



A partial revision of *Allium* (Amaryllidaceae) in Korea and north-eastern China

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A taxonomic revision of *Allium* in Korea and north-eastern China is presented based on critical observations of wild populations and extensive herbarium material. Species delimitations are re-evaluated on the basis of macro- and micromorphological and cytological characters, resulting in the recognition of 24 species comprised of 26 taxa, among which, four species and two varieties are endemic to Korea, and one species is endemic to China. One previously recognized species is placed into synonymy: *A. deltoideifistulosum* (under *A. sacciferum*). *Allium spirale* and *A. tenuissimum* are newly recorded for Korea, and the common names ‘Cham-du-me-bu-chu’ and ‘Ae-gi-silbu-chu’ are given for these species, respectively. Lectotypes are designated for *A. deltoideifistulosum*, *A. monanthum* and *A. ophiopogon*. Illustrations, photographs and a key to species and varieties are provided in addition to complete descriptions including information on nomenclatural types, synonymies, chromosome numbers, distributions, habitat and specimens examined. This study will provide sound foundation for a future global monograph and the systematic understanding of *Allium*. © 2011 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2011, 167, 153–211.

ADDITIONAL KEYWORDS: Alliaceae – chromosome number – lectotype – microstructure – morphology – taxonomy – unrecorded species.

INTRODUCTION

The genus *Allium* L. was traditionally affiliated to tribe Allieae under Liliaceae (Bentham & Hooker, 1883; Vvedensky, 1935; Lawrence, 1951; Xu & Kamelin, 2000), but more recently it has frequently been placed in Alliaceae (Dahlgren, Clifford & Yeo, 1985; Takhtajan, 1997; Rahn, 1998; Friesen *et al.*, 2000) or in an expanded Amaryllidaceae (APG III, 2009; Chase, Reveal & Fay, 2009). The genus is characterized by the presence of bulbs enclosed in membranous (sometimes becoming fibrous) tunics, free or almost-free tepals and often a subgynobasic style (Friesen, Fritsch & Blattner, 2006). Most taxa produce remarkable amounts of cysteine sulphoxides, causing their well-known characteristic odour and

taste of garlic, onion, shallot and leek (Fritsch & Keusgen, 2006).

With over 800 species, *Allium* is distributed naturally in the Northern hemisphere and South Africa (one species only), mainly in seasonally dry regions (de Sarker *et al.*, 1997; Friesen *et al.*, 2006; Nguyen, Driscoll & Specht, 2008; Neshati & Fritsch, 2009). The greatest diversity of *Allium* is observed in southwestern and central Asia and the Mediterranean region, the primary centre of diversification, but a smaller secondary area of diversification is found in North America (Friesen *et al.*, 2006; Nguyen *et al.*, 2008). For generations, humans have used >20 cultivated *Allium* spp. (van der Meer, 1997). More recently, Old and New World edible and ornamental *Allium* taxa are becoming more popular worldwide, including culinary species, for example, Chinese chives (*A. tuberosum* Rottl. ex Spreng.), and attractive ornamental plants such as the nodding onion

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(*A. cernuum* Roth) (Rabinowitch & Currah, 2002). Similarly, consumers and researchers are more aware of the health benefits and medical properties of *Allium* spp. (Keusgen, 2002).

Despite the cultural, economic and health significance of *Allium* in human society, to date, its taxonomy remains complex because of the proliferation of synonyms and disagreement on taxonomic characters used for species boundaries. Consequently, no comprehensive generic monograph has been compiled since that of Regel (1875). The infrageneric classification history of *Allium* began prior to Linnaeus (1753), who recognized 30 species in three alliances. Later authors recognized more infrageneric groups with increased number of species: six sections and 262 species (Regel, 1875); nine sections and 228 species for the former USSR alone (Vvedensky, 1935); three subgenera, 36 sections and c. 600 species (Traub, 1968); six subgenera, 30 sections and 14 subsections (Kamelin, 1973); and six subgenera, 50 sections and subsections for 600–700 species (Hanelt *et al.*, 1992). The most recent *Allium* classification accepted approximately 800 species belonging to 15 subgenera and 56 sections (Friesen *et al.*, 2006). This complex taxonomic history involves 1800 specific epithets, often based on inadequate or incomplete material, many of which have later proved to be synonymous with existing species (Gregory *et al.*, 1998).

The investigation of north-eastern Asian *Allium* spp. is significant because, in addition to including the ancestors of some commercial *Allium* crops, these entities are distributed on the outskirts of the Old World and border the New World in relation to the worldwide distribution of the genus. Nguyen *et al.* (2008) considered eastern Asia as an additional centre of diversity for this genus. At present, 19 species are known from the Russian Far East (Vvedensky, 1935; Barkalov, 1987; Kovtonyuk, Barkalov & Friesen, 2009), 27 from north-eastern China (defined here as provinces Heilongjiang, Jilin and Liaoning; Fig. 1) (Xu & Kamelin, 2000), 12 from Japan (Ohwi, 1984; Hotta, 1998) and 18 from Korea (Choi *et al.*, 2004c). Based on our field and herbarium observations to date, 26 *Allium* taxa, excluding cultivated species, are being recognized in Korea and north-eastern China (Choi, 2009). Notwithstanding the high diversity of taxa distributed in north-eastern Asia, there are few systematic studies of these species. In particular, taxonomic understanding of *Allium* has been limited in part because of the fact that the accurate recognition of *Allium* spp. is sometimes difficult using only dried specimens in herbaria (H. J. Choi & B. U. Oh, pers. observ.).

Several criteria have been used in *Allium* classification, with sexuality of plants, structure and shape

of the underground parts (including rhizome and bulb), anatomical features of root, leaf, scape and ovary, and basic chromosome number having proved useful at subgeneric and sectional levels (Fritsch, 1992; Hanelt *et al.*, 1992; Kruse, 1992; McNeal, 1992; Friesen *et al.*, 2006; Gurushidze, Fritsch & Blattner, 2008; Nguyen *et al.*, 2008; Choi, 2009). In addition, shape and size of floral organs such as perianth, filament, pistil, capsule and seed have provided diagnostic characters at the specific level, together with somatic chromosome number (McNeal, 1992; Choi *et al.*, 2004a, 2006, 2007; Ko, Choi & Oh, 2009; Choi & Cota-Sánchez, 2010; Choi & Oh, 2010), and scanning electron microscopy (SEM) has allowed the characterization of cell pattern and ornamentation of the bulb coat, leaf and seed coat, improving the taxonomy of *Allium* (Kruse, 1992; McNeal, 1992; Choi *et al.*, 2004b; Fritsch *et al.*, 2006; Choi, 2009; Neshati & Fritsch, 2009; Choi & Cota-Sánchez, 2010).

Although there is general agreement regarding the number of species in Korea and north-eastern China, a formal taxonomic treatment is lacking. Here, we have combined quantitative investigations with qualitative observations of vegetative, reproductive and cytological characters to address the taxonomy of *Allium* in Korea and north-eastern China. The goals of this study are: (1) to expand the current knowledge on general morphology (in addition to Xu & Kamelin, 2000; Choi *et al.*, 2004c, 2007; Choi & Oh, 2010), microstructures (in addition to Choi *et al.*, 2004b), somatic chromosome numbers (in addition to Choi *et al.*, 2004a, 2006; Ko *et al.*, 2009; Choi & Oh, 2010) and distribution (in addition to Xu & Kamelin, 2000; Choi *et al.*, 2004c) by including unstudied species and different accessions of already reported and studied taxa; and (2) to address taxonomic issues, clarify type identifications and provide a clear taxonomic treatment with new descriptions and illustrations of the species. This study, together with that of Choi & Cota-Sánchez (2010), will provide a sound foundation for a future global monograph and the systematic understanding of *Allium*.

MATERIAL AND METHODS

Our taxonomic revision is based on the use of living and herbarium material from various systematic collections. More than 3000 herbarium specimens, including type material, were examined from 11 major herbaria in South Korea, China, Japan and Russia (CBU, HNHM, KH, KNU, KWNU, LE, PE, SNU, SNUA, TI and TUT). Some photographs of type specimens were also provided by B, LINN and NY. Extensive field studies were carried out from April 2000 to October 2008, leading to a total of 97 *Allium* accessions (Fig. 1; Table 1). All taxa recognized here



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Figure 1. Investigated areas and main collection sites in this study (1–60: site number of Table 1). Acronyms for each province are: HE, Heilongjiang; JI, Jilin; LI, Liaoning; HB, Hambuk; HN, Hamnam; YG, Yanggang; JG, Jagang; PB, Pyeongbuk; PN, Pyeongnam; WB, Hwangbuk; WN, Hwangnam; GW, Gangwon; GG, Gyeonggi; CB, Chungbuk; CN, Chungnam; JB, Jeonbuk; JN, Jeonnam; GB, Gyeongbuk; GN, Gyeongnam; JJ, Jeju.

Table 1. Collection data, voucher information and chromosome numbers of mainly investigated accessions in this study (*: type locality)

Taxon	Collection site (Site number in Fig. 1) and date	Voucher	2n
<i>A. monanthum</i>	GW: Taehwasan, Yeongwol (34), 21 Apr 2001 GW: Taebaeksan, Taebaek (35), 10 May 2003 GG: Soheul, Pocheon (24), 24 Apr 2008 GG: Pungdo, Ansan (30), 15 Apr 2002 CB: Woraksan, Jecheon (39), 3 May 2001 CB: Bukgachi, Songnisan (41), 1 May 2001 GB: Seonamsan, Gunwi (42), 13 Apr 2000	B.U.Oh et al. 010007 (CBU) B.U.Oh et al. 030001 (CBU): Fig. 2A H.J.Chi 080001 (KH): Fig. 4A, C, D, E, F1, G, I-K H.J.Chi & Y.Y.Kim s.n. (CBU) H.J.Chi et al. 010006 (CBU): Fig. 4B, F2, H H.J.Chi 010005 (CBU) B.U.Oh 000002 (CBU)	
<i>A. neriniflorum</i>	HE: Qiqihar (5), 5 July 2008 LI: Daegosan, Dandong (17), 5 July 2007	D.G.Jo et al. 070001 (KH): Fig. 3A CBU-037 (KH): Figs 2B, I, 5A1, B-L	16
<i>A. macrostemon</i>	JI: Jian (15), 5 Sept 2007 GW: Taehwasan, Yeongwol (34), 26 May 2001 GG: Soheul, Pocheon (24), 24 Apr 2008 GG: Pungdo, Ansan (30), 23 Mar 2002 CB: Songnisan, Boeun (41), 11 June 2000 CB: Gaesin, Cheongju (40), 13 June 2003 GB: Wolseong (49), 10 June 2006 GN: Aengsan, Geojedo (56), 18 May 2003 JJ: Iho beach, Jeju (59), 27 May 2002	B.U.Oh et al.s.n. (CBU) B.U.Oh et al. 010020 (CBU) H.J.Chi 080002 (KH): Fig. 6A1, C, D-L H.J.Chi & Y.Y.Kim 020002 (CBU) H.J.Chi 000003 (CBU): Fig. 2C H.J.Chi 030002 (CBU): Fig. 6A2, B2 H.J.Chi s.n. (KH) B.U.Oh et al. 030003 (CBU): Fig. 6B3 H.J.Chi & Y.Y.Kim 020055 (CBU): Fig. 6B1	
<i>A. microdictyon</i>	GW: Bukdae, Odaesan (28), 25 June 2001 GW: Duwibong, Jeongseon (32), 25 June 2008 GW: Gariwangsan, Pyeongchang (31), 7 July 2004 GW: Daecheongbong, Seoraksan (27), 27 June 2007	H.J.Chi et al. 010008 (CBU): Fig. 2D H.J.Chi 080166 (KH) H.J.Chi 040002 (KH): Fig. 7A-K H.J.Chi 070009 (KH) H.J.Chi & S.J.Ji 030004 (CBU)	
<i>A. ochotense</i>	CB: Birobong, Sobaeksan (37), 14 June 2003 GB: Seonginbong, Ulleungdo (33), 18 May 2002	H.J.Chi 020056 (CBU): Figs 3B, 8A-J	16
<i>A. tuberosum</i>	JI: Jian (15), 5 Sept 2007 GG: Daecheongdo, Incheon (22), 10 Aug 2008 CN: Seodaesan, Geumsan (44), 3 Oct 2002 JN: Jangdo, Wando (57), 15 Aug 2007 GB: Nagok beach, Uljin (36), 30 Aug 2001 GB: Yeonji, Gyeongsan (48), 28 Oct 2001	B.U.Oh et al. s.n. (CBU) H.J.Chi 080254 (KH): Fig. 9A1, B-J Y.Y.Kim et al. 020075 (CBU) H.J.Chi 070098 (KH): Fig. 3C	32
<i>A. ramosum</i>	HE: Qiqihar (5), 1 Sept 2003 HE: Tahe (2), 2 Aug 2008	B.U.Oh et al. 010010 (CBU) H.J.Chi & Y.Y.Kim 010021 (CBU) L-61237 (KH): Figs 2E, J, 10A-J	
<i>A. spirale</i>	LI: Héngsan, Daeryeon (19), 11 Aug 2008 JI: Ipbeopsan, Gyoha (9), 2 Sept 2006 JI: Aprokgang, Dandong (17), 6 Sept 2007 HN: Sinpo (21), 3 Oct 2002	Y.M.Lee & H.J.Chi 080001 (KH) B.U.Oh et al. s.n. (CBU) Jilin23-060902-007 (CBU): Fig. 11A-J H.J.Chi & J.W.Han 070012 (KH)	
<i>A. minus</i>	GB: Cheongnyangsan, Bonghwa (38), 6 Sept 2008	B.U.Oh 020062 (CBU)	16¶
<i>A. senescens</i>	GW: Wolhaksam, Inje (26)*, 18 May 2008 HE: Palryeon (6), 3 July 2007	H.J.Chi 080390 (KH) H.J.Chi 080063 (KH): Fig. 12A-J	16¶
<i>A. pseudosenescens</i>	LI: Héngsan, Daeryeon (19), 11 Aug 2008	B.U.Oh et al. s.n. (CBU)	32¶
<i>A. bidentatum</i>	GW: Misiryeong, Seoraksan (27), 23 Sept 2001 GB: Dodong, Ulleungdo (33), 18 Sept 2007 HE: Talin Linchang, Tahe (2)*, 31 July 2008	H.J.Chi et al. 010009 (CBU)	
<i>A. anisopodium</i>	HE: Tahe (2), 7 July 2007	H.J.Chi 070001 (KH): Figs 2F, 13A-J	32¶
<i>A. tenuissimum</i>	LI: Héngsan, Daeryeon (19), 7 July 2007 LI: Daegosan, Dandong (17), 5 July 2007 LI: Kuanjiasan, Zhuanghe (18), 6 July 2007 LI: Héngsan, Daeryeon (19), 7 July 2007	H.J.Chi 080199 (KH): Fig. 14A-J D.G.Jo et al. 070050 (KH): Figs 2K, 15A-K CBU-280 (KH)	
<i>A. koreanum</i>	GG: Dumujin, Baengnyeongdo (22), 1 May 2003 GG: Daecheongdo, Incheon (22), 10 Aug 2008 JB: Maisan, Jinan (45)*, 16 Aug 2002 GN: Ganwoljae, Ulju (50), 10 Aug 2007	B.U.Oh et al. 030009 (CBU): Fig. 16A1, B-J CBU-038 (KH): Fig. 2L CBU-266 (KH) CBU-277 (KH)	16
<i>A. splendens</i>	HE: Tahe (2), 7 July 2007 JI: Seopa, Jangbaeksan (13), 25 July 2003 JI: Seopa, Jangbaeksan (13), 7 Sept 2007	H.J.Chi 030008 (CBU): Figs 3D, 17A-J H.J.Chi 080255 (KH) H.J.Chi 020057 (CBU): Fig. 18A-I ParkSH 73933 (KH) D.G.Jo et al. 070054 (KH)	16†
		B.U.Oh et al. 030005 (CBU): Fig. 19A-J H.J.Chi & J.W.Han 070050 (CBU): Fig. 2G, M	32†

Table 1. *Continued*

Taxon	Collection site (Site number in Fig. 1) and date	Voucher	2n
<i>A. condensatum</i>	HE: Palryeon (6), 3 July 2007 JI: Gunhamsan, Hwaryong (11), 26 July 2003 JI: Ipbeopsan, Gyoha (9), 2 Sept 2006 LI: Daeheuksan, Daeryeon (19), 7 July 2007	<i>B.U.Oh et al. s.n.</i> : Fig. 20A1 <i>B.U.Oh et al. 030012</i> (CBU): Figs 3E, 20B–I <i>Jilin23-060902-005</i> (CBU) <i>B.U.Oh et al. s.n.</i> (CBU)	16
<i>A. maximowiczii</i>	HE: Mohe (1), 8 July 2007 HE: Tahe (2), 13 Aug 2008	<i>D.G.Jo et al. 070070</i> (KH): Fig. 21A–J <i>Y.M.Lee & H.J.Choi 080002</i> (KH): Fig. 2N	
<i>A. taquetii</i>	JJ: 1100goji seupji, Hallasan (59)*, 27 Sept 2002 JJ: Yeongsil, Hallasan (59), 1 Oct 2006	<i>H.J.Choi et al. 020063</i> (CBU): Fig. 22A–D1, E–J <i>G.H.Nam 06125</i> (KH): Fig. 22D2	16§
<i>A. linearifolium</i>	CB: Woraksan, Jecheon (39)*, 2 Oct 2002	<i>H.J.Choi et al. 020001</i> (CBU): Fig. 23A–I	16§
<i>A. thunbergii</i> var. <i>thunbergii</i>	GW: Misiryeong, Seoraksan (27), 23 Sept 2001 GW: Yukdam falls, Seoraksan (27), 31 Aug 2001 GG: Yongmansan, Yangpyeong (29), 30 Sept 2002 GG: Manisan, Ganghwado (23), 13 Oct 2002 CB: Munsubong, Songnisan (41), 28 Sept 2001 CN: Seodaeasan, Geumsan (44), 3 Oct 2002 GN: Bangeo, Ulsan (50), 2 Nov 2007 GN: Gayasan, Hapcheon (47)*, 23 Sept 2003	<i>H.J.Choi et al. 010017</i> (CBU): Figs 2O, 24A, C, D5, E–J <i>B.U.Oh et al. 010018</i> (CBU): Fig. 24D3 <i>Y.Y.Kim 020065</i> (CBU): Fig. 2H <i>H.J.Choi & Y.Y.Kim 020066</i> (CBU) <i>H.J.Choi 010019</i> (CBU) <i>Y.Y.Kim et al. 020067</i> (CBU): Fig. 24D4 <i>ParkSH 71927</i> (KH) <i>H.J.Choi 030007</i> (CBU): Fig. 24D1	16§
var. <i>deltoides</i>	JB: Hyangjeokbong, Deogyusan (46)*, 7 Oct 2002	<i>H.J.Choi 020068</i> (CBU): Fig. 24D2	16§
var. <i>teretifolium</i>	GN: Jungbong, Jirisan (53), 10 June 2007	<i>C.S.Jang 49475</i> (CBU): Fig. 24B	
<i>A. longistylum</i>	GW: Bukhangang, Hwacheon (25), 8 Oct 2002 GW: Donggang, Jeongseon (32), 1 Oct 2007	<i>B.U.Oh et al. 020038</i> (CBU): Fig. 25A–J <i>E.S.Jeon & H.J.Choi 070001</i> (KH)	16§
<i>A. sacculiferum</i>	GG: Hantangang, Yeoncheon (24), 23 Oct 2007 JI: Gunhamsan, Hwaryong (11), 8 Sept 2007 JI: Idobaekha, Ando (12), 8 Sept 2007 LI: Cheonsan, Ansan (16), 9 July 2007 LI: Senyang (14), 4 Sept 2007 HN: Sinpo (21), 3 Oct 2002 GW: Taegisan, Pyeongchang (31), 22 Sept 2001 GW: Duwibong, Jeongseon (32), 25 June 2008 CB: Mulhan, Yeongdong (43), 8 Oct 2001 CB: Sangdangsan, Cheongju (40), 13 Oct 2001 CN: Seodaeasan, Geumsan (44), 3 Oct 2002 JB: Segeolsan, Namwon (54), 20 Oct 2001 JN: Deogrimsan, Yeonggwang (55), 19 Nov 2001 GB: Hyodong, Gyeongju (49), 4 Nov 2000 GN: Sancheong (52), 27 Oct 2002 GN: Georyongsan, Geoje (56), 24 Aug 2003 GN: Gijang, Busan (51), 2 Oct 2005 JN: Geomundo, Yeosu (58), 16 Oct 2005 JJ: Pyoseon beach, Seogwipo (59), 24 June 2007 JAPAN: Ishara, Tsushima (60)*, 4 Apr 2004	<i>H.J.Choi s.n.</i> (KH) <i>B.U.Oh et al. s.n.</i> (CBU) <i>H.J.Choi & J.W.Han 070052</i> (KH) <i>B.U.Oh et al. s.n.</i> (CBU) <i>LiaoningI-070703-001</i> (CBU) <i>B.U.Oh 020061</i> (CBU) <i>H.J.Choi et al. 010012</i> (CBU): Fig. 26A–D1, E–I <i>H.J.Choi 080167</i> (KH) <i>H.J.Choi & Y.Y.Kim 010013</i> (CBU) <i>H.J.Choi 010014</i> (CBU) <i>Y.Y.Kim 020062</i> (CBU) <i>H.J.Choi & Y.Y.Kim 010011</i> (CBU) <i>H.J.Choi & S.J.Ji 010015</i> (CBU): Fig. 26D2, 3 <i>H.J.Choi et al. 000004</i> (CBU) <i>Y.Y.Kim 020064</i> (CBU) <i>H.J.Choi et al. 030186</i> (CBU) <i>H.J.Choi 050512</i> (KH) <i>H.J.Choi 50377</i> (KH): Figs 2P, 27A–J <i>H.J.Choi 070040</i> (KH) <i>Oh & Jang-Tsushima-040404-001</i> (CBU): Fig. 3F	32
<i>A. pseudojaponicum</i>			32

Acronyms for each province are the same as in Figure 1.

Symbols indicate the previously published results with the vouchers used in this study (†Choi *et al.*, 2004a; ‡Choi *et al.*, 2006; §Ko *et al.*, 2009; ¶Choi & Oh, 2010).

have been brought into cultivation in the experimental field at the Department of Biology, Chungbuk National University, South Korea. Material preserved in formalin–acetic acid–alcohol (FAA) (Jensen, 1962) was used for observation and measurement of micro-morphological characters, cross sections of leaf, scape and pedicel and reproductive organs. The source of distributional, ecological and phenological information about *Allium* spp. in Korea and north-eastern

China was obtained from data on specimen labels and the authors' field observations.

GENERAL MORPHOLOGY

Characters from vegetative (rhizome, bulb, leaf, scape and pedicel) and reproductive (perianth, stamen, pistil, fruit and seed) structures were analysed in each species. Measurements were based on a

minimum of 30 samples. An Olympus SZX7 stereoscope with a Canon A630 was used for observations and taking photographs of specimens. Segments from the middle third of the second leaf blade, scape and pedicel were used for anatomical observation of the cross section. Tissues fixed in FAA were free-hand sectioned, stained with safranin, washed with distilled water and photographed. Line drawings were generated from photographs and voucher specimens using Adobe Photoshop 7.01 software. Vouchers for line drawings and photographs are indicated in Table 1, except for those redrawn from Wu, Raven & Hong (2002).

MICROSTRUCTURES

For the observation of micromorphological structures of bulb tunics and leaf epidermis, tissues were fixed in FAA, washed twice with 0.1 M phosphate buffer (pH 6.8), refixed in 2.5% glutaraldehyde, dehydrated through an alcohol-isoamylacetate series, critical-point dried, mounted on stubs, and coated with gold in an ion sputter coater (thickness: 200–250 nm). In all cases, at least five samples per taxon were analysed, characterized and photographed with a LEO 1420 SEM at the Plant Taxonomy Laboratory of the Andong National University, South Korea.

CYTOLOGICAL CHARACTERS

Shoot tips were pretreated in 0.002 M 8-hydroxyquinoline for 4–6 h in total darkness at 4 °C and then fixed in Carnoy's fluid (3 parts absolute ethanol:1 part glacial acetic acid, v/v) for 1 h at room temperature (23 °C). The shoot tips were macerated in 1 M hydrochloric acid at 60 °C for 10–15 s. After washing three to five times to eliminate residual hydrochloric acid and staining with 1% aceto-orcein for 8 h, the material was squashed for observation in 45% acetic acid. More than ten chromosome micrographs were observed for each accession using an optical microscope (Olympus AX-70). Semi-permanent microscope slides and photographs of representative cells have been retained in the Plant Taxonomy Laboratory of the Chungbuk National University, South Korea.

RESULTS

MACROMORPHOLOGICAL CHARACTERS

Our data indicate that several macromorphological characters are of taxonomic utility. Among these, the shape and development of rhizome, texture and sculpture of the outer tunic of the bulb, shape and structure of leaf and scape in cross section, growing patterns of leaf and scape, bulbel and bulbil develop-

ment and shape and size of various floral parts are useful diagnostic traits at the specific level (Choi *et al.*, 2004c, 2007). The qualitative and quantitative taxonomic characters of the *Allium* spp. in Korea and north-eastern China were summarized in Tables 3 and 4 of Choi (2009), with a general description of their variability.

MICROSTRUCTURES

Bulb tunics

Cellular patterns on the bulb tunics in *Allium* spp. were observed using an SEM (Fig. 2A–H). Tunics of various textures are arranged as subsquare (Fig. 2B), rectangular (Fig. 2C), wavy-linear (Fig. 2A) or linear (Fig. 2D–H) cells. *Allium monanthum* Maxim. is the only Korean and north-eastern Chinese member showing a herringbone pattern with wavy-linear cells (Fig. 2A), which is also observed in some North American species (McNeal, 1992; Nguyen *et al.*, 2008). *Allium neriniflorum* (Herb.) Baker and *A. macrostemon* Bunge are also easily distinguished from the others by distinctive subsquare (Fig. 2B) and rectangular (Fig. 2C) cell shapes, respectively. The linear type is most common in investigated taxa and observed in the remainder. Within this type, however, *A. microdictyon* Prokh., *A. ochotense* Prokh., *A. tuberosum*, *A. ramosum* L., *A. koreanum* H.J. Choi & B.U.Oh and *A. splendens* Willd. ex Schult.f. are characteristically distinguished by fibrous and reticulate tunics (Fig. 2D, E, G).

Leaf epidermis

The leaf epidermal cells of the species investigated are usually rectangular to linear in shape, with straight anticinal walls (Fig. 2I–P; Choi *et al.*, 2004b). Within species, the shape of the epidermal cells is similar on the adaxial and abaxial side of the leaf (Choi *et al.*, 2004b). The cuticular cell sculpture pattern is smooth (Fig. 2N, O), ridged (Fig. 2I, J, L, M), beaded (Fig. 2P) or verrucate (Fig. 2K). *Allium bidentatum* Fisch. ex Prokh. & Ikonn.-Gal. is characteristically distinguished by the prominently verrucate walls (compared with the other Korean and north-eastern Chinese *Allium* in Figure 2I–P and Choi *et al.*, 2004b). This character varies among taxa, but displays consistency within the same taxon. It is particularly useful in distinguishing some closely related taxa; for example, *A. anisopodium* Ledeb. from *A. tenuissimum* L., *A. thunbergii* G.Don var. *thunbergii* from *A. pseudojaponicum* Makino and *A. thunbergii* var. *teretifolium* H.J. Choi & B.U.Oh from *A. longistylum* Baker. The stomatal apparatus in Korean and north-eastern Chinese *Allium* is anomocytic, and mostly amphistomatic or rarely hyposomatic (Choi *et al.*, 2004b).

