.	AF206821	Soltis <i>et al.</i> in press
<i>Celastraceae</i>	<i>Stackhousia minima</i> Hook. f.	AJ235795	Savolainen <i>et al.</i> in press
<i>Celastraceae</i>	<i>Tripterococcus brunonis</i> Endl.	AJ403012	this paper (<i>Chase</i> 2193 K)
<i>Celtidaceae</i>	<i>Celtis yunnanensis</i> C. K. Schneid.	L12638	<i>Chase</i> <i>et al.</i> 1993
<i>Ceratophyllaceae</i>	<i>Ceratophyllum demersum</i> L.	M77030	<i>Les</i> <i>et al.</i> 1991
<i>Cercidiphyllaceae</i>	<i>Cercidiphyllum japonicum</i> Siebold & Zucc.	L11673	Olmstead <i>et al.</i> 1992
<i>Chrysobalanaceae</i>	<i>Atuna racemosa</i> Rafin.	AF089758	Litt & Chase 1999
<i>Chrysobalanaceae</i>	<i>Chrysobalanus icaco</i> L.	L11178	Morgan & Soltis 1993
<i>Chrysobalanaceae</i>	<i>Hirtella bicornis</i> Mart. & Zucc.	AF089756	Litt & Chase 1999
<i>Circaeasteraceae</i>	<i>Circaeaster agrestis</i> Maxim.	AF092116	Hoot & Crane 1995
<i>Circaeasteraceae</i>	<i>Kingdonia uniflora</i> Balf. f. & W.W. Sm.	AF093719	Hoot & Crane 1995
<i>Cistaceae</i>	<i>Cistus revolutus</i> H. J. Costé & Soulie	AF035902	Savolainen <i>et al.</i> in press
<i>Cistaceae</i>	<i>Helianthemum grandiflorum</i> DC.	Y15141	Fay <i>et al.</i> 1998a
<i>Clethraceae</i>	<i>Clethra alnifolia</i> L.	L12609	Kron & Chase 1993
<i>Clusiaceae</i>	<i>Calophyllum</i> sp.	Z75672	Fay <i>et al.</i> 1997b
<i>Clusiaceae</i>	<i>Clusia gundlachi</i> Stahl	Z75673	Fay <i>et al.</i> 1997b
<i>Clusiaceae</i>	<i>Garcinia hessii</i> (Britton) Alain	AJ402952	this paper (Axelrod 4537 UPR)
<i>Clusiaceae</i>	<i>Hypericum empetrifolia</i> Willd.	AF206779	Soltis <i>et al.</i> in press
<i>Clusiaceae</i>	<i>Mesua</i> sp.	AF206794	Soltis <i>et al.</i> in press
<i>Cochlospermaceae</i>	<i>Amoreuxia wrightii</i> A. Gray	Y15142	Fay <i>et al.</i> 1998a
<i>Cochlospermaceae</i>	<i>Cochlospermum intermedium</i> Mildbr.	Y15143	Fay <i>et al.</i> 1998a
<i>Columelliaceae</i>	<i>Columellia oblonga</i> Ruiz & Pav.	Y10675	Backlund & Bremer 1997
<i>Combretaceae</i>	<i>Quisqualis indica</i> L.	L01948	Albert <i>et al.</i> 1992
<i>Combretaceae</i>	<i>Terminalia catappa</i> L.	U26338	Chase <i>et al.</i> 1993
<i>Connaraceae</i>	<i>Connarus conchocarpus</i> F. Muell.	L29493	Fernando <i>et al.</i> 1993
<i>Convolvulaceae</i>	<i>Convolvulus tricolor</i> L.	L11683	Olmstead <i>et al.</i> 1992
<i>Coriariaceae</i>	<i>Coriaria myrtifolia</i> L.	L01897	Albert <i>et al.</i> 1992
<i>Cornaceae</i>	<i>Cornus officinalis</i> Sieb. et Zucc.	L11216	Xiang <i>et al.</i> 1993
<i>Cornaceae</i>	<i>Griselinia lucida</i> G. Forst.	L11225	Xiang <i>et al.</i> 1993
<i>Cornaceae</i>	<i>Nyssa ogeche</i> Marshall	L11228	Xiang <i>et al.</i> 1993
<i>Cornaceae</i>	<i>Toricellia tilifolia</i> DC.	N/A	Xiang & Soltis 1998

<i>Corynocarpaceae</i>	<i>Corynocarpus laevigatus</i> J. R. Forst. & G. Forst.	X69731	Savolainen <i>et al.</i> 1997
<i>Crassulaceae</i>	<i>Crassula marnierana</i> H. Huber & H. Jacobsen	L01899	Albert <i>et al.</i> 1992
<i>Crassulaceae</i>	<i>Dudleya viscida</i> Moran	L11182	Morgan & Soltis 1993
<i>Crassulaceae</i>	<i>Kalanchoe daigremontiana</i> Raym.-Hamet & H. Perrier	L11189	Morgan & Soltis 1993
<i>Crassulaceae</i>	<i>Sedum rubrotinctum</i> R. T. Clausen	L01956	Albert <i>et al.</i> 1992
<i>Crossosomataceae</i>	<i>Crossosoma californicum</i> Nutt.	L11179	Morgan & Soltis 1993
<i>Crypteroniaceae</i>	<i>Crypteronia paniculata</i> Blume	AF215545	Clausing & Renner, unpubl.
<i>Ctenolophonaceae</i>	<i>Ctenolophon englerianus</i> Mildbr.	AJ402940	this paper (<i>Dourse</i> 1572 K)
<i>Cucurbitaceae</i>	<i>Cucurbita pepo</i> L.	L21938	Chase <i>et al.</i> 1993
<i>Cucurbitaceae</i>	<i>Neoalsomitra sarcophylla</i> (Wall.) Hutch.	U59823	Swensen 1996
<i>Cunoniaceae</i>	<i>Bauera rubioides</i> Andrews	L11174	Morgan & Soltis 1993
<i>Cunoniaceae</i>	<i>Davidsonia puriens</i> F. Muell.	AF206759	Soltis <i>et al.</i> in press
<i>Cunoniaceae</i>	<i>Eucryphia lucida</i> Druce	L01918	Albert <i>et al.</i> 1992
<i>Cyclocheilaceae</i>	<i>Cyclocheilon somaliense</i> Oliv.	U28871	Wagstaff & Olmstead unpubl.
<i>Cyrillaceae</i>	<i>Cyrilla racemiflora</i> L.	L01900	Albert <i>et al.</i> 1992
<i>Daphniphyllaceae</i>	<i>Daphniphyllum</i> sp.	L01901	Albert <i>et al.</i> 1992
<i>Datiscaceae</i>	<i>Datisca cannabina</i> L.	L21939	Chase <i>et al.</i> 1993
<i>Datiscaceae</i>	<i>Octomeles sumatrana</i> Teijsm. & Binn. ex Hassk.	L21942	Swenson unpubl.
