Chromosome numbers and polyploidy events in Korean non-commelinids monocots: A contribution to plant systematics

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ABSTRACT: The evolution of chromosome numbers and the karyotype structure is a prominent feature of plant genomes contributing to or at least accompanying plant diversification and eventually leading to speciation. Polyploidy, the multiplication of whole chromosome sets, is widespread and ploidy-level variation is frequent at all taxonomic levels, including species and populations, in angiosperms. Analyses of chromosome numbers and ploidy levels of 252 taxa of Korean non-commelinid monocots indicated that diploids (ca. 44%) and tetraploids (ca. 14%) prevail, with fewer triploids (ca. 6%), pentaploids (ca. 2%), and hexaploids (ca. 4%) being found. The range of genome sizes of the analyzed taxa (0.3–44.5 pg/1C) falls well within that reported in the Plant DNA C-values database (0.061–152.33 pg/1C). Analyses of karyotype features in angiosperm often involve, in addition to chromosome numbers and genome sizes, mapping of selected repetitive DNAs in chromosomes. All of these data when interpreted in a phylogenetic context allow for the addressing of evolutionary questions concerning the large-scale evolution of the genomes as well as the evolution of individual repeat types, especially ribosomal DNAs (5S and 35S rDNAs), and other tandem and dispersed repeats that can be identified in any plant genome at a relatively low cost using next-generation sequencing technologies. The present work investigates chromosome numbers (n or 2n), base chromosome numbers (x), ploidy levels, rDNA loci numbers, and genome size data to gain insight into the incidence, evolution and significance of polyploidy in Korean monocots.

Keywords: base chromosome number, chromosome number, ploidy level, FISH, hybridization, polyploidization

Chromosome numbers and karyotype structure have always been considered to be an important character in analyses of the phylogenetic relationships and evolutionary processes in angiosperms (Levin and Wilson, 1976; Guerra, 2008; Jang et al., 2013). To date, chromosome numbers have been reported for about 25–30% of flowering plants (Bennett, 1998; Weiss-Schneeweiss and Schneeweiss, 2013). The chromosome numbers in angiosperms vary 160–fold (Weiss-Schneeweiss and Schneeweiss, 2013) ranging from 2n = 4 (Poaceae, Hyacinthaceae, Asteraceae, Cyperaceae: Vanzela et al., 1996; Roberto, 2005) to 2n = 640 (Crassulaceae: Uhl, 1978). The haploid chromosome numbers of the majority of angiosperms range between n = 7 and n = 20 (Grant, 1982; Masterson, 1994). Taxonomic groups display varying degrees of chromosome number changes both among and within genera (e.g., 2n = 8, 10, 12, 14, 19, 20, 25, 26, 27, 28, 35, 42 in Prospero/Hyacinthaceae: Jang, 2013; 2n = 18, 20, 22, 24, 28, 36, 40, 46, 48, 54, 56, 60, 66 in Melampodium/Asteraceae: Stuessy, 1971; Weiss-Schneeweiss et al., 2009; 2n = 24 in Lilium/Liliaceae: Sultana et al., 2010), and such changes continue to be used in systematics and elucidating evolutionary patterns within these groups of plants (Mayrose et al., 2010; Schubert and Lysak, 2011; Husband et al., 2013; McCann et al., 2016).

Hybridization and polyploidization have been commonly observed in many economically important plant groups (Lim et al., 2007; Mandáková et al., 2013), but recent studies have demonstrated that these processes have also been a major force
in the diversification and speciation of angiosperms in general (Leitch and Leitch, 2008). Hybrids and polyploids experience numerous chromosomal rearrangements (e.g., inversions, deletions, translocations, centromeric shifts, etc.) and more subtle changes in sequence composition (sequence loss or gain, expansion/reduction of repetitive DNA), and they continue to generate species diversity contributing to speciation events (Solís and Solís, 2009; Weiss-Schneeweiss and Schneeweiss, 2013). The propensity for polyploidization appears to be unequally distributed in plant groups with polyploidy in angiosperms being more common in monocots (ca. 58%) than in dicots (ca. 43%) (Solís and Solís, 2009; Weiss-Schneeweiss et al., 2013).

There are two general types of polyploidy: autopolyploidy (i.e., multiplication of chromosome sets within a single species or genome) and allopolyploidy (i.e., multiplication of chromosome sets accompanied by merger of genomes of two or more species), both of which arise as a result of a failure of either meiotic or mitotic cell division (Stebbins, 1971; Otto and Whiffin, 2000; Ramsey and Schemske, 2002). Although autopolyploidy has historically been considered as being less frequent and less important than allopolyploidy (Stebbins, 1971; Solís et al., 2007), natural autopolyploids are much more common than originally assumed (Ramsey and Schemske, 2002; Parisod et al., 2010), as recent studies continue to demonstrate. Multiple ploidy levels have been demonstrated to exist within many species (autopolyploidy), which often influences the degree of morphological variation in those taxa. Current focus of polyploidy research is on the genetic, epigenetic, chromosomal, and genomic consequences of polyploidization (Bowers et al., 2003; Liu and Wendel, 2003; Osborn et al., 2003; Rapp and Wendel, 2005), mechanisms of polyploid formation and establishment (Ramsey and Schemske, 2002), the ecological effects of polyploidization (Weiss-Schneeweiss et al., 2013; Solís et al., 2016), and most of all, the impact of polyploidy on plant diversity (Mandáková et al., 2017; Jang et al., 2018).

Modern cytology greatly profits from technical advances especially in situ hybridization (e.g., fluorescence in situ hybridization [FISH] and genomic in situ hybridization [GISH], respectively), large scale screening for polyploidy incidence using flow cytometry, and the advent of next-generation sequencing (NGS) technologies. These allow identification, quantification and localization on the genomes of various repeat types, which contribute to genome size variation and changes of which accompany species diversification and speciation (Weiss-Schneeweiss et al., 2015). Repetitive DNA fraction in plant genomes comprises tandem repeats (e.g., satellite DNAs, microsatellites, and ribosomal RNA genes [5S and 35S rRNA genes]) and dispersed repeats represented by mobile genetic elements (Weiss-Schneeweiss et al., 2015). The localization and evolution of tandemly repeated genes encoding 35S (18S-5.8S-25S) and 5S rRNAs in plants have been particularly useful for analysing systematic relationships between closely related species (Weiss-Schneeweiss and Schneeweiss, 2013).

