Clematis L. (Ranunculaceae) in Korea

Clematis, a widely distributed genus in Ranunculaceae, is one of the most difficult groups of taxa from a taxonomic point of view. A study on achene morphology and anatomy indicated that some of the achene features could be useful as an alternative source to highlight the infrageneric relationship within the genus.

1. Introduction

Clematis L. is one of the largest genera in Ranunculaceae with about 280–350 species [1][2][3] most of which are woody or herbaceous vines, but a few are shrubs, subshrubs, or erect perennial herbs. The genus is widely distributed throughout the world but with considerable diversity in temperate and subtropical regions of the Northern Hemisphere, especially eastern Asia. China, which is believed to be the center of diversity of the genus, alone has 147 species, of which 93 are endemic [4][5][6]. Its remarkable climatic plasticity, showy flowers, and easy hybridization process make *Clematis* a horticulturally important genus that is widely cultivated in Europe, North America, and East Asian countries [7].

2. Classifications

With respect to morphology-based monographs, *Clematis* has been subjected to several infrageneric classifications [1][3][4][5][8][9]. Tamura [1] divided *Clematis* into four subgenera including 16 sections some of which were subdivided into subsections and series. Grey-Wilson [4] later grouped 297 species in nine subgenera, 16 sections, and 26 subsections whereas Johnson [5] recognized 18 sections and 36 subsections covering 325 species of the genus. Based on analyses of the various morphological and palynological characters of 345 *Clematis* species, Wang and Li [3] more recently purposed a system of classification establishing four subgenera two similar to those of Tamura [1] and two new subgeneric names within the genus, which are further divided into 15 sections and numerous subsections and series. These three classification systems largely agree with one another on species separations but vary in infrageneric discrimination. In this study, we follow Johnson [5][9] for infrageneric classification and Lee [10], Chang et al. [11], the Korea National Arboretum [12], and Kim [13] for species delimitations.

According to a comprehensive classification of Ranunculaceae by Tamura [2], *Clematis* belongs to the tribe Anemoneae of the subfamily Ranunculoideae. Furthermore, within Anemoneae the genus has been considered to be closely related to two small genera *Archiclematis* (Tamura) Tamura and *Naravelia* DC., which are together grouped in the subtribe Clamatidinae [2]. Morphologically, these three genera share a similar climbing habit and persistent hairy style in their mature achenes. The only feature that distinguishes the monotypic genus *Archiclematis* within the subtribe is the alternate leaf phyllotaxy. However, the close affinity of *Archiclematis alternata* (Kitam. and Tamura) Tamura—including similar flower morphology—with the subgenus *Viorna* Gray in *Clematis* led Wang and Li [3], Grey-Wilson [4], Wang and Bartholomew [6], and Johnson [9] to include this species within *Clematis*.

Several studies considering various morphological, anatomical, palynological, and cytological characters of *Clematis* have been performed [1][2][3][4][9][14][15][16][17][18][19][20][21][22][23][24][25]. Unfortunately, none of these morphological characters seem to provide enough information to resolve the infrageneric ambiguity of this large genus. As morphological and anatomical characters are subject to varied interpretations, the accurate infrageneric classification of this large genus, especially at the sectional level remains notoriously difficult. Due to this complex morphological variation within the genus and the different characters underlined in each system, the existing classifications systems for the genus diverge from one other [1][3][4][5][8][9]. Several molecular phylogenetic studies have also been performed in recent years [26][27][28][29][30][31] mostly supporting the monophyly of *Clematis* with clear suggestions for the retention of *Archiclematis* and *Naravelia* in a separate section within *Clematis* [27][29][30]. Unfortunately, the phylogenetic hypotheses supported by the morphological data were vastly incompatible with molecular hypotheses. Lehtonen et al. [31] recently studied 132 taxa of *Clematis* to clarify the infrageneric relationships within the genus by optimizing the phenotypic and molecular data. Their results [31] do not

agree with the previous subgeneric classifications of the genus due to poor support, short branch lengths and a lack of morphologically designated units. However, they obtained 12 stable and well supported clades conceptually matching the sectional divisions of Johnson [5][9].

Fruit and seed morphological characters have contributed useful phylogenetic data and are thus frequently used to discriminate the taxa in different taxonomic ranks. In particular, the surface sculpture of fruits, seeds or a combination of both provided a valuable reference for phylogenetic and/or systematic studies [32][33][34][35][36][37][38][39][40]. Different researchers have performed fruit and seed morphological studies emphasizing the taxonomic value of several Ranunuculaceae taxa [14][39][41][42][43][44][45][46][47][48][49][50][51][52] but studies pertaining to the fruit morphology and anatomy of *Clematis* are entirely absent in previous reports. Previous molecular phylogenetic studies [27][29] concluded that many morphological features in this genus traditionally considered to be useful for determining systematic relationships were highly homoplasious and not phylogenetically indicative. However, Lehtonen et al. [31] believed that the careful re-analysis of characters may facilitate a much better character coding and understanding of morphological evolution in *Clematis*.

There is a longstanding argument among plant taxonomists regarding the exact number of species and taxonomic nomenclature of the *Clematis* taxa in Korea. Nakai [53] reported 21 species and 14 varieties of *Clematis* in a synoptical sketch of Korean flora but Lee [54] later described 16 species, 11 varieties, and five forma in the genus. Before Moon et al. [55], who claimed a new record of *C. takedana* Makino in Korea, the Korea National Arboretum and The Plant Taxonomic Society of Korea [56] included 24 taxa of *Clematis* in the synonymic list of vascular plants in Korea. Despite the new record of *C. takedana* claimed by Moon et al. [55], the origin and distribution of this species are doubtful, and not all taxonomists have accepted this taxon [10][11][12][13]. In the book New Flora of Korea, Lee [8] described 18 taxa including *C. taeguensis* Y. Lee, which was first described by Lee [57], whereas Chang et al. [8] only described 12 species and three varieties in the Illustrated Encyclopedia of Fauna & Flora of Korea. *Clematis taeguensis* was not included in the Illustrated Encyclopedia of Fauna & Flora [10] and The Flora of Korea [13] although it has been recognized as an accepted species name in the World Flora Online (WFO) [58]. The Korea National Arboretum [12] recently listed 17 species and five varieties of *Clematis* in the Checklist of Vascular Plants in Korea whereas Kim [13] described 13 species and seven varieties within the genus in The Flora of Korea. After a careful review of Lee [10], Chang et al. [11], the Korea National Arboretum [12], and Kim [13] we have included 16 species and three varieties, taking *C. takedana* as an individual species.

3. Conclusions

Achene indumentum, surface sculpture, and pericarp and endocarp structure proved to be the most useful achene features for characterizing *Clematis* taxa. The results also indicated that taxa of section *Atragene* and *Tubulosae* displayed similarity in certain key achene features; however, the number of taxa sampled was very low for these sections, and thus any interpretation made on this basis is arbitrary. Further studies considering as many taxa as possible from different sections will certainly be helpful for resolving the taxonomy of the genus. The understanding from this study is that achene morphology alone as a single source of characters, cannot be expected to elucidate the problematic infrageneric relationships but a thorough analysis of current and other morphological, as well as molecular data, will be helpful to accomplish this. Our results, however, demonstrated that achene features can contribute valuable information and could be used as descriptive and/or diagnostic characters of the *Clematis* species.

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