<i>Datiscaceae</i>	<i>Tetrameles nudiflora</i> R. Br.	L21943	Chase <i>et al.</i> 1993
<i>Desfontainiaceae</i>	<i>Desfontainia spinosa</i> Ruiz & Pav.	Z29670	Bremer <i>et al.</i> 1994
<i>Diapensiaceae</i>	<i>Diapensia lapponica</i> L.	L12612	Kron & Chase 1993
<i>Dichapetalaceae</i>	<i>Dichapetalum crassifolium</i> Chodat	X69733	Savolainen <i>et al.</i> in press
<i>Dichapetalaceae</i>	<i>Tapura amazonica</i> Poepp. & Endl.	AF089763	Litt & Chase 1999
<i>Didiereaceae</i>	<i>Alluaudia procera</i> Drake	M62563	Rettig <i>et al.</i> 1992
<i>Didymelaceae</i>	<i>Didymelae perrieri</i> Leandri	AF094541	Hoot <i>et al.</i> 1999
<i>Diegodendraceae</i>	<i>Diegodendron humbertii</i> Capuron	YI5138	Fay <i>et al.</i> 1998a
<i>Diervillaceae</i>	<i>Diervilla sessifolia</i> Buckley	Z29672	Bremer <i>et al.</i> 1994
<i>Dilleniaceae</i>	<i>Dillenia indica</i> L.	L01903	Albert <i>et al.</i> 1992
<i>Dilleniaceae</i>	<i>Hibbertia volubilis</i> Andrews	AF093721	Hoot <i>et al.</i> 1999
<i>Dilleniaceae</i>	<i>Pachynema juncea</i> Benth.	AJ402980/AJ403030	this paper (<i>Carlquist</i> 15460 NY)
<i>Dilleniaceae</i>	<i>Schumacheria</i> sp.	AF095734	Savolainen <i>et al.</i> in press
<i>Dilleniaceae</i>	<i>Tetracera asiatica</i> Hoogland	AJ235796	Savolainen <i>et al.</i> in press
<i>Dioncophyllaceae</i>	<i>Triphyophyllum peltatum</i> (Hutch. & Dalziel) Airy Shaw	Z97637	Lledó <i>et al.</i> 1998
<i>Dipsacaceae</i>	<i>Dipsacus sativus</i> (L.) Honck.	L13824	Olmstead <i>et al.</i> 1992
<i>Dipterocarpaceae</i>	<i>Monotes</i> sp.	N/A	Dayanandan <i>et al.</i> 1999
<i>Dipterocarpaceae</i>	<i>Pakaraimaea dipterocarpa</i> Maguire & P. S. Ashton	N/A	Dayanandan <i>et al.</i> 1999
<i>Dipterocarpaceae</i>	<i>Shorea worthingtonii</i> P. S. Ashton	N/A	Dayanandan <i>et al.</i> 1999

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<i>Dirachmaceae</i>	<i>Dirachma socotrana</i> Schweinf. ex Balf.	AJ225789	Thulin <i>et al.</i> 1998
<i>Donatiaceae</i>	<i>Donatia fascicularis</i> J. R. Forst. & G. Forst.	X87385	Gustafsson <i>et al.</i> 1996
<i>Droseraceae</i>	<i>Drosera spathulata</i> Labill.	L13168	Chase <i>et al.</i> 1993
<i>Drosophyllaceae</i>	<i>Drosophyllum lusitanicum</i> (L.) Link	L01907	Albert <i>et al.</i> 1992
<i>Ebenaceae</i>	<i>Diospyros virginiana</i> L.	L12613	Kron & Chase 1993
<i>Elaeagnaceae</i>	<i>Elaeagnus angustifolia</i> L.	V17038	Soltis <i>et al.</i> 1995
<i>Elaeocarpaceae</i>	<i>Aceratium ferrugineum</i> C. T. White	L28947	Martin & Dowd unpubl.
<i>Elaeocarpaceae</i>	<i>Crinodendron hookerianum</i> Gay	AF206754	Soltis <i>et al.</i> in press
<i>Elaeocarpaceae</i>	<i>Elaeocarpus</i> sp.	AF206765	Soltis <i>et al.</i> in press
<i>Elaeocarpaceae</i>	<i>Platytheca verticellata</i> Baill.	L01944	Chase <i>et al.</i> 1993
<i>Elaeocarpaceae</i>	<i>Sloanea latifolia</i> Schum.	AF022131	Alverson <i>et al.</i> 1998
<i>Elaeocarpaceae</i>	<i>Vallea stipularis</i> L.	AJ403015/AJ403035	this paper (<i>Lewis</i> 2657 K)
<i>Elatinaceae</i>	<i>Bergia ammannoides</i> Heyne ex Roth.	AJ402927	this paper (<i>Drummond</i> 7782 K)
<i>Elatinaceae</i>	<i>Elatine hydropiper</i> L.	AJ402948	this paper (<i>Liden</i> s.n. GB)
<i>Emblingiaceae</i>	<i>Emblingia calceoliflora</i> F. Muell.	AJ402949	this paper (<i>Chase</i> 2161 K)
<i>Eremosynaceae</i>	<i>Eremosyne pectinata</i> Endl.	L47969	Hibscher-Jetter <i>et al.</i> 1997
<i>Ericaceae</i>	<i>Erica australis</i> L.	L12617	Kron & Chase 1993
<i>Ericaceae</i>	<i>Rhododendron hippophaeoides</i> Balf. f. & W. W. Sm.	L01949	Albert <i>et al.</i> 1992
<i>Erythroxylaceae</i>	<i>Erythroxylum confusum</i> Britton	L13183	Chase <i>et al.</i> 1993
<i>Erythroxylaceae</i>	<i>Nectaropetalum zuluense</i> (Schönland) Corbishley	AJ402976	this paper (<i>Chase</i> 1128 K)
<i>Escalloniaceae</i>	<i>Escallonia coquimbensis</i> J. Rémy ex Gay	L11183	Morgan & Soltis 1993
<i>Escalloniaceae</i>	<i>Polyosma cunninghamii</i> Benn.	AJ402992	Xiang & Soltis 1998
<i>Eucommiaceae</i>	<i>Eucommia ulmoides</i> Oliv.	L01917	Albert <i>et al.</i> 1992
<i>Euphorbiaceae</i>	<i>Bernardia incana</i> C. V. Morton	AJ402928	this paper (<i>McGill & Sundell</i> 5459 K)
<i>Euphorbiaceae</i>	<i>Dysopsis glechomoides</i> Müll. Arg.	AJ402946	this paper (<i>Wallen & Moore</i> 3815 NY)
<i>Euphorbiaceae</i>	<i>Endospermum moluccanum</i> Becc.	AJ402950	this paper (<i>Chase</i> 1258 K)
<i>Euphorbiaceae</i>	<i>Euphorbia polychroma</i> A. Kern.	L13183	Chase <i>et al.</i> 1993
<i>Euphorbiaceae</i>	<i>Koilodepas batamense</i> Hassk.	AJ402965	this paper (<i>Chase</i> 1263 K)
<i>Euphorbiaceae</i>	<i>Micrandra minor</i> Benth.	AJ402974	this paper (<i>Rimachi</i> 8731 NY)
<i>Euphorbiaceae</i>	<i>Neoscortechinia kingii</i> Pax & K. Hoffm.	AJ402977	this paper (<i>Chase</i> 1265 K)
<i>Euphorbiaceae</i>	<i>Omalanthus populneus</i> Kuntze	AJ402978	this paper (<i>Chase</i> 1266 K)
<i>Euphorbiaceae</i>	<i>Ostodes paniculata</i> Blume	AJ402979	this paper (<i>Chase</i> 1267 K)
<i>Eupteleaceae</i>	<i>Euptelea polyandra</i> Siebold et Zucc.	L12645	Chase <i>et al.</i> 1993
<i>Fabaceae</i>	<i>Albizia</i> sp.	Z70149	Käss unpubl.

<i>Fabaceae</i>	<i>Bauhinia candicans</i> Benth.	Z70161	Käss unpubl.
<i>Fabaceae</i>	<i>Cercis canadensis</i> L.	U74188	Doyle <i>et al.</i> 1997
<i>Fabaceae</i>	<i>Chamaecrista fasciculata</i> Greene	U74187	Doyle <i>et al.</i> 1997
<i>Fabaceae</i>	<i>Gymnocladus dioica</i> C. Koch	U74193	Doyle <i>et al.</i> 1997
<i>Fabaceae</i>	<i>Medicago sativa</i> L.	Z70173	Käss & Wink 1995
<i>Fabaceae</i>	<i>Parkia roxburghii</i> G. Don	Z70152	Käss unpubl.