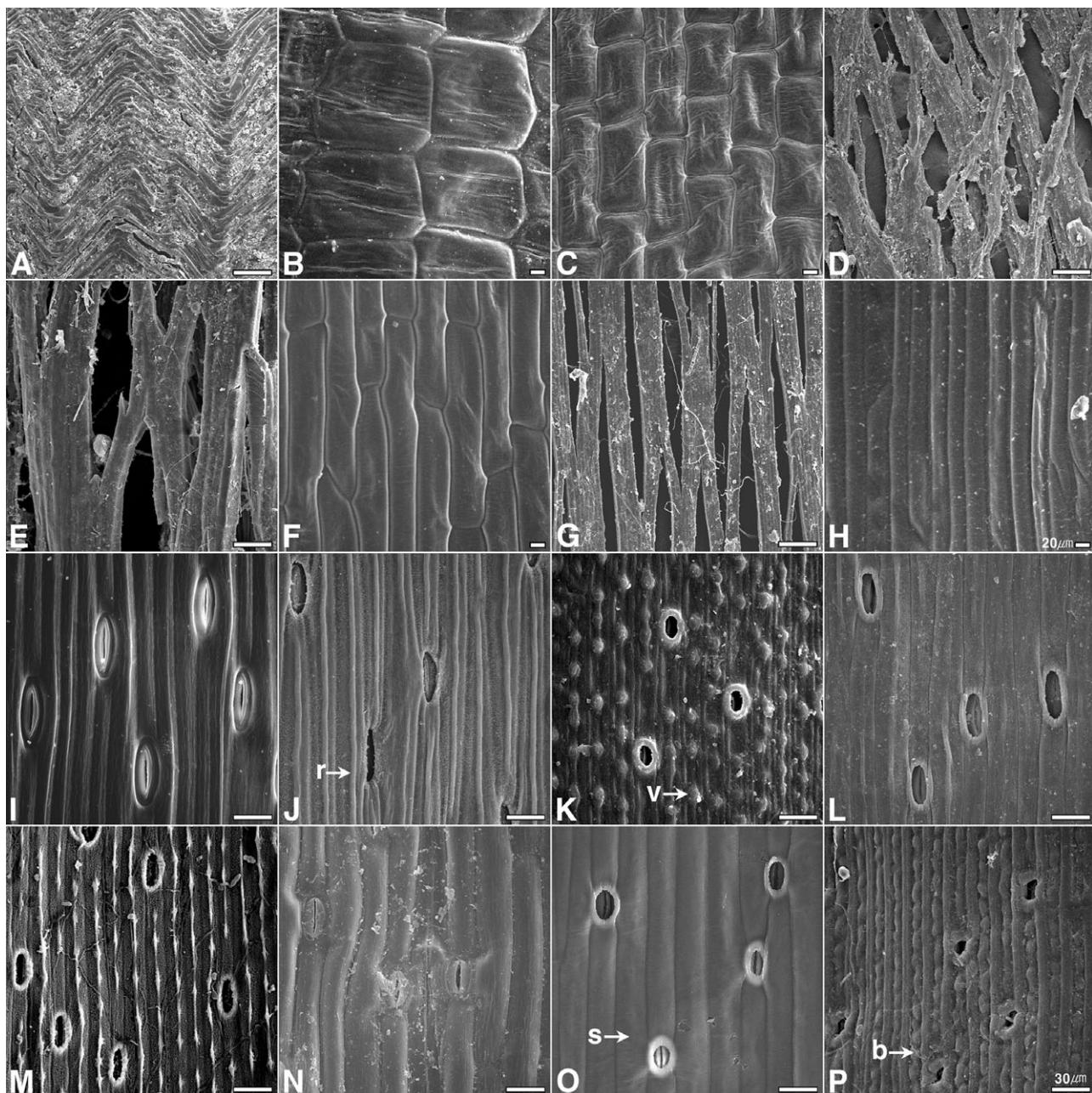


Figure 2. Microstructures (A–H, bulb tunics; I–P, abaxial surfaces of leaf epidermis) of *Allium* species (b, beaded; r, ridged; s, smooth; v, verrucate). A, *A. monanthum*. B, I, *A. neriniflorum*. C, *A. macrostemon*. D, *A. microdictyon*. E, J, *A. ramosum*. F, *A. senescens*. G, M, *A. splendens*. H, O, *A. thunbergii* var. *thunbergii*. K, *A. bidentatum*. L, *A. anisopodium*. N, *A. maximowiczii*. P, *A. pseudojaponicum*. Leaf epidermal structures of the other Korean and north-eastern Chinese species were presented in Choi *et al.* (2004b).

CHROMOSOME NUMBERS

The somatic chromosome numbers of *Allium* spp. investigated are counted as diploid ($2n = 2x = 16$; Fig. 3A, B, D, E) or tetraploid ($2n = 4x = 32$; Fig. 3C, F) and so the basic chromosome number is $x = 8$ (Table 1). The somatic chromosome number can be

used as valuable characters in delimiting *Allium* spp. in Korea and north-eastern China. It is particularly useful in distinguishing some closely related taxa; for example, *A. koreananum* from *A. splendens* (Choi *et al.*, 2004a) and *A. thunbergii* var. *thunbergii* from *A. pseudojaponicum* (Choi *et al.*, 2006).

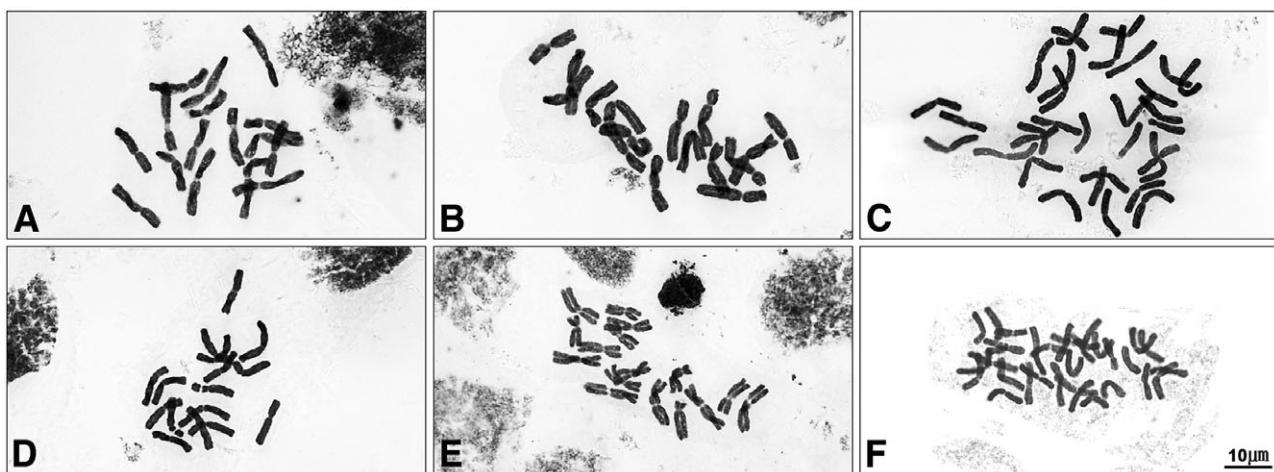


Figure 3. Mitotic metaphase chromosomes of *Allium* species. A, *A. neriniflorum* ($2n = 16$). B, *A. ochotense* ($2n = 16$). C, *A. tuberosum* ($2n = 32$). D, *A. tenuissimum* ($2n = 16$). E, *A. condensatum* ($2n = 16$). F, *A. pseudojaponicum* ($2n = 32$). The chromosome numbers of the other Korean and north-eastern Chinese species are indicated in Table 1.

TAXONOMIC TREATMENT

The general distributional data in each taxon is partly based on the following representative studies: Vvedensky (1935), Ohwi (1984), Friesen (1987, 1995), Xu & Kamelin (2000) and Kovtonyuk *et al.* (2009).

ALLIUM L., SP. PL. 1: 294 (1753)

Type: *A. sativum* L. (lectotype).

Description: Herbs perennial, bulbiferous, hermaphroditic (monoecious) or rarely dioecious. Rhizomes condensed or elongated, sometimes thick and branched or thread-like, erect to horizontal. Bulbs tunicate, solitary to clustered, sometimes with basal bulbils, cylindrical to globose; tunics consisting of subsquare, rectangular, wavy-linear or linear cells, membranous, papery, fibrous or rarely thinly leathery, smooth, herringbone patterned or reticulate, white, grey, brown or rarely reddish. Leaves alternate, sometimes withering at anthesis; leaf sheaths buried or exposed above ground, striped or not, sometimes tinged red; leaf blades ascending to spreading, straight or tortuous, sometimes lustrous, linear or elliptical to oval, flat, angular or terete, with one or two rows of vascular bundles and solid or hollow in cross section, sessile, attenuate or rarely narrowed into pseudo-petiole at base, acuminate to rounded in apex; leaf epidermal cells rectangular to linear, usually with smooth, ridged, beaded or verrucate cuticles, amphistomatic or rarely hypostomatic. Scapes usually central from bulbs, sometimes enclosed at base, together with leaves by a hyaline sheath, slender or not, erect to recurved (drooping) at the upper parts before flowering, terete, angular or flattened-winged, solid or hollow in cross section.

Inflorescences terminal, usually umbellate, sometimes replaced totally or partially by bulbils, wholly enclosed by a scarious spathe-like bract before flowering; umbels fascicled to globose; pedicels terete or rarely angular, thinner or rarely thicker than the scapes, subequal to distinctly unequal in length, sometimes slender. Flowers bisexual or rarely degenerating into unisexual, actinomorphic; perianth campanulate to stellately spreading or rarely funnelform, with greenish or reddish midvein abaxially; tepals six, in two series, usually unequal, connate at base, persistent after flowering; inner ones oblong to ovate or obovate, acute to truncate at apex; outer ones oblong to oval, acute to rounded at apex; stamens six; filaments adnate to the lower part of tepals, exserted or not, connate and usually dilated at base, entire or toothed at margin; anthers bilocular, longitudinally dehiscent, oblong, elliptical or oval, yellowish or reddish; ovary superior, variously shaped, greenish, reddish or brownish, trigonous or not, sometimes with hood-like appendages at base, locules three, ovules one to several (usually two) per locule, placenta axile; style one, erect, filiform, terete or rarely trigonous, exserted or not; stigma conically smooth, capitate or rarely trifid. Fruits capsules, dehiscent, subglobose, ellipsoid or cordiform, trigonous or not. Seeds black, elliptical to circular, flat to circular in cross section.

Chromosome number: $2n = 16$ or 32 (basic chromosome number $x = 8$) in most species of Korea and north-eastern China.

Notes: In this revision of Korean and north-eastern Chinese species, we recognize 26 taxa of 24 species (Table 1). Among them, four species and two varieties

are endemic to Korea and one species is endemic to China. *Allium tuberosum* is the only introduced and naturalized species in this study. Compared with the *Flora of China* (Xu & Kamelin, 2000), ten taxa reported occurring in the north-eastern Chinese provinces of Heilongjiang, Jilin and Liaoning were excluded in this revision because of inadequate

material seen in the field or in herbaria: *A. altaicum* Pall., *A. anisopodium* Ledeb. var. *zimmermannianum* (Gilg) F.T.Wang & Tang, *A. elegantulum* Kitag., *A. ledebourianum* Schult.f., *A. leucocephalum* Turcz. ex Ledeb., *A. listera* Stearn, *A. maackii* (Maxim.) Prokh., *A. mongolicum* Regel, *A. polyrhizum* Turcz. ex Regel and *A. spurium* G.Don.

KEY TO *ALLIUM* SPECIES IN KOREA AND NORTH-EASTERN CHINA

1. Herbs usually dioecious; rhizomes thread-like; bulb tunics herringbone patterned; leaf blades with one row of vascular bundles in cross section; hyaline sheaths present; scapes slender; inflorescences one to three flowered; pedicels not thinner than the scape; inner tepals narrower than outer ones; style trigonous; stigma three-cleft; flowering from late March to May.....1. *A. monanthum*
- 1*. Herbs hermaphroditic (monoecious); rhizomes non-thread-like; bulb tunics smooth to reticulate; leaf blades usually with two rows of vascular bundles in cross section; hyaline sheaths absent; scapes not slender; inflorescences more than four flowered; pedicels thinner than the scape; inner tepals not narrower than outer ones; style terete; stigma smooth, capitate or three-lobed; flowering from May to October.....2
2. Pedicels longer than 45 mm; perianth funnelform; ovules five to eight per locule; stigma three-lobed.....2. *A. neriniflorum*
- 2*. Pedicels shorter than 32 mm; perianth campanulate to stellately spreading; ovules one to four per locule; stigma smooth or capitate.....3
3. Bulbs subglobose, with bulbils; inflorescences sometimes with bulbils.....3. *A. macrostemon*
- 3*. Bulbs cylindrical to ovoid, without bulbils; inflorescences without bulbils.....4
4. Leaf blades elliptical to oval, pseudo-petiolate at base; pedicels angular; ovary obconical, with one ovule per locule; seeds circular, circular in cross sections.....5
- 4*. Leaf blades linear, sessile at base; pedicels terete; ovary ovoid, obovoid or ellipsoid, with two to four ovules per locule; seeds elliptical or oval, flat to semicircular in cross section.....6
5. Leaf blades elliptical, acute at apex, 27.9–50.8 mm wide; leaf sheaths reddish brown; perianth pale yellow; inner tepals 5.2–6.5 × 2.4–3.0 mm; outer tepals 4.0–5.5 × 1.2–1.5 mm; anthers 1.6–1.9 mm long.....4. *A. microdictyon*
- 5*. Leaf blades elliptical to oval, obtuse to subrounded at apex, 62–135 mm wide; leaf sheaths pale green; perianth white; inner tepals 6.7–8.5 × 3.0–3.7 mm; outer tepals 5.7–7.2 × 1.6–1.8 mm; anthers 2.3–2.6 mm long.....5. *A. ochotense*
6. Ovary without hood-like appendages at base.....7
- 6*. Ovary with hood-like appendages at base.....15
7. Bulb tunics fibrous, reticulate; perianth white; tepals mucronate at apex.....8
- 7*. Bulb tunics membranous or papery, smooth; perianth pink or lilac; tepals obtuse to rounded at apex.....9
8. Leaf blades solid in cross section; perianth with greenish midvein abaxially; inner tepals ovately elliptical, 5.6–6.5 × 3.3–4.7 mm; outer tepals oblong-lanceolate, 5.8–6.9 × 1.8–2.3 mm; ovules two per locule.....6. *A. tuberosum*
- 8*. Leaf blades usually hollow in cross section; perianth with reddish midvein abaxially; inner tepals elliptical, 6–11 × 2.0–4.2 mm; outer tepals elliptical, 5–10 × 1.8–3.5 mm; ovules two to four per locule.....7. *A. ramosum*
9. Rhizomes clearly elongated, branched; bulb tunics membranous; leaf blades flat in cross section; scapes drooping at the upper parts before flowering.....10
- 9*. Rhizomes condensed, non-branched; bulb tunics papery; leaf blades angular to terete in cross section; scapes erect before flowering.....13
10. Leaf sheaths buried under ground; leaf blades leathery, lustrous; scapes flattened-winged in cross section; perianth campanulate, pinkish violet; inner tepals ovate-elliptical.....8. *A. spirale*
- 10*. Leaf sheaths exposed above ground; leaf blades fleshy, glaucous; scapes subterete to rhomboid in cross section; perianth radially spreading, reddish pink or pale pink; inner tepals elliptical.....11
11. Leaf blades 2.8–4.5 mm wide; scapes subterete in cross section, 11.7–20.5 mm long; inner tepals 3.5–4.7 × 1.0–1.8 mm; outer tepals 3.4–4.0 × 0.8–1.2 mm; filaments non-exserted, 3.8–4.8 mm long; capsules 3.5–3.7 × 3.6–4.0 mm; seeds 2.0–2.2 × 1.3–1.5 mm; flowering from May to July ($2n = 16$).....9. *A. minus*
- 11*. Leaf blades 3.8–15.0 mm wide; scapes subterete to rhomboid in cross section, 23.4–70.0 mm long; inner tepals 6–7 × 2.5–3.5 mm; outer tepals 4.5–5.5 × 2.0–2.7 mm; filaments exserted, 6.2–11 mm long; capsules 4.5–5.6 × 4.5–5.8 mm; seeds 3.0–3.8 × 2.2–2.6 mm; flowering from July to October ($2n = 32$).....12
12. Pedicels not slender; perianth reddish pink; inner filaments narrowly triangular, entire at margin; inner tepals 3.0–3.4 mm wide; anthers reddish; ovary 3.0–3.5 mm wide.....10. *A. senescens*
- 12*. Pedicels slender; perianth pale pink; inner filaments subulate, entire or with two teeth at margin; inner tepals 2.5–3.0 mm wide; anthers yellowish; ovary 2.2–2.6 mm wide.....11. *A. pseudosenescens*

13. Bulbs cylindrically ovoid; inner tepals elliptical; outer tepals ovately elliptical; ovary greenish; inner filaments with two teeth at margin; anthers elliptical, reddish; capsules cordiform.....	12. <i>A. bidentatum</i>
13*. Bulbs cylindrical; inner tepals obovate; outer tepals elliptically oval; ovary brownish; inner filaments entire at margin; anthers oval, yellowish; capsules subglobose.....	14
14. Leaf blade minutely angular; pedicels unequal.....	13. <i>A. anisopodium</i>
14*. Leaf blade terete; pedicels subequal.....	14. <i>A. tenuissimum</i>
15. Bulb tunics fibrous, reticulate; inner filaments clearly with two to four teeth at the middle parts.....	16
15*. Bulb tunics papery or thinly leathery, smooth; inner filaments usually entire or rarely with two minute teeth at base	17
16. Perianth stellately spreading, pale pink; inner tepals $4.8\text{--}5.3 \times 2.5\text{--}2.8$ mm; outer tepals $4.0\text{--}4.6 \times 2.4\text{--}2.5$ mm; anthers $1.5\text{--}1.6$ mm long; filaments $6.0\text{--}8.4$ mm long; stigma smooth ($2n = 16$).....	15. <i>A. koreanum</i>
16*. Perianth campanulate, reddish lilac; inner tepals $4.3\text{--}4.6 \times 1.7\text{--}1.9$ mm; outer tepals $3.5\text{--}4.3 \times 1.3\text{--}1.7$ mm; anthers $1.0\text{--}1.2$ mm long; filaments $4.3\text{--}4.9$ mm long; stigma capitata ($2n = 32$).....	16. <i>A. splendens</i>
17. Bulb tunics thinly leathery, reddish brown; perianth pale yellow; ovary ovoid.....	17. <i>A. condensatum</i>
17*. Bulb tunics papery, brown; perianth purple or reddish pink; ovary obovoid or elliptical.....	18
18. Rhizomes oblique; scapes hollow in cross section; perianth reddish pink; tepals equal, oblong-lanceolate, acute at apex; ovary ellipsoid; filaments non-exserted; capsules ellipsoid; seed elliptical, angular in cross section; flowering from July to August.....	18. <i>A. maximowiczii</i>
18*. Rhizomes erect; scapes solid in cross section; perianth purple; tepals unequal, elliptical to oval, obtuse to rounded at apex; ovary obovoid; filaments exserted; capsules cordiform; seed oval, flat in cross section; flowering from late August to October.....	19
19. Perianth semi-stellately spreading.....	19. <i>A. taquetii</i>
19*. Perianth campanulate.....	20
20. Leaf sheaths non-exposed above ground.....	21
20*. Leaf sheaths exposed above ground.....	22
21. Leaf blades spreading, terete, $19.0\text{--}80.5$ cm long, tinged red at base.....	20. <i>A. linearifolium</i>
21*. Leaf blades ascending to curved, flat, angular or terete, $10.0\text{--}49.5$ cm long, pale green at base.	21. <i>A. thunbergii</i>
22. Leaf blades terete.....	22. <i>A. longistylum</i>
22*. Leaf blades flat or angular.....	23
23. Leaf blades angular, ascending; scapes central from bulbs, $33.0\text{--}103.5$ cm long; tepals elliptical; inner filaments entire or rarely with two minute teeth at base; seeds $3.2\text{--}3.5$ mm long.....	23. <i>A. sacculiferum</i>
23*. Leaf blades flat, curved; scapes usually lateral from bulbs, $15\text{--}72$ cm long; tepals elliptical to oval; inner filaments entire at margin; seeds $4.0\text{--}4.6$ mm long.....	24. <i>A. pseudojaponicum</i>

1. *ALLIUM MONANTHUM* MAXIM., *BULL. ACAD. IMP. SCI. SAINT-PÉTERSBOURG* 31(1): 109 (1886). (FIG. 4)

Type: Russia. Mandshuria sustroorientalis prope limites Koreae, ad fl. Sedemi, Apr 1882, *M.Jankowski* 17 (lectotype: LE!, here designated).

= *A. biflorum* Nakai, *Bot. Mag. (Tokyo)* 27: 214 (1913). Type: Korea. Monte Tempōsan, *K.Hotta* s.n., herbaria unclear.

= *A. monanthum* Maxim. var. *floribundum* Z.J.Zhong & X.T.Huang, *Bull. Bot. Res. North-East. Forest. Univ.* 17(1): 53 (1997). Type: China. Jilin, Changbai Shan, on forest edge, 750 m, 10 May 1987, Z.J.Zhong 87093 (holotype: Institute of Mt Changbai Natural Reserve).

Description: Herbs usually dioecious, rarely hermaphroditic or gynomonoecious. Rhizomes elongated, 3–10 cm long, terminated by bulbels and/or one or two basal bulbels that in turn may produce thread-like rhizomes. Bulbs solitary, globose, sometimes with bulbels, 4.4–11.1 mm in diameter; tunics consisting of wavy-linear cells, papery, herringbone patterned,

light brown, sometimes tinged red. Leaves one or two; leaf sheaths buried under ground, 2.2–4.5 cm high; leaf blades spreading, more or less broadly linear, flat, $15.9\text{--}23.8$ cm \times 3.3–6.0 mm, with one row of vascular bundles and solid in cross section, attenuate at base, tapered in apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, slender, subangular, nearly erect before flowering, solid in cross section, enclosed at base together with leaves by a hyaline sheath, 8.7–13.4 cm \times 0.5–1.0 mm. Inflorescences solitary or few flowered; male plants one to three (usually two or three) flowered; female plants one or two (usually one) flowered; pedicels terete, unequal in length, as thick as (in female) or thicker (in male) than the scapes, 1.6–7.9 mm long; bracts 4.7–8.5 mm long. Flowers usually unisexual; perianth campanulate, reddish white to white; inner tepals narrower than outer ones, oblong, obtuse at apex, $4.5\text{--}5.5 \times 1.5\text{--}2.0$ mm; outer tepals elliptical, obtuse at apex, $4.5\text{--}6.9 \times 2.0\text{--}2.7$ mm. Male flowers with six stamens; filaments equal, non-exserted, 4.5–5.1 mm long, entire at margin; anthers

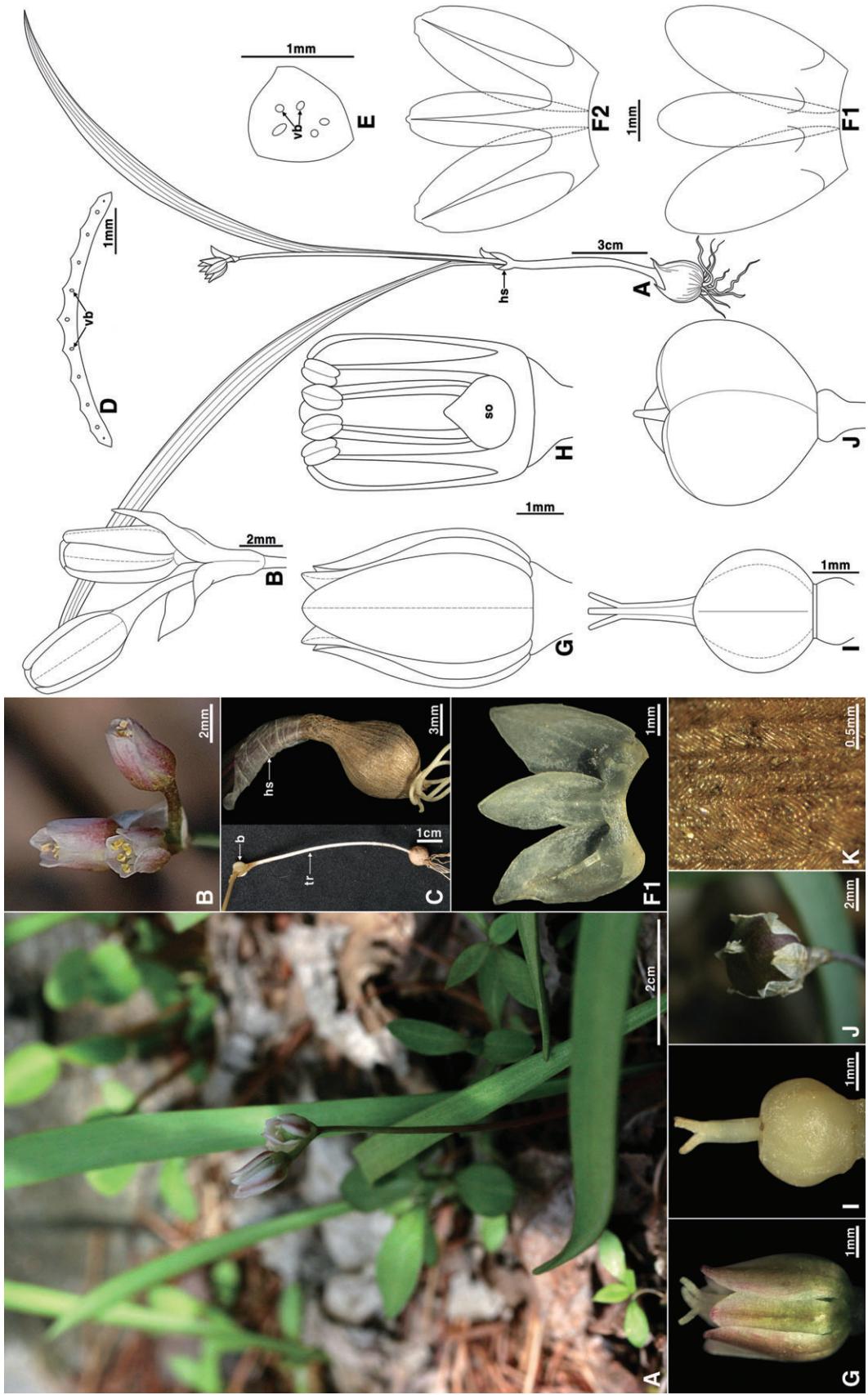


Figure 4. *Allium monanthum* (A, C–F1, G, I–K; female; B, F2, H; male). A, habit (hs, hyaline sheath). B, inflorescence. C, underground structure (b, bulb); tr, thread-like rhizome; hs, hyaline sheath. D, shape of leaf in cross section (outside, abaxial; vd, vascular bundles). E, shape of sheath in cross section (vh, vascular bundles). F1, capsule. F2, ovary. G, flower. H, internal structure of flower (so, sterile ovary). I, pistil. J, capsule. K, bulb tunic.

elliptical, yellowish, 0.9–1.1 mm long; ovary subglobose, without appendages, 1.5–2.4 × 1.8–2.5 mm, ovules absent or rarely with one sterile per locule. Female flowers with degenerated stamens; ovary globose, without appendages, 2–3 × 2.2–2.8 mm, ovules two per locule; style trigonous, non-exserted; stigma three-cleft. Capsules cordiform, 3.9–4.9 × 4–5 mm. Seeds elliptical to oval, angular in cross section, 2.0–3.1 × 2.0–2.8 mm.