The chromosome numbers in Korean non-Commelinids monocots have previously been reported for a number of taxonomically closely related taxa (Rice et al., 2015, references therein), although the incidence of polyploids and its evolutionary aspects have not been addressed in detail. It is therefore timely to summarize the knowledge of chromosome numbers, genome sizes, and polyploidy incidence in the Korean monocots (Rice et al., 2015; Vitales et al., 2017) and to identify the most important taxonomic groups in which questions of chromosomal evolution can be addressed most effectively.

**Chromosome numbers and the incidence of polyploidy in non-Commelinids monocot species native to Korea**

All available chromosome numbers and base chromosome numbers for Korean non-Commelinids monocots were obtained from the Chromosome Counts Database (CCDB, version 1.45: [http://cytodb.tau.ac.il/Angiosperms/](http://cytodb.tau.ac.il/Angiosperms/), accessed on 2018 May 22) (Rice et al., 2015) following APG IV classification system (Angiosperm Phylogeny Group IV) (Appendix 1) (The Angiosperm Phylogeny Group, 2016). Due to the scarcity of available data on chromosome numbers and ploidy levels variation in Korean Commelinids including Arecales, Commelinales, Poales, and Zingiberales (The Angiosperm Phylogeny Group, 2016), these were excluded from the current analyses.

The systematic ranking of taxa adopted in this study was mainly based on the recent online resources for monocot plants ([http://e-monocot.org/](http://e-monocot.org/)), the World Checklist of Selected Plant Families ([http://wesp.science.kew.org](http://wesp.science.kew.org)), the Missouri Botanical Garden Tropicos Database ([http://www.tropicos.org/](http://www.tropicos.org/)), and the nomenclature was adopted from the most accepted taxonomic treatment for the species based on the Korean Plant Names Index Committee ([http://www.nature.go.kr/kpni/index.do](http://www.nature.go.kr/kpni/index.do)) (Appendix 1).

The genome size values and ploidy level inferences in Korean non-Commelinids monocots were retrieved from the Plant DNA C-values database ([http://www.kew.org/cvalues/](http://www.kew.org/cvalues/), accessed on 2018 May 22) (Bennett and Leitch, 2012). The
data on number and chromosomal localization of rDNA loci (5S and 35S rDNA) in Korean non-Commelinids monocots obtained applying fluorescent in situ hybridization were retrieved from the third release of the plant rDNA database (Vitales et al., 2017; http://www.plantrDNAdatabase.com/, accessed on 2018 May 22).

Chromosome numbers are reported for 252 taxa (232 species, 2 subspecies, and 18 varieties) of Korean monocots, with the exception of Commelinids, due to the scarcity of published chromosome numbers for this very speciose this group (Appendix 1). Base chromosome numbers and ploidy levels variation is given for each taxon in Appendix 1. The chromosome numbers reported for Korean non-Commelinids monocots vary between $2n = 2x = 10$ in *Paris verticillata* M. Bieb. and $2n = 40x = 400$ in *Dioscorea japonica* Thunb. (Appendix 1). To date, the documented chromosome numbers in angiosperms vary from $2n = 4$ (e.g., *Ornithogalum tenuifolium* Delaroche in Hyacinthaceae) to $2n = 640$ (*Sedum sueculea* Kinnach in Crassulaceae), although most species possess between $2n = 14$ and $2n = 40$ chromosomes (Guerra, 2008; Weiss-Schneeweiss and Schneeweiss, 2013). The base chromosome numbers of analyzed Korean species vary from $x = 5$ in the genus *Paris* L. to $x = 30$ in the genus *Hosta* Tratt. (Appendix 1). Not only interspecific base chromosome number variation is found in thirteen genera analyzed here (*Acorus* L., *Arisaema* Mart., *Alisma* L., *Hydrocharis* L., *Potamogeton* L., *Lycoris* Herb., *Asparagus* Tourn. ex L., *Polygonatum* Mill., *Scilla* L., *Iris* Tourn. ex L., *Cephalanthera* Rich., *Gastrodia* R. Br., *Fritillaria* Tourn. ex L.) (Appendix 1) but also intraspecific base chromosome number variation is found within several species ($x = 9, 11, 12$ in *Acorus calamus* L.; $x = 13, 14$ in *Arisaema amurense* Maxim.; $x = 13, 14$ in *Arisaema peninsulae* Nakai; $x = 13, 14$ in most of taxa in the genus *Potamogeton* L.; $x = 9, 10$ in *Polygonatum falcatum* A. Gray; $x = 10, 11$ in *Polygonatum humile* Fisch. ex Maxim.; $x = 9, 10, 11$ in *Polygonatum involucratum* (Franch. & Sav.) Maxim.; $x = 8, 9$ in *Scilla scilloides* (Lindl.) Druce) (Appendix 1). The incidence of both interspecific ($x = 5, 6, 7$ in *Lotus/Fabaceae*; Grant, 1991; $x = 9, 10, 11, 12, 13, 14$ in *Melampodium/Asteraceae*: Blöch et al., 2009; $x = 3, 4, 5, 6$ in *Crepis/Asteraceae*: Babcock and Jenkins, 1943) and intraspecific base chromosome number variation ($x = 5, 6, 7$: *Prospero autumnale* complex: Jang et al., 2013; $x = 8, 9$: *Scilla scilloides* complex: Choi et al., 2008) have quite frequently been reported in angiosperms (Hubbard et al., 2003). Due to very low levels of phenotypic variation and thus lack of diagnostic morphological characters for species delimitations in some taxonomically intricate plant groups (often treated as species complexes), more detailed karyological investigations of the chromosome number variations and karyotype structure are needed for correct interpretation of taxonomic and evolutionary patterns as well as classifications of angiosperms in general, but also specifically of monocot species native in Korea in global world-wide context.