<i>Fabaceae</i>	<i>Pisum sativum</i> L.	X03853	Zurawski <i>et al.</i> 1986
<i>Fabaceae</i>	<i>Xanthocercis zambesiaca</i> (Baker) Dumaz-le-Grand	U74189	Doyle <i>et al.</i> 1997
<i>Fagaceae</i>	<i>Chrysolepis sempervirens</i> (Kellogg) Hjelmq.	AF061995	Chase <i>et al.</i> 1993
<i>Fagaceae</i>	<i>Fagus sylvatica</i> L.	L13340	Martin & Dowd 1993
<i>Fagaceae</i>	<i>Quercus rubra</i> menta Trel.	AF132888	Soltis <i>et al.</i> in press
<i>Fagaceae</i>	<i>Trigonobalanus verticillata</i> Forman	AJ235812	Chase <i>et al.</i> 1993
<i>Fouquieriaceae</i>	<i>Idria columnaria</i> Kellogg	Z80210	Morton <i>et al.</i> 1997c
<i>Frankeniacae</i>	<i>Frankenia pulverulenta</i> L.	Z97638	Fay <i>et al.</i> 1997a
<i>Garryaceae</i>	<i>Garrya elliptica</i> Douglas	L01919	Morgan & Soltis 1993
<i>Geissolomataceae</i>	<i>Geissoloma marginata</i> (L.) A. Juss.	AJ402953/AJ403022	this paper (<i>Savolainen gmal G</i>)
<i>Gelsemiaceae</i>	<i>Gelsemium sempervirens</i> (L.) Pers.	L14397	Olmstead <i>et al.</i> 1993
<i>Gentianaceae</i>	<i>Anthocleista grandiflora</i> Gilg	L14389	Olmstead <i>et al.</i> 1993
<i>Gentianaceae</i>	<i>Exacum affine</i> Balf. f. ex Regel	L11684	Olmstead <i>et al.</i> 1992
<i>Gentianaceae</i>	<i>Fagraea</i> sp.	L14396	Olmstead <i>et al.</i> 1993
<i>Gentianaceae</i>	<i>Gentiana procera</i> Holm	L14398	Olmstead <i>et al.</i> 1993
<i>Gentianaceae</i>	<i>Gentianella rapunculoides</i> (Willd. ex Schult.) J. S. Pringle	Y11862	Bremer & Thulin 1998
<i>Geraniaceae</i>	<i>Geranium cinereum</i> Cav.	L14695	Price & Palmer 1993
<i>Geraniaceae</i>	<i>Hypseocharis</i> sp.	L14699	Price & Palmer 1993
<i>Geraniaceae</i>	<i>Monsonia emarginata</i> (L.) L' Her.	L14701	Price & Palmer 1993
<i>Geraniaceae</i>	<i>Pelargonium cotyledonis</i> L' Her.	L01919	Albert <i>et al.</i> 1992
<i>Geraniaceae</i>	<i>Wendtia gracilis</i> Meyen	L14708	Price & Palmer 1993
<i>Gesneriaceae</i>	<i>Streptocarpus holstii</i> Engl.	L14409	Olmstead <i>et al.</i> 1993
<i>Goodeniaceae</i>	<i>Scaevola aemula</i> R. Br.	L13932	Michaels <i>et al.</i> 1993
<i>Goupiaceae</i>	<i>Gounia glabra</i> Aubl.	AJ235780	Savolainen <i>et al.</i> in press
<i>Grossulariaceae</i>	<i>Ribes aureum</i> Pursh	L11204	Morgan & Soltis 1993
<i>Grubbiaceae</i>	<i>Grubbia tomentosa</i> (Thunb.) Harms	Z83141	Morton <i>et al.</i> 1997b
<i>Gunneraceae</i>	<i>Gunnera manicata</i> Linden	L11186	Morgan & Soltis 1993
<i>Gyrostemonaceae</i>	<i>Gyrostemon</i> sp.	L22439	Rodman <i>et al.</i> 1994
<i>Halophytaceae</i>	<i>Halophytum ameghinoi</i> Specg.	AJ402958/AJ403024	this paper (<i>Chase 1753 K</i>)
<i>Haloragaceae</i>	<i>Haloragis serra</i> Brongn.	U26325	Conti <i>et al.</i> 1996

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<i>Haloragaceae</i>	<i>Myriophyllum exalbescens</i> Fernald	L11195	Morgan & Soltis 1993
<i>Hamamelidaceae</i>	<i>Corylopsis pauciflora</i> Siebold & Zucc.	AF094548	Hoot <i>et al.</i> 1999
<i>Hamamelidaceae</i>	<i>Disanthus cercidifolia</i> Maxim.	AF094549	Hoot <i>et al.</i> 1999
<i>Hamamelidaceae</i>	<i>Exbucklandia populnea</i> (R. Br. ex Griff.) R. W. Br.	AF060708	Qiu <i>et al.</i> 1998
<i>Hamamelidaceae</i>	<i>Hamamelis mollis</i> Oliv.	L01922	Albert <i>et al.</i> 1992
<i>Hamamelidaceae</i>	<i>Trichocladus crinitis</i> Pers.	AF060711	Qiu <i>et al.</i> 1998
<i>Helwingiaceae</i>	<i>Helwingia japonica</i> (Thunb.) F. Dietr.	L11226	Xiang <i>et al.</i> 1993
<i>Huaceae</i>	<i>Afrostyrax</i> sp.	AJ235771	Savolainen <i>et al.</i> in press
<i>Huaceae</i>	<i>Hua gabonii</i> Pierre ex De Wild.	AJ402960	this paper (<i>Wieringa</i> 3177 WAG)
<i>Humiriaceae</i>	<i>Humiria balsamifera</i> Aubl.	L01926	Albert <i>et al.</i> 1992
<i>Humiriaceae</i>	<i>Vantanea guianensis</i> Aubl.	Z75679	Fay <i>et al.</i> 1997b
<i>Hydrangeaceae</i>	<i>Hydrangea macrophylla</i> Torr.	L11187	Morgan & Soltis 1993
<i>Hydrangeaceae</i>	<i>Philadelphus lewisii</i> Pursh	L11198	Morgan & Soltis 1993
<i>Hydroleaceae</i>	<i>Hydrolea ovata</i> Nutt.	L14293	Olmstead <i>et al.</i> 1993
<i>Hydrostachyaceae</i>	<i>Hydrostachys multifida</i> A. Juss.	U17879	Hempel <i>et al.</i> 1995
<i>Icacinaceae</i>	<i>Chlamydocharya thomsoniana</i> Baill.	AJ402939	this paper (<i>Chatelain</i> s.n. G, IIRSDA forest coll. 7.97)
<i>Icacinaceae</i>	<i>Iacina mannii</i> Oliv.	AF206780	Soltis <i>et al.</i> in press
<i>Icacinaceae</i>	<i>Iodes liberica</i> Stapf	AJ402962/AJ403025	this paper (<i>Chatelain</i> s.n. G, IIRSDA forest coll. 7.97)
<i>Icacinaceae</i>	<i>Pyrenacantha malvaefolia</i> Engl.	AJ402995	this paper (<i>Chase</i> 683 K)
<i>Icacinaceae</i>	<i>Sarcostigma kleinii</i> Wight & Arn.	AJ402999	this paper (<i>Chase</i> 1296 K)
<i>Irvingiaceae</i>	<i>Irvingia malayana</i> Oliv.	AF123278	Soltis <i>et al.</i> in press
<i>Iteaceae</i>	<i>Choristylis rhamnoides</i> Harv.	AJ238132	this paper (<i>Bremer</i> 3763 UPS)
<i>Iteaceae</i>	<i>Itea virginica</i> L.	L11188	Soltis <i>et al.</i> 1990
<i>Ixerbaceae</i>	<i>Ixerba brexioides</i> A. Cunn.	AF084475	Koontz & Soltis 1999
<i>Ixonanthaceae</i>	<i>Ochthocosmus</i> sp.	Z75680	Fay <i>et al.</i> 1997b
<i>Juglandaceae</i>	<i>Carya glabra</i> (Mill.) Sweet	L12637	Chase <i>et al.</i> 1993
<i>Juglandaceae</i>	<i>Juglans nigra</i> L.	U00437	Gunter <i>et al.</i> 1994
<i>Kigellariaceae</i>	<i>Kiggelaria africana</i> L.	AF206786	Soltis <i>et al.</i> in press
<i>Kigellariaceae</i>	<i>Guthriea capensis</i> Bolus	AJ402956	this paper (<i>Abbott</i> 6071 BOL)
<i>Kiggeleriaceae</i>	<i>Erythrospermum phytolaccoides</i> Gardner	AJ402951	this paper (<i>Chase</i> 1277 K)
<i>Kiggeleriaceae</i>	<i>Flacourtie jangomas</i> Steud.	AF206768	Soltis <i>et al.</i> in press
<i>Kiggeleriaceae</i>	<i>Gynocardia odorata</i> R. Br.	AJ402957	this paper (<i>Chase</i> 1276 K)