Chromosome number: $2n = 16, 24, 32$ (Noda & Kawano, 1988; Bang, 2004).

Distribution and habitat: Russia (Far East), China (Hebei; Heilongjiang; Jilin; Liaoning), Korea (all provinces) and Japan. In shaded broad-leaved forests and lowlands.

Phenology: Flowering from late March to May.

Notes: *Allium monanthum* is a typical spring ephemeral, appearing above ground for only 2–3 weeks in late March to early or late April in the lowlands, and mid-April to early May at higher elevations, or in northern populations before canopy closure in deciduous forests (Kawano, Nagai & Hayashi, 2005). Although a good number of populations are still recorded in north-eastern Asia, including Korea and north-eastern China, sympatric populations of both male and female individuals are exceedingly rare (in the case of Japan, only three populations are known to date), and thus the maintenance of populations is exclusively dependent on asexual reproduction by means of bulbul formation (Kawano *et al.*, 2005). It can be immediately distinguished from all other Korean and north-eastern Chinese *Allium* spp. by herringbone patterned bulb tunics (Figs 2A, 4K), thread-like rhizomes (Fig. 4C), hyaline sheaths enclosing the scape and leaf (Fig. 4A, C), one row of vascular bundles in leaf cross section (Fig. 4D), slender scape (Fig. 4A, E; mean 0.8 mm wide), solitary or few flowered inflorescences (Fig. 4A, B), trigonous style (Fig. 4I) and three-cleft stigma (Fig. 4I). Most previous studies described the inflorescence of *Allium*, including this species as an umbel (Vvedensky, 1935; Ohwi, 1984; Xu & Kamelin, 2000). However, *A. monanthum* has a different inflorescence type based on our observation, thus we divided it from other species by describing ‘solitary or few flowered’ inflorescences in this study.

Specimens examined: CHINA: HEILONGJIANG – Dailing, Ichun, 14 May 1953, Song 041 (PE). JILIN – Ando, 1990, s.n. (PE). LIAONING – Lianshanquan, 30 Apr 1925, J.Sato 9233 (PE); Qianshan, 24 May 1956,

Zhu *et al.* 275 (PE). KOREA: GANGWON – Daeryongsan, Chungseong, 14 May 1988, W.T.Lee 0022815 (KNU); Jangjeon, 20 Apr 1997, W.T.Lee 0022817 (KNU); 1234goji, 5 May 1999, W.T.Lee 0022818 (KNU); Taebaeksan, Taebaek, 10 May 2003, B.U.Oh *et al.* 030001 (CBU); Taehwasan, Yeongwol, 21 Apr 2001, B.U.Oh *et al.* 010007 (CBU); Yongdae, Inje, 1 May 2006, B.U.Oh *et al.*-Injegun-060501 (KH); Guksabong, Gangneung, 16 May 2006, Kiss 0991 (KH); Ohumsan, Hongcheon, 15 Apr 2004, K.Heo 1555 (KH); Dongmakgol, Yeoncheon, 1 Apr 2002, ESJeon s.n. (KH); Deokhangsan, Samcheok, 24 Apr 2005, KTAPS 20050022 (KH); Seokbyeongsan, Gangneung, 8 Apr 2006, J.O.Hyun *et al.* 101018 (KH). GYEONGGI – Unaksan, Gapyeong, 18 Apr 2006, ESJeon 60131 (KH); Pungdo, Ansan, 15 Apr 2002, H.J.Choi & Y.Y.Kim s.n. (CBU); Soheul, Pocheon, 24 Apr 2008, H.J.Choi 080001 (KH); Aengjabong, Gwangju, 11 Apr 2004, kjs 040138 (KH); Cheonmasan, Namyangju, 12 Apr 2000, G.W.Seo s.n. (KH). CHUNGBUK – Sobaeksan, Danyang, H.B.Sim *et al.* s.n. (CBU); Bukgachi, Songnisan, 1 May 2001, H.J.Choi 010005 (CBU); Woraksan, Jecheon, 3 May 2001, H.J.Choi *et al.* 010006 (CBU). CHUNGNAM – Gyeryongsan, 17 Apr 2000, J.H.Kim *et al.* s.n. (TUT). JEONBUK – Deogyusan, Muju, 4 Apr 2002, J.H.Kim *et al.* 2002-0506 (KH). JEONNAM – Oenarodo, Goheung, 16 Mar 2002, ESJeon s.n. (KH); Malbongsan, Hwasun, 29 Apr 2005, ParkSH 50544 (KH); Yongyeun, Gwangju, 25 Mar 2007, WR-070325-035 (KH). GYEONGBUK – Samseongsan, Gyeongsan, 3 Apr 2006, ESJeon 60051 (KH); Seonamsan, Gunwi, 13 Apr 2000, B.U.Oh 000002 (CBU); Palgongsan, Gunwi, 22 Apr 2006, CBU-070664 (KH); Geomsan, Gumi, 21 Apr 2006, CBU-070665 (KH); Janggunbong, Bonghwa, 21 Apr 2007, CBU-070122 (KH); Sobaeksan, Yeongju, 12 Apr 2007, NAPI-0015 (KH); Geommasan, Yeongyang, 11 Apr 2004, ANH 0410023 (KH). GYEONGNAM – Namhae, 4 Apr 2003, G.Y.Chung *et al.* s.n. (CBU); Mangunsan, Namhae, 4 Apr 2003, Namhae 1-030404-027 (KH).

2. *ALLIUM NERINIFLORUM* (HERB.) BAKER, *J. BOT* 3: 290 (1874). (FIG. 5)

Basionym: *Caloscordum neriniflorum* Herb., *Edward's Bot. Reg.* 30: 67 (1844). *Type:* China. Chusan Island (location with doubt), collector and herbaria unclear.

≡ *Northoscordum neriniflorum* (Herb.) Benth. & Hook.f., *Gen. Pl.* 3(2): 802 (1883).

Description: Herbs hermaphroditic. Rhizomes condensed, nearly obsolete, erect, 0.9–3.5 mm long. Bulbs solitary, subglobose, 10.0–21.6 mm in diameter; tunics consisting of nearly square cells, membranous

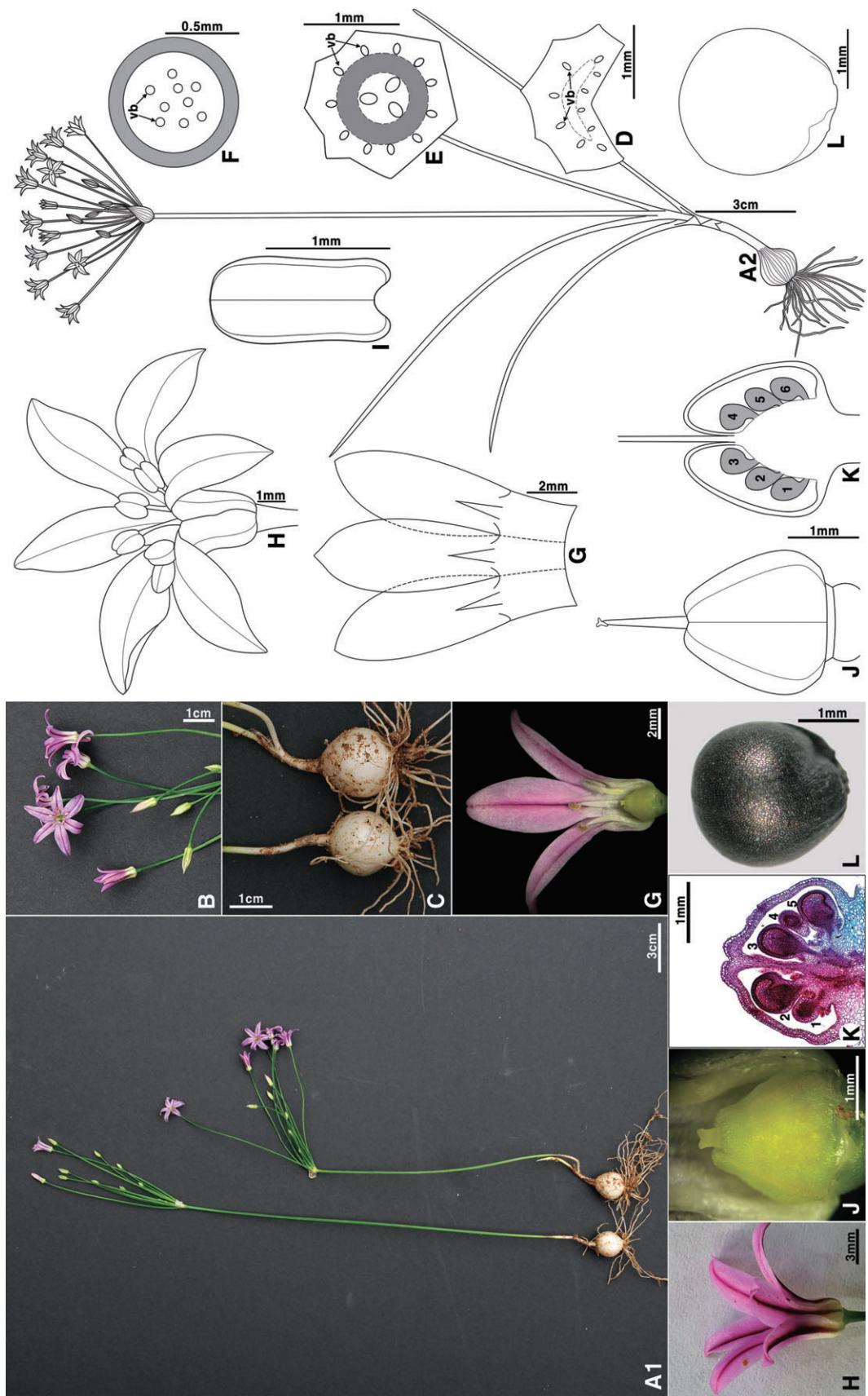


Figure 5. *Allium nemorinum*. A, habit (A2: redrawn from Wu *et al.*, 2002). B, inflorescence. C, underground structure. D, shape of leaf in cross section (upside, abaxial; vb, vascular bundle). E, shape of scape in cross section (vb, vascular bundle; shading, fibre). F, shape of pedicel in cross section (vb, vascular bundle; shading, fibre). G, flower. H, anther. I, pistil. K, shape of ovary in longitudinal section (1–6: ovules). L, seed.

to papery, smooth, greyish white to white. Leaves withering from tip by anthesis, two to six; leaf sheaths non-exposed above ground, 3–5 cm high, striped green; leaf blades spreading, linear, minutely angular, adaxially channelled, 20–30 cm × 1–3 mm, with two rows of vascular bundles and hollow in cross section, sessile at base, tapered in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, multi-angular, erect before flowering, solid in cross section, 15–50 cm × 1.5–2.8 mm. Inflorescences umbellate, subfascicled, 12–30 flowered, without bulbils, 70–100 × 70–135 mm; pedicels subterete, unequal in length, 45–110 mm long, thinner than the scapes; bracts 5.5–13.5 mm long. Flowers bisexual; perianth funnelform (stellately spreading in the upper parts), reddish pink, rarely whitish; inner tepals longer than outer ones, oblong, obtuse at apex, 6.7–8.0 × 2.3–2.6 mm; outer tepals oblong, obtuse at apex, 6.0–6.5 × 1.9–2.3 mm; filaments non-exserted, 2.5–3.9 mm long, subulate, entire at margin; anthers elliptical, yellowish, 1.1–1.3 mm long; ovary ovoid, green, without appendages, 1.6–2.0 × 1.7–2.3 mm, ovules five to eight (mean six) per locule; style terete, exserted; stigma three-lobed. Capsules subglobose, slightly trigonous, 4–5 × 4.5–5.2 mm. Seeds oval to circular, circular in cross section (globose or nearly so), 2.3–3.2 × 2.0–2.7 mm.

Chromosome number: $2n = 16$ (Fig. 3A; Li *et al.*, 1996).

Distribution and habitat: Russia (eastern Siberia; Far East), Mongolia and China (Hebei; Nei Mongol; Heilongjiang; Jilin; Liaoning). In slopes, damp places, meadows and sandy places.

Phenology: Flowering from July to August.

Notes: *Allium neriniflorum* is one of the most characteristic species of the genus and has sometimes been considered as the genus *Caloscordum* Herb. (Friesen, 1995), but it has recently been treated as a member of the genus *Allium* based on molecular as well as morphological evidences (Friesen *et al.*, 2006). The type specimen of *A. neriniflorum* could not be located, but it can be divided markedly from all other *Allium* spp. by its distinctive morphological characters such as the multi-angular scape (Fig. 5E), relatively long pedicels (Fig. 5A1; mean 68.6 mm long), funnelform perianth (Fig. 5B, H), multiovulate locules (Fig. 5K) and three-lobed stigma (Fig. 5J). The type locality is still in doubt because there is no record of this species in Chusan Island (Zhejiang province, China) based on the *Flora of China* (Xu & Kamelin, 2000).

Specimens examined: CHINA: HEBEI – Bashang, Weichang, 1 Aug 2002, J.H.Kang 53 (KH). HEILONGJIANG – Qiqihar, 5 July 2008, D.G.Jo *et al.* 070001 (KH); Qiqihar, 28 July 1956, Zhong 294 (PE); Saertu, s.n. (PE). JILIN – Beidagang, 8 Aug 1959, Baichengzu 69 (PE). LIAONING – Daegosan, Dandong, 5 July 2007, CBU-037 (KH); Daegosan, Dandong, 28 Aug 1959, Wang 1201 (PE); Saowudameng keshikelong, 24 July 1973, Yang 340 (PE); Daheshan, Jinaouqu, 18 Sept 1951, Wang & Liu *et al.* 1085 (PE).

3. *ALLIUM MACROSTEMON* BUNGE, *ENUM. PL. CHINA BOR.* 65 (1833). (FIG. 6)

Type: China. Ad vias prope Pekinum, without collection date and number (holotype: LE!).

= *A. nereidum* Hance, *Ann. Sci. Nat., Bot.* 5: 224 (1866). Type not traced.

= *A. grayi* Regel, *Trudy Imp. S.-Peterburgsk. Bot. Sada* 3(2): 125 (1875). Type not traced.

= *A. nipponicum* Franch. & Sav., *Enum. Pl. Jap.* 2: 76 (1875). *Type:* Japan. In circa Yokoska sat frequens, Savatier 1279; in provinciâ Isé, Savatier 3699, herbaria unclear.

= *A. uratense* Franch., *Pl. Davidian.* 1: 304 (1884).

= *A. macrostemon* Bunge var. *uratense* (Franch) Airy Shaw, *Notes. Roy. Bot. Gard. Edinb.* 14: 136 (1931). Type not traced.

= *A. ouensanense* Nakai, *Bot. Mag. (Tokyo)* 27: 215 (1913). *Type:* Korea. In montibus Ouensan, T.Nakai s.n. (holotype: TI!).

= *A. chanetii* H.Lév., *Repert. Spec. Nov. Regni Veg.* 12: 184 (1913). *Type:* China. Montagne du Pin-Chan, frontière du Chan-Si, 15 June 1908, L.Chanet 224, herbaria unclear.

Description: Herbs hermaphroditic. Rhizomes condensed, nearly obsolete, erect, 0.9–4.1 mm long. Bulbs solitary, subglobose, sometimes with bulbils, 12.8–28.2 mm in diameter; tunics consisting of rectangular cells, membranous, smooth, greyish white to white. Leaves three to five; leaf sheaths exposed above ground, 17.3–37.8 cm high, striped green; leaf blades fragile, spreading, linear, minutely angular, adaxially channelled, 21.5–55.0 cm × 2.0–4.1 mm, with two rows of vascular bundles and hollow in cross section, sessile at base, tapered in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 46–90 cm × 2.6–4.5 mm. Inflorescences umbellate, globose, 0–280 flowered, sometimes replaced totally or partially by pseudoviviparous bulbils, 10.9–53.6 × 12.5–57.6 mm; pedicels terete, subequal in length, 11.4–22.4 mm long, thinner than the scapes; bracts 5.2–10.1 mm long.

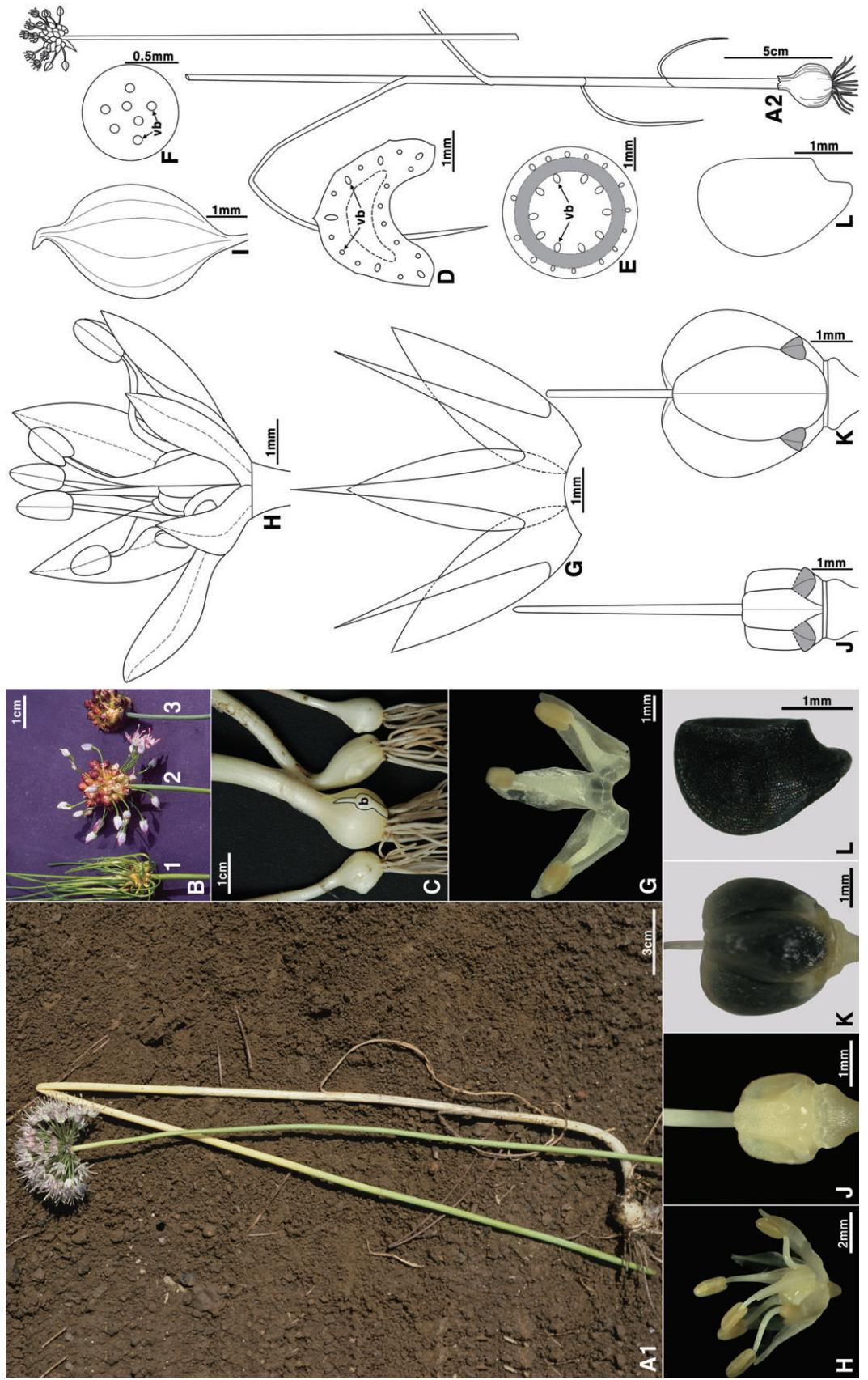


Figure 6. *Allium macrostemon*. A, habit. B, inflorescence. C, underground structure (b, bulblet). D, shape of leaf in cross section (upside, abaxial; vb, vascular bundles). E, shape of scape in cross section (vb, vascular bundles; shading fibre). F, shape of pedicel in cross section (vb, vascular bundles). G, capsule (shading, hood-like appendage). H, flower. I, bulb (shading, hood-like appendage). K, capsule (shading, hood-like appendage). L, seed. M, tepal and filament. N, capsule. O, cross-section of capsule. P, longitudinal section of capsule. Q, seedling. R, seedling. S, seedling. T, seedling. U, seedling. V, seedling. W, seedling. X, seedling. Y, seedling. Z, seedling.

Flowers bisexual; perianth stellately spreading, whitish pink; inner tepals slightly longer than outer ones, oblong-lanceolate, acute at apex, $4.8-5.1 \times 1.7-2$ mm; outer tepals oblong-lanceolate, acute at apex, $4.7-5.1 \times 1.4-1.9$ mm; filaments exserted, 4.5–6.9 mm long, entire at margin; anthers elliptical, yellowish, 1.5–1.7 mm long; ovary subcubical, green, with hood-like appendages at base, $1.9-2.1 \times 1.9-2.1$ mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, $3.6-3.7 \times 3.3-3.6$ mm. Seeds oval, flat in cross section, $2.5-2.7 \times 1.5-1.7$ mm.

Chromosome number: $2n = 32$ (Zhu & Xu, 1999).

Distribution and habitat: Russia (Far East), Mongolia, Taiwan, China (except Hainan, Qinghai and Xinjiang), Korea (all provinces) and Japan. In sunny lowland meadows, forest margins and mountain foothills.

Phenology: Flowering from May to June.

Notes: *Allium macrostemon* is easily distinguished from the other Korean and north-eastern Chinese *Allium* members by having underground bulbils in bulbs (Fig. 6C) and aerial bulbils in inflorescences (Fig. 6B). This is one of the most popular edible *Allium* spp. in Korea and north-eastern China, because it is the most widely spread species with the highest abundance.

Specimens examined: CHINA: HEILONGJIANG – Acheng, 14 June 1951, Wang et al. 597 (PE). JILIN – Near Peitayeng, O-muhsien, 14 July 1931, H.W.Kung 1845 (PE); Jian, 5 Sept 2007, B.U.Oh et al. s.n. (KH); Deli, 24 June 1928, J.Sato 3818 (PE); Dalintian-chuan, 27 June 1928, J.Sato 3817 (PE); Gongzhuling, 30 July 1956, Zhung 556 (PE); Jingyu-xian?, Liushene et al. 1218 (PE). LIAONING – Qilingzi, 50 May 1950, Liushene et al. 641 (PE); Qianshan, 25 May 1950, Liushene et al. 428 (PE); Tangchizidaguding, Dangdong, 8 Sept 1959, Jiang 198 (PE); Lingyuan, 16 May 1965, Cui & Ju 617 (PE); Beizhen, 11 June 1951, Li et al. 2859 (PE). KOREA: GANGWON – Odaesan, Pyeongchang, 9 June 2006, Pyeongchang-gun (Odaesan)-060609-010 (KH); Hwacheon, 1 June 1998, C.G.Chang s.n. (CBU); Taehwasan, Yeongwol, 26 May 2001, B.U.Oh et al. 010020 (CBU); Dutasan, Samcheok, 1 July 2007, H.J.Chi 703012 (KH). GYEONGGI – Pyeonghwa Park, Seoul, 7 May 2005, ParkSH 53931 (KH); Seonneung, Seoul, 22 May 2005, ESJeon 51147 (KH); Baengnyeongdo, Incheon, 14 May 1998, Y.M.Lee S-0828 (KH); Gwanggyosan, 17 June 1979, J.S.Chang & G.H.Lee 4293 (SNUA); Bongboksan, Hoengseong, J.S.Seo et al. 013760 (HNHM); Soheul, Pocheon, 24 Apr 2008, H.J.Chi 080002 (KH); Suweonsan,

Pocheon, 17 June 2002, S.S.Jung s.n. (KH); Seonggapdo, Incheon, 29 June 2001, Gwang 10919 (KH); Pungdo, Ansan, 23 Mar 2002, H.J.Chi & Y.Y.Kim 020002 (CBU). CHUNGBUK – Semokjae, Danyang, 16 May 2006, ParkSH 63315 (KH); Cheongdong, Sobaeksan, 14 June 2003, H.J.Chi & S.J.Ji 030002 (CBU); Gunjasan, Goesan, 9 June 2002, H.J.Chi & S.J.Ji 020054 (CBU); Songnisan, Boeun, 11 June 2000, H.J.Chi 000003 (CBU); Gaesin, Cheongju, 13 June 2003, H.J.Chi 030002 (CBU); Seongmubong, Cheongwon, 28 May 2006, Cheongwon-gun(Seongmubong)-060528-004 (KH); Woraksan, Chungju, 12 June 2006, Chungju-si(Woraksan)-060612-003 (KH); Cheonghwasan, Geosan, 3 June 2006, Geosan-gun (Cheonghwasan)-060603-010 (KH). CHUNGNAM – Anmyeondo, Taean, 20 June 2005, ParkSH 51554 (KH); Yubudo, Seocheon, 31 May 2007, ESJeon 73196 (KH); Yongun, Daejeon, 3 June 2000, T.S.Kim et al. s.n. (KH); Chilgapsan, Cheongyang, 6 June 1996, Y.C.An et al. 960001 (CBU); Minjujisan, Yeongdong, 3 June 1995, C.G.Chang et al. s.n. (CBU). JEONBUK – Paekwoonsan, Muju, 30 June 2004, Muju-gun(Paekwoonsan)-040630-297 (KH); Daedunsan, Wanju, 15 Apr 2004, Wanju-gun(Daedunsan)-040415-009 (KH); Manggeumbong, Wido, Buan, 29 June 2004, Buangun(Wido)-040629-204 (KH). JEONNAM – Umdalsan, Yeosu, 13 June 2003, Yeosu 9-30613-005-1 (KH); Manghyangsan, Yeosu, 14 June 2003, Yeosu 10-30614-015-1 (KH); Suncheon, 5 June 1993, KimDS 0078 (KH); Bongdaesan, Muan, 23 May 2007, WR-070523-069 (KH); Daesa, Haeje, Muan, 23 May 2007, WR-070523-163 (KH); Jirisan, Gurye, 1 May 1992, M.J.Yang s.n. (CBU); Daedoryedo, Sinan, 10 June 2002, ParkSH 22179 (KH); Yucheon, Sinan, 23 May 2007, ParkSH 70444 (KH); Oedo, Sinan, 27 June 2001, H.T.Im s.n. (KH); Dudo, Sinan, 9 June 2001, H.T.Im & H.H.Hong 011570 (KH); Sangsachido, Sinan, 10 June 2002, ParkSH 22134 (KH); Jido, Sinan, 16 June 2000, H.T.Im & H.H.Hong 007411-c (KH); Jiseokcheon, Hwasun, 15 May 2006, WR-060517-017 (KH). GYEONGBUK – Wolseong, 10 June 2006, H.J.Chi s.n. (KH); Hwanghaksan, Uiseong, 22 June 2006, CBU-070662 (KH); Noejeongsan, Mungyeong, 1 June 2002, B.U.Oh et al. s.n. (CBU); Ilwolsan, 2 July 1987, Y.K.Jung s.n. (KNU); Dodong, Ulleungdo, 8 June 2000, ParkSH et al. s.n. (KH); Sadong, Ulleungdo, 23 May 2002, ParkSH 0021469 (KH); Nari to Anpyeongjeon, Ulleungdo, 3 June 2001, ESJeon s.n. (KH); Jukdo, Ulleung, 16 May 2004, ParkSH 40982 (KH); Hakgasan, Yecheon, 21 May 2006, Yecheon-gun(Hakgasan)-060521-002 (KH). GYEONGNAM – Aengsan, Geojedo, 18 May 2003, B.U.Oh et al. 030003 (CBU); Mangsan, Geoje, 8 July 2003, Geoje-08-03-0708-035 (KH); Jrisan, 8 Aug 1965, I.S.Yang s.n. (KNU); Uponeup, Changnyeon, 4 June 2006, ParkSH 60563 (KH); Geumsan, Namhae,

8 June 2003, *Namhae* 2-030608-106 (KH). JEJU – Iho beach, Jeju, 27 May 2002, *H.J.Choi & Y.Y.Kim* 020055 (CBU); Hallasan, Jeju, 3 May 2004, *J.O.Hyeon & H.K.Park* 2004225 (KH); Sanbangsan, Namjeju, 28 May 1996, *J.H.Park et al.* s.n. (KNU); Andeok, Namjeju, 4 May 2004, *ParkSH* 41701 (KH).