Two general types of polyploids can be distinguished, autopolyploids and allopolyploids. Allopolyploids originate via hybridization of at least two different taxa, thus carrying different multiplied sets of chromosomes, while autopolyploids result from multiplication of entire chromosome sets within one taxon, typically species. Thus, both hybridization and polyploidization may play an important role in creating new species diversity in angiosperms (Guerra, 2008; Solis and Solis, 2009; Hubbard et al., 2013; Weiss-Schneeweiss and Schneeweiss, 2013). In this study, the incidence of polyploidy has frequently been reported in *Araceae* Juss., *Hydrocharitaceae* Juss, *Juncaginaceae* Rich., *Amaryllidaceae* J. St.-Hil., *Asparagaceae* Juss., *Dioscoreaceae* R. Br., *Liliaceae* Juss., *Melanthiaceae* Batsch ex Borkh., *Smilacaceae* Vent. (Appendix 1). Analyses of ploidy levels distribution among these groups indicated that diploids (ca. 44%) and tetraploids (ca. 14%) prevail, with triploids (ca. 6%), pentaploids (ca. 2%), and hexaploids (ca. 4%) being found less frequently (Fig. 1, Appendix 1). Polyploidy is less frequent in *Orchidaceae* than in other families of Korean non-Commelinids monocots (Appendix 1), in agreement with previous reports for this region (Goldblatt, 1980; Ko et al., 2009; Rice et al., 2015, references therein). Despite the relatively high incidence of polyploidy in Korean non-Commelinids monocot flora and ease of inferring more recent polyploidy events based purely on increase of chromosome numbers, the clear inference of the mode of polyploids origin and inferences of the patterns of their post-polyploidization genome evolution are non-trivial and thus are not attempted here. These require rigorous phylogenetic analyses of the genera harboring polyploids to infer putative parental species and subsequent molecular cytogenetic analyses as well as genome size measurements to infer the patterns of their genome evolution. Such data are available only for a handful of selected monocot taxa (Appendix 1) and thus, more in-depth and group-oriented molecular cytological analyses are required to assist and guide species delimitation and interpretation of phylogenetic relationships and evolutionary patterns among Korean monocots (Choi et al., 2008; Jang et al., 2013; Jang and Weiss-Schneeweiss, 2015).
Fig. 1. Distribution of ploidy level variation containing two to eight ploidy levels in non-Commelinids monocot species occurring in Korea (representing their worldwide distribution).

Fig. 2. Distribution of genome size variation in non-Commelinids monocot species occurring in Korea (representing their worldwide distribution).
Genome size variation in non-commelinids monocots species native to Korea (in worldwide context)

The dynamics of genome size variation in a group of related diploid taxa can be very high despite lack of change in chromosome number. Genome size increase is, however, directly correlated to polyploidization, particularly recent one. Genome size changes in the absence of chromosome number changes are attributed to differential accumulation of various types of repetitive DNA elements (Leitch and Leitch, 2013). The range of genome sizes of Korean monocots falls within that reported in the Plant DNA C-values database which ranges from 0.061 pg/1C of DNA in *Genlisea tuberosa* Rivadavia, Gonella & A. Fleischm. (Fleischmann et al., 2014) to 152.33 pg/1C of DNA in *Paris japonica* Franch. (Pellicer et al., 2010). The 1C-values of species studied here differ nearly 150-fold and range from 0.3 pg in *Spirodea polyrrhiza* (L.) Schl. (Araceae) to 44.5 pg in *Trillium kamtschaticum* Pall. ex Pursh (Melanthiaceae) (Fig. 2, Appendix 1). In general, the broad range of variation of genome sizes in flowering plants correlates with the differences of total karyotype length and incidence of polyploidy, but also correlates with other factors, like the life cycle types (annual/perennial) (Bennett, 1972; Chumová et al., 2015).

Patterns of genome evolution: the use of molecular cytogenetics and phylogenetic analyses in Plant Systematics

Extensive studies of chromosome numbers (including polyploidy incidence) and genome sizes in evolutionary context, aiming to elucidate the genome dynamics and often aiding taxonomic classifications have often been carried out in plants of agricultural importance or in model plants (Gong et al., 2012; Renny-Byfield et al., 2013; Novák et al., 2014; Zhang et al., 2014; Jang et al., 2014; and Weiss-Schneeweiss, 2015). Repetitive DNA fraction of plant genomes is composed of tandem repeats encompassing satellite DNAs, microsatellites and rDNAs (5S and 35S ribosomal RNA genes) as well as dispersed repeats represented by mobile genetic elements, known also as transposable elements. The latter comprise class I retroelements and class II DNA transposons (Weiss-Schneeweiss et al., 2015). In-depth analyses of repeatomes have recently been demonstrated to be informative for inferences of phylogenetic relationships in plants (Table 1) (Dodsorth et al., 2015, 2017; McCann et al., 2018).

Molecular cytogenetic mapping of the nuclear ribosomal RNA genes encoding for 35S (18S-5.8S-25S) and 5S rDNAs have proved useful for identifying the patterns and dynamics of chromosomal changes in closely related species groups (Jang et al., 2013, 2016a; Vitales et al., 2017). The distribution of rDNA loci has been reported for some Korean monocots, as summarized in Table 1 (data retrieved from Plant rDNA Database; http://www.plantrDNAdatabase.com; 2018 May 22). The number and localization of rDNA loci in diploids and polyploids was intensively studied in selected genera of Alismatales (Wan et al., 2012), Asparagales (Hizume, 1994; Hizume and Araki, 1994; Lee et al., 1999; Do et al., 1999, 2001; Remon-Büttner et al., 1999; Kim et al., 2004; Hayashi et al., 2005; Lim et al., 2007; Deng et al., 2012; Son et al., 2012), and Liliales (Sultana et al., 2010). A survey of rDNA loci numbers reported for Korean monocots indicated that rDNA loci number can vary at the interspecific level in the genera *Allium*, *Lilium*, and *Potamogeton* (between 2 and 6) (Table 1) regardless of chromosome number and ploidy level variation between species, as show for many other plant groups (Table 1, Appendix 1). The rDNA loci number variation within species or among closely related taxa have often been shown to be correlated with geographic and/or populational factors (e.g., Jang et al., 2016a). Thus, the localization of rDNA loci analyzed in comparative context aids not only the analyses of chromosomal structural changes, but when interpreted in phylogenetic context (e.g., Jang et al., 2013, 2016b), it also allows broader conclusions with implications for taxonomy. Monocot genomes are often more dynamically evolving than those of the dicots. Thus, further cytogenetic analyses of selected groups of Korean monocots will be undertaken to shed light into their genome evolution and evolutionary relationships. Such analyses should and will certainly include also populations and relatives from other geographical areas to allow for more robust conclusions to be drawn.
Table 1. Summary of the chromosome numbers, ploidy level variation, and numbers of 5S and 35S rDNA signals in non-Commelinids monocot species occurring in Korea (representing their worldwide distribution)