<i>Kiggeleriaceae</i>	<i>Trichadenia zeylanica</i> Thwaites	AJ403011	this paper (<i>Chase</i> 1289 K)
<i>Kiggeleriaceae</i>	Unknown species	AF206783	Soltis <i>et al.</i> in press
<i>Koeberliniaceae</i>	<i>Koeberlinia spinosa</i> Zucc.	L14600	Rodman <i>et al.</i> 1993
<i>Krameriaceae</i>	<i>Krameria lanceolata</i> Torr.	Y15032	<i>Chase</i> <i>et al.</i> 1993
<i>Lacistemataceae</i>	<i>Lacistema aggregatum</i> Rusby	AF206787	Soltis <i>et al.</i> in press
<i>Lamiaceae</i>	<i>Lavandula angustifolia</i> Bubani	Z37407	Kaufmann & Wink 1994
<i>Lardizabalaceae</i>	<i>Decaisnea fargesii</i> Franch.	L37907	Hoot <i>et al.</i> 1995
<i>Lardizabalaceae</i>	<i>Sargentodoxa cuneata</i> Rehder & E. H. Wilson	AF093731	Hoot <i>et al.</i> 1999
<i>Lecythidaceae</i>	<i>Asteranthes brasiliensis</i> Desf.	Z80198	Morton <i>et al.</i> 1997b
<i>Lecythidaceae</i>	<i>Couroupita guianensis</i> Aubl.	Z80181	Morton <i>et al.</i> 1997b
<i>Lecythidaceae</i>	<i>Eschweilera odora</i> Miers	Z80182	Morton <i>et al.</i> 1997b
<i>Lecythidaceae</i>	<i>Oubanguia alata</i> Baker f.	Z80201	Morton <i>et al.</i> 1997b
<i>Lentibulariaceae</i>	<i>Utricularia biflora</i> Roxb.	L13190	Albert <i>et al.</i> 1992
<i>Lepidobotryaceae</i>	<i>Lepidobotrys staudtii</i> Engl.	AJ402966	this paper (<i>Louis</i> 10837 K)
<i>Lepidobotryaceae</i>	<i>Ruptiliocarpon caracolito</i> Hammel & N. Zamora	AJ402997	this paper (<i>Pennington</i> & <i>Zamora</i> 631 K)
<i>Limnanthaceae</i>	<i>Limnanthes douglasii</i> R. Br.	L14700	Rodman <i>et al.</i> 1993
<i>Linaceae</i>	<i>Hugonia platysepala</i> Welw. ex Oliv.	Z75678	Fay <i>et al.</i> 1997b
<i>Linaceae</i>	<i>Linum perenne</i> Guss.	Z75681	Fay <i>et al.</i> 1997b
<i>Linaceae</i>	<i>Reinwardtia indica</i> Dumort.	L13188	<i>Chase</i> <i>et al.</i> 1993
<i>Linnaeaceae</i>	<i>Abelia</i> sp.	AF206727	Soltis <i>et al.</i> in press
<i>Lissocarpaceae</i>	<i>Lissocarpa benthamii</i> Baill.	AJ402968	this paper (<i>Maguire</i> <i>et al.</i> 29964 NY)
<i>Loasaceae</i>	<i>Eucnide lobata</i> A. Gray	U17874	Hempel <i>et al.</i> 1995
<i>Loasaceae</i>	<i>Schismocarpus matudai</i> Steyermark.	U17878	Hempel <i>et al.</i> 1995
<i>Loganiaceae</i>	<i>Geniostoma rupestre</i> J. R. Forst. & G. Forst.	Z68828	Endress <i>et al.</i> 1996
<i>Loganiaceae</i>	<i>Mostuea brunonis</i> Didr.	L14404	Olmstead <i>et al.</i> 1993
<i>Loganiaceae</i>	<i>Neuburgia corynocarpa</i> (A. Gray) Leenhardt	AJ001755	Oxelman unpubl.
<i>Loganiaceae</i>	<i>Spigelia marilandica</i> L.	L14410	Olmstead <i>et al.</i> 1993
<i>Loganiaceae</i>	<i>Strychnos nux-vomica</i> L.	L14410	Olmstead <i>et al.</i> 1993
<i>Lophopyxidaceae</i>	<i>Lophopyxis maingayi</i> Hook. f.	AJ402970/AJ403026	this paper (<i>Adelbai</i> P10203 US)
<i>Loranthaceae</i>	<i>Gaiadendron punctatum</i> G. Don	L26072	Nickrent & Soltis 1995
<i>Lythraceae</i>	<i>Lythrum hyssopifolia</i> L.	L10218	Conti <i>et al.</i> 1993
<i>Lythraceae</i>	<i>Punica protopunica</i> Balf.	L10223	Conti <i>et al.</i> 1993
<i>Lythraceae</i>	<i>Trapa natans</i> L.	L10226	Conti <i>et al.</i> 1993
<i>Malesherbiaceae</i>	<i>Malesherbia linearifolia</i> Poir.	Z75683	Fay <i>et al.</i> 1997b
<i>Malpighiaceae</i>	<i>Barnebya dispar</i> (Griseb.) W. R. Anderson & B. Gates	AJ402924/AJ403020	this paper (<i>Leoni</i> 1473 MICH)
<i>Malpighiaceae</i>	<i>Byrsinima crassifolia</i> Humb., Bonpl. & Kunth.	L01892	Albert <i>et al.</i> 1992
<i>Malpighiaceae</i>	<i>Dicella nucifera</i> Chodat	AJ235802	<i>Chase</i> <i>et al.</i> 1993

Family	Species	Accession number	Citation (voucher)
Malvaceae	<i>Fremontodendron mexicanum</i> Davidson	AF022124	Alverson <i>et al.</i> 1998
Malvaceae	<i>Gossypium robinsoni</i> F. Muell.	L13186	Chase <i>et al.</i> 1993
Malvaceae	<i>Quararibea gomeziana</i> W. S. Alverson	AF022121	Alverson <i>et al.</i> 1998
Malvaceae	<i>Sterculia tragacantha</i> Lindl.	AF022126	Bayer <i>et al.</i> 1999
Marcgraviaceae	<i>Marcgravia rectiflora</i> Triana & Planch.	Z83148	Morton <i>et al.</i> 1997b
Marcgraviaceae	<i>Norantea guianensis</i> Aubl.	Z80200	Morton <i>et al.</i> 1997b
Martyniaceae	<i>Proboscidea louisianica</i> Thell.	L01946	Albert <i>et al.</i> 1992
Melastomataceae	<i>Osbeckia stellata</i> Wall.	U26330	Conti <i>et al.</i> 1996
Meliaceae	<i>Azadirachta indica</i> A. Juss.	AJ402917	this paper (<i>Chase</i> 1307 K)
Meliaceae	<i>Capuronianthus mahafalensis</i> Leroy	AJ402935	this paper (<i>Fosberg</i> 52439 K)
Meliaceae	<i>Cedrela odorata</i> Cham. & Schtdl.	AJ402938	this paper (<i>Chase</i> 2112 K)
Meliaceae	<i>Ekebergia capensis</i> Sparrm.	AJ402947	this paper (<i>Chase</i> 5807 K)
Meliaceae	<i>Guarea glabra</i> Vahl	U39085	Gadek <i>et al.</i> 1996
Meliaceae	<i>Heckeldora staudtii</i> (Harms) Staner	AJ402959	this paper (<i>Chase</i> 3311 K)
Meliaceae	<i>Khaya anthotheca</i> DC.	AJ402964	this paper (<i>Chase</i> 2859 K)
Meliaceae	<i>Vavaea amicorum</i> Benth.	AJ403016/AJ403036	this paper (<i>Katik</i> <i>et al.</i> 74722 K)
Meliaceae	<i>Walsura tubulata</i> Hiern	AJ403017	this paper (<i>Chase</i> 1314 K)
Melianthaceae	<i>Bersama lucens</i> Szyszyl.	AJ235774	Savolainen <i>et al.</i> in press
Melianthaceae	<i>Francoa sonchifolia</i> Cav.	L11184	Soltis <i>et al.</i> 1990
Melianthaceae	<i>Greyia radlkoferi</i> Szyszyl.	L11185	Morgan & Soltis 1993
Melianthaceae	<i>Melianthus major</i> L.	AJ402972/AJ403027	Gadek <i>et al.</i> 1996
Memecylaceae	<i>Mouriri cyphocarpa</i> Standl.	U26327	Conti <i>et al.</i> 1996
Menispermaceae	<i>Menispermum canadensis</i> L.	AF093726	Hoot <i>et al.</i> 1999
Menyanthaceae	<i>Menyanthes trifoliata</i> L.	L14006	Olmstead <i>et al.</i> 1993
Misodendraceae	<i>Misodendron brachystachyum</i> DC.	L26074	Nickrent & Soltis 1995
Molluginaceae	<i>Mollugo verticillata</i> L.	M62566	Rettig <i>et al.</i> 1992