4. ALLIUM MICRODICTYON PROKH., TR. PRIKL. BOT. GEN. SEL. 24(2): 174 (1930). (FIG. 7)

Type: Russia. Ad ripam fl, Konovalovka, prope pagum Miichailovskit, 15 June 1911, *C.Mamaev*. 812 (holotype: LE!, photograph: CBU!).

Description: Herbs hermaphroditic. Rhizomes condensed, oblique, 4.0–10.1 mm long. Bulbs solitary or clustered, cylindrically conical, without bulbils, 9.1–15.2 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulate, brown. Leaves two or three; leaf sheaths exposed above ground, 11.5–21.5 cm high, non-striped, tinged reddish brown; leaf blades ascending, elliptical, flat, 11.5–21.5 cm × 27.9–50.8 mm, with more or less one row of vascular bundles and solid in cross section, pseudo-petiolate at base, acute in apex; leaf epidermal cells with smooth cuticles, hypostomatic. Scapes central from bulbs, not slender, subterete, curved before flowering in the upper parts, solid in cross section, 38–59 cm × 1.6–3.2 mm. Inflorescences umbellate, globose, 25.9–40.4 × 28.1–40.4 mm, without bulbils, 20–55 flowered; pedicels multi-angular, subequal in length, 10.5–23.9 mm long, thinner than the scapes; bract 5.7–13.4 mm long. Flowers bisexual; perianth campanulate, pale yellow; inner tepals longer than outer ones, elliptical, obtuse apex, 5.2–6.5 × 2.4–3.0 mm; outer tepals oblong, obtuse at apex, 4.0–5.5 × 1.2–1.5 mm; filaments exserted, 6.2–8.5 mm long, entire at margin; anthers elliptical, yellowish, 1.6–1.9 mm long; ovary obconical, green, without appendages, 3.9–4.8 × 2.5–3.0 mm, ovules one per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.5–5.7 × 4.5–7.0 mm. Seeds circular, circular in cross section (globose or nearly so), 2.1–2.3 × 2.1–2.2 mm.

Chromosome number: $2n = 16$ (*Yoo et al.*, 1998a).

Distribution and habitat: Russia (Ural; Siberia), Kazakhstan (western Altai), Mongolia, central to eastern China (including Heilongjiang, Jilin and Liaoning) and Korea (North Korea; Gangwon: Odaesan, Seoraksan, Gariwangsang, Taebaeksan, Hambaeksan, Duwibong, Cheongoksan; Chungbuk: Sobaeksan; Gyeongbuk: Cheongoksan; Gyeongnam: Jirisan). In shaded and moist slopes, pastures and stream sides

in China (Xu & Kamelin, 2000). In shaded and wet forests of high mountain slopes, above 1300 m in Korea.

Phenology: Flowering from June to July.

Notes: *Allium microdictyon* was frequently treated as a member of *A. victorialis* s.l. with another north-eastern Asian taxon, *A. ochotense* (Vvedensky, 1935; Xu & Kamelin, 2000). This species, however, differs in its appearance considerably from the European *A. victorialis* s.s., especially in its thin narrow leaves, usually developing only two on each shoot (Hultén, 1927). Also, a significant difference can be observed in the filaments, the European type having them more dilated at the base (Hultén, 1927: fig. 16e). Compared with *A. ochotense*, this species can also be distinguished by the combination of the pale yellow perianth (vs. white) with relatively small sizes of the leaf and various reproductive organs such as tepal, stamen, pistil, capsule and seed. We concluded therefore that this taxon should be taken as a separate species rather than an infraspecific member or a synonym of *A. victorialis* L. Phytogeographically, this species is distributed from central Asia to central Korea passing through Russia, Mongolia and China. It is quite rare in South Korea, and has been listed among the 5th degree (i.e. the most endangered) taxa of specially designated plants by the Korean Ministry of Environment (2006). Besides, we recognize that the populations of Jirisan and Sobaeksan are under risk of extermination by artificial damage of its natural habitats.

Specimens examined: CHINA: JILIN – Ando, 30 May, s.n. (PE); Ando, 30 June 1963, 704 (PE). KOREA: HAMNAM – Myeongdangbong, 17 July 1934, *B.S.To & H.J.Sim* 20405 (SNU). GANGWON – Bukdae, Odaesan, 25 June 2001, *H.J.Choi et al.* 010008 (CBU); Taebaeksan, Taebaek, 25 June 2000, *W.T.Lee* 0027906 (KNU); 1234goji, 22 June 1999, *W.T.Lee* 0022926 (KNU); Gariwangsang, Jeongseon, 17 June 1997, *W.T.Lee* 0022925 (KNU); Cheongoksan, Jeongseon, 25 June 2000, *W.T.Lee* 0027901 (KNU); Duwibong, Jeongseon, 25 June 2008, *H.J.Choi* 080166 (KH); Daecheongbong, Seoraksan, 22 June 1994, s.n. (SNU); Daecheongbong, Seoraksan, 27 June 2007, *H.J.Choi* 070009 (KH); Gariwangsang, Pyeongchang, 7 July 2004, *H.J.Choi* 040002 (KH). CHUNGBUK – Birobong, Sobaeksan, 14 June 2003, *H.J.Choi & S.J.Ji* 030004 (CBU); Sobaeksan, Danyang, 7 Ju1. 2007, NAPI-0036 (KH). GYEONGBUK – Cheongoksan, Bonghwa, 23 Sept 2006, *Bonghwa-gun(Cheongoksan)-060923-007* (KH). GYEONGNAM – Seseok, Jirisan, 4 Aug 1960, *T.B.Lee* s.n. (SNUA); Seseok, Jirisan, 31 July 1963, *T.B.Lee et al.* s.n. (SNUA).

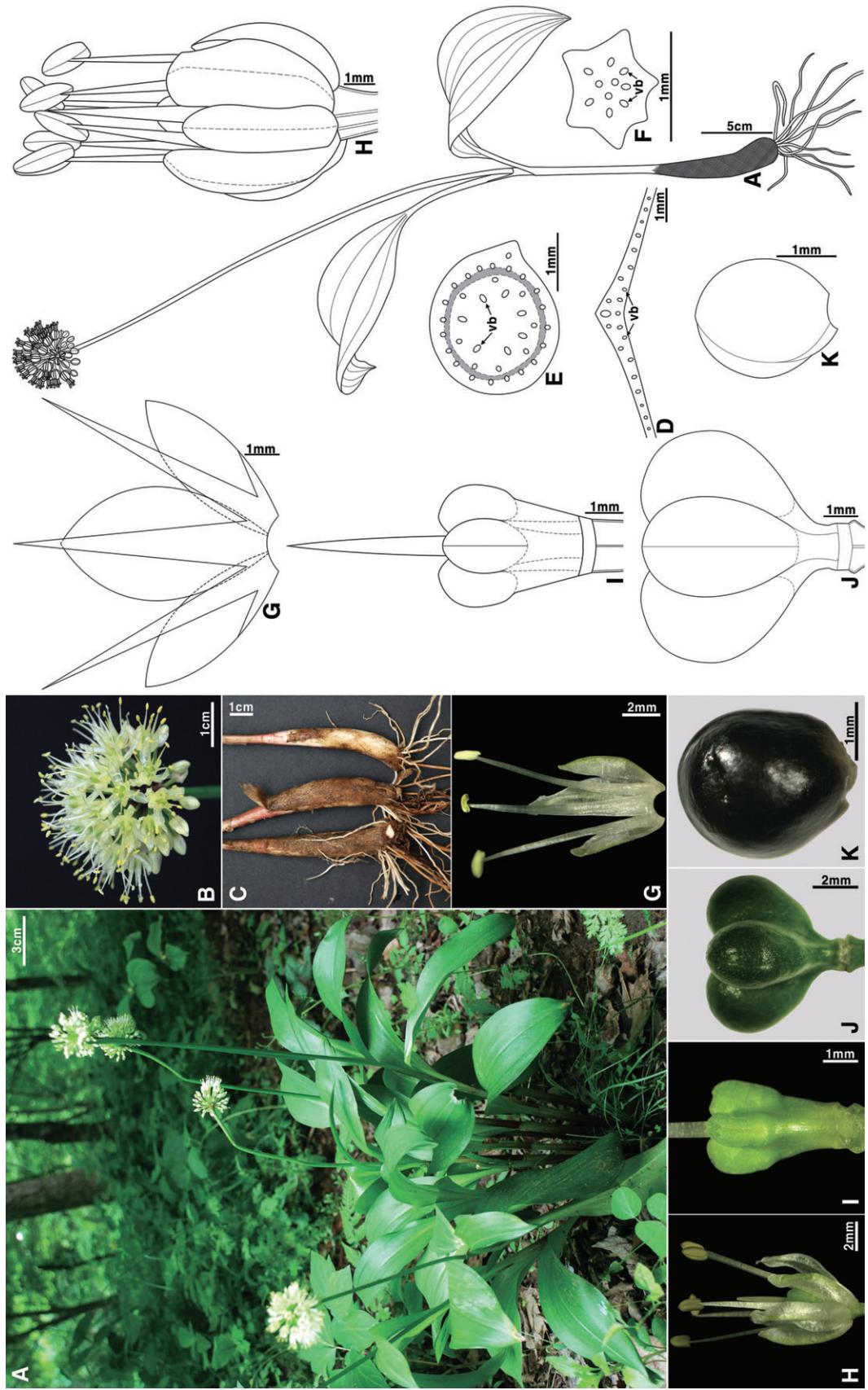


Figure 7. *Allium microdictyon*. A, habit. B, inflorescence. C, underground structure. D, shape of pedicel in cross section (upside, abaxial; upside, adaxial). E, shape of stipe in cross section (upside, abaxial; upside, adaxial). F, shape of leaf in cross section (upside, abaxial; upside, adaxial). G, stamen. H, flower. I, pistil. J, capsule. K, seed.

5. ALLIUM OCHOTENSE PROKH., TR. PRIKL. BOT. GEN. SEL. 24(2): 174 (1930). (FIG. 8)

Type: Russia. Kamtschatka, river Kamtschatka, south slope of Troschenky range, Kljuchi, 28 June 1908, S.Besais 3979 (holotype: LE!, photograph: CBU!).

= *A. victorialis* L. ssp. *platyphyllum* Hultén, Fl. Kamtch. 1: 239 (1927). **Type:** Russia. Kamtchatka, no holotype was designated (syntypes?:; possible type: NY photograph!).

= *A. latissimum* Prokh., Tr. prikl. bot. gen. sel. 24(2): 174 (1930). **Type:** Russia. Primorskaja Oblast, river Tjutiche, north of gulf St Vladimira, 21 June 1921, N.V.Djurina 225 (holotype: LE!, photograph: CBU!).

Description: Herbs hermaphroditic. Rhizomes condensed, oblique, 5–15 mm long. Bulbs solitary or clustered, cylindrically conical, without bulbels, 11.6–19.6 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulated, brown. Leaves two or three; leaf sheaths exposed above ground, 17.2–31.5 cm high, non-striped, pale green; leaf blades ascending, elliptical to oval, flat, 19.8–30.0 cm × 62–135 mm, with more or less one row of vascular bundles and solid in cross section, pseudo-petiolate at base, obtuse to subrounded in apex; leaf epidermal cells with smooth cuticles, hypostomatic. Scapes central from bulbs, not slender, subterete, curved before flowering in the upper parts, solid in cross section, 40.3–86.0 cm × 2.2–6.1 mm. Inflorescences umbellate, globose, 26.6–53.4 × 31.1–50.3 mm, without bulbils, 26–85 flowered; pedicels multi-angular, subequal in length, 14.3–25 mm long, thinner than the scapes; bracts 7.9–16.8 mm long. Flowers bisexual; perianth campanulate, white or sometimes tinged reddish; inner tepals longer than outer ones, elliptical, obtuse apex, 6.7–8.5 × 3.0–3.7 mm; outer tepals oblong, obtuse at apex, 5.7–7.2 × 1.6–1.8 mm; filaments exserted, 7.5–9.1 mm long, entire at margin; anthers elliptical to oblong, yellowish, 2.3–2.6 mm long; ovary obconical, green, without appendages, 3.8–4.8 × 2.9–3.3 mm, ovules one per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 6.0–6.5 × 6.5–7.5 mm. Seeds circular, circular in cross section (globose or nearly so), 3.8–4.1 × 3.2–3.4 mm.

Chromosome number: $2n = 16, 32$ (Fig. 3B; Yoo *et al.*, 1998a; Jing, Xu & Yang, 1999; Kawano & Nagai, 2005).

Distribution and habitat: North America (Attu Island), eastern Russia (Far East), northern China (including Heilongjiang, Jilin and Liaoning), Korea (Gyeongbuk: Ulleungdo) and Japan. In shaded and wet forests.

Phenology: Flowering from May to June.

Notes: Sometimes *A. ochotense* has been treated as a synonym of *A. victorialis* with *A. latissimum* and *A. microdictyon* (Vvedensky, 1935; Yu, Lee & Lee, 1981; Xu & Kamelin, 2000). However, some authors have recognized that there are two distinct entities of *A. ochotense* and *A. microdictyon* in north-eastern Asia in terms of external morphology as shown by numerical taxonomy (Friesen, 1987, 1995; Yoo *et al.*, 1998b; Choi *et al.*, 2004c). During our examination of available material from herbaria and fields, we also confirmed clear morphological differences, especially in reproductive organs between these two entities, and concluded that the two related taxa must be treated as independent species rather than synonymous members, or as infraspecific taxa of *A. victorialis*, with *A. ochotense* becoming ssp. *platyphyllum*. Consequently, an entity with relatively broad leaves (mean 107.4 mm wide; Fig. 8A) and a larger whitish perianth is accurately and easily identified as *A. ochotense*, and the other taxon with narrower leaves (mean 40.3 mm wide; Fig. 7A) and smaller yellowish perianth is recognized as *A. microdictyon*. Analysis of the internal transcribed spacer (ITS) of nuclear ribosomal DNA sequences also indicates that these two related species are genetically distinct from each other (Choi, 2009). Phytoogeographically, *A. ochotense* is a forest species occurring from Russian Far East to Attu Island of North America, passing through northern China, Ulleungdo of Korea and Japan (Hultén, 1927; Vvedensky, 1935; McNeal & Jacobsen, 2002; Kawano & Nagai, 2005; Kovtunyuk *et al.*, 2009). In particular, Korean populations, isolated in Ulleungdo, need to be conserved. Cytologically, the Ulleungdo population is diploid, $2n = 2x = 16$ (Fig. 3B; Yoo *et al.*, 1998a; Jing *et al.*, 1999), whereas Asiatic plants of the species are usually known to be tetraploid with $2n = 4x = 32$ (Kawano & Nagai, 2005).

Specimens examined: CHINA: LIAONING – Jijishan, 24 May 1939, 7799 (PE). KOREA: GYEONGBUK – Seonginbong, Ulleungdo, 18 May 2002, H.J.Choi 020056 (CBU); Seonginbong, Ulleungdo, 20 May 1989, S.G.March *et al.* s.n. (SNUA); Seonginbong, Ulleungdo, 28 July 1961, T.B.Lee s.n. (SNUA); Albong, Ulleungdo, 14 May 2004, ParkSH 40940 (KH); Chusan, Ulleungdo, 21 May 2002, ParkSH 21587 (KH); Anpyeongjeon to Nari, Ulleungdo, 3 June 2001, ESJeon s.n. (KH); Naribunji to Seonginbong, Ulleungdo, 12 May 2003, ParkSH 30602 (KH).

6. ALLIUM TUBEROSUM ROTTL. EX SPRENG., SYST. VEG. 2: 38 (1825). (FIG. 9)

Type: India. Malabar, without collection data and number (holotype: B).

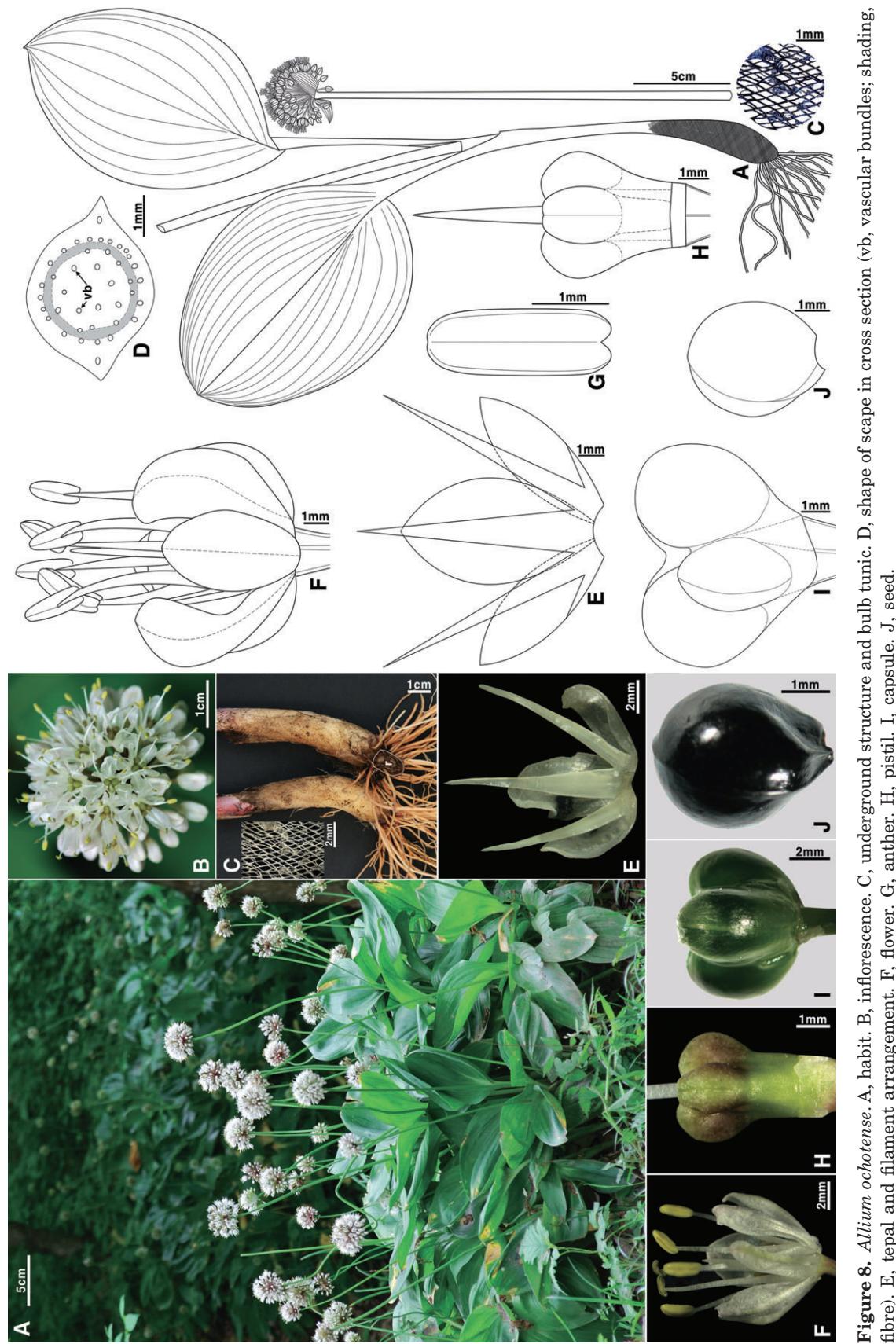


Figure 8. *Allium ochotense*. A, habit; B, inflorescence; C, underground structure and bulb tunicle; D, shape of sepal in cross section (vb., vascular bundle; shad., fibre); E, tepal and filament arrangement; F, flower; G, anther; H, pistil; I, capsule; J, seed.

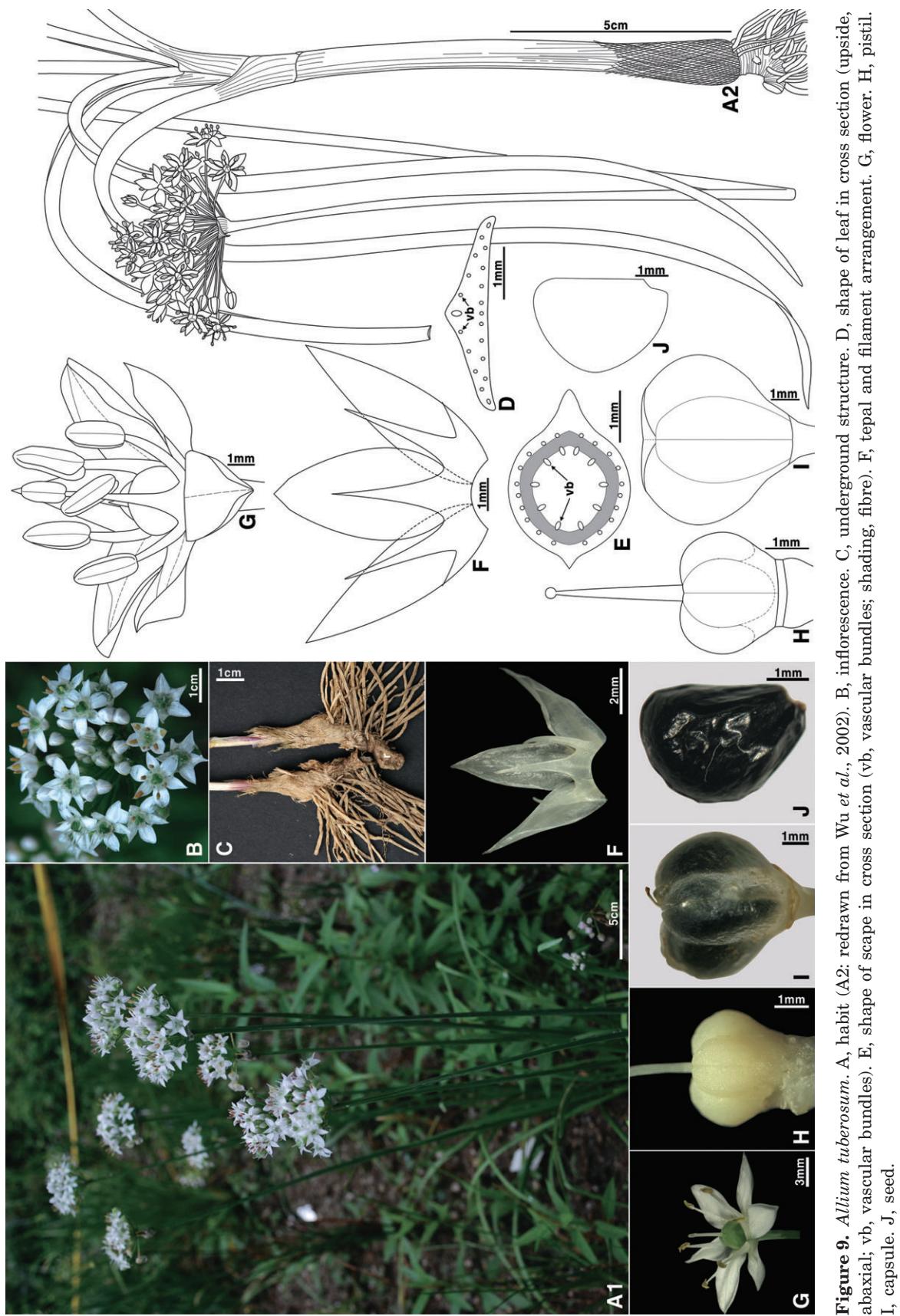


Figure 9. *Allium tukerosum*. A, habit (A2: redrawn from Wu *et al.*, 2002). B, inflorescence. C, underground structure. D, shape of leaf in cross-section. E, staminal tube. F, epiphylle. G, flower. H, capsule. I, seed. J, vascular bundle. vb, vascular bundle; db, vascular bundle; shabd, sheath; abne, abne. H, pista; I, abaxial; vb, vascular bundle; db, vascular bundle. E, shape of sepal in cross-section. G, flower. H, pistil.

= *A. sulvia* Buch.-Ham., *Prodr. Fl. Nepal.* 53 (1825).

Type: Nepal. Ad Suembu in Nepalia superior, July, Hamilton 4, herbaria unclear.

= *A. uliginosum* G.Don, *Mem. Wern. Soc.* 6: 60 (1827). Type: China, Cochinchina and Japan. Without locality, type specimen not designated (protologue).

= *A. chinense* Maxim., *Prim. Fl. Amur.* 284 (1859). Type: China. Kultivirt am Ussuri, in den Kūchengärten der Chinesen, 10 Aug 1855, herbaria unclear.

= *A. clarkei* Hook.f., *Fl. Brit. India* 6: 344 (1892). Type not traced.

= *A. argyi* H.Lév., *Nouv. Contrib. Liliac. & c. Chine* 16 (1906). Type not traced.

= *A. yesoense* Nakai, *Bot. Mag. (Tokyo)* 36: 117 (1922). Type: Japan. In araneis Zenibako prov. Ishikari, T.Nakai s.n. (holotype: TI?).

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, oblique, 14.7–48.0 mm long. Bulbs clustered, cylindrically ovoid, without bulbils, 6.8–10.2 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulate, brown. Leaves three to six; leaf sheaths exposed above ground, 7.0–16.2 cm high, striped green; leaf blades ascending, linear, flat, 20–37 cm × 2.1–5.4 mm, with two rows vascular bundles and solid in cross section, sessile at base, acute in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, subterete, erect before flowering, solid in cross section, 27.0–63.4 cm × 1.8–4.4 mm. Inflorescences umbellate, hemiglobose, 22.1–33.5 × 20.9–47 mm, without bulbils, 13–57 flowered; pedicels terete, subequal in length, 16.0–24.9 mm long, thinner than the scapes; bracts 5.6–16.1 mm long. Flowers bisexual; perianth stellately spreading, white with greenish midvein abaxially; inner tepals usually shorter than outer ones, ovately elliptical, mucronate at apex, 5.6–6.5 × 3.3–4.7 mm; outer tepals oblong-lanceolate, mucronate at apex, 5.8–6.9 × 1.8–2.3 mm; filaments non-exserted, 4.3–5.1 mm long, entire at margin; anthers elliptical, yellowish, 2.0–2.5 mm long; ovary obovoid, green, without appendages, 2.6–2.9 × 2.6–2.7 mm, ovules two per locule; style terete, non-exserted; stigma capitate. Capsules cordiform, trigonous, 5.2–5.5 × 5.5–6.2 mm. Seeds oval, semi-circular in cross section, 3.8–4.1 × 2.8–3.1 mm.

Chromosome number: $2n = 16, 32$ (Fig. 3C; Yang *et al.*, 1998; Zhou *et al.*, 2007).