| Taxon | 2n | Ploidy levels | 5S rDNA | 35S rDNA | References |
|-------|----|---------------|---------|----------|------------|
| Potamogeton crispus L. | 48 | 4x | 2 | 2 | Wan et al. (2012) |
| P. distinctus A. Benn. | 52 | 4x | 2 | 2 | Wan et al. (2012) |
| P. malaiamia Miq. | 52 | 4x | 2 | 4 | Wan et al. (2012) |
| P. natans L. | 52 | 4x | 4 | 6 | Wan et al. (2012) |
| P. octandrus Poir. | 28 | 2x | 2 | 2 | Wan et al. (2012) |
| P. perfoliatus L. | 50 | 4x | 2 | 4 | Wan et al. (2012) |
| Alismatales R. Br. ex Bercht. & J. Presl | | | | | |
| Allium cepa L. | 16 | 2x | 4 | 2 | Hizume (1994) |
| A. fistulosum L. | 16 | 2x | 2 | 2 | Do et al. (2001) |
| A. sativum L. | 16 | 2x | 2 | 4 | Do et al. (2001) |
| Lycoris radiata (L'Hér.) Herb. | 33 | 3x | 4 | 6 | Hayashi et al. (2005) |
| Asparagus officinalis L. | 20 | 2x | 2 | 6 | Remon-Büttner et al. (1999) |
| Liliales Perleb | | | | | |
| Lilium amabile Palib. | 24 | 2x | 2 | 6 | Sultana et al. (2010) |
| L. callosum Siebold & Zucc. | 24 | 2x | 2 | 10 | Sultana et al. (2010) |
| L. cernuum Kom. | 24 | 2x | 2 | 10 | Sultana et al. (2010) |
| L. concolor Salish. | 24 | 2x | 2 | 10 | Sultana et al. (2010) |
| L. dauricum K. Gawl. | 24 | 2x | 2 | 8 | Sultana et al. (2010) |
| L. distichum Nakai ex Kamih. | 24 | 2x | 2 | 8 | Sultana et al. (2010) |
| L. hansonii Leichtlin ex D. D. T. Moore | 24 | 2x | 2 | 15 | Sultana et al. (2010) |
| L. lancifolium Thumb. | 24 | 2x | 2 | 10 | Sultana et al. (2010) |
| L. lancifolium Thumb. | 36 | 3x | 3 | 15 | Sultana et al. (2010) |
| L. tsingtana use Gilg | 24 | 2x | 2 | 8 | Sultana et al. (2010) |
| L. tsingtana use Gilg | 24 | 2x | 2 | 8 | Sultana et al. (2010) |
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Conflict of Interest

The authors declare that there are no conflicts of interest.

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Appendix 1. Information on base chromosome number, ploidy level (if known), and genome size data with emphasis on non-Commelinids monocot species occurring in Korea (representing their worldwide distribution)

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|----------------------------|------------------------|-----------------------------|---------------|--------------|-------------|
| Acorales Mart.             |                        |                             |               |              |             |
| Acoraceae Martinov         |                        |                             |               |              |             |
| Acorus calamus L.          | 18, 24, 36, 44, 45, 48, 66 | x = 9, 11, 12              | 2x, 4x, 5x, 6x | 1.3          | 창포         |
| A. gramineus Aiton         | 18, 22, 24             | x = 9, 11, 12              | 2x            | 0.8          | 석창포       |
| Alismatales R. Br. ex Bercht. & J. Presl | | | | | |
| Araceae Juss.              |                        |                             |               |              |             |
| Arisaema amurensce Maxim.  | 26, 28, 39, 48, 52, 56, 70 | x = 13, 14               | 2x, 3x, 4x, 5x | -            | 동근잎천남성 |
| A. heterophyllum Blume     | 28, 56, 84, 140, 168   | x = 13, 14                | 2x, 4x, 10x, 12x | -            | 두루미천남성 |
| A. negishii Makino         | 28                    | x = 14                    | 2x            | -            | 석천남성     |
| A. peninsulac Nakai        | 26, 28                 | x = 13, 14                | 2x            | -            | 젤봉잎천남성  |
| A. ringens (Thunb.) Schott | 28                    | x = 14                    | 2x            | -            | 큰천남성     |
| A. thunbergii Blume        | 28                    | x = 14                    | 2x            | -            | 무늬천남성    |
| Calla palustris L.         | 36, 60, 72             | x = 18                    | 2x, 3x, 4x    | 2.1          | 산부채       |
| Lemna perpusilla Torr.     | 20, 40, 50, 60, 70, 72, 84 | x = 10                  | 2x, 4x, 5x, 6x, 7x, 8x | 0.8          | 좀개구리밥   |
| Pinellia ternata (Thumb.) Breitenb. | 26, 42, 54, 72, 78, 90, 91, 99, 104, 108, 115, 117 | x = 13          | 2x, 3x, 4x, 5x, 6x, 7x, 8x | 7.0          | 밤하         |
| P. tripartita (Blume) Schott | 26, 52             | x = 13                    | 2x, 4x        | -            | 대반하       |
| Spirodela polyrrhiza (L.) Schleid. | 30, 32, 38, 40, 50, 80 | Unknown                 | Unknown       | 0.6          | 개구리밥      |
| Symlocarpus nipponicus Makino | 30                  | x = 15                    | 2x            | -            | 애기있는부채 |
| S. renifolius Schott ex Tzvelev | 60                | x = 15                    | 4x            | -            | 은근부채     |
| Tofieldiaceae Takht.       |                        |                             |               |              |             |
| Tofieldia coccinea Richardon | 30, 32            | x = 15, 16                 | 2x            | -            | 숙은돌창포   |
| Alismataceae Vent.         |                        |                             |               |              |             |
| Alisma canaliculatum A. Braun & C. D. Bouché | 26, 28, 40, 42 | x = 13, 14               | 2x, 3x        | -            | 탱사         |
| A. plantago-aquatica subsp. orientale (Sam.) Sam. | 14, 28 | x = 7                   | 2x, 4x        | -            | 결경이랑사    |
| Sagittaria aginashii Makino | 22                  | x = 11                    | 2x            | -            | 보풀         |
| S. natans Pall.            | 22                    | x = 11                    | 2x            | -            | 대택소귀나물 |
| S. pygmaea Miq.            | 22                    | x = 11                    | 2x            | -            | 옥미         |
| S. trifolia L.             | 22                    | x = 11                    | 2x            | -            | 뿔풀         |
| Hydrocharitaceae Juss.     |                        |                             |               |              |             |
| Blyxa aubertii Rich.       | 24, 32, 40             | x = 8, 12                  | 2x, 4x, 5x    | -            | 은행이자리    |
| B. japonica (Miq.) Maxim. ex Asch. & Gürke | 72    | x = 12                   | 6x            | -            | 은행이송      |
| Hydrilla verticillata (L.) Royle | 16, 24, 32      | x = 8                     | 2x, 3x, 4x    | -            | 구경밥       |
| Najas graminea Delile      | 12, 24, 36, 48, 72    | x = 6                     | 2x, 4x, 6x, 8x, 12x | -         | 나가스말      |
| N. marina L.               | 12, 24, 48, 60        | x = 6                     | 2x, 4x, 8x, 10x | -           | 민나가스말     |
### Appendix 1. Continued.