Montiniaceae	<i>Kaliphora madagascariensis</i> Hook. f.	AJ402963	Xiang & Soltis 1998
Montiniaceae	<i>Montinia caryophyllacea</i> Thunb.	L11194	Morgan & Soltis 1993
Moraceae	<i>Ficus trigonata</i> L.	AF206767	Chase <i>et al.</i> 1993
Morinaceae	<i>Morina coulteriana</i> Royle	Y10706	Backlund & Bremer 1998
Moringaceae	<i>Moringa oleifera</i> Lam.	L11359	Rodman <i>et al.</i> 1993
Muntingiaceae	<i>Dicraspidia donnell-smithii</i> Standl.	Y15145	Fay <i>et al.</i> 1998a
Muntingiaceae	<i>Muntingia calabura</i> L.	Y15146	Fay <i>et al.</i> 1998a
Myoporaceae	<i>Myoporum mauritanum</i> DC.	L36403	Olmstead & Reeves 1995

<i>Myricaceae</i>	<i>Myrica cerifera</i> L.	L01934	Albert <i>et al.</i> 1992
<i>Myrothamnaceae</i>	<i>Myrothamnus flabellifolius</i> Welw.	AF060707	Qiu <i>et al.</i> 1998
<i>Myrsinaceae</i>	<i>Ardisia crenata</i> Sims.	L12599	Kron & Chase 1993
<i>Myrsinaceae</i>	<i>Maesa myrsinoidea</i> Lév.	Z80203	Morton <i>et al.</i> 1997c
<i>Myrtaceae</i>	<i>Heteropyxis natalensis</i> Harv.	U26326	Soltis <i>et al.</i> in press
<i>Myrtaceae</i>	<i>Metrosideros nervulosa</i> C. Moore & F. Muell.	AJ402973/AJ403028	Conti <i>et al.</i> 1996
<i>Nelumbonaceae</i>	<i>Nelumbo lutea</i> Pers.	M77032	Les <i>et al.</i> 1991
<i>Nepenthaceae</i>	<i>Nepenthes alata</i> Blanco	L01935	Albert <i>et al.</i> 1992
<i>Neuradaceae</i>	<i>Grielum humifusum</i> Thunb.	AJ402955/AJ403023	this paper (<i>Chase</i> 5711 K)
<i>Neuradaceae</i>	<i>Neurada procumbens</i> L.	U06814	Morgan <i>et al.</i> 1993
<i>Nothofagaceae</i>	<i>Nothofagus dombeyi</i> (Mirb.) Oerst.	L13350	Qiu <i>et al.</i> 1998
<i>Nyctaginaceae</i>	<i>Bougainvillea glabra</i> Choisy	M88340	Rettig <i>et al.</i> 1992
<i>Nyctaginaceae</i>	<i>Mirabilis jalapa</i> L.	M62565	Rettig <i>et al.</i> 1992
<i>Ochnaceae</i>	<i>Luxemburgia ciliosa</i> (Mart.) Tiegh.	Z75685	Fay <i>et al.</i> 1997b
<i>Ochnaceae</i>	<i>Medusagyne oppositifolia</i> Baker	Z75670	Fay <i>et al.</i> 1997b
<i>Ochnaceae</i>	<i>Ochna serratula</i> Walp.	Z75273	Chase <i>et al.</i> 1993
<i>Ochnaceae</i>	<i>Quiina pteridophylla</i> (Radlk.) Pires	Z75689	Fay <i>et al.</i> 1997b
<i>Olacaceae</i>	<i>Heisteria parvifolia</i> Sm.	AJ131771	this paper (<i>Savolainen</i> hpa G)
<i>Olacaceae</i>	<i>Schoepfia schreberi</i> J. F. Gmel.	L11205	Chase <i>et al.</i> 1993
<i>Oleaceae</i>	<i>Jasminum suavissimum</i> Lindl.	L01929	Albert <i>et al.</i> 1992
<i>Oliniaceae</i>	<i>Olinia cymosa</i> Thunb.	U26329	Conti <i>et al.</i> 1996
<i>Onagraceae</i>	<i>Clarkia xantiiana</i> A. Gray	L10896	Olmstead <i>et al.</i> 1992
<i>Onagraceae</i>	<i>Epilobium angustifolium</i> L.	L10217	Conti <i>et al.</i> 1993
<i>Oncothecaceae</i>	<i>Oncotheca balansae</i> Baill.	AJ131950	Savolainen <i>et al.</i> in press
<i>Opiliaceae</i>	<i>Opilia amentacea</i> Roxb.	AJ131773	Savolainen <i>et al.</i> in press
<i>Oxalidaceae</i>	<i>Averrhoa carambola</i> L.	L14692	Price & Palmer 1993
<i>Oxalidaceae</i>	<i>Oxalis dillenii</i> Jacq.	L01938	Albert <i>et al.</i> 1992
<i>Paeoniaceae</i>	<i>Paeonia humilis</i> Willd.	AJ402981/AJ403031	this paper (<i>Chase</i> 504 K)
<i>Paeoniaceae</i>	<i>Paeonia suffruticosa</i> Andrews	AJ402982	this paper (<i>Chase</i> 486 K)
<i>Paeoniaceae</i>	<i>Paeonia tenuifolia</i> L.	L13687	Chase <i>et al.</i> 1993
<i>Pandaceae</i>	<i>Microdesmis puberula</i> Hook. f.	AJ402975/AJ403029	this paper (<i>Chase</i> 5986 K)
<i>Papaveraceae</i>	<i>Argemone mexicana</i> L.	U86621	Hoot <i>et al.</i> 1997
<i>Papaveraceae</i>	<i>Dicentra spectabilis</i> (L.) Lem.	L08761	Chase <i>et al.</i> 1993
<i>Papaveraceae</i>	<i>Pteridophyllum racemosum</i> Siebold & Zucc.	U86631	Hoot <i>et al.</i> 1997
<i>Paracryphiaceae</i>	<i>Paracryphia alticola</i> (Schltr.) Steenis	AJ402983	this paper (<i>Chase</i> 9604 K)
<i>Parnassiaceae</i>	<i>Lepuropetalon spathulatum</i> (Muhl.) Elliott	L11192	Morgan & Soltis 1993
<i>Parnassiaceae</i>	<i>Parnassia fimbriata</i> Banks	L01939	Soltis <i>et al.</i> 1990

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<i>Passifloraceae</i>	<i>Adenia digitata</i> Engl.	Z75687	Fay <i>et al.</i> 1997b
<i>Passifloraceae</i>	<i>Paropsia madagascariensis</i> (Baill.) H. Perrier	AF206802	Soltis <i>et al.</i> in press
<i>Passifloraceae</i>	<i>Passiflora quadrangularis</i> L.	L01940	Albert <i>et al.</i> 1992
<i>Paulowniaceae</i>	<i>Paulownia tomentosa</i> (Thunb.) Steud.	L36447	Olmstead & Reeves 1995
<i>Pedaliaceae</i>	<i>Sesamum indicum</i> L.	L14408	Olmstead <i>et al.</i> 1993
<i>Peganaceae</i>	<i>Malacocarpus crithmifolius</i> Fisch. & C. A. Mey.	U39280	Gadek <i>et al.</i> 1996
<i>Peganaceae</i>	<i>Nitaria retusa</i> Asch.	U39278	Gadek <i>et al.</i> 1996
<i>Peganaceae</i>	<i>Peganum harmala</i> L.	U38279	Gadek <i>et al.</i> 1996
<i>Peganaceae</i>	<i>Tetradiclis tenella</i> (Ehrenb.) Litv.	AJ403009	this paper (<i>F. A. Barkley</i> 7848 K)
<i>Pelliceriaceae</i>	<i>Pelliciera rhizophora</i> Planch. & Triana	AF206804	Morton <i>et al.</i> 1997b
<i>Penaeaceae</i>	<i>Penaea mucronata</i> L.	U26331	Conti <i>et al.</i> 1996
<i>Pentadiplandraceae</i>	<i>Pentadiplandra brazzeana</i> Baill.	U38533	Rodman <i>et al.</i> 1996
<i>Pentaphragmataceae</i>	<i>Pentaphragma ellipticum</i> Poulsen	L18794	Cosner <i>et al.</i> 1994
<i>Pentaphylacaceae</i>	<i>Pentaphylax euroides</i> Gardner & Champ.	AJ402986	this paper (<i>Hu</i> 11401 K)
<i>Penthoraceae</i>	<i>Penthorum sedoides</i> L.	L11197	Morgan & Soltis 1993
<i>Peridiscaceae</i>	<i>Whitttonia guianensis</i> Sandwith	AJ403018	this paper (<i>Whitten</i> 84 NY)
<i>Petiveriaceae</i>	<i>Petiveria alliacea</i> L.	AJ402987	this paper (<i>Whitten</i> 1743 FLAS)
<i>Phellinaceae</i>	<i>Phelline comosa</i> Labill.	X69748	Savolainen <i>et al.</i> in press
<i>Phrymaceae</i>	<i>Phryma leptostachya</i> L.	L28881	Wagstaff & Olmstead unpubl.