Distribution and habitat: Tropical Asia, India, eastern Russia, Mongolia, China (native in south-western Shanxi: Yongji Xian, and usually cultivated in north-eastern China), Korea (all provinces: mostly culti-

vated) and Japan (cultivated). Widely cultivated as a vegetable and naturalized in some areas.

Phenology: Flowering from August to September.

Notes: *Allium tuberosum* is generally regarded as a cultivated species with a tetraploid chromosome number ($2n = 4x = 32$; Fig. 3C) in the areas of Korea and north-eastern China, although a wild population was recently discovered in Shanxi of China with a diploid number ($2n = 2x = 16$) (Yang *et al.*, 1998; Xu & Kamelin, 2000; Blattner & Friesen, 2006). We observed various escaped populations, especially in islands of the western to southern coastal areas of Korea and Chinese border areas against North Korea.

Specimens examined: CHINA: HEILONGJIANG – Keshan agricultural experiment farm, 26 July 1956, Chung 280 (PE); Gamoksa, 12 July 1956, Chung 78 (PE). JILIN – ?, 1931, F.H.Chen 317 (PE); Jian, 5 Sept 2007, B.U.Oh *et al.* s.n. (CBU). LIAONING – Shaowutaimeng keshiketengqi baiyinaobao forestry farm, 22 July 1973, Chang *et al.* 239 (PE). KOREA: GANGWON – Baegunsan, 20 Aug 1989, W.T.Lee 0022918 (KNU); Taebaeksan, Taebaek, 8 Aug 1959, I.S.Yang s.n. (KNU); Mandeokbong, Gangneung, 1 Sept 1996, W.T.Lee 0022919 (KNU); Seokbyeongsan, Gangneung, 9 Sept 2006, J.O.Hyun *et al.* 1202027 (KH). GYEONGGI – Bulgwangcheon, Seoul, 13 Oct 2004, ParkSH 42994 (KH); Daecheongdo, Incheon, 10 Aug 2008, H.J.Choi 080254 (KH); Guksabong, Daemuido, Incheon, 13 Sept 2001, ESJeon s.n. (KH); Seongapdo, Incheon, 29 Aug 2001, ESJeon s.n. (KH). CHUNGBUK – Dongrimsan, Cheongwon, 9 Sept 2005, Y 256 (KH); Sobaeksan, Danyang, 2 Sept 2007, NAPI-0157 (KH); Geumsusan, Jecheon, 24 Sept 2005, O 357 (KH); Donam, Yeongcheon, 28 Sept 1995, S-1575 (KH); Maepo, Danyang, 6 Oct 2005, ESJeon 53204 (KH). CHUNGNAM – Seodaesan, Geumsan, 3 Oct 2002, Y.Y.Kim *et al.* 020075 (CBU); Guksabong, Taean, 30 Aug 2005, Taean-gun(Guksabong)-050830-090 (KH). JEONNAM – Mundok, Boseong, 11 Aug 2005, ParkSH 52756 (KH); Jangdo, Wando, 15 Aug 2007, H.J.Choi 070098 (KH); Obongsan, Suncheon, 12 Sept 2004, Suncheonsi(Obongsan)-040912-032 (KH); Jirisan, Hamyang, 25 Aug 2004, Hamyang-gun(Jirisan)-040825-400 (KH); Umdalsan, Yeosu, 2 Aug 2003, Yeosu 9-30802-031-1 (KH). GYEONGBUK – Nagok beach, Uljin, 30 Aug 2001, B.U.Oh *et al.* 010010 (CBU); Yeonji, Gyeongsan, 28 Oct 2001, H.J.Choi & Y.Y.Kim 010021 (CBU); Ulleungdo, 27 Aug 2002, S-0281 (KH); Cheongnyangsan, Bonghwa, 8 Aug 2006, Bonghwa-gun (Cheongnyangsan)-060808-005 (KH); GYEONGNAM – Hyeongjebong, Hamyang, 9 May 2003, Hamyang-gun (Jirisan)-040825-432 (KH).

7. *ALLIUM RAMOSUM* L., SP. PL.

1: 296 (1753). (FIG. 10)

Type: Russia. Siberia, LINN 419.8/9 (lectotype: LINN photograph!).

= *A. odorum* L., Mant. Pl. 1: 62 (1767). Type: China. Xizang, type specimen not designated (protologue).

= *A. weichanicum* Palib., Trudy Imp. S.-Peterburgsk. Bot. Sada 14: 142 (1895). Type not traced.

= *A. lancipetalum* Y.P.Hsu, Acta Bot. Boreal.-Occid. Sin. 7(4): 259 (1987). Type not traced.

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, oblique, 14–25 mm long. Bulbs clustered, cylindrically ovoid, without bulbels, 5–15 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulate, brown. Leaves three to seven; leaf sheaths exposed above ground, 6–13 cm high, striped green; leaf blades ascending, linear, flat, 20–40 cm × 2–4 mm, with two rows of vascular bundles and usually hollow in cross section, sessile at base, acute in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, subterete, erect before flowering, solid in cross section, 20–60 cm × 2.0–5.5 mm. Inflorescences umbellate, hemiglobose, 25–48 × 35–70 mm, without bulbils, 13–45 flowered; pedicels terete, subequal in length, 16–26 mm long, thinner than the scapes; bracts 8.0–16.5 mm long. Flowers bisexual; perianth stellately spreading, white with reddish midvein abaxially; inner tepals usually longer than outer ones, elliptical, mucronate at apex, 6–11 × 2.0–4.2 mm; outer tepals elliptical, mucronate at apex, 5–10 × 1.8–3.5 mm; filaments non-exserted, 4.8–7.5 mm long, entire at margin; anthers elliptical, yellowish, 2.2–2.7 mm long; ovary obovoid, green, without appendages, 2.5–3.1 × 2.8–3.8 mm, ovules two to four (mean three) per locule; style terete, non-exserted; stigma usually capitate. Capsules cordiform, trigonous, 5.8–6.8 × 6.2–7.0 mm. Seeds oval, semi-circular in cross section, 4.0–4.5 × 2.8–3.2 mm.

Chromosome number: $2n = 16, 32$ (Tolgor, Zhao & Xu, 1994; Shang *et al.*, 1997; Zhou *et al.*, 2007).

Distribution and habitat: Russia (Siberia; Far East), south-eastern Kazakhstan, Mongolia and China (Gansu; Hebei; Nei Mongol; Ningxia; Qinghai; Shaanxi; Shandong; Shanxi; Xinjiang; Heilongjiang; Jilin; Liaoning). In sunny hills and pastures, and sometimes cultivated as a vegetable in north-eastern China.

Phenology: Flowering from June to August.

Notes: *Allium ramosum* is closely related to *A. tuberosum*, but readily distinguished by having usually hollow leaf blades, longer tepals (6–11 mm vs. 5.6–6.9 mm) with red veins (vs. green), and ovaries with two to four ovules (vs. two) per locule. Phytogeographically, the former occurs in steppes of Siberia, Mongolia and northern China, whereas the latter is native to south-western China.

Specimens examined: CHINA: HEILONGJIANG – Andal, 12 July 1959, Chung 335 (PE); Jixiang railway station, 13 Aug 1956, Chung 7992 (PE); Harbin, 12 Aug 1950, Wang 115a (PE); Harbin, 12 Aug 1950, Wang 115 (PE); Qiqihar, 1 Sept 2003, L-61237 (KH); Tahe, 2 Aug 2008, Y.M.Lee & H.J.Choi 080001 (KH). JILIN – Tongyu, East cow-breeding farm, 22 Aug 1960, Yeop 367 (PE). LIAONING – Fushun, Jiguangshan, 30 Aug 1926, J.Sato 3813 (PE); Héngsan, Daeryeon, 11 Aug 2008, B.U.Oh *et al.* s.n. (CBU).

8. *ALLIUM SPIRALE* WILLD., ENUM. PL. SUPPL. 17 (1814). (FIG. 11)

Type: Russia. Far East, specimen without collection date and number (holotype: B photograph!).

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, horizontal, 6–20 mm long. Bulbs paired or clustered, cylindrically conical, without bulbels, 7–20 mm in diameter; tunics consisting of linear cells, membranous, smooth, white or sometimes tinged red. Leaves two to seven; leaf sheaths not exposed above ground, 3–5 cm high, non-striped; leaf blades curved, straight, flat, papery, usually glossy, linear, 20–45 cm × 1.5–10.0 mm, with two rows of vascular bundles and solid in cross section, sessile at base, acute at apex; leaf epidermal cells amphistomatic. Scapes central from bulbs, not slender, flattened-winged, drooping before flowering, solid in cross section, 33–65 cm × 1.5–5.1 mm. Inflorescences umbellate, globose, 25–45 × 30–50 mm, without bulbils, 30–90 flowered; pedicels terete, subequal in length, 8.5–22.0 mm long, thinner than the scapes; bracts 5–8 mm long. Flowers bisexual; perianth campanulate, pinkish violet; inner tepals longer than outer ones, ovately elliptical, obtuse at apex, 5.0–5.5 × 2.5–3.3 mm; outer tepals ovately elliptical, obtuse at apex, 4.0–4.3 × 2.0–2.5 mm; filaments exserted, 5–8 mm long, entire at margin; anthers elliptical, reddish, 1.7–2.0 mm long; ovary obovoid, reddish, without appendages, 2.5–3.0 × 2.2–2.4 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 5.0–5.3 × 4.5–5.0 mm. Seeds oval, semi-circular in cross section, 3.0–3.3 × 2.0–2.2 mm.

Chromosome number: $2n = 16$ (Table 1).

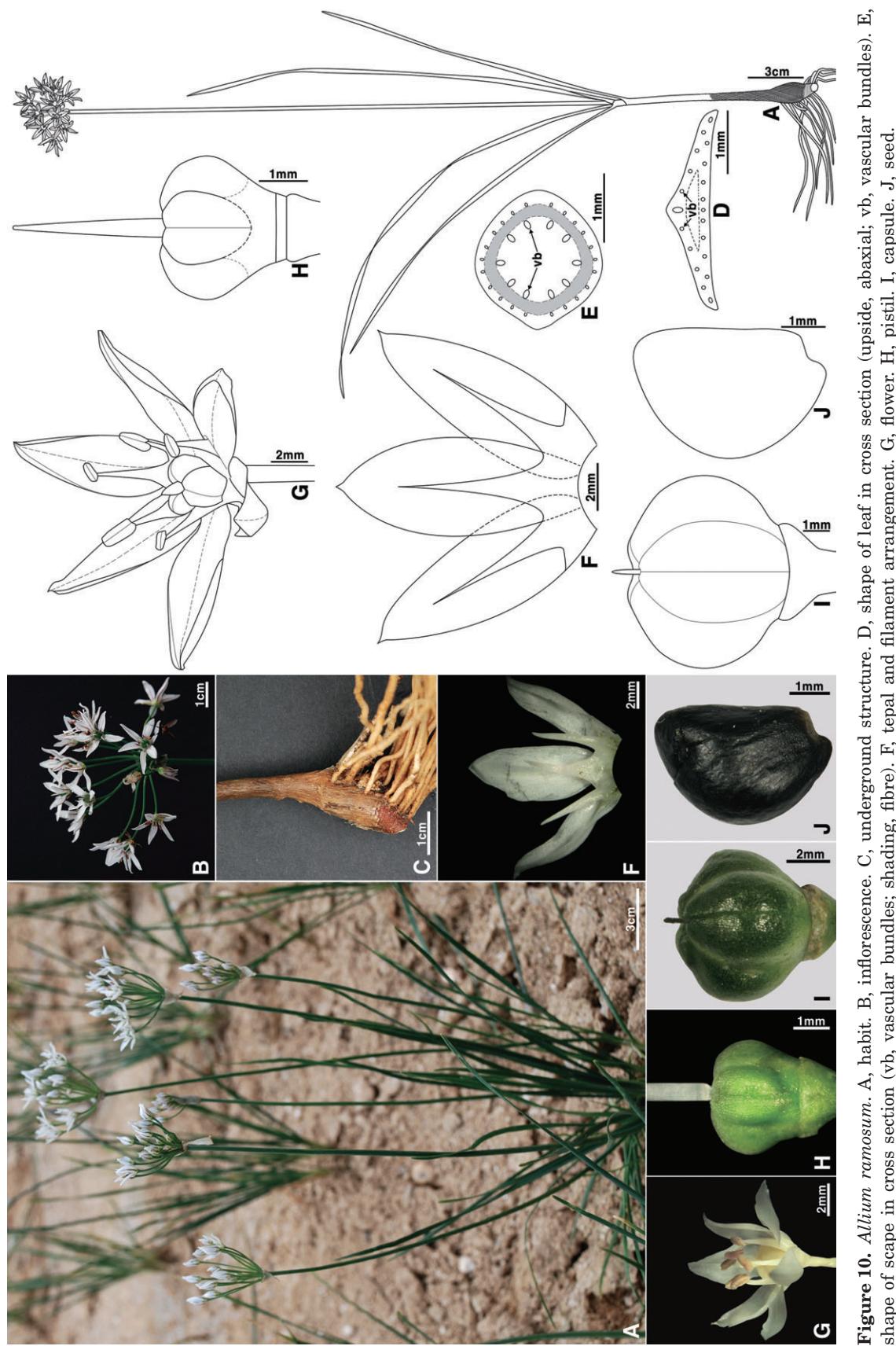


Figure 10. *Allium ramosum*. A, habit. B, inflorescence. C, undifferentiated structure. D, shape of leaf in cross section (abaxial, vb, vascular bundle; sb, siliques). E, shape of siliques in cross section (ab, vascular bundle; sb, siliques). F, epal and filament arrangement. G, flower. H, pistil. I, capsule. J, seed.

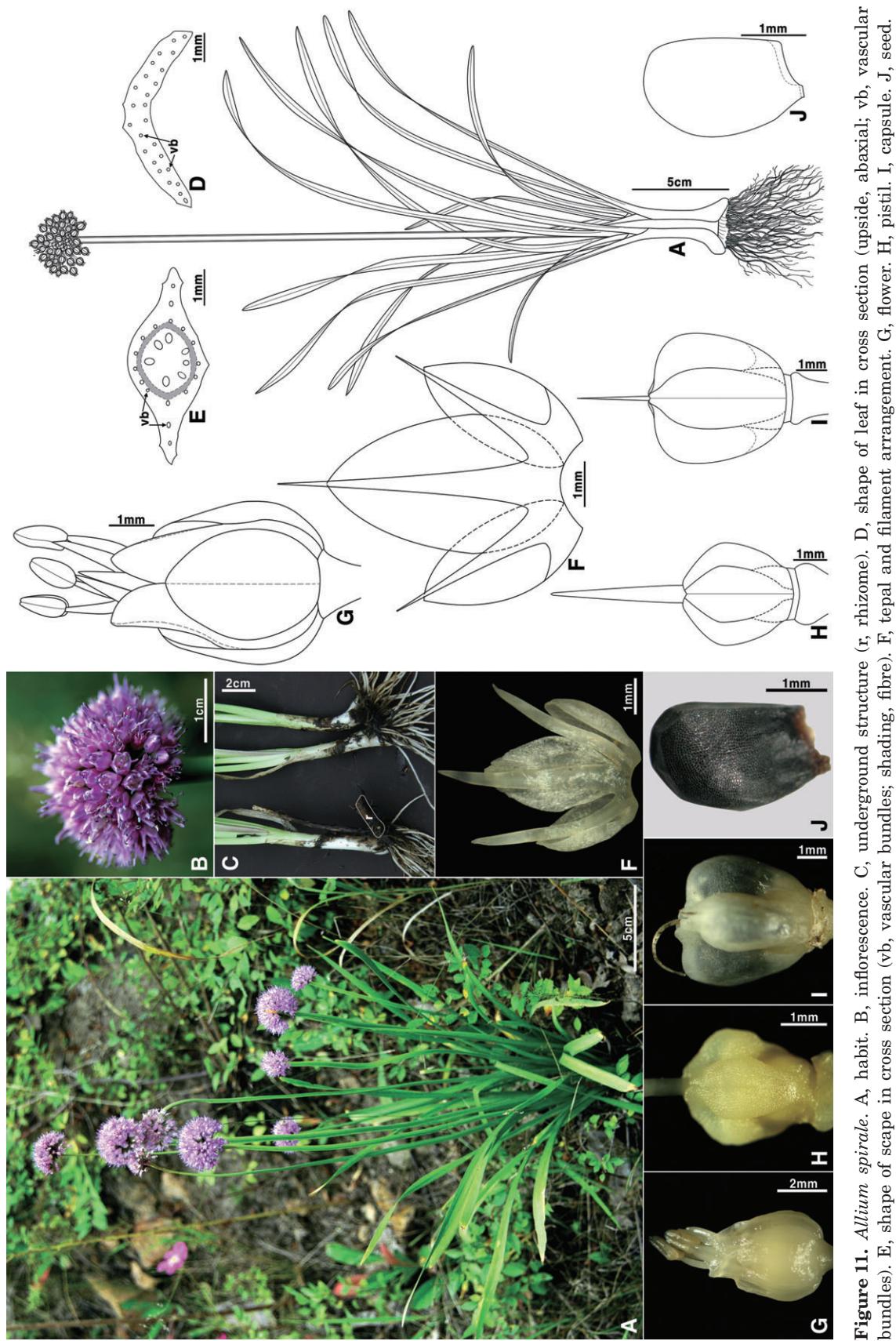


Figure 11. *Allium spirale*. A, Habit. B, Inflorescence. C, underground structure (rhizome), D, shape of leaf in cross section (upside, abaxial); v_b, vascular bundle. E, shape of scape in cross section (v_b, vascular bundle; s, shadow, blue). F, tepal and filament arrangement. G, flower. H, piast. I, capsule. J, seed.

Korean common name: Cham-du-me-bu-chu (new name).

Distribution and habitat: Russia (eastern Siberia; Far East), Mongolia, north-eastern China (Heilongjiang; Jilin; Liaoning) and Korea (North Korea; Gangwon; Goseong; Gyeongbuk: Cheongnyangsan). In forest margins and dry slopes of mountains.

Phenology: Flowering from August to September.

Notes: *Allium spirale* is occasionally confused with *A. senescens* L. because of its more or less similar growth habit, but the most distinctive characters include papery and glossy leaf blades (Fig. 11A), clearly flattened-winged scapes (Fig. 11E), campanulate perianth (Fig. 11G) and ovate tepals (Fig. 11F). This is a previously unrecorded species of the Korean flora, and the new Korean common name, ‘Cham-du-me-bu-chu’, was given in consideration of its habitat of dry slopes of mountainous areas in Korea. It is recognized as a regionally rare plant of South Korea, as evidenced by the existence of few collections in fields and herbaria, with only the two localities of *H.J.Choi* 080390 and *T.B.Lee et al.* s.n. (see specimens examined below) known up to present. Besides, Cheongnyangsan of South Korea (site number 38 of Fig. 1) is the southernmost limit for geographical distribution of *A. spirale*.

Specimens examined: CHINA: HEILONGJIANG – Harbin, 22 Aug 2001, *G.W.Park* s.n. (KH); Qinggang, Aug 1953, North-eastern group 571 (PE); Saertu,?, s.n. (PE). JILIN – Ipbeopsan, Gyoha, 2 Sept 2006, *Jilin23-060902-007* (CBU); Nampyeong, Yongjeong, 8 Sept 2007, *H.J.Choi & J.W.Han* 070014 (KH); Aprokgang, Dandong, 6 Sept 2007, *H.J.Choi & J.W.Han* 070012 (KH); Tungwi, 26 Aug 1960, *Jilin Teaching Uni.* 399 (PE); Tungwi, 14 July 1960, *Yeop* 183 (PE); Near O-mu Hsien, 28 Aug 1931, *H.W.Kung* 2195 (PE); Ning-gu-ta, Ching-po Lake, Shu-yi Valley, 5 Sept 1931, *F.H.Chen* 541 (PE). LIAONING – Benxi, Xiaodonggou, 26 Aug 1965, *Liu et al.* 1319 (PE). KOREA: HAMNAM – Sinpo, 3 Oct 2002, *B.U.Oh* 020062 (CBU). GANGWON – Hyeonnae, Goseong, 15 Sept 1965, *T.B.Lee et al.* s.n. (KH). GYEONGBUK – Cheongnyangsan, Bonghwa, 6 Sept 2008, *H.J.Choi* 080390 (KH).

9. ALLIUM MINUS (S.YU, W.LEE & S.LEE) H.J.CHOI & B.U.OH, BRITTONIA 62(3): 200 (2010). (FIG. 12)

Basionym: *A. senescens* L. var. *minus* S.Yu, W.Lee & S.Lee, J. Korean Pl. Taxon. 11: 32 (1981) [‘minor’]. *Type:* Korea. Gangwon, Inje, mesic pine-forest underground c. 400 m toward a hill of Wolhaksamri, Yoo

5101 (holotype: Wonkwang University herbarium; isotypes: KWNU!, SNU, JNU).

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, oblique, 4.3–8.6 mm long. Bulbs clustered, cylindrically conical, without bulbels, 4.3–8.6 mm in diameter; tunics consisting of linear cells, membranous, smooth, white. Leaves five to seven; leaf sheaths slightly exposed above ground, 2.8–4.0 cm high, non-striped; leaf blades ascending, spirally tortuous, flat, flesh, linear, 11.4–24.5 cm × 2.8–4.5 mm, with two rows of vascular bundles and solid in cross section, sessile at base, obtuse to rounded at apex; leaf epidermal cells amphistomatic. Scapes central from bulbs, not slender, subterete, drooping before flowering, solid in cross section, 11.7–20.5 cm × 1.5–1.6 mm. Inflorescences umbellate, hemiglobose, 15.0–25.4 × 25–33 mm, without bulbils, 32–85 flowered; pedicels terete, subequal in length, 6–8 mm long, thinner than the scapes; bracts 2.7–4.8 mm long. Flowers bisexual; perianth stellately spreading, pale pink; inner tepals longer than outer ones, elliptical, obtuse at apex, 3.5–4.7 × 1.0–1.4 mm; outer tepals ovately oblong, obtuse at apex, 3.4–4.1 × 0.8–1.2 mm; filaments non-exserted, 3.8–4.8 mm long, entire at margin; anthers elliptical, reddish, 1.1–1.3 mm long; ovary ovoid, reddish, without appendages, 2.0–2.3 × 1.7–1.9 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 3.5–3.7 × 3.6–4.0 mm. Seeds oval, semi-circular in cross section, 2.0–2.2 × 1.8–1.5 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Gangwon: Inje; Gyeonggi: Taegisan, Yangju). In mesic forests and dry slopes. It is cultivated as an edible plant named ‘Yeong-yang-bu-chu’ mainly in Gyeonggi, South Korea.

Phenology: Flowering from May to July.

Notes: This species had been recognized as a variety of *A. senescens* (Yu et al., 1981). However, this Korean endemic taxon is a biologically distinct species. It is remarkably well distinguished from the other Korean and north-eastern Chinese related members of the genus; for example, *A. senescens*, *A. spirale* and *A. pseudosenescens* H.J.Choi & B.U.Oh of section *Rhizirideum* G.Don ex Koch, in having much narrower and shorter leaf blades and scapes, conspicuously smaller floral organs, non-exserted filaments (Fig. 12F) and an earlier flowering season from May to July. Moreover, this is a diploid ($2n = 2x = 16$) taxon along with *A. spirale*, whereas *A. senescens*

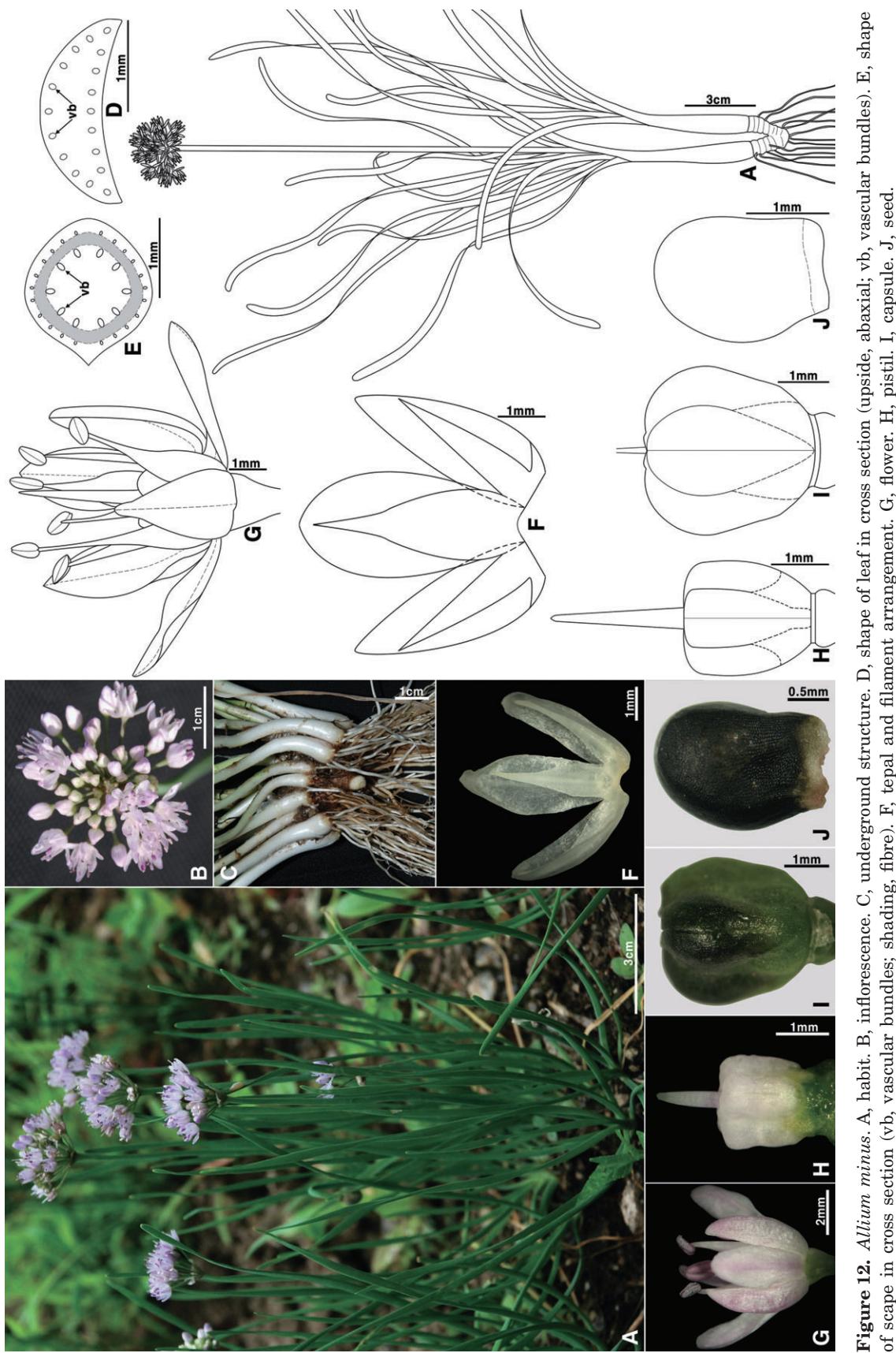


Figure 12. *Allium minus*. A, habit; B, inflorescence; C, underground structure; D, shape of leaf in cross section (inside); E, basal plate; F, scape cross-section (inside); G, flower; H, pistil; I, capsule; J, seed; K, shape of scape in cross section (abaxial view); L, vascular bundle; M, seedling; N, seed.

and *A. pseudosenescens* are tetraploids ($2n = 4x = 32$) (Table 1). Considering these major differences, Choi & Oh (2010) proposed the rank of species for this taxon as more appropriate than that of variety. In addition, the appropriate epithet for the neuter genus *Allium* is not '*minor*' of Yu *et al.* (1981), but '*minus*' (Choi & Oh, 2010). Although it is cultivated as a vegetable in South Korea, its natural populations are infrequent and only found in the type locality so far. To our knowledge, there is no designation record about its rarity status in Korea, and we recommend a more thorough survey to evaluate its distribution and demography to accurately determine the rarity status of this species.