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name       |
|---------------------------|------------------------|----------------------------|---------------|---------------|------------------|
| *N. minor* All.           | 12, 24, 36, 46, 56     | x = 6                      | 2x, 4x, 6x, 8x, 9x | -             | 들나나자스말       |
| *Vallisneria natans* (Lour.) H. Hara | 20                  | x = 10                     | 2x            | -             | 나사말            |
| **Scheuchzeriaceae F. Rudolphi** |                       |                            |               |               |                  |
| *Scheuchzeria palustris* L. | 22                   | x = 11                     | 2x            | -             | 장지채            |
| **Juncaginaceae Rich.**    |                        |                            |               |               |                  |
| *Hydrocharis dubia* (Blume) Backer | 16, 22                | x = 8, 11                  | 2x            | -             | 자라풀            |
| *Ottelia alismoides* (L.) Pers. | 22, 44, 66, 88        | x = 11                     | 2x; 4x; 6x; 8x | -             | 물질경이          |
| *Triglochin maritima* L.   | 12, 24, 36, 48, 96, 120 | x = 6                      | 2x; 4x; 6x; 8x; 16x; 20x | -             | 지채              |
| **Zosteraceae Dumort.**    |                        |                            |               |               |                  |
| *Zostera asiatica* Miki    | 12                    | x = 6                      | 2x            | -             | 왕거머리말         |
| *Z. marina* L.             | 12                    | x = 6                      | 2x            | 1.2          | 거머리말          |
| *Z. nana* Roth             | 12                    | x = 6                      | 2x            | 1.5          | 애기거머리말       |
| **Phyllospadix iwatensis** Makino | 16, 20                | x = 8, 10                  | 2x            | -             | 새우말            |
| **Potamogetonaceae Bercht. & J. Presl** |                |                            |               |               |                  |
| *Potamogeton berehtoldii* Fieber | 26                   | x = 13                     | 2x            | -             | 실말              |
| *P. crispus* L.            | 48, 52, 56            | x = 13, 14                 | 3x; 4x       | 1.0          | 밭중              |
| *P. cristatus* Regel & Maack | 28                   | x = 14                     | 2x            | -             | 가느가례           |
| *P. distinctus* A. Benn.   | 52                    | x = 13                     | 4x            | -             | 가례              |
| *P. fryeri* A. Benn.       | 42, 48                | x = 13, 14                 | 3x            | -             | 선가례           |
| *P. maackianus* A. Benn.   | 52, 56                | x = 13, 14                 | 4x            | -             | 새우가례          |
| *P. malayanus* Miq.        | 26, 52                | x = 13                     | 2x; 4x       | -             | 대가래            |
| *P. natans* L.             | 42, 52, 195           | x = 13                     | 3x; 4x; 15x  | -             | 대동가래          |
| *P. octandrus* Poir.       | 28                    | x = 14                     | 2x            | -             | 애기가래          |
| *P. oxyphyllus* Miq.       | 26, 28                | x = 13, 14                 | 2x            | -             | 밭                |
| *P. pectinatus* L.         | 42, 78                | x = 13                     | 4x; 6x       | -             | 솔잎가래          |
| *P. perforata* L.          | 50, 52, 78            | x = 13                     | 4x; 6x       | -             | 네촌일말          |
| *Ruppia maritima* L.       | 20, 40                | x = 10                     | 2x; 4x       | --           | 종말              |
| *R. rostellata* Koch       | 40                    | x = 10                     | 4x            | -             | 나가줄말          |
| **Zannichellia palustris subsp. pedicellata** (Wahlenb. & Rosén) Hook. | 24, 36                | x = 12                     | 2x; 3x       | -             | 톨말              |
| **Dioscoreales Mart.**     |                        |                            |               |               |                  |
| **Nartheciaceae Fr. ex Bjurzon** |                    |                            |               |               |                  |
| *Aletris glabra* Bureau & Franch. | 52                   | x = 13                     | 4x            | -             | 여우모리풀         |
| *A. spicata* (Thunb.) Franch. | 26, 52                | x = 13                     | 2x; 4x       | -             | 취모리풀          |
| *Metanarthecium luteoviride* Maxim. | 52                   | x = 13                     | 4x            | -             | 철보치마          |
### Appendix 1. Continued.

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|----------------------------|------------------------|-----------------------------|---------------|--------------|------------|
| **Dioscoreaceae R. Br.**   |                        |                             |               |              |            |
| Dioscorea batatas Deene.   | 140                    | x = 10                      | 14x           | -            | 마          |
| D. bulbifera L.            | 40, 60, 80             | x = 10                      | 2x, 4x, 6x    | 2.4          | 동근마      |
| D. japonica Thunb.         | 100, 400               | x = 10                      | 10x, 40x      | -            | 찜마        |
| D. nipponica Makino        | 20, 40                 | x = 10                      | 2x, 4x        | -            | 부채마      |
| D. septemloba Thunb.       | 20, 40                 | x = 10                      | 2x, 4x        | -            | 국화마      |
| D. tenuipes Franch. & Sav. | 20, 40                 | x = 10                      | 2x, 4x        | -            | 각시마      |
| **D. tokoro Makino ex Miyabe** | 20                 | x = 10                      | 2x            | 0.8          | 도꼬로마     |
| **Liliales Perleb**        |                        |                             |               |              |            |
| Melanthiaceae Batsch ex Borkh. |                  |                             |               |              |            |
| Chionographis japonica (Willd.) Maxim. | 24, 42                | x = 12                      | 2x, 4x        | -            | 실향물     |
| Heloniopsis orientalis (Thunb.) Tanaka | 34                  | x = 17                      | 2x            | 5.3          | 처녀차마    |
| Paris verticillata M. Bieb. | 10, 15, 20            | x = 5                       | 2x, 3x, 4x    | -            | 삿갓나물    |
| Trillium kamtschaticum Pall. ex Pursh | 10, 30                | x = 5                       | 2x, 6x        | 89.0         | 안영초      |
| T. tschonoskii Maxim.      | 10, 20                 | x = 5                       | 2x, 4x        | -            | 큰김단초    |
| Veratrum bohnhojii var. lattifolium Nakai | 16, 32               | x = 8                       | 2x, 4x        | -            | 삼수여로    |
| V. dolichopetalum O. Loes. | 32                     | x = 8                       | 4x            | -            | 부른박새    |
| V. maackii Regel           | 16                     | x = 8                       | 2x            | -            | 간단여로    |
| V. maackii var. parviflorum (Maxim.) H. Hara | 16, 32           | x = 8                       | 2x, 4x        | -            | 파란여로    |
| V. nigrum var. ussuriense Lose. f.   | 16               | x = 8                       | 2x            | -            | 잠여로      |
| V. oxysepalum Turcz.       | 32, 64, 80            | x = 8                       | 4x, 8x, 10x   | -            | 박새        |
| V. versicolor Nakai        | 16                     | x = 8                       | 2x            | -            | 빨여로      |
| Zygadenus sibiricus (L.) A. Gray | 32              | x = 8                       | 4x            | -            | 나노여로    |
| Colchicaceae DC.           |                        |                             |               |              |            |
| Disporum sessile (Thunb.) D. Don ex Schult. & Schult. | 16, 24         | x = 8                       | 2x, 3x, 5x    | 37.2         | 육성나물     |
| D. smilacinum A. Gray      | 16                     | x = 8                       | 2x            | -            | 에기나리    |
| D. viridescens (Maxim.) Nakai | 16, 17            | x = 8                       | 2x            | -            | 큰에기나리   |
| **Smilacaceae Vent.**      |                        |                             |               |              |            |
| Smilax china L.            | 32, 64, 96            | x = 16                      | 2x, 4x, 6x    | -            | 정미레덩굴   |
| S. nipponica Miq.          | 32                     | x = 16                      | 2x            | -            | 선לכא꽃나물 |
| S. riparia var. ussuriensis (Regel) Hara & T. Koyama | 32             | x = 16                      | 2x            | -            | 밋나물      |
| S. sieboldii Miq.          | 32                     | x = 16                      | 2x            | -            | 정가시덩굴   |
| **Lilaeae Juss.**          |                        |                             |               |              |            |
| Clintonia udensis Trautv. & C. A. Mey. | 14, 28, 38      | x = 7                       | 2x, 4x, 5x    | -            | 나도옥잠화   |
| Erythronium japonicum (Balrer) Deene. | 24              | x = 12                      | 2x            | -            | 염래지      |
| Fritillaria ussuriensis Maxim. | 22, 24           | x = 11, 12                  | 2x            | -            | 패모        |
### Appendix 1. Continued.