<i>Phyllanthaceae</i>	<i>Phyllanthus liebmannianus</i> Müll. Arg.	Z75676	Fay <i>et al.</i> 1997b
<i>Phyllonomaceae</i>	<i>Phyllonoma laticuspis</i> Engl.	L11201	Morgan & Soltis 1993
<i>Physenaceae</i>	<i>Physena</i> sp.	Y13116	Morton <i>et al.</i> 1997a
<i>Phytolaccaceae</i>	<i>Ercilla volubilis</i> A. Juss.	AJ235800	Savolainen <i>et al.</i> in press
<i>Phytolaccaceae</i>	<i>Phytolacca americana</i> L.	M62567	Rettig <i>et al.</i> 1992
<i>Phytolaccaceae</i>	<i>Stegnosperma halimifolium</i> Benth.	M62570	Rettig <i>et al.</i> 1992
<i>Picramniaceae</i>	<i>Alvaradoa amorphoides</i> Liebm.	AF123277	Fernando <i>et al.</i> 1993
<i>Picramniaceae</i>	<i>Picramnia polyantha</i> Planch.	AF127025	Fernando <i>et al.</i> 1993
<i>Pittosporaceae</i>	<i>Pittosporum japonicum</i> Hort. ex C. Presl	L11202	Morgan & Soltis 1993
<i>Platanaceae</i>	<i>Platanus occidentalis</i> L.	L01943	Albert <i>et al.</i> 1992
<i>Plocospermataceae</i>	<i>Plocosperma buxifolium</i> Benth.	Z68829	Endress <i>et al.</i> 1996
<i>Plumbaginaceae</i>	<i>Aegialitis annulata</i> R. Br.	AJ402918	this paper (<i>Ingrouille</i> M1196002, no voucher)
<i>Plumbaginaceae</i>	<i>Limonium dendroides</i> Svent.	Z97644	Fay <i>et al.</i> 1997a
<i>Plumbaginaceae</i>	<i>Plumbago auriculata</i> Blume	M77701	Giannasi <i>et al.</i> 1992
<i>Podostemaceae</i>	<i>Marathrum oxycarpum</i> Tul.	AJ402971	this paper (<i>Amaral</i> s.n. UEC)

<i>Podostemaceae</i>	<i>Tristicha trifaria</i> (Bory ex Willd.) Spreng.	U68089	Les <i>et al.</i> 1997
<i>Polemoniaceae</i>	<i>Cobaea scandens</i> Cav.	Z83143	Morton <i>et al.</i> 1997b
<i>Polemoniaceae</i>	<i>Phlox longifolia</i> Nutt.	AF156732	Albach unpubl.
<i>Polygonaceae</i>	<i>Comesperma ericinum</i> DC.	L29492	Fernando <i>et al.</i> 1993
<i>Polygalaceae</i>	<i>Polygala cruciata</i> L.	L01945	Albert <i>et al.</i> 1992
<i>Polygalaceae</i>	<i>Securidaca diversifolia</i> (L.) S. F. Blake	L01955	Olmstead <i>et al.</i> 1992
<i>Polygalaceae</i>	<i>Xanthophyllum</i> sp.	AJ235799	Savolainen <i>et al.</i> in press
<i>Polygonaceae</i>	<i>Polygonum sachalinense</i> F. Schmidt	AJ235789	Lledó <i>et al.</i> 1998
<i>Polygonaceae</i>	<i>Rheum x cultorum</i> Thorsrud & Reisaeter	M77702	Chase <i>et al.</i> 1993
<i>Portulacaceae</i>	<i>Portulaca grandiflora</i> Hook.	M62568	Rettig <i>et al.</i> 1992
<i>Primulaceae</i>	<i>Anagallis arvensis</i> L.	M88343	Chase <i>et al.</i> 1993
<i>Proteaceae</i>	<i>Isopogon latifolius</i> R. Br.	U79179	Plunkett <i>et al.</i> unpubl.
<i>Proteaceae</i>	<i>Lambertia inermis</i> R. Br.	L11190	Morgan & Soltis 1993
<i>Proteaceae</i>	<i>Protea repens</i> Andrews	U79182	Plunkett <i>et al.</i> unpubl.
<i>Pseudanthaceae</i>	<i>Androstachys johnsonii</i> Prain	AJ402922	this paper (<i>Chase</i> 1904 K)
<i>Pseudanthaceae</i>	<i>Hyaenanche globosa</i> Lamb.	AJ402961	this paper (<i>Chase</i> 1445 K)
<i>Pseudanthaceae</i>	<i>Stachystemon axillare</i> A. S. George	AJ403006	this paper (<i>Chase</i> 2165 K)
<i>Psiloxylaceae</i>	<i>Psiloxylon mauritianum</i> Baill.	U26333	Conti <i>et al.</i> 1996
<i>Pterostemonaceae</i>	<i>Pterostemon rotundifolium</i> Ramírez	L11203	Morgan & Soltis 1993
<i>Putranjivaceae</i>	<i>Drypetes macrostigma</i> J. J. Sm.	AJ402945	this paper (<i>Chase</i> 1259 K)
<i>Putranjivaceae</i>	<i>Putranjiva roxburghii</i> (Wall.) Hurus.	M95757	Rodman <i>et al.</i> 1993
<i>Quillajaceae</i>	<i>Quillaja saponaria</i> Poir.	U06822	Morgan <i>et al.</i> 1994
<i>Ranunculaceae</i>	<i>Coptis trifolia</i> Salisb.	AF093730	Hoot <i>et al.</i> 1999
<i>Ranunculaceae</i>	<i>Glaucidium palmatum</i> Siebold & Zucc.	AF093723	Hoot & Crane 1995
<i>Resedaceae</i>	<i>Reseda alba</i> L.	M95756	Rodman <i>et al.</i> 1993
<i>Rhabdodendraceae</i>	<i>Rhabdodendron amazonicum</i> Huber	Z97649	Fay <i>et al.</i> 1997a
<i>Rhamnaceae</i>	<i>Rhamnus cathartica</i> L.	L13189	Chase <i>et al.</i> 1993
<i>Rhamnaceae</i>	<i>Zizyphus glabrata</i> Heyne ex. Roth	U60313	Thulin <i>et al.</i> 1998
<i>Rhizophoraceae</i>	<i>Carallia brachiata</i> Merr.	AF006757	Soltis <i>et al.</i> in press
<i>Rhizophoraceae</i>	<i>Cassipourea rotundifolia</i> Alston	AF006762	Setoguchi <i>et al.</i> unpubl.
<i>Rhizophoraceae</i>	<i>Kandelia candel</i> Druce	AF006755	Setoguchi <i>et al.</i> unpubl.