Specimens examined: KOREA: GANGWON – Inje, 26 May 1979, B.S.Gil 0022887 (KNU); Inje, ?, W.T.Lee 0022892 (KNU); Wolhaksam, Inje, 18 May 2008, H.J.Choi 080063 (KH).

10. *ALLIUM SENESCENS* L., SP. PL.
1: 299 (1753). (FIG. 13)

Type: Russia. From Siberia (forebaical region), LINN 419.25 (lectotype: LINN photograph!).

= *A. baicalense* Willd., *Enum. Hort. Berol.* 860 (1809). *Type:* Russia. Type specimen not designated (protologue).

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, oblique or horizontal, 15.7–40 mm long. Bulbs clustered, cylindrically conical, without bulbils, 9.6–15.0 mm in diameter; tunics consisting of linear cells, membranous, smooth, white. Leaves four to nine; leaf sheaths slightly exposed above ground, 4.0–7.8 cm high, non-striped; leaf blades ascending, slightly tortuous, linear, flat, flesh, 19.5–38.0 cm × 3.8–13.0 mm, with two rows of vascular bundles and solid in cross section, sessile at base, obtuse to rounded at apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes sometimes lateral from bulbs, not slender, subterete to rhomboid, drooping before flowering, solid in cross section, 23.4–49 cm × 2.5–5.6 mm. Inflorescences umbellate, subglobose, 23.0–41.5 × 37–53 mm, without bulbils, 48–113 flowered; pedicels terete, subequal in length, 10–20 mm long, thinner than the scapes; bracts 3.2–5.0 mm long. Flowers bisexual; perianth stellately spreading, reddish pink; inner tepals longer than outer ones, elliptical, obtuse at apex, 6–7 × 3.0–3.4 mm; outer tepals ovately elliptical, obtuse at apex, 4.7–5.5 × 2.0–2.6 mm; filaments exserted, 6.2–9.5 mm long, entire at margin; anthers elliptical, reddish, 1.9–2.1 mm long; ovary obovoid, reddish, without appendages, 3.5–4.0 × 3.0–3.5 mm, ovules two per locule; style terete, exserted; stigma

smooth. Capsules cordiform, trigonous, 5.4–5.6 × 5.6–5.8 mm. Seeds oval, semi-circular in cross section, 3.7–3.8 × 2.4–2.6 mm.

Chromosome number: $2n = 32$ (Table 1).

Distribution and habitat: Russia (southern Siberia; Far East), Mongolia, China (Nei Mongol; northern Xinjiang; Heilongjiang; Jilin; Liaoning) and Korea (North Korea; Gangwon: Gangneung, Seoraksan; Gyeongbuk: Ulleungdo). In forests, rocky slopes, steppes, saline meadows and gravelly places.

Phenology: Flowering July to August in north-eastern China and September to October in Korea.

Notes: *Allium senescens*, originally described from the Baikal area of Russia, is certainly one of the most popular ornamental *Allium* spp. of the world, and is widely distributed from Russia to central Korea. However, it is rare in South Korea and has been listed as an endangered species by the Korea Forest Service (Lee & Lee, 1997). In fact, its distribution in South Korea is restricted to coastal areas of Gangwon and Ulleungdo. Yu *et al.* (1981) reported that this species also occurs in the Miryang of Gyeongnam (southern part of Korea). In this study, however, no material was available in botanical collections to sufficiently demonstrate its native distribution in Miryang. There is always the possibility that Yu *et al.* (1981) made the record using specimens from plantings at the National Institute of Crop Science in Miryang. The rarity of this taxon in Korea may be correlated with it being at its southernmost range, as it is a relatively common species in north-eastern China. Regardless of this distributional pattern, proactive research such as population monitoring should be implemented to protect this species in Korea. Understanding the forms that the geographical range limits of species take, their causes and their consequences are key issues in ecology and evolutionary biology.

Specimens examined: CHINA: HEILONGJIANG – ?, 1959, Wang 163 (PE); Huadehuanghaunaobao, 7 Sept 1949, Choi 871 (PE); Palryeon, 3 July 2007, B.U.Oh *et al.* s.n. (CBU). JILIN – Wharyoung, 8 Sept 1959, 700828 (PE). LIAONING – Daeryeon, 14 Sept 1951, Wang *et al.* 965 (PE); Héngsan, Daeryeon, 11 Aug 2008, B.U.Oh *et al.* s.n. (CBU). KOREA: GANGWON – Gyeongpo beach, Gangneung, 19 July 1978, s.n. (KH); Gangneung, 16 Oct 1991, S.Noda s.n. (KNU); Gyeongpodaeg, Gangneung, 10 Sept 1988, W.T.Lee 0022370 (KNU); Misiryeong, Seoraksan, 23 Sept 2001, H.J.Choi *et al.* 010009 (CBU). GYEONGBUK – Tongumi, Ulleungdo, 26 Sept 1995, S-4255 (KH);

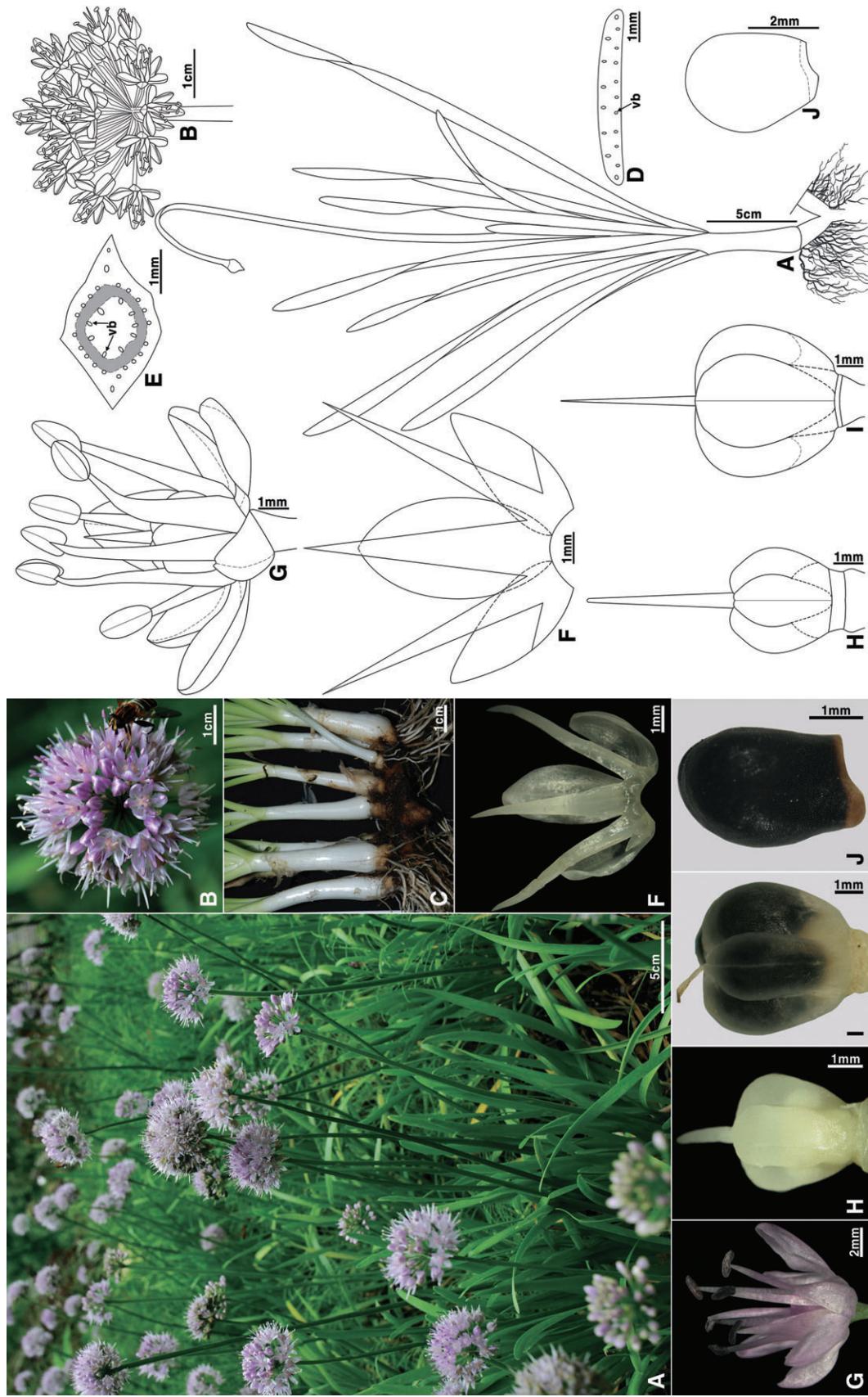


Figure 13. *Allium senescens*. A, habit. B, inflorescence. C, underground structure. D, shape of epal and filament structure. E, stamen. F, underground bulb. G, flower. H, capsule. I, seed. J, seed.

Dodong, Ulleungdo, 21 May 2002, *H.J.Choi* 020058 (CBU); Dodong, Ulleungdo, 18 Sept 2007, *H.J.Choi* 070001 (KH); Namyang valley, Ulleungdo, 11 Sept 2006, *ParkSH* 61820 (KH).

11. *ALLIUM PSEUDOSENESCENS* H.J.CHOI & B.U.OH, BRITTONIA 62(3): 200 (2010). (FIG. 14)

Type: China. Heilongjiang, Tahe, Talin Linchang, open slope of rocky area, 52°19'52.9"N, 124°37'45.4"E, alt. 374 m, 31 July 2008, *H.J.Choi* 080119 (holotype: KH!; isotypes: CBU!, KH!).

Description: Herbs hermaphroditic. Rhizomes elongated, thick and branched, horizontal, 16.0–52.8 mm long. Bulbs clustered, cylindrically conical, without bulbels, 12–20 mm in diameter; tunics consisting of linear cells, membranous, smooth, white. Leaves four to ten; leaf sheaths slightly exposed above ground, 4–8 cm high, non-striped; leaf blades ascending, slightly tortuous, linear, flat, flesh, 23–45 cm × 5–15 mm, with two rows of vascular bundles and solid in cross section, sessile at base, obtuse to rounded at apex; leaf epidermal cells amphistomatic. Scapes sometimes lateral from bulbs, not slender, subterete to rhomboid, drooping before flowering, solid in cross section, 25.8–70.0 cm × 3.0–5.5 mm. Inflorescences umbellate, subglobose, 30–60 × 40–60 mm, without bulbils, 31–120 flowered; pedicels terete, subequal in length, 10–32 mm long, thinner than the scapes, slender; bracts 4.8–6.5 mm long. Flowers bisexual; perianth stellately spreading, pale pink; inner tepals longer than outer ones, elliptical, obtuse at apex, 6.0–6.8 × 2.5–3.0 mm; outer tepals ovately elliptical, obtuse at apex, 4.5–5.5 × 2.0–2.7 mm; filaments exserted, 7–11 mm long, entire or with two teeth (middle part of inner ones) at margin; anthers elliptical, yellowish, 1.9–2.1 mm long; ovary ovoid, reddish, without appendages, 3.2–4.0 × 2.2–2.6 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.5–5.5 × 4.5–5.6 mm. Seeds oval, semi-circular in cross section, 3.0–3.5 × 2.2–2.4 mm.

Chromosome number: $2n = 32$ (Table 1).

Distribution and habitat: Endemic to China (northern Heilongjiang). In open meadows and arid slopes.

Phenology: Flowering from July to September.

Notes: *Allium pseudosenescens* has been misidentified as *A. senescens* in various Chinese herbaria, but the former is clearly distinguished from the latter by its more or less slender pedicels, pale pink perianth,

narrower tepals and ovaries, yellowish anthers and sometimes toothed subulate filaments (Fig. 14E) (Choi & Oh, 2010).

Specimens examined: CHINA: HEILONGJIANG – Xifeng Linchang, Tahe, 1 Aug 2008, *H.J.Choi* 080278 (KH); Dashinganryeong, Aug 1954, *Linxingzu* 07577 (PE).

12. *ALLIUM BIDENTATUM* FISCH. EX PROKH. & IKONN.-GAL., MASTER. KOMISSII PO ISSLED. MONGOLII I TUVY 2: 83 (1929). (FIG. 15)

Type: Russia. From Transbaical, 'Schangin', specimen without collection date and number (lectotype: LE!, designated by N. Friesen, 8 Aug 1996, photograph: CBU!).

= *A. omiostema* Airy Shaw, *Notes Roy. Bot. Gard. Edinburgh* 16: 144 (1931). *Type:* China. Hebei, Mt Gulick, Kalgan, 11 Aug 1921, *N.H.Cowdry* 1889 (holotype: K).

= *A. edentatum* Y.P.Hsu, *Acta Bot. Boreal.-Occid. Sin.* 7(4): 258 (1987). Type not traced.

= *A. bidentatum* Fisch. ex Prokh. & Ikon.-Gal. var. *andaense* Q.S.Sun, *Bull. Bot. Res., Harbin* 15(3): 332 (1995). *Type:* China. Heilongjiang, Daqing, 17 Sept 1951, *Y.L.Chang* 752 (holotype: IFP).

Description: Herbs hermaphroditic. Rhizomes condensed, more or less slender, oblique, 2–5 mm long. Bulbs clustered, cylindrically ovoid, without bulbels, 3.0–5.6 mm in diameter; tunics consisting of linear cells, papery, smooth, greyish brown. Leaves three to five; leaf sheaths exposed above ground, 2.5–4.5 cm high, striped green; leaf blades ascending, linear, semiterete, 10–20 cm × 0.8–1.5 mm, with two rows of vascular bundles and solid in cross section, sessile at base, tapered at apex; leaf epidermal cells with verrucate cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 10–30 cm × 0.9–1.6 mm. Inflorescences umbellate, subfascicled, 12–20 × 18–27 mm, without bulbils, nine to 20 flowered; pedicels terete, subequal in length, 4–14 mm long, thinner than the scapes; bracts 4–6 mm long. Flowers bisexual; perianth campanulate, pale pink; inner tepals longer than outer ones, elliptical, rounded at apex, 5.8–7.5 × 2.4–3.2 mm; outer tepals ovately elliptical, rounded at apex, 4–6 × 2–2.8 mm; filaments non-exserted, 3.7–6.0 mm long, with two teeth (upper part of inner ones) at margin; anthers elliptical, reddish, 1.4–1.6 mm long; ovary ovoid, greenish, without appendages, 2.5–3.0 × 1.8–2.0 mm, ovules two per locule; style terete, non-exserted; stigma smooth. Capsules cordiform, trigonous, 3.8–4.2 × 3.5–3.9 mm. Seeds oval, dully angular in cross section, 2.6–2.8 × 1.7–1.9 mm.

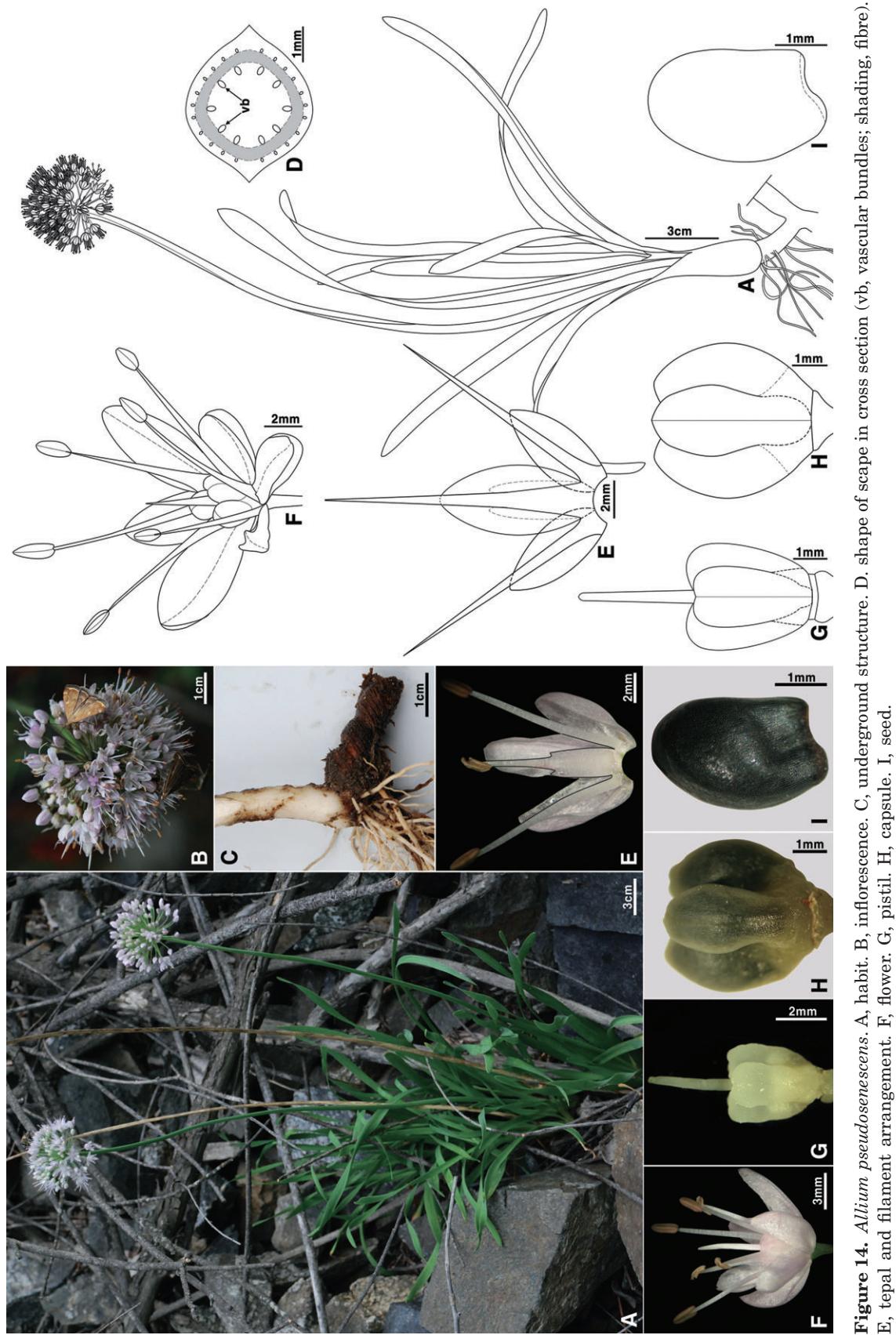


Figure 14. *Allium pseudosensees*. A, habit; B, inflorescence; C, underground structure; D, shape of scape in cross section (vb, vascular bundles; shading, fibre).

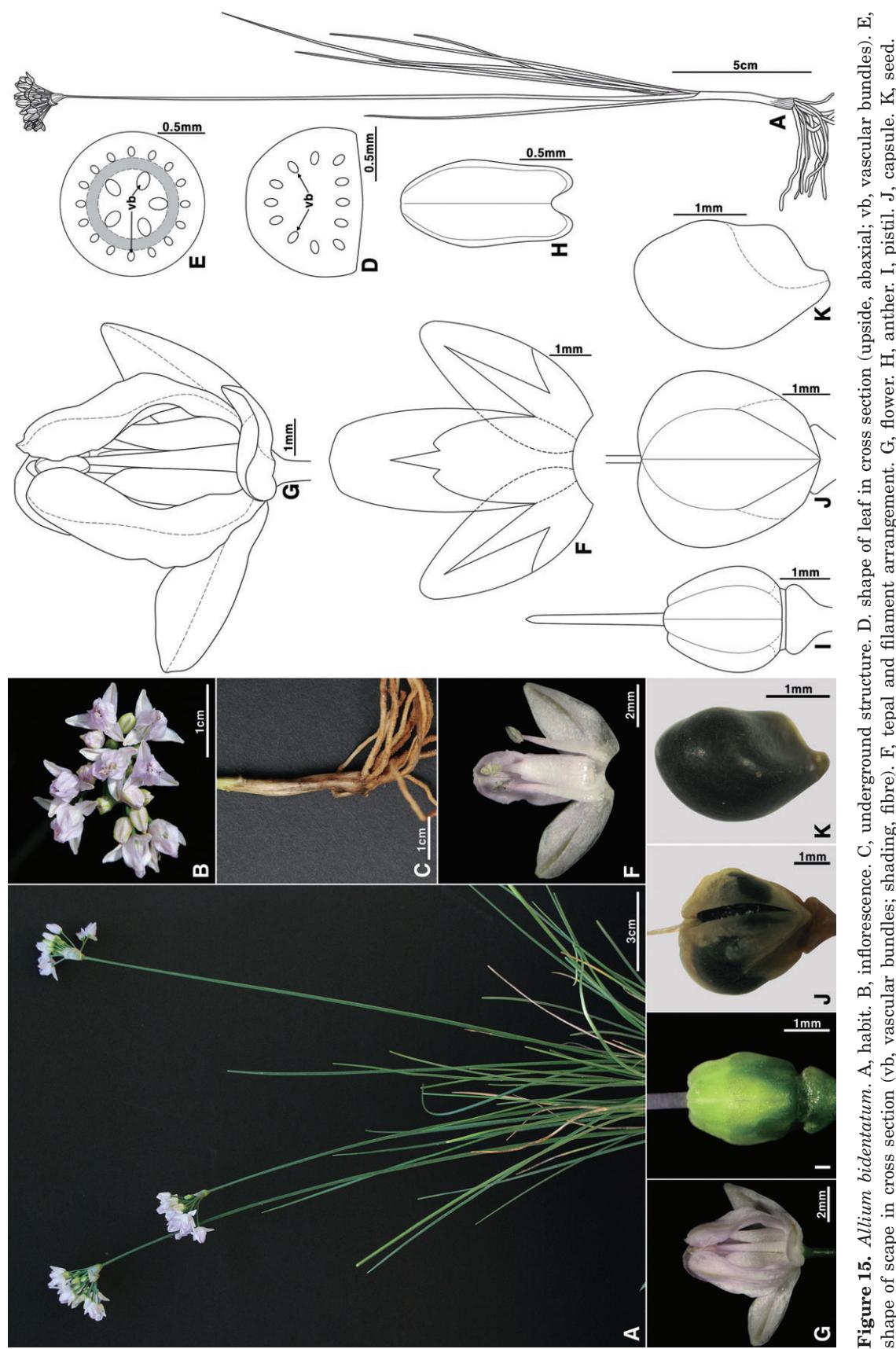


Figure 15. *Allium bidentatum*. A, habit. B, inflorescence. C, root system. D, shape of leaf in cross section. E, flower. F, stamen. G, pistil. H, capsule. I, seed. J, vascular bundle; K, sheath of vascular bundle. L, vascular bundle; M, seed. E, vascular bundle; F, sheath of vascular bundle; G, flower; H, capsule; I, seed; J, vascular bundle; K, sheath of vascular bundle; L, vascular bundle; M, seed.

Chromosome number: $2n = 32$ (Tolgor *et al.*, 1994).

Distribution and habitat: Russia (southern Siberia; Far East), south-eastern Kazakhstan, Mongolia and China (Hebei; Nei Mongol; Shanxi; north-eastern Xinjiang; Heilongjiang; Jilin; Liaoning). In sunny slopes, pastures, meadows and saline places.

Phenology: Flowering from July to September.

Notes: During our field surveys, we found various habitats for *A. bidentatum* especially in the western part of north-eastern China. It is clearly distinguished by having semiterete leaves (Fig. 15D), toothed inner filaments (Fig. 15F) and cordiform capsules (Fig. 15J) from its morphologically related species, *A. anisopodium* and *A. tenuissimum*. In addition, it is the only species having verrucate cuticular layers in the leaf epidermis among Korean and north-eastern Chinese *Allium* (Fig. 2K).

Specimens examined: CHINA: HEILONGJIANG – Saertu, Andal, 12 Sept 1951, Cho *et al.* 752 (PE); Tahe, 7 July 2007, D.G.Jo *et al.* 070050 (KH). JILIN – Tongyu, 28 July 1960, Jilin Teaching Uni. 290 (PE); Tongyu, 24 Aug 1960, Yeop 374 (PE); Tongyu, 14 July 1960, Yeop 195 (PE); Sapyeong, 9 Sept 1952, J.Sato 9231 (PE). LIAONING – Héngsan, Daeryeon, 7 July 2007, CBU-280 (KH); Xilingou, 22 July 1962, Mong *et al.* 1078 (PE).

13. *ALLIUM ANISOPODIUM* LEDEB., *FL. ROSS.* 4: 183 (1853). (FIG. 16)

Type: Russia. De campis Transbaicalensis, Herbar Ledebour 991.49, 1823, Turczaninov s.n. (lectotype: LE!, designated by N. Friesen, 8 Aug 1996, photograph: CBU!).

≡ *A. tenuissimum* L. var. *anisopodium* (Ledeb.) Regel, *Trudy Imp. S.-Peterburgsk. Bot. Sada* 3(2): 157 (1875).

= *A. tchefouense* Debeaux, *Acta Soc. Linn. Bordeaux* 32: 25 (1878). Type not traced.

Description: Herbs hermaphroditic. Rhizomes condensed, distinctly oblique, 4.5–7.0 mm long. Bulbs solitary or clustered, cylindrical, without bulbils, 3–8 mm in diameter; tunics consisting of linear cells, papery, smooth, brown. Leaves two to six; leaf sheaths exposed above ground, 4–20 cm high, striped green; leaf blades ascending, linear, angular, 26–48 cm × 0.8–3.0 mm, with two rows of vascular bundles and solid in cross section, sessile at base, tapered at apex; leaf epidermal cells with slightly ridged cuticles, amphistomatic. Scapes central

from bulbs, not slender, terete or sometimes minutely angular, erect before flowering, solid in cross section, 30.0–66.3 cm × 1.2–2.8 mm. Inflorescences umbellate, subfascicled, 14.8–35.8 × 14.4–50.0 mm, without bulbils, sparsely nine to 35 flowered; pedicels terete, unequal in length, 6.5–30.0 mm long, thinner than the scapes; bracts 10–16 mm long. Flowers bisexual; perianth campanulate, pale purple; inner tepals longer than outer ones, obovate, obtuse to truncate at apex, 4.5–5.2 × 2.5–2.8 mm; outer tepals oval, obtuse to rounded at apex, 4.4–4.6 × 2.6–2.8 mm; filaments non-exserted, 3.0–3.6 mm long, entire at margin; anthers oval, yellowish, 1.3–1.5 mm long; ovary ovoid, brownish, without appendages, 2.2–2.4 × 1.8–2.0 mm, ovules two per locule; style terete, non-exserted; stigma smooth. Capsules subglobose, not trigonous, 3.2–3.9 × 3.6–4.0 mm. Seeds oval, angular in cross section, 2.4–2.6 × 1.9–2.1 mm.