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|----------------------------|-----------------------|---------------------------|---------------|--------------|-------------|
| *Gagea lutea* (L.) K. Gawl. | 36, 48, 72, 96, 132   | x = 16, 18               | 2x, 3x, 4x, 6x, 8x | 39.5         | 중의무릇     |
| *Lilium amabile* Palib.     | 24                    | x = 12                  | 2x            | 27.4         | 밭중나리     |
| *L. callosum* Siebold & Zucc. | 24                | x = 12                  | 2x            | -            | 명나리       |
| *L. cernuum* Kom.           | 24                    | x = 12                  | 2x            | -            | 송나리       |
| *L. concolor* Salish.       | 24                    | x = 12                  | 2x            | -            | 하늘나리     |
| *L. dauricum* K. Gawl.      | 24                    | x = 12                  | 2x            | -            | 날개하늘나리  |
| *L. distichum* Nakai ex Kamib. | 24          | x = 12                  | 2x            | -            | 밭나리       |
| *L. hansonii* Leichtlin ex D. D. T. Moore | 24 | x = 12 | 2x | - | 참나리 |
| *L. lancifolium* Thunb.     | 24, 36                | x = 12                  | 2x, 3x        | -            | 중나리       |
| *L. leichtlinii* var. maximowiczii (Regel) Baker | 26 | x = 12 | 2x | - | 정발나리 |
| *L. tenuifolium* Fisch.     | 24                    | x = 12                  | 2x            | -            | 농송나리     |
| *L. tsingtauense* Gilg      | 24                    | x = 12                  | 2x            | -            | 헬로ў나리    |
| *Lloydia serotina* (L.) Reichb. | 24           | x = 12                  | 2x            | -            | 개감채       |
| *L. triflora* (Ledebr.) Baker | 24            | x = 12                  | 2x            | -            | 감대산자고   |
| *Streptopus amplexifolius* (L.) DC. | 16, 32 | x = 8                  | 2x, 4x        | 13.0         | 국대아재비   |
| *S. koreanus* (Kom.) Ohwi   | 24, 48                | x = 8                  | 3x, 6x        | -            | 콜육대아재비  |
| *S. ovalis* (Ohwi) F. T. Wang & Y. C. Tang | 16 | x = 8 | 2x | - | 진부계가나리 |
| *Tricyrtis macropoda* Miq.  | 26                    | x = 13                  | 2x            | 8.5          | 배꼽나리     |
| *Tulipa edulis* (Miq.) Baker | 24                  | x = 12                  | 2x            | -            | 산자고       |
| *T. heterophylla* (Regel) Baker | 24            | x = 12                  | 2x            | 37.5         | 금대산자고    |
| **Asparagales** Link        |                       |                          |               |              |             |
| **Orchidaceae** Juss.       |                       |                          |               |              |             |
| *Amitostigma gracile* (Blume) Schltr. | 42 | x = 21 | 2x | - | 벼가리난초 |
| *Bletilla striata* (Thunb.) Reichb. | 32, 76 | x = 16, 19 | 2x, 4x | 5.9 | 자란 |
| *Bulbophyllum drymoglossum* Maxim. | 40 | x = 20 | 2x | - | 송하개난 |
| *B. inconsicuum* Maxim.     | 38                    | x = 19                  | 2x            | -            | 흉난초      |
| *Calanthe discolor* Lindl.  | 40                    | x = 20                  | 2x            | -            | 세두난초    |
| *C. reflexa* Maxim.         | 40                    | x = 20                  | 2x            | -            | 여름세두난   |
| *C. striata* R. Br. ex Lindl. | 40                  | x = 20                  | 2x            | -            | 금세두난    |
| *Calyso bulbosa* (L.) Oakes | 28                    | x = 14                  | 2x            | -            | 풍선난초    |
| *Cephalanthera ecretia* (Thunb.) Blume | 34 | x = 17 | 2x | - | 손난초 |
| *C. falcula* (Thunb.) Blume  | 34                    | x = 17                  | 2x            | -            | 금난초      |
| *C. longibracteata* Blume   | 32                    | x = 16                  | 2x            | -            | 손대난초    |
| *Coeloglossum viride* var. bracteatum* (Willd.) Rich. | 40 | x = 20 | 2x | - | 개냅비난 |
| *Corallorhiza trifida* Chatel. | 42                  | x = 21                  | 2x            | -            | 산호란     |
Appendix 1. Continued.