<i>Rhizophoraceae</i>	<i>Rhizophora mangle</i> L.	U26335	Conti <i>et al.</i> 1996
<i>Rhoipteleaceae</i>	<i>Rhoiptelea chilantha</i> Diels & Hand.-Mazz.	AF017687	Chen <i>et al.</i> 1998
<i>Roridulaceae</i>	<i>Roridula gorgonias</i> Planch.	L01950	Albert <i>et al.</i> 1992
<i>Rosaceae</i>	<i>Dryas drummondii</i> Richardson	U59818	Swensen 1996
<i>Rosaceae</i>	<i>Rosa woodsii</i> Lindl.	U06824	Morgan <i>et al.</i> 1994
<i>Rosaceae</i>	<i>Spirea vanhouttei</i> Zabel	L11206	Morgan & Soltis 1993

Family	Species	Accession number	Citation (voucher)
Rousseaceae	<i>Rousseea simplex</i> Sm.	AJ235792	Savolainen <i>et al.</i> in press
Rubiaceae	<i>Cephaelanthus occidentalis</i> L.	X83629	Bremer <i>et al.</i> 1995
Rubiaceae	<i>Cinchona pubescens</i> Vahl	X83630	Bremer <i>et al.</i> 1995
Rubiaceae	<i>Dialypetalanthus fuscescens</i> Kuhlm.	AJ251366	Fay <i>et al.</i> in press
Rubiaceae	<i>Galium album</i> Garsault	X81090	Manen & Natali 1995
Rubiaceae	<i>Gardenia thunbergia</i> L.	X83637	Bremer <i>et al.</i> 1995
Rutaceae	<i>Bottegoa insignis</i> Chiov.	AJ402931	this paper (Chiov. 4824 K)
Rutaceae	<i>Chloroxylon swietenia</i> DC.	AF066802	Chase <i>et al.</i> 1999
Rutaceae	<i>Cneorum pulverulentum</i> Vent.	AF066828	Gadek <i>et al.</i> 1996
Rutaceae	<i>Dictyoloma vandellianum</i> A. Juss.	AF066823	Chase <i>et al.</i> 1993
Rutaceae	<i>Flindersia australis</i> R. Br.	U38861	Gadek <i>et al.</i> 1996
Rutaceae	<i>Poncirus trifoliata</i> Raf.	AJ235806	Chase <i>et al.</i> 1993
Rutaceae	<i>Ptaeroxylon obliquum</i> Radlk.	AF123276	Gadek <i>et al.</i> 1996
Rutaceae	<i>Ruta graveolens</i> L.	U39281	Gadek <i>et al.</i> 1996
Rutaceae	<i>Spathelia excelsa</i> (K. Krause) R. S. Cowan & Brizicky	AF066798	Chase <i>et al.</i> 1993
Sabiaceae	<i>Meliosma simplicifolia</i> Walp.	AF19587	Qiu <i>et al.</i> 1998
Sabiaceae	<i>Sabia swinhonis</i> Hemsl. ex F. B. Forbes & Hemsl.	L12662	Chase <i>et al.</i> 1993
Salicaceae	<i>Banara guianensis</i> Aubl.	AJ402923	this paper (Pennington & Zamora 593 K)
Salicaceae	<i>Bembicia</i> sp.	AJ402926/AJ403021	this paper (Civeyrel 1374 K)
Salicaceae	<i>Casearia sylvestris</i> Sw.	AF206746	Soltis <i>et al.</i> in press
Salicaceae	<i>Dovyalis rhamnoides</i> Burch. ex Harv. & Sond.	Z75677	Fay <i>et al.</i> 1997b
Salicaceae	<i>Poliothyrsis sinensis</i> Oliv.	AJ402991	this paper (Wurdack s.n. K)
Salicaceae	<i>Populus euphratica</i> Olivier	AJ402993	this paper (M. D. Lledó & M. B. Crespo 368 ABH)
Salicaceae	<i>Salix reticulata</i> L.	AJ235793	Savolainen <i>et al.</i> in press
Salicaceae	<i>Scyphostegia borneensis</i> Stapf	AJ403000	this paper (Davis s.n. BH)
Salicaceae	<i>Salvadora persica</i> L.	X69755	Savolainen <i>et al.</i> 1994
Salvadoraceae	<i>Osyris lanceolata</i> Hochst. & Steud.	L11196	Morgan & Soltis 1993
Santalaceae	<i>Santalum album</i> L.	L26077	Nickrent & Soltis 1995
Santalaceae	<i>Viscum album</i> L.	L26078	Nickrent & Soltis 1995
Sapindaceae	<i>Acer saccharum</i> L.	L01881	Chase <i>et al.</i> 1993
Sapindaceae	<i>Aesculus pavia</i> Castigl.	U39277	Gadek <i>et al.</i> 1996
Sapindaceae	<i>Billia hippocastanum</i> Peyr.	AJ402929	this paper (Pennington & Zamora 604 K)
Sapindaceae	<i>Ditadenopteryx sorbilofolia</i> Radlk.	AJ402943	this paper (Tressens <i>et al.</i> 3504 K)
Sapindaceae	<i>Diplopeltis huegelii</i> Endl.	AJ402944	this paper (Chase 2192 K)

<i>Sapindaceae</i>	<i>Dipteronia sinensis</i> Oliv.	U39268	Gadek <i>et al.</i> 1996
<i>Sapindaceae</i>	<i>Koebreutera paniculata</i> Laxm.	U39283	Gadek <i>et al.</i> 1996
<i>Sapindaceae</i>	<i>Paranephelium macrophyllum</i> King	AJ402984/AJ403032	this paper (<i>Chase</i> 1356 K)
<i>Sapindaceae</i>	<i>Serjania communis</i> Cambess.	AJ403001	this paper (<i>Chase</i> 2138 K)
<i>Sapindaceae</i>	<i>Talisia nervosa</i> Radlk.	AJ403008	this paper (<i>Pennington</i> 628 K)
<i>Sapindaceae</i>	<i>Ungnadia speciosa</i> Endl.	AJ403014	this paper (<i>Chase</i> 2854 K)
<i>Sapindaceae</i>	<i>Xanthoceras sorbifolia</i> Bunge	AJ403019	this paper (<i>Chase</i> 2866 K)
<i>Sapotaceae</i>	<i>Manilkara zapota</i> Royen	L01932	Albert <i>et al.</i> 1992
<i>Sarcolaenaceae</i>	<i>Sarcolaena</i> sp.	YI5147	Fay <i>et al.</i> 1998a
<i>Sarraceniaceae</i>	<i>Sarracenia flava</i> L.	L01952	Albert <i>et al.</i> 1992
<i>Saxifragaceae</i>	<i>Astilbe taquetii</i> Koidz.	L11173	Soltis <i>et al.</i> 1990
<i>Saxifragaceae</i>	<i>Heuchera micrantha</i> Douglas	L11173	Soltis <i>et al.</i> 1990
<i>Saxifragaceae</i>	<i>Saxifraga integrifolia</i> Hook.	L01953	Morgan & Soltis 1993
<i>Schlegeliaceae</i>	<i>Schlegelia parviflora</i> (Oerst.) Monach.	L36448	Olmstead & Reeves 1995
<i>Scrophulariaceae</i>	<i>Antirrhinum majus</i> L.	L11688	Olmstead <i>et al.</i> 1992
<i>Scrophulariaceae</i>	<i>Calceolaria</i> sp.	AF123669	Olmstead <i>et al.</i> unpubl.
<i>Scrophulariaceae</i>	<i>Mimulus aurantiacus</i> Renjifo	AF026835	Wolfe & dePamphilis 1998
<i>Scrophulariaceae</i>	<i>Pedicularis foliosa</i> Gunnerus	AF026836	Wolfe & dePamphilis 1998
<i>Scrophulariaceae</i>	<i>Scrophularia</i> sp.	L36449	Olmstead & Reeves 1995
<i>Scrophulariaceae</i>	<i>Veronica catenata</i> Pennell	L36453	Olmstead & Reeves 1995
<i>Setchellanthaceae</i>	<i>Setchellanthus caeruleus</i> Brandegee	U41455	Rodman <i>et al.</i> 1993
<i>Simaroubaceae</i>	<i>Ailanthus altissima</i> L.	L12566	Chase <i>et al.</i> 1993
<i>Simaroubaceae</i>	<i>Harrisonia perforata</i> (Blanco) Merr.	U38863	Gadek <i>et al.</i> 1996
<i>Simaroubaceae</i>	<i>Kirkia wilmsii</i> Engl.	U38857	Gadek <i>et al.</i> 1996
<i>Simmondsiaceae</i>	<i>Simmondsia chinensis</i> C. K. Schneid.	AF093732	Fay <i>et al.</i> 1997a
<i>Sladeniaceae</i>	<i>Sladenia celastrifolia</i> Kurz	AJ403004	this paper (<i>Borsch</i> s.n. BONN)
<i>Solanaceae</i>	<i>Duckeodendron celastroides</i> Kuhlm.	YI4760	Fay <i>et al.</i> 1998b
<i>Solanaceae</i>	<i>Goetzia elegans</i> Wydler	AF035738	Fay <i>et al.</i> 1998b
<i>Solanaceae</i>	<i>Metternichia princeps</i> Miers.	AF022182	Fay <i>et al.</i> 1998b
<i>Solanaceae</i>	<i>Nicotiana tabacum</i> L.	Z00044	Lin <i>et al.</i> 1986
<i>Solanaceae</i>	<i>Schizanthus pinnatus</i> Ruiz. & Pav.	U08619	Fay <i>et al.</i> 1998b
<i>Solanaceae</i>	<i>Schwenckia lateriflora</i> (Vahl) Carvalho	AF035739	Fay <i>et al.</i> 1998b
<i>Spaerosepalaceae</i>	<i>Rhopalocarpus</i> sp.	YI5148	Fay <i>et al.</i> 1998a
<i>Sphaerosepalaceae</i>	<i>Dialyceras parvifolium</i> Capuron	AJ402942	this paper (<i>Schatz</i> s.n. MO)
<i>Sphenocleaceae</i>	<i>Sphenoclea zeylanica</i> Gaertn.	L18798	Cosner <i>et al.</i> 1994
<i>Sphenostemonaceae</i>	<i>Sphenostemon lobosporus</i> (F. Muell.) L. S. Sm.	AJ403005	this paper (<i>Jensen</i> 280 QRS)
<i>Stachyuraceae</i>	<i>Stachyurus praecox</i> Siebold & Zucc.	AJ235794	Savolainen <i>et al.</i> in press

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Staphyleaceae	<i>Staphylea trifoliata</i> Marshall	AJ238406	Gadek <i>et al.</i> 1996
Staphyleaceae	<i>Turpinia paniculata</i> Vent.	AJ403013/AJ403034	this paper (Axelrod 4236 UPR)
Strasburgeriaceae	<i>Strasburgeria robusta</i> (Vieill. ex Pancher & Sebert) Guillaumin	AJ403007	this paper (Bernardi 9444 K)
Styliadiaceae	<i>Styliodium graminifolium</i> Sw. ex Willd.	L18790	Cosner <i>et al.</i> unpubl.