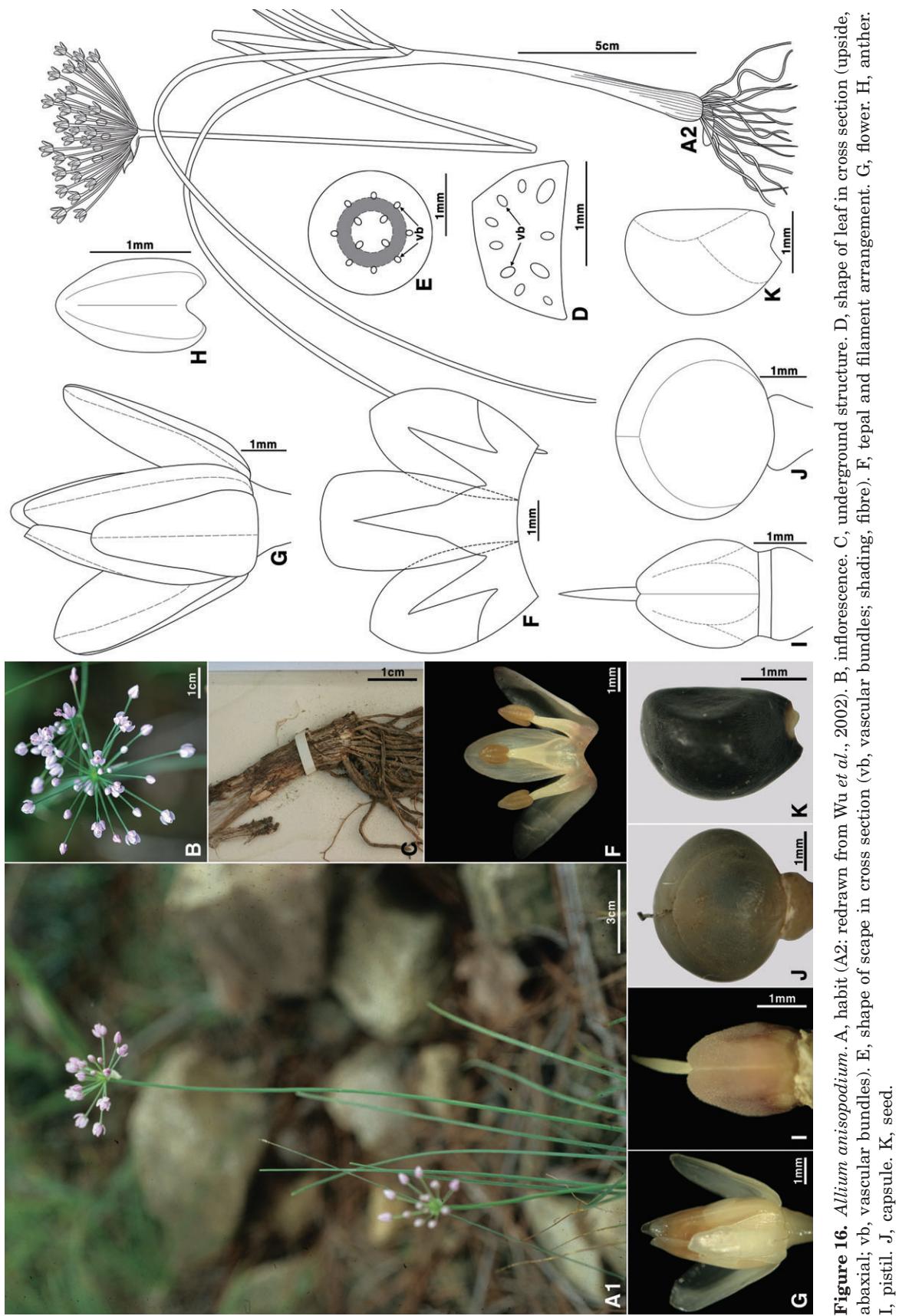
Chromosome number: $2n = 16$ (Tolgor *et al.*, 1994; Shang *et al.*, 1997).

Distribution and habitat: Russia (southern Siberia; Far East), eastern Kazakhstan, Mongolia, China (Hebei; Nei Mongol; Shandong; northern Xinjiang; Heilongjiang; Jilin; Liaoning) and North Korea. In slopes, pastures and sandy places.

Phenology: Flowering from July to August.

Notes: *Allium anisopodium* is distributed from Russia to North Korea. The earlier report from South Korea (Choi *et al.*, 2004c) is because of the misidentification of herbarium specimens, the identity of which we determined as *A. tenuissimum* in this study. In fact, the two species are closely related, but the former is clearly distinguished by angular leaf cross sections (Fig. 16D), obviously unequal pedicels in length (Fig. 16B) and slightly longer tepals (4.5–5.2 mm vs. 4–5 mm) from the latter. In addition, *A. anisopodium* has slightly ridged cuticular walls in the leaf epidermis (Fig. 2L), whereas *A. tenuissimum* is characterized by clearly smooth cuticles (Choi *et al.*, 2004b). The nuclear ribosomal ITS sequence analysis also indicates that the two related species are genetically distinct from each other (Choi, 2009).

Specimens examined: CHINA: HEILONGJIANG – ?, 7 July 1963, Kang *et al.* 236 (PE); Boketu, 24 July 1928, J.Sato 3810 (PE); Duerbete Mongolian Autonomous county, 21 Sept 1951, Cho *et al.* 921 (PE). JILIN – Illsongjeong, Yongjeong, 27 July 2003, B.U.Oh *et al.* 030009 (CBU); Domun, 27 July 2003, B.U.Oh *et al.* s.n. (CBU); Ning-gu-ta, Ching-po Lake, 27 July 1931,



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Figure 16. *Allium anisopodium*. A, habit (A2: redrawn from Wu *et al.*, 2002). B, inflorescence. C, underground structure. D, shape of scape in cross section (vb, vascular bundles; sdb, starchy bundle; vb, vascular bundle). E, vascular bundle arrangement. F, tepal and filament arrangement. G, flower. H, anther. I, pistil. J, capsule. K, seed. L, petiole. M, blade. N, scape. O, bulb. P, root. Q, bulb scale. R, rootlet. S, starchy bundle. T, vascular bundle. U, petiole. V, blade. W, scape. X, bulb. Y, root. Z, rootlet.

F.H.Chen 157 (PE); Jilin, Xiaowushan, 27 Aug 1950, Zhu & Jeon 2158 (PE); Jilin, Longtanshan, 27 Aug 1950, Chang et al. 900 (PE); Tongyu, 17 July 1960, Jilin group 222 (PE); Chikuanshan, Fengtien, 18 July 1930, H.W.Kung 644 (PE); Tiehling, Fengtien, 10 July 1930, H.W.Kung K432 (PE); Sapyeong, 9 Sept 1925, J.Sato 9230 (PE). LIAONING – Yuxian, 21 June 1959, Li et al. 120 (PE); Zhangwuxian, 5 Oct 1952, Liu et al. 5511 (PE); Fengtien, 12 July 1930, H.W.Kung 502 (PE); Daegosan, Dandong, 5 July 2007, CBU-038 (KH); Héngsan, Daeryeon, 7 July 2007, CBU-286 (KH).

14. *ALLIUM TENUISSIMUM* L., SP. PL.
1: 301 (1753). (FIG. 17)

Type: Russia. From Siberia. LINN 419.43 (lectotype: LINN photograph!).

Description: Herbs hermaphroditic. Rhizomes condensed, oblique, 4.0–6.7 mm long. Bulbs solitary or clustered, cylindrical, without bulbils, 3–6 mm in diameter; tunics consisting of linear cells, papery, smooth, reddish brown, sometimes tinged red. Leaves three to five; leaf sheaths exposed above ground, 3.5–18.0 cm high, striped green; leaf blades ascending, linear, terete, 20–40 cm × 0.8–2.5 mm, with two rows of vascular bundles and solid in cross section, sessile at base, tapered at apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 25–60 cm × 1.2–2.5 mm. Inflorescences umbellate, subfascicled, 13–25 × 20–40 mm, without bulbils, sparsely nine to 40 flowered; pedicels terete, subequal in length, 5–20 mm long, thinner than the scapes; bracts 8–15 mm long. Flowers bisexual; perianth campanulate, pale pink; inner tepals longer than outer ones, obovate, obtuse to truncate at apex, 4–5 × 2.4–3.1 mm; outer tepals oval, obtuse to rounded at apex, 4.0–4.5 × 2.2–2.5 mm; filaments non-exserted, 2.2–3.5 mm long, entire at margin; anthers oval, yellowish, 1.3–1.5 mm long; ovary ovoid, brownish, without appendages, 1.5–2.0 × 1.6–1.8 mm, ovules two per locule; style terete, non-exserted; stigma smooth. Capsules subglobose, not trigonous, 3.2–3.8 × 3.6–4.0 mm. Seeds oval, angular in cross section, 2.4–2.6 × 1.6–2.0 mm.

Chromosome number: $2n = 16$ (Fig. 3D; Tolgor et al., 1994).

Korean common name: Ae-gi-sil-bu-chu (new name).

Distribution and habitat: Russia (eastern Siberia), Kazakhstan, Mongolia, China (Gansu; Hebei; Henan; northern and southern Jiangsu; Nei Mongol; Ningxia;

Shaanxi; Shandong; Shanxi; Sichuan; northern Xinjiang; Zhejiang; Heilongjiang; Jilin; Liaoning) and Korea (North Korea; Gyeonggi: Baengnyeongdo, Daecheongdo, Muido). In slopes, pastures and sandy places.

Phenology: Flowering from July to September.

Notes: *Allium tenuissimum* has been described as occurring from Russia to north-eastern China (Vvedensky, 1935; Friesen, 1995; Xu & Kamelin, 2000). From this study, this species has also been collected in central Korea (Table 1). In addition, Friesen et al. (2006: 379) used material of this species in their molecular phylogenetic study from the Pyeongyang Botanical Garden, North Korea. Therefore, we concluded that it is a formerly unrecorded species of *Allium* in Korea. The new Korean common name ‘Ae-gi-sil-bu-chu’ was given considering the property of habit: that is more or less fragile and smaller than *A. anisopodium*. It is recognized as a regional rare plant of South Korea, occurring on just a few islands of the western sea.

Specimens examined: CHINA: HEILONGJIANG – ?, 24 July 1963, s.n. (PE). JILIN – Tongyu, 24 June 1960, Yeop 87 (PE); Maolin veterinary farm, 27 June 1960, Yeop 130 (PE); Zhenganxian, 8 Aug 1959, Baichengzu 70 (PE); Zhenganxian, 7 Aug 1959, Baichengzu 42 (PE). LIAONING – Daegosan, Gushan zhen, 5 July 2007, Liaoning 8-070705-045 (KH); Kuanjiasan, Zhuanghe, 6 July 2007, CBU-266 (KH); Héngsan, Daeryeon, 7 July 2007. CBU-277 (KH); Laohutan, 23 Sept 1975, Guan 75563 (PE); Dalian, Lushunkou, Aug 1926, J.Sato 3788 (PE); Jianping, 4 July 1959, Wang et al. 3625 (PE). KOREA: PYEONGNAM – Myohyang-san, 20 Aug 1979, s.n. (KH); Yongaksan, 16 Aug 1987, Hungary 6102 (KH). HWANGHAE – Seohueng, 14 Sept 1935, B.S.To s.n. (SNU). GYEONGGI – Dumujin, Baengnyeongdo, 8 Aug 1984, B.R.Yinger et al. s.n. (SNUA); Dumujin, Baengnyeongdo, 1 May 2003, H.J.Choi 030008 (CBU); Baengnyeongdo, Incheon, 4 Sept 2002, Gwang 10968 (KH); Daecheongdo, Incheon, 3 Sept 2002, L-60672 (KH); Daecheongdo, Incheon, 3 Sept 2002, J.O.Hyun & H.K.Park 2002308 (KH); Daecheongdo, Incheon, 3 Sept 2002, Gwang 10959 (KH); Daecheongdo, Incheon, 10 Aug 2008, H.J.Choi 080255 (KH).

15. *ALLIUM KOREANUM* H.J.CHOI & B.U.OH,
KOREAN J. PL. TAXON. 34(2): 76 (2004). (FIG. 18)

Type: Korea. Jeonbuk, Jinan, Maisan, Ammaibong, open slope of rocky area, 650–660 m, 16 Aug 2002, H.J.Choi 020057 (holotype: CBU!; isotypes: CBU!, KH!).

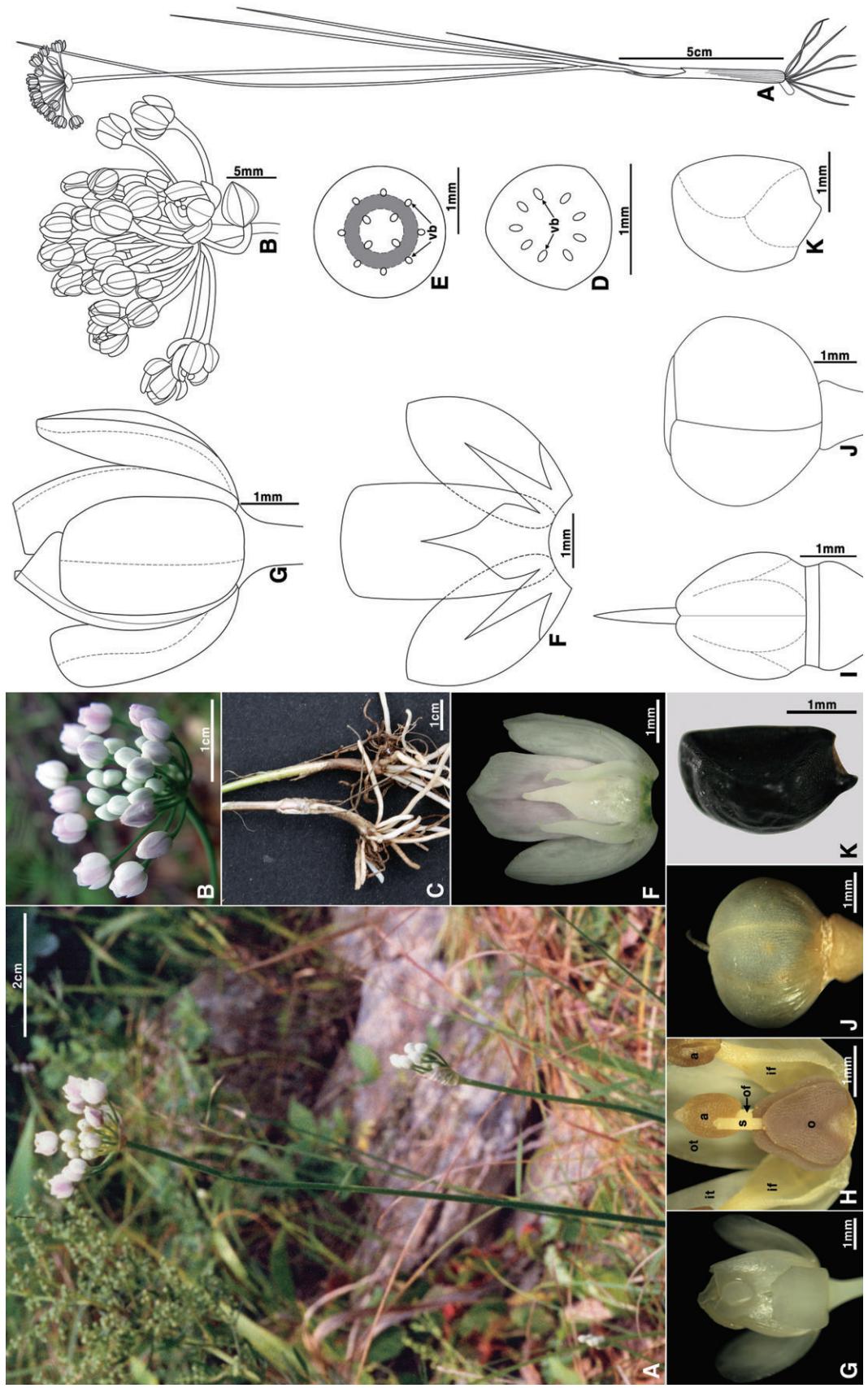
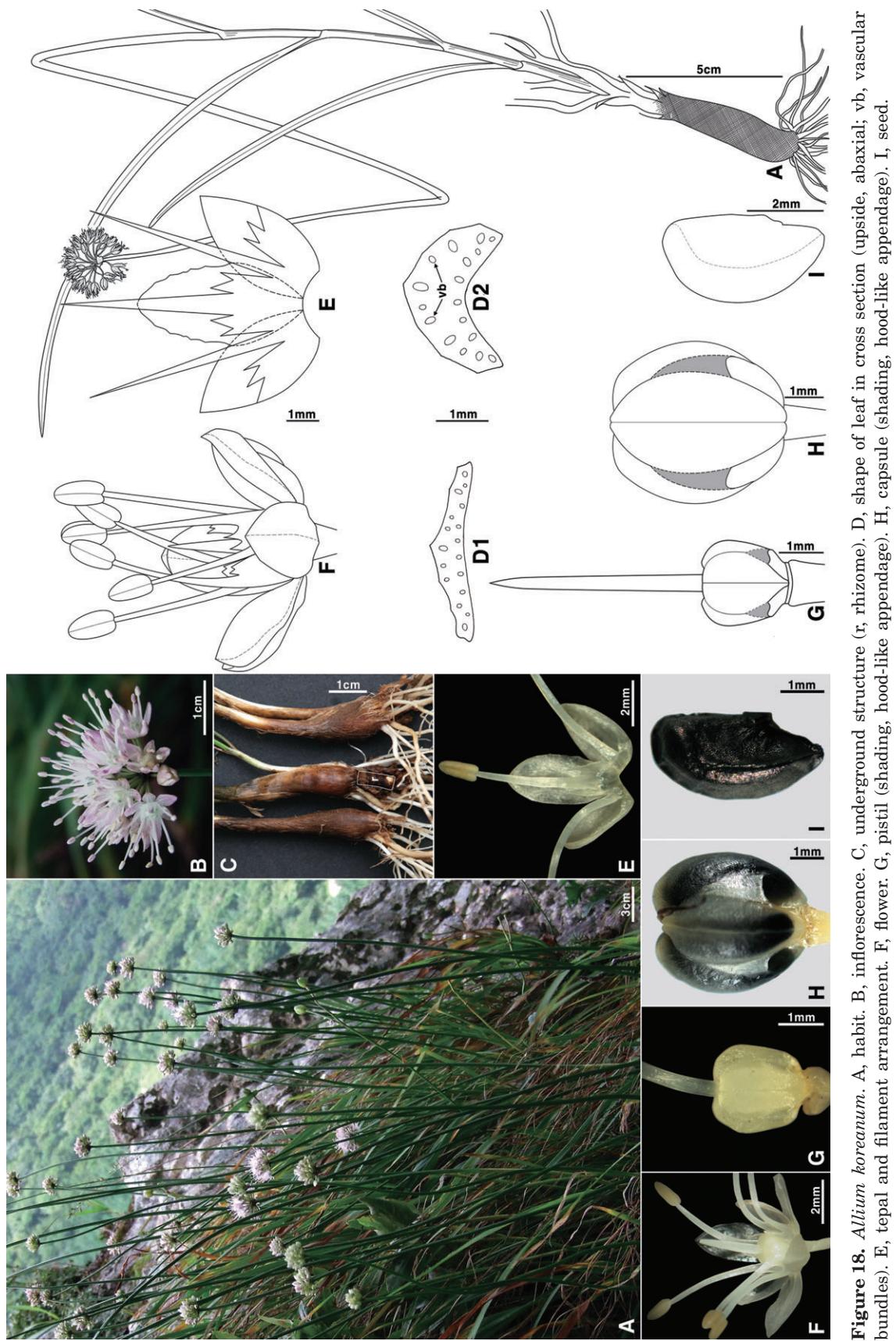


Figure 17. *Allium tenuissimum*. A, habit. B, inflorescence. C, underground structure. D, shape of leaf in cross section (upside, abaxial; vb, vascular bundle). E, shape of sepal in cross section (vb, vascular bundle; o, ovary; s, style). F, stamens. G, flower. H, longitudinal structure of flower (a, anther; if, inner filament; ot, outer filament; s, style). I, perianth. J, stamen. K, seed. L, pistil. M, capsule. N, seed.



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Description: Herbs hermaphroditic. Rhizomes condensed, erect, 2.5–10.0 mm long. Bulbs usually paired, cylindrically ovoid, without bulbels, 7.7–12.7 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulate, brown. Leaves three to eight; leaf sheaths exposed above ground, 11.7–25.3 cm high, striped green; leaf blades curved, linear, flat, 13–40 cm × 1.9–3.2 mm, with two rows of vascular bundles and solid in cross section, sessile at base, acute in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 33.8–57.0 cm × 1.3–2.3 mm. Inflorescences umbellate, subglobose, 16.9–36.4 × 20.3–37.7 mm, without bulbils, 20–120 flowered; pedicels terete, subequal in length, 5.9–11.0 mm long, thinner than the scapes; bracts 5.0–6.8 mm long. Flowers bisexual; perianth stellately spreading, pale pink; inner tepals longer than outer ones, ovately elliptical, obtuse at apex, 4.8–5.3 × 2.5–2.8 mm; outer tepals ovately elliptical, obtuse at apex, 4.0–4.6 × 2.4–2.5 mm; filaments exserted, 6.0–8.4 mm long, with two to four teeth (middle part of inner ones) at margin; anthers elliptical, reddish, 1.5–1.6 mm long; ovary obovoid, greenish, with hood-like appendages at base, 2.0–2.2 × 1.8–1.9 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules ellipsoid, 3.7–4.7 × 4.2–4.3 mm. Seeds elliptical, angular in cross section, 4.0–4.3 × 2.0–2.1 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Jeonbuk: Minjujisan, Maisan; Gyeongnam: Ganwolsan, Jaeaksan, Sinbulsan, Bulmosan, Busan). In sunny and rocky slopes.

Phenology: Flowering from July to August.

Notes: *Allium koreanum*, occurring in southern Korea, has usually been misidentified as *A. splendens* in Korea (Choi *et al.*, 2004c). However, the former is clearly distinguished from the latter, which is widely distributed in north-eastern China, by its larger and stellately spreading pale pink perianth (Fig. 18B, F), apparently exserted filaments (Fig. 18B, E, F) and smooth stigma (Fig. 18G). In addition, *A. koreanum* proved to be diploid ($2n = 2x = 16$), whereas *A. splendens* from north-eastern China is tetraploid ($2n = 4x = 32$) (Table 1). This Korean endemic taxon can be considered as a post-glacial relict species based on its phytogeography: its distribution is restricted to southern Korea, and it is clearly isolated from closely related species such as *A. splendens*, *A. lineare* L. and *A. strictum* Schrad. of section *Reticulatobulbosa* Kamelin.

Specimens examined: KOREA: GYEONGNAM – Bulmosan, Jinhae, 8 Aug 1977, W.T.Lee 0022896 (KNU); Jaeaksan, Miryang, 6 Aug 1987, S.C.Ko & K.H.Tae 009100 (HNHM); Ganwoljae, Ulju, 10 Aug 2007, ParkSH 73933 (KH); Gyeongpo beach, Busan, 15 Aug 2008, H.J.Choi s.n. (KH).

16. *ALLIUM SPLENDENS* WILLD. EX SCHULT.F., SYST. VEG., ED. 16, 7(2): 1025 (1830). (FIG. 19)

Type: Russia. From Siberia, specimen without collection date and number (holotype: B photograph!).

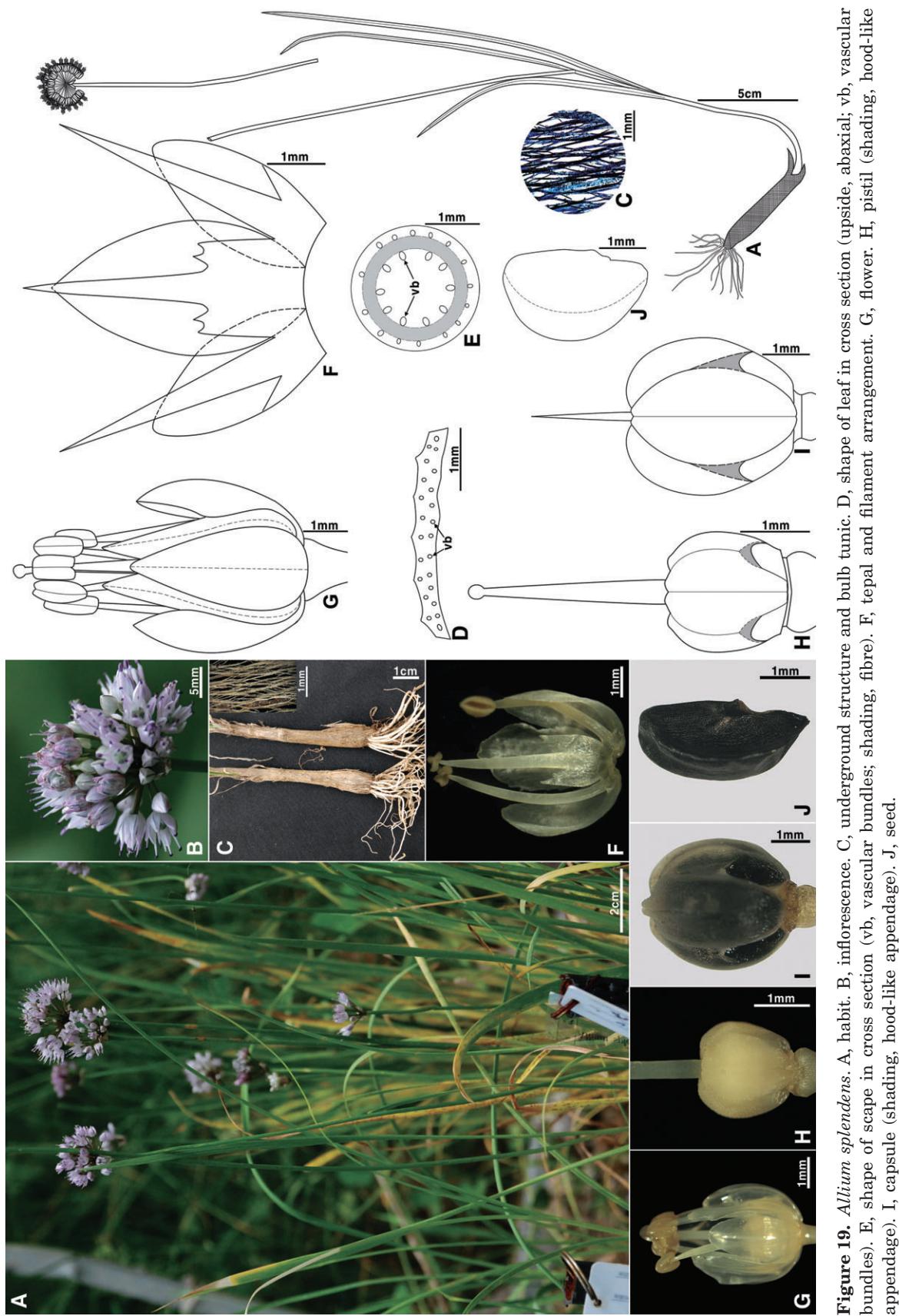
Description: Herbs hermaphroditic. Rhizomes condensed, erect, 3.9–9.3 mm long. Bulbs usually solitary or paired, cylindrically ovoid, without bulbels, 5.0–10.6 mm in diameter; tunics consisting of nearly linear cells, fibrous, reticulate, brown. Leaves two to four; leaf sheaths exposed above ground, 13.5–33.3 cm high, striped green; leaf blades ascending, linear, flat, 16.0–30.5 cm × 1.9–4.7 mm, with two rows of vascular bundles and solid in cross section, sessile at base, acute in apex; leaf epidermal cells with ridged cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 35.2–67.5 cm × 1.5–3.1 mm. Inflorescences umbellate, subglobose, 13.8–24.9 × 15.9–28.8 mm, without bulbils, 25–110 flowered; pedicels terete, subequal in length, 4.0–10.7 mm long, thinner than the scapes; bracts 5.5–8.0 mm long. Flowers bisexual; perianth campanulate, reddish lilac; inner tepals longer than outer ones, ovately elliptical, obtuse at apex, 4.3–4.6 × 1.7–1.9 mm; outer tepals ovately elliptical, obtuse at apex, 3.5–4.3 × 1.3–1.7 mm; filaments slightly exserted, 4.3–4.9 mm long, with two to four teeth (middle part of inner ones) at margin; anthers elliptical, reddish, 1.0–1.2 mm long; ovary obovoid, greenish, with hood-like appendages at base, 1.7–1.8 × 1.6–1.7 mm, ovules two per locule; style terete, exserted; stigma capitate. Capsules ellipsoid, 3.7–4.2 × 3.2–3.5 mm. Seeds elliptical, angular in cross section, 2.9–3.4 × 1.3–2.6 mm.