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|----------------------------|------------------------|----------------------------|---------------|---------------|-------------|
| Cremastra appendiculata (D. Don) Makino | 48 | x = 24 | 2x | - | 약난초 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. macranthos Sw. | 20 | x = 10 | 2x | 64.7 | 노랑복주머니란 |
| C. japonicum Thunb. | 20 | x = 10 | 2x | 64.0 | 광릉요강꽃 |
| C. kanran Makino | 40 | x = 20 | 2x | 74.8 | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| C. macranthos Sw. | 20 | x = 10 | 2x | 64.7 | 노랑복주머니란 |
| C. japonicum Thunb. | 20 | x = 10 | 2x | 64.0 | 광릉요강꽃 |
| C. kanran Makino | 40 | x = 20 | 2x | 74.8 | 한란 |
| Cremastra appendiculata (D. Don) Makino | 48 | x = 24 | 2x | - | 약난초 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. macranthos Sw. | 20 | x = 10 | 2x | 64.7 | 노랑복주머니란 |
| C. japonicum Thunb. | 20 | x = 10 | 2x | 64.0 | 광릉요강꽃 |
| C. kanran Makino | 40 | x = 20 | 2x | 74.8 | 한란 |
| Cremastra appendiculata (D. Don) Makino | 48 | x = 24 | 2x | - | 약난초 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| C. unguiculata (Finet) Finet | 48 | x = 24 | 2x | - | 두잎약난초 |
| Cymbidium goeringii (Rchb.) Rchb. | 40 | x = 20 | 2x | - | 보춘화 |
| C. kanran Makino | 40 | x = 20 | 2x | - | 한란 |
| C. macrorhizon Lindl. | 38 | x = 19 | 2x | - | 대홍란 |
| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|---------------------------|------------------------|---------------------------|---------------|--------------|-------------|
| Myrmechis japonica (Rchb.) Rolfe | 56 | x = 14 | 4x | - | 개미난초 |
| Neofinetia falcata (Thunb.) Hu | 38 | x = 19 | 2x | 4.7 | 평란 |
| Neottia acuminata Schltr. | 18 | x = 9 | 2x | - | 애기무엽란 |
| N. nidus-avis var. manshurica Kom. | 36 | x = 9 | 4x | - | 세동지란 |
| Oberonia japonica (Maxim.) Makino | 30 | x = 15 | 2x | - | 작긴비란 |
| Orchis cyclochila (Franch. & Sav.) Maxim. | 42 | x = 21 | 2x | - | 나도제비란 |
| O. graminifolia (Rchb.) Tang & F. T. Wang | 42 | x = 21 | 2x | - | 나미니초 |
| O. jooiokiana Makino | 42 | x = 21 | 2x | - | 나도제비난 |
| Orbeochis patens (Lindl.) Lindl. | 48 | x = 24 | 2x | - | 감자난 |
| Platanthera hologlottis Maxim. | 42 | x = 21 | 2x | - | 땅째기난초 |
| P. japonica (Thunb.) Lindl. | 42 | x = 21 | 2x | - | 산제비난 |
| P. minor (Miq.) Rchb. | 42 | x = 21 | 2x | - | 한라잠자리난 |
| P. orthrodioides F. Schmidt | 42 | x = 21 | 2x | - | 구름제비난 |
| P. sachalinensis F. Schmidt | 42 | x = 21 | 2x | - | 큰제비난 |
| Pogonia japonica Rchb. | 20 | x = 10 | 2x | - | 큰방울새난 |
| P. minor (Makino) Makino | 18 | x = 9 | 2x | - | 방울새난 |
| Sedirea japonica (Rchb. f.) Garay & Sweet | 38 | x = 19 | 2x | - | 나도풍란 |
| Spiranthus sinensis (Pers.) Ames | 30 | x = 15 | 2x | - | 타래난초 |
| Taeniophyllum glandulosum Blume | 38 | x = 19 | 2x | - | 금란 |
| Tipularia ussuriensis (Regel) H. Hara | 42 | x = 21 | 2x | - | 나도장지란 |
| Vexillabium yakushimense (Yamam.) F. Mack. | 26 | x = 13 | 2x | - | 백운란 |
| Iridaceae Juss. | | | | | |
| Belamcanda chinensis (L.) DC. | 32 | x = 16 | 2x | - | 밤부채 |
| Iris dichotoma Pall. | 34 | x = 17 | 2x | - | 대청부채 |
| I. ensata var. spontanea (Makino) Nakai | 24 | x = 12 | 2x | - | 꽃창포 |
| I. korana Nakai | 50 | x = 25 | 2x | - | 노랑붓꽃 |
| I. lactea var. chinensis (Fisch.) Koidz. | 32, 40 | x = 16, 20 | 2x | - | 타래붓꽃 |
| I. laevigata Fisch. | 28, 32, 34 | x = 14, 16, 17 | 2x | - | 제비붓꽃 |
| I. minuta aurea Makino | 22 | x = 11 | 2x | - | 금붓꽃 |
| I. rossii Baker | 32 | x = 16 | 2x | - | 밤부채 |
| I. rutherenia K. Gawl. | 32, 40, 84 | x = 16, 20, 21 | 2x, 4x | - | 슬롯붓꽃 |
| I. sanguinea Donn ex Hornem. | 26, 28 | x = 13, 14 | 2x | - | 붓꽃 |
| I. setosa Pall. ex Link | 40 | x = 20 | 2x | - | 부채붓꽃 |
| I. uniflora var. caricina Kitag. | 42 | x = 21 | 2x | - | 난장이붓꽃 |
### Appendix 1. Continued.