Styracaceae	<i>Halesia carolina</i> L.	Z80190	Morton <i>et al.</i> 1997a
Styracaceae	<i>Styrax americana</i> Lam.	L12623	Kron & Chase 1993
Surianaceae	<i>Cadellia pentastylis</i> F. Muell.	L29491	Fernando <i>et al.</i> 1993
Surianaceae	<i>Guilfoylia monostylis</i> F. Muell.	L29494	Fernando <i>et al.</i> 1993
Surianaceae	<i>Stylobasium spathulatum</i> Desf.	U06828	Soltis <i>et al.</i> 1993
Surianaceae	<i>Suriana maritima</i> L.	U07680	Fernando <i>et al.</i> 1993
Symplocaceae	<i>Symplocos costata</i> Cboisy	L12624	Kron & Chase 1993
Tamaricaceae	<i>Tamarix pentandra</i> Hampe ex Bunge	Z97650	Fay <i>et al.</i> 1997a
Tapisciaceae	<i>Tapiscia sinensis</i> Oliv.	AF206825	Soltis <i>et al.</i> in press
Ternstroemiacae	<i>Eurya japonica</i> Thunb.	Z80207	Morton <i>et al.</i> 1997b
Ternstroemiacae	<i>Ternstroemia stahlii</i> Krug & Urb.	Z80211	Morton <i>et al.</i> 1997b
Tetracarpaeceae	<i>Tetracarpaea tasmanica</i> Hook. f.	L11207	Morgan & Soltis 1993
Tetrachondraceae	<i>Tetrachondra hamiltonii</i> Petrie	U28885	Wagstaff & Olmstead unpubl.
Tetrameristaceae	<i>Tetramerista</i> sp.	Z80199	Morton <i>et al.</i> 1997c
Theaceae	<i>Camellia japonica</i> L.	L12602	Kron & Chase 1993
Theaceae	<i>Schima superba</i> Gardner & Champ.	Z80208	Morton <i>et al.</i> 1997b
Theophrastaceae	<i>Clavija eggersiana</i> Mez	L12608	Kron & Chase 1993
Thymelaeaceae	<i>Dirca palustris</i> L.	U26322	Conti <i>et al.</i> 1996
Thymelaeaceae	<i>Aquilaria beccariana</i> Tiegh.	YI5149	Fay <i>et al.</i> 1998a
Thymelaeaceae	<i>Gonystylus macrophyllus</i> (Miq.) Airy Shaw	YI5150	Fay <i>et al.</i> 1998a
Thymelaeaceae	<i>Lethedon setosa</i> (C. T. White) Kosterm.	AJ402967	this paper (Heyland 7741 K)
Thymelaeaceae	<i>Phaleria chermsideana</i> (F. M. Bailey) C. T. White	AJ402988	this paper (Chase 1383 K)
Thymelaeaceae	<i>Ploiarium</i> sp.	AJ402990	this paper (Cameron s.n. NCU)
Ticodendraceae	<i>Ticodendron incognitum</i> J. Goméz-Laur. & L. D. Goméz	AF061197	Qiu <i>et al.</i> 1998
Tovariaceae	<i>Tovaria pendula</i> Ruiz & Pav.	M95758	Rodman <i>et al.</i> 1993
Tribelaceae	<i>Tribeles australis</i> Phil.	AJ403010	this paper (Gardner & Knees 3879 K)
Trigoniaceae	<i>Trigonia nivea</i> Cambess.	AF089761	Chase <i>et al.</i> 1993
Trochodendraceae	<i>Tetracentron sinensis</i> Oliv.	L12668	Chase <i>et al.</i> 1993
Trochodendraceae	<i>Trochodendron aralioides</i> Siebold & Zucc.	L01958	Albert <i>et al.</i> 1992

<i>Tropaeolaceae</i>	<i>Tropaeolum tricolor</i> Lindl.	L14706	Price & Palmer 1993
<i>Turneraceae</i>	<i>Turnera ulmifolia</i> L.	Z75691	Fay <i>et al.</i> 1997b
<i>Ulmaceae</i>	<i>Ampelocera hottlei</i> (Standl.) Standl.	D86314	Ueda <i>et al.</i> 1997
<i>Ulmaceae</i>	<i>Trema micrantha</i> Blume	U03844	Chase <i>et al.</i> 1993
<i>Ulmaceae</i>	<i>Ulmus parvifolia</i> Jacq.	D86316	Ueda <i>et al.</i> 1997
<i>Unnamed family</i>	<i>Aphanopetalum resinosum</i> Endl.		this paper (<i>Bradford</i> 845 MO)
<i>Urticaceae</i>	<i>Boehmeria nivea</i> (L.) Gaudich.	AF062005	Qiu <i>et al.</i> 1998
<i>Vahliaeae</i>	<i>Vahlia capensis</i> Thunb.	L11208	Morgan & Soltis 1993
<i>Valerianaceae</i>	<i>Valeriana officinalis</i> L.	L13934	Olmstead <i>et al.</i> 1992
<i>Verbenaceae</i>	<i>Euthystachys abbreviata</i> (E. Mey) A. DC.	Z29671	Bremer <i>et al.</i> 1994
<i>Verbenaceae</i>	<i>Verbena bonariensis</i> L.	L14412	Olmstead <i>et al.</i> 1992
<i>Violaceae</i>	<i>Hymenanthera alpina</i> Oliv.	Z75692	Fay <i>et al.</i> 1997b
<i>Violaceae</i>	<i>Leonia glycycarpa</i> Ruiz & Pav.	Z75693	Fay <i>et al.</i> 1997b
<i>Violaceae</i>	<i>Viola sororia</i> Willd.	L11674	Olmstead <i>et al.</i> 1992
<i>Viscaceae</i>	<i>Phoradendron serotinum</i> (Raf.) M. C. Johnst.	L11199	Morgan & Soltis 1993
<i>Vitaceae</i>	<i>Ampelocissus thrysifolia</i> Planch.	AJ402919	this paper (<i>Chase</i> 1386 K)
<i>Vitaceae</i>	<i>Ampelopsis megalophylla</i> Diels & Gilg	AJ402920	this paper (<i>Chase</i> 849 K)
<i>Vitaceae</i>	<i>Leea guineense</i> G. Don	AJ235783	Savolainen <i>et al.</i> in press
<i>Vitaceae</i>	<i>Parthenocissus quinquefolia</i> Planch.	AJ402985	this paper (<i>Chase</i> 967 K)
<i>Vitaceae</i>	<i>Vitis aestivalis</i> Michx.	L01960	Albert <i>et al.</i> 1992
<i>Vitaceae</i>	<i>Vitis rotundifolia</i> Michx.	AF119174	Wang & Lincoln, unpubl.
<i>Vivianiaceae</i>	<i>Viviania marifolia</i> Cav.	L14707	Price & Palmer 1993
<i>Vochysiaceae</i>	<i>Euphronia guianensis</i> (R. H. Schomb.) Hallier f.	AF089762	Litt & Chase 1999
<i>Vochysiaceae</i>	<i>Qualea</i> sp.	U02730	Olmstead <i>et al.</i> 1992
<i>Zygophyllaceae</i>	<i>Balanites maughamii</i> Sprague	Y15016	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Fagonia indica</i> Burm.	Y15018	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Guaiacum sanctum</i> L.	AJ1311770	Chase <i>et al.</i> 1993
<i>Zygophyllaceae</i>	<i>Porlieria chilensis</i> Gay	Y15024	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Sisymbrite sparteae</i> E. Mey. ex Sond. & Harv.	Y15026	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Tribulus macropterus</i> Boiss.	Y15028	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Viscainoa geniculata</i> (Kellogg) Greene	Y15029	Sheahan & Chase 1996
<i>Zygophyllaceae</i>	<i>Zygophyllum simplex</i> L.	Y15031	Sheahan & Chase 1996