| Order/Family/Genus/Species            | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name        |
|--------------------------------------|------------------------|-----------------------------|---------------|---------------|--------------------|
| Asphodelaceae Juss.                 |                        |                             |               |               |                    |
| Hemerocallis dumortieri E. Morren   | 22                     | x = 11                      | 2x            | -             | 각시원추리          |
| H. fulva (L.) L.                     | 22, 33                 | x = 11                      | 2x, 3x        | -             | 원추리              |
| H. lilioasphodelas L.                | 22                     | x = 11                      | 2x            | -             | 곤임원추리          |
| H. littorea Makino                   | 22                     | x = 11                      | 2x            | -             | 홍도원추리          |
| H. middendorffii Trautv. & C. A. Mey.| 22                     | x = 11                      | 2x            | -             | 큰원추리            |
| H. minor Mill.                       | 22                     | x = 11                      | 2x            | -             | 애기원추리          |
| H. thunbergii Barr                   | 22                     | x = 11                      | 2x            | -             | 노랑원추리          |
| Amaryllidaceae J. St.-Hil.          |                        |                             |               |               |                    |
| Allium condensatum Turcz.           | 16                     | x = 8                       | 2x            | -             | 노랑부추            |
| A. longistylum Baker                | 16                     | x = 8                       | 2x            | -             | 강부추              |
| A. linearifolium H. J. Choi & B. U. Oh | 16               | x = 8                       | 2x            | -             | 선부추              |
| A. macrostemon Maxim.               | 32, 40, 48             | x = 8                       | 4x, 5x, 6x    | 43.2          | 산담래              |
| A. maximowiczii Regel               | 16                     | x = 8                       | 2x            | -             | 산파                |
| A. microdictyon Prokh.              | 16                     | x = 8                       | 2x            | -             | 산마늘              |
| A. monocanthum Maxim.               | 16, 24, 32             | x = 8                       | 2x, 3x, 4x    | -             | 달래                |
| A. ochotense Prokh.                 | 16, 32                 | x = 8                       | 2x, 4x        | -             | 옹동산마늘          |
| A. sacculiferum Maxim.              | 16, 32, 42             | x = 8                       | 2x, 4x, 5x    | -             | 참산부추            |
| A. senescens L.                     | 16, 32                 | x = 8                       | 2x, 4x        | -             | 두배부추            |
| A. taquetii H. Lév. & Vaniot        | 16                     | x = 8                       | 2x            | -             | 한라부추            |
| A. thunbergii G. Don                | 16, 32                 | x = 8                       | 2x, 4x        | -             | 산부추              |
| A. thunbergii var. deltaoides (S. Yu, W. Lee & S. Lee) H. J. Choi & B. U. Oh | 16 | x = 8 | 2x | - | 세모산부추 |
| A. thunbergii var. teretifolium H. J. Choi & B. U. Oh | 16 | x = 8 | 2x | - | 동근산부추 |
| Crinum asiaticum var. japonicum Baker | 22               | x = 11                      | 2x            | -             | 문주란              |
| Lycoris albiflora Koidz.            | 17, 18, 19             | x = 9                       | 2x            | -             | 환상사화            |
| L. radiata (L’Hér.) Herb.           | 33                     | x = 11                      | 3x            | -             | 석산                |
| L. sanguinea var. koreana (Nakai) T. Koyama | 21, 22, 33, 45 | x = 11 | 2x, 3x, 4x | - | 백양꽃 |
| Asparagaceae Juss.                  |                        |                             |               |               |                    |
| Anemarrhena asphodeloides Bunge     | 22                     | x = 11                      | 2x            | 5.7           | 지모                |
| Asparagus cochinichenensis (Lour.) Merr. | 20               | x = 10                      | 2x            | -             | 천문동              |
| A. oligoclonos Maxim.               | 20, 40                 | x = 10                      | 2x, 4x        | -             | 방울비짜루          |
| A. schoberioides Kunth              | 20, 40                 | x = 10                      | 2x, 4x        | -             | 비짜루              |
| Convallaria keiskei Miq.            | 38                     | x = 19                      | 2x            | -             | 은방울비짜루        |
| Hosta capitata (Koidz.) Nakai       | 60                     | x = 30                      | 2x, 3x        | 19.3          | 임월비비추          |
| H. clausa Nakai                     | 60, 90, 96             | x = 30                      | 2x, 3x        | 28.5          | 참비비추            |
### Appendix 1. Continued.

| Order/Family/Genus/Species | Chromosome number (2n) | Base chromosome number (x) | Ploidy levels | 2C-value (pg) | Korean name |
|----------------------------|------------------------|-----------------------------|---------------|---------------|-------------|
| *H. clausa* var. *normalis* F. Maek. | 48, 60, 90 | x = 30 | 2x, 3x | 19.3 | 주걱비비추 |
| *H. longipes* (Franch. & Sav.) Matsum. | 60 | x = 30 | 2x | 26.3 | 비비추 |
| *H. longissima* F. Maek. | 60 | x = 30 | 2x | 19.3 | 산옥잠화 |
| *H. minor* (Baker) Nakai | 60 | x = 30 | 2x | - | 종비비추 |
| *Liriope platyphylla* F. T. Wang & T. Tang | 36, 72, 108, 112 | x = 18 | 2x, 4x, 6x | 21.1 | 맥문동 |
| *L. spicata* Lour. | 36, 72, 108 | x = 18 | 2x, 4x, 6x | 25.6 | 개맥문동 |
| *Maianthemum bifolium* (L.) F. W. Schmidt | 36, 54 | x = 18 | 2x, 3x | 30.6 | 두루미꽃 |
| *M. dilatatum* (A. Wood) A. Nelson & J. F. Maechr. | 36, 54 | x = 18 | 2x, 3x | 33.4 | 큰두루미꽃 |
| *Ophiopogon jaburan* (Siebold) Lodd. | 36 | x = 18 | 2x | - | 맥문아재비 |
| *O. japonicus* (Thunb.) K. Gawl. | 36, 67, 68, 70, 72 | x = 18 | 2x, 4x | 21.6 | 소엽맥문동 |
| *Polygonatum falcatum* A. Gray | 18, 20 | x = 9, 10 | 2x | - | 진황정 |
| *P. humile* Fisch. ex Maxim. | 20, 22, 30 | x = 10, 11 | 2x, 3x | - | 각시동굴레 |
| *P. inflatum* Kom. | 22 | x = 11 | 2x | - | 동동굴레 |
| *P. involucratum* (Franch. & Sav.) Maxim. | 18, 20, 22 | x = 9, 10, 11 | 2x | - | 용동굴레 |
| *P. lasianthum* Maxim. | 20 | x = 10 | 2x | - | 죽대 |
| *P. odoratum var. pluriflorum* (Miq.) Ohwi | 20, 30 | x = 10 | 2x, 3x | - | 동굴레 |
| *P. stenophyllum* Maxim. | 20, 24, 30 | x = 10, 12 | 2x, 3x | - | 충충동굴레 |
| *Scilla scilloides* (Lindl.) Druce | 16, 18, 26, 27, 34, 36, 38, 44, 53, 70 | x = 8, 9 | 2x, 3x, 4x, 5x, 6x | - | 무릇 |
| *Smilacina dahurica* Turcz. ex Fisch. & C. A. Mey. | 36 | x = 18 | 2x | - | 민솜대 |
| *S. japonica* A. Gary | 36 | x = 18 | 2x | - | 풀솜대 |
| *S. trifolium* (L.) Desf. | 36 | x = 18 | 2x | 22.2 | 세잎솜대 |

The table is arranged alphabetically by order, family, and genus recognized by APG IV classification system (The Angiosperm Phylogeny Group, 2016).

Note: All chromosome number information was taken from Rice et al. (2015).