Chromosome number: $2n = 32$ (Table 1).

Distribution and habitat: Russia (eastern and central Siberia; Far East), Mongolia, China (Nei Mongol; Heilongjiang; Jilin; Liaoning), North Korea and Japan. In forests, shrubs, meadows and moist slopes.

Phenology: Flowering from June to July.

Notes: *Allium splendens* is a rather common species in north-eastern China growing in various habitats. In Korea, however, it is restricted to alpine habitats of



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North Korea, and the previously reported record of this species from South Korea (Yu *et al.*, 1981) has proved to be a misidentification of herbarium specimens, the correct identity of which is *A. koreanum* (Choi *et al.*, 2004a).

Specimens examined: CHINA: HEILONGJIANG – Tahe, 7 July 2007, D.G.Jo *et al.* 070054 (KH); Tahe, 31 July 2008, Y.M.Lee & H.J.Chi s.n. (KH); Shangzi, 15 July 1951, Li *et al.* 86 (PE). JILIN – Seopa, Jangbaeksan, 25 July 2003, B.U.Oh *et al.* 030005 (CBU); Seopa, Jangbaeksan, 13 July 2004, L-60091 (KH); Wangji, Seopa, Jangbaeksan, 4 Sept 2004, Yeongil 13-040904-015 (KH); Jangbaeksan, 10 July 2004, Y.H.Ahn s.n. (KH); Seopa, Jangbaeksan, 7 Sept 2007, H.J.Chi & J.W.Han 070050 (KH); Jangbaeksan, 9 Aug 1986, PB86059 (PE); Hunchun, 17 July 1959, Fu 797 (PE); Wusong, 19 July 1950, M.Noda *et al.* 289 (PE); Huangsongbao, 19 Aug 1959, Yenji 1388 (PE)?, 10 Sept 1959, Tongwha 357 (PE); Jangbaeksan, 31 July 1962, Temperate forest 0409 (PE); Manjiangzhen Tianchi, Haixiaowangchishan, 14 July 1962, Temperate forest 276 (PE); Manjiangzhen Tianchi, 13 July 1962, Temperate forest 254 (PE); Wenbei to Yimianpo, 2 Aug 1959, Jeon 591 (PE).

17. *ALLIUM CONDENSATUM* TURCZ., BULL. SOC.
IMP. NATURALISTES MOSCOU 27(2):
121 (1885). (FIG. 20)

Type: Russia. De Pratis Dauriae inter chailassatui et Sochtui, 1831 (holotype: LE; isotypes: LE!, photographs CBU!).

= *A. jaluanum* Nakai, Bot. Mag. (Tokyo) 27: 214 (1913). *Type:* Korea. Flum. Jalu, Komarov 380 (holotype: TI?).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 6.4–10.9 mm long. Bulbs solitary or clustered, cylindrically ovoid, without bulbils, 8.8–20.0 mm in diameter; tunics consisting of linear cells, thinly leathery, smooth, reddish brown, more or less lustrous. Leaves three to seven; leaf sheaths exposed above ground, 20.7–28.2 cm high, striped green; leaf blades ascending, linear, terete, adaxially channelled, 36–60 cm × 1.7–3.5 mm, with two rows of vascular bundles and solid to hollow in cross section, sessile at base, tapered at apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 30–80 cm × 2.4–2.8 mm. Inflorescences umbellate, globose, 25.8–37.1 × 26.6–36.6 mm, without bulbils, 35–125 flowered; pedicels terete, subequal in length, 7.6–12.1 mm long, thinner than the scapes; bracts 8.8–16.6 mm long.

Flowers bisexual; perianth campanulate, pale yellow; inner tepals longer than outer ones, ovately elliptical, obtuse at apex, 3.9–5.6 × 1.6–2.7 mm; outer tepals ovately elliptical, obtuse at apex, 3–5 × 1.3–2.5 mm; filaments exserted, 5.3–7.8 mm long, entire at margin; anthers elliptical to oblong, yellowish, 1.4–2.1 mm long; ovary ovoid, greenish, with hood-like appendages at base, 2.4–3.0 × 1.8–2.2 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules ellipsoid, trigonous, 4.8–6.1 × 4.1–4.5 mm. Seeds elliptical, angular in cross section, 3.8–5.3 × 1.9–2.3 mm.

Chromosome number: $2n = 16$ (Fig. 3E; Tolgor *et al.*, 1994).

Distribution and habitat: Russia (eastern Siberia; Dauria; Far East), Mongolia, China (Hebei; Nei Mongol; Shandong; Shanxi; Heilongjiang; Jilin; Liaoning) and North Korea (Dumangang region). In rocky slopes and meadows.

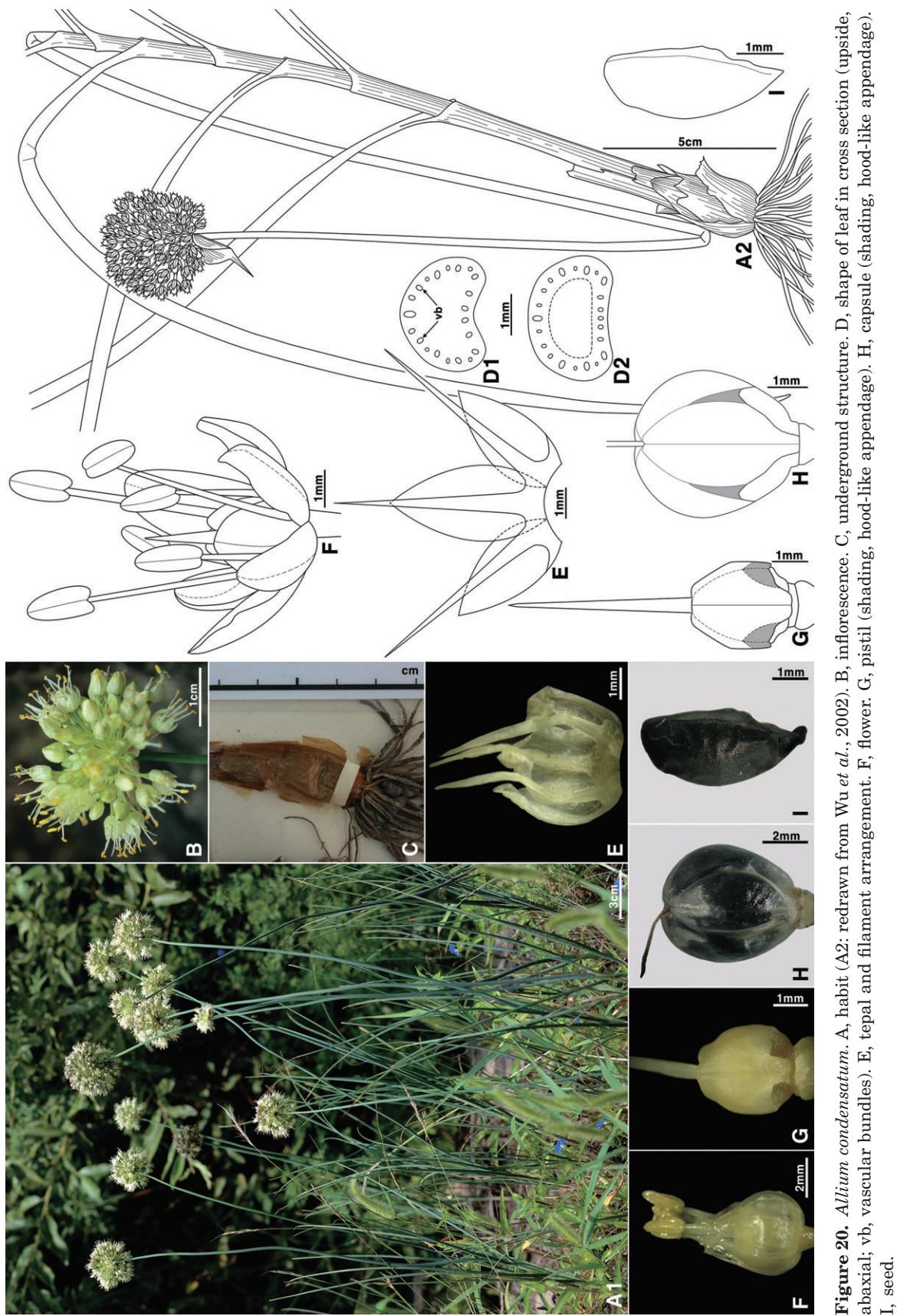
Phenology: Flowering from July to August.

Notes: This species is immediately distinguishable from the other Korean and north-eastern Chinese *Allium* by the combination of whip-like and solid to hollow leaf blades (Fig. 20A, D) with the pale yellow perianth. Populations of *A. condensatum* are infrequent in north-eastern China; however, it is usually locally abundant where it occurs.

Specimens examined: CHINA: HEILONGJIANG – Palryeon, 3 July 2007, B.U.Oh *et al.* s.n. (CBU); Hulunbeiermeng, 27 July 1958, Zhang & Liu 240 (PE); Anda, 30 July 1956, Zhang 365 (PE); Yilanxian, 7 Aug 1959, Zhang 1976 (PE); Ichun, 19 Aug 1963, Li *et al.* 10154 (PE). JILIN – Gunhamsan, Hwaryong, 26 July 2003, B.U.Oh *et al.* 030012 (CBU); Gunhamsan, Hwaryong, 4 Sept 2004, Yeongil 5-040906-004 (KH); Ipbeopsan, Gyoja, 2 Sept 2006, Jilin23-060902-005 (CBU); Beidagang, Zhenganxian, 7 Aug 1959, Baichengzu 14 (PE); Jiaohexian, 7 Sept 1950, Fu 2371 (PE); Chikiawantu, Chingpohu, 17 Aug 1931, H.W.Kung 2128 (PE). LIAONING – Daeheuksan, Daeryeon, 7 July 2007, B.U.Oh *et al.* s.n. (CBU); Daeryeon, 10 Sept 1951, Wang, Fu & Liu 851 (PE).

18. *ALLIUM MAXIMOWICZII* REGEL, TRUDY IMP.
S.-PETERBURGSK. BOT. SADA 3(2):
153 (1875). (FIG. 21)

Type: Russia. River Ussuri by cap Aya, 9 Aug 1855, Maximowicz s.n. (holotype: LE!, photograph CBU!).



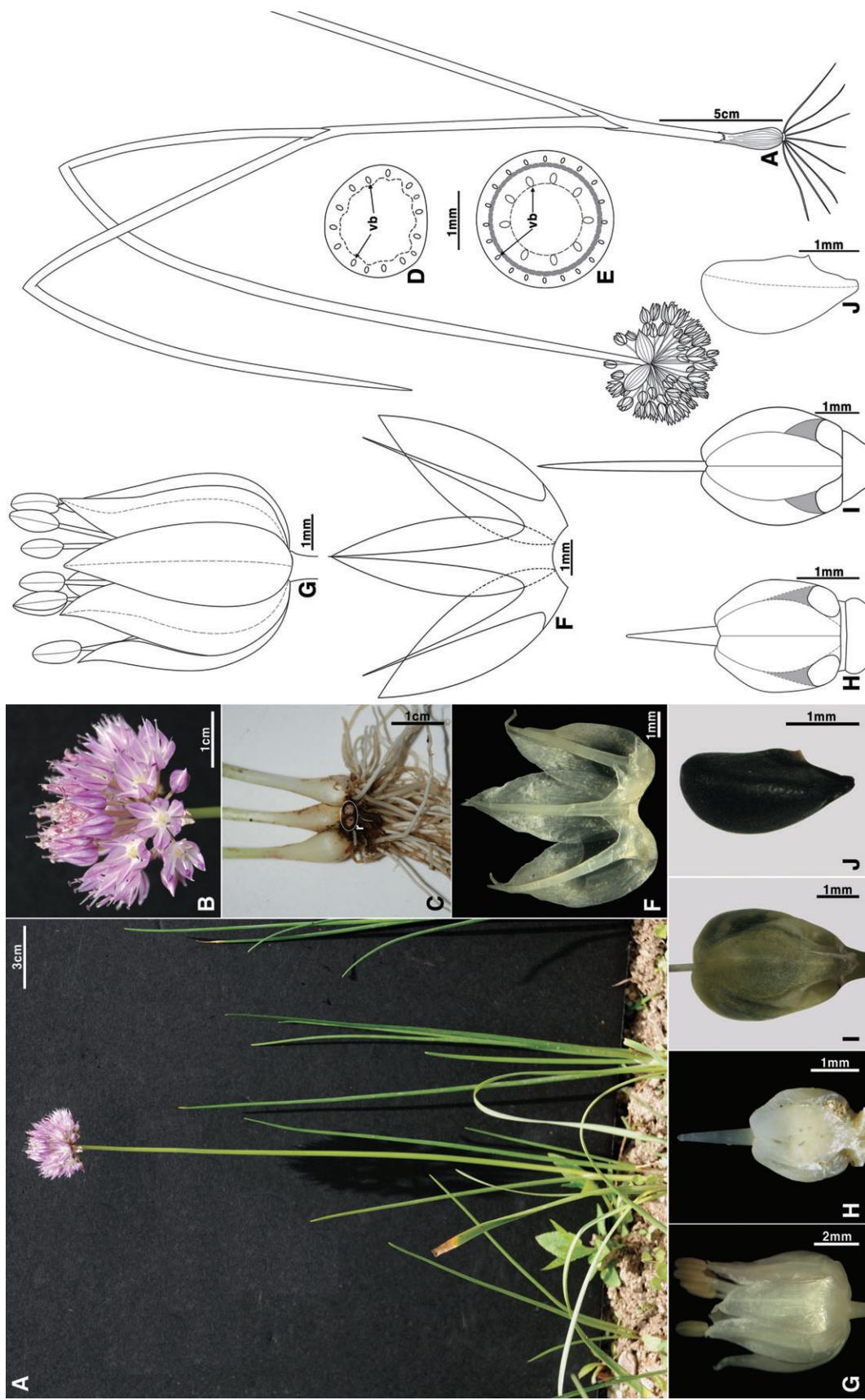


Figure 21. *Allium maximowiczii*. A, habit. B, inflorescence. C, underground structure (r, rhizome). D, shape of leaf in cross section (vb, vascular bundle). E, shape of leaf in cross section (vb, vascular bundle; shaded, fibre). F, leaf and lamina arrangement. G, flower. H, stamens (stamen, filament, anther, pollen). I, capsule (seed, seed appendage). J, seed.

=*A. schoenoprasum* L. var. *orientale* Regel, *Trudy Imp. S.-Peterburgsk. Bot. Sada* 3(2): 97 (1875). Type not traced.

Description: Herbs hermaphroditic. Rhizomes condensed, distinctly oblique, 5.5–11.0 mm long. Bulbs solitary or clustered, cylindrically conical, without bulbels, 6.5–10.6 mm in diameter; tunics consisting of linear cells, papery, brown. Leaves one or two; leaf sheaths exposed above ground, 7.5–48.0 cm high, striped; leaf blades ascending, linear, terete, 15–45 cm × 2.0–6.3 mm, with two rows of vascular bundles and hollow in cross section, sessile at base, tapered at apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, hollow in cross section, 20–85 cm × 3–6 mm. Inflorescences umbellate, subglobose, 21–41 × 34.5–43.5 mm, without bulbils, 25–95 flowered; pedicels terete, subequal in length, 5.3–16.0 mm long, thinner than the scapes; bracts 10–20 mm long. Flowers bisexual; perianth campanulate, reddish pink; inner tepals nearly equal to outer ones, oblong-lanceolate, acute at apex, 6.0–7.5 × 2.2–2.6 mm; outer tepals oblong-lanceolate, acute at apex, 6.0–7.5 × 2.3–2.8 mm; filaments slightly non-exserted, 5.7–7.0 mm long, entire at margin; anthers elliptical, reddish, 1.0–1.3 mm long; ovary ellipsoid, greenish, with hood-like appendages at base, 1.8–2.5 × 1.5–2.0 mm, ovules two per locule; style terete, slightly exserted; stigma smooth. Capsules ellipsoid, 3.0–3.8 × 2.4–2.8 mm. Seeds elliptical, angular in cross section, 2.3–2.7 × 1.0–1.3 mm.

Chromosome number: $2n = 16$ (Friesen, 1995; Xu & Kamelin, 2000).

Distribution and habitat: Russia (eastern Siberia; Far East), Mongolia, China (Nei Mongol; Heilongjiang; Jilin; Liaoning), North Korea (Hambuk; Gwanmobong) and northern to central Japan. In meadows, riversides, forest margins and wetlands.

Phenology: Flowering from July to August.

Notes: This species is easily distinguished from the other Korean and north-eastern Chinese *Allium* by its hollow scapes (Fig. 21E). We believe that the existing records of *A. ledebourianum* in north-eastern China and *A. schoenoprasum* in Korea (Xu & Kamelin, 2000) are all the result of misidentification of herbarium specimens, the identity of which we have verified to be *A. maximowiczii*. Therefore, we propose the exclusion of *A. ledebourianum* and *A. schoenoprasum* from the *Allium* species lists for north-eastern China and Korea, respectively. The currently recognized distribution range of *A. ledebourianum* is restricted to the

Altai region (Friesen, 1987), whereas *A. maximowiczii* is widely distributed in Russia, Mongolia, China, North Korea and Japan (Vvedensky, 1935; Friesen, 1995; Xu & Kamelin, 2000). *Allium schoenoprasum* is not native to Korea (Choi *et al.*, 2004c).

Specimens examined: CHINA: HEILONGJIANG – Near Ergunaqi, 11 July 1951, Wang 1329 (PE); Mohe, 8 July 2007, D.G.Jo *et al.* 070070 (KH); Tahe, 13 Aug 2008, Y.M.Lee & H.J.Chi 080002 (KH); Eerguaqi, 11 July 1951, Wang *et al.* 1329 (PE). JILIN – Fusongxian, 24 July 1950, Wang *et al.* 531 (PE); Jangbaishan, Shanbongryeong, 15 Aug 1986, Hong & Ku FB86073 (PE); ?, s.n. (PE1598711). LIAONING – Fenghuangshan, 12 Sept 1931, H.W.Kung 2273 (PE). KOREA: HAMBUK – Gwanmobong, 18 July 1936, B.S.To 20382 (SNU).

19. *ALLIUM TAQUETII* H.LÉV. *REPRT. SPEC. NOV.* *REGNI VEG.* 5: 238 (1908). (FIG. 22)

Type: Korea. Quelpaert, supra 1200 m, Oct 1906, Faurie 259; Hallaisan 1400 m, Oct 1907, Taquet 385 (syntypes: TI, photographs KWNU!, CBU!).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 2.5–5.5 mm long. Bulbs solitary or clustered, cylindrically ovoid to ovoid, without bulbels, 4.4–10.0 mm in diameter; tunics consisting of linear cells, papery, brown. Leaves two to five; leaf sheaths slightly exposed above ground, 3–10 cm high, striped, sometimes tinged reddish; leaf blades ascending, linear, terete or rarely flat, 10.2–28.0 cm × 0.8–2.4 mm, with two rows of vascular bundles and usually hollow in cross section, sessile and pale green at base, tapered at apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 13.3–36.0 cm × 0.9–2.1 mm. Inflorescences umbellate, subglobose, 10.9–28.5 × 11–30 mm, without bulbils, six to 38 flowered; pedicels terete, subequal in length, 5.0–12.6 mm long, thinner than the scapes; bracts 5.5–8.7 mm long. Flowers bisexual; perianth semi-stellately spreading, reddish purple to purple; inner tepals longer than outer ones, oval, obtuse to rounded at apex, 5.0–5.7 × 3.2–3.6 mm; outer tepals oval, obtuse to rounded at apex, 3.9–4.7 × 2.3–3.5 mm; filaments exserted, 4.5–8.2 mm long, entire or with two small teeth (base part of inner ones) at margin; anthers elliptical, yellowish, 1.6–1.8 mm long; ovary ovoid, greenish, with hood-like appendages at base, 2.3–2.9 × 2.0–2.8 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 5–6 × 5.0–5.1 mm. Seeds oval, flat in cross section, 3.1–4.1 × 2.4–3.0 mm.

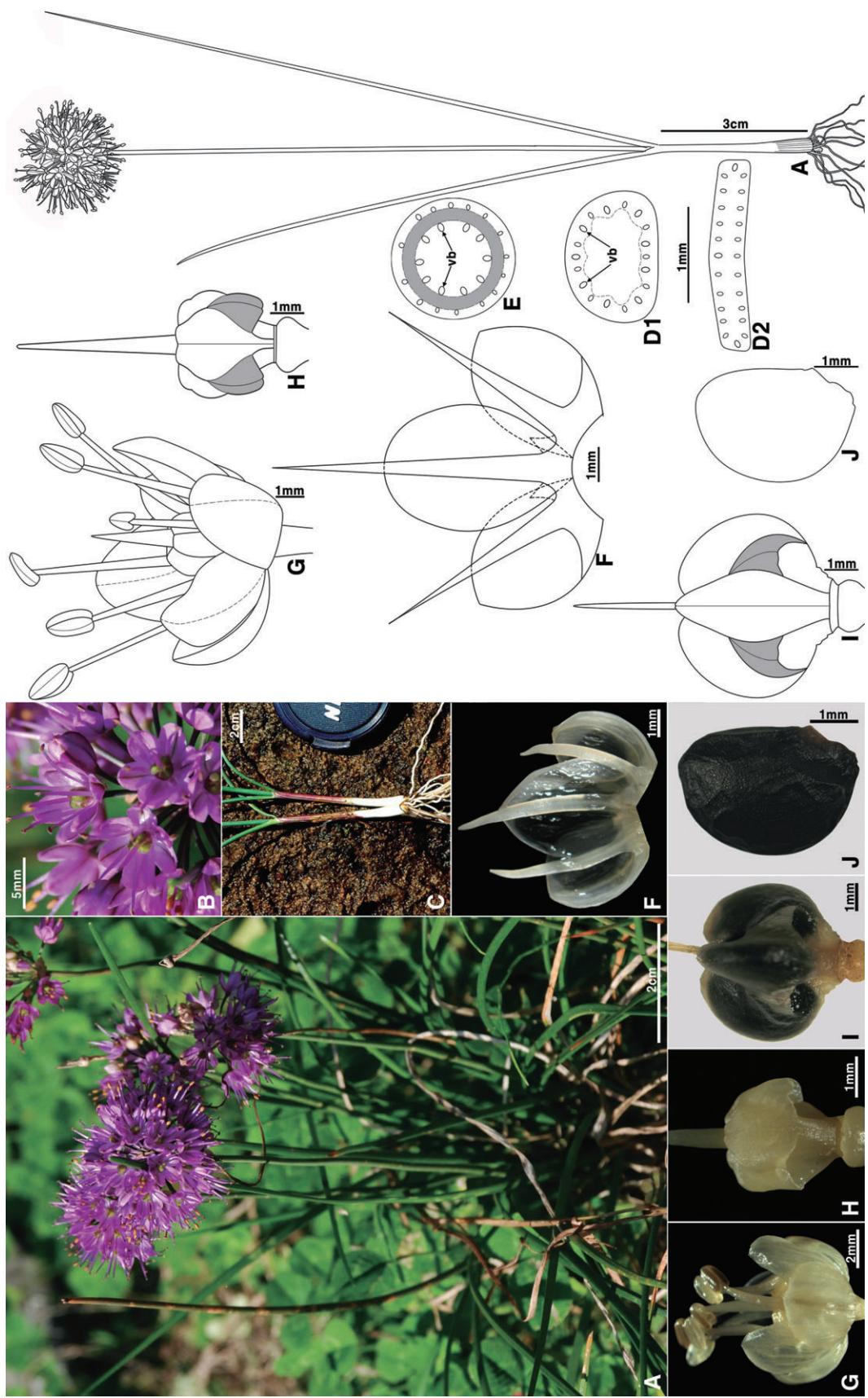


Figure 22. *Allium taquetii*. A, habit. B, inflorescence. C, underground structure. D, shape of leaf in cross section (upside, abaxial; vb, vascular bundle; sb, sclerenchymatous band). E, shape of scape in cross section (vb, vascular bundle; sb, sclerenchymatous band). F, tepal and filament. G, stamen. H, pistil (stigma, hood-like appendage, l, claw-like appendage). I, capsule (slabding, hood-like appendage). J, seed.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Jeju: Hallasan). In sunny slopes and wet meadows, above 900 m.

Phenology: Flowering from September to October.

Notes: Since *A. taquetii* was originally described from Jeju Island, Korea, it has usually been treated as a synonym of *A. cyaneum* Regel and considered to occur in Deogyusan and Jirisan as well as Jeju in Korea (Choi & Oh, 2003). However, *A. taquetii* of section *Sacculiferum* P.P.Gritzenko is clearly different from *A. cyaneum* of section *Sikkimensia* (Traub) N.Friesen by having papery bulb tunics (vs. fibrous), purple perianth (vs. blue) and later flowering season from September (vs. from August); therefore, it is here reinstated as a Korean endemic species distributed only in Hallasan on Jeju (Choi & Oh, 2003; Choi *et al.*, 2004c). In addition, plants from Deogyusan and Jirisan that had been recognized as *A. cyaneum* or *A. taquetii* were recently treated as *A. thunbergii* var. *teretifolium* (Choi *et al.*, 2004a). Thus, the previous records of *A. cyaneum* in Korea (Yu *et al.*, 1981; Xu & Kamelin, 2000) were the result of misidentifications of specimens the identities of which are either *A. taquetii* or *A. thunbergii* var. *teretifolium* (Choi & Oh, 2003; Choi *et al.*, 2004a). The erroneous treatment of *A. taquetii* as a synonym of *A. thunbergii* (Xu & Kamelin, 2000) may have arisen from the misapplication of *A. taquetii* to material from Deogyusan or Jirisan. *Allium taquetii* is closely related with *A. thunbergii*, but the former is well distinguished from the latter by having a dwarf habitus (Fig. 22A and Choi & Oh, 2003: figs 1–4) and more or less stellately spreading perianth of oval tepals (Fig. 22B, G; Choi & Oh, 2003; Choi *et al.*, 2004c). This species is typically described as having terete and hollow leaf blades (Fig. 22D1; Yu *et al.*, 1981; Choi *et al.*, 2004c); however, we discovered an accession (G.H.Nam 06125; Table 1) with flat and solid leaves (Fig. 22D2) in this study. Flat-leaved plants are sporadically distributed among typical populations in Hallasan, Jeju Island.

Specimens examined: KOREA: JEJU – 1100goji seupji, Hallasan, 27 Sept 2002, H.J.Choi *et al.* 020063 (CBU); Yeongsil, Hallasan, 1 Oct 2006, G.H.Nam 06125 (KH); Hallasan, 2 Oct 1983, Kim s.n. (KH); Seongpanak, Hallasan, 31 Aug 2003, ESJeon 32642 (KH); Hallasan, 1 Sept 2003, ESJeon 32681 (KH); Jungmun, Seogwipo, 13 Oct 2005, ESJeon 53313 (KH).

**20. *ALLIUM LINEARIFOLIUM* H.J.CHOI & B.U.OH,
KOREAN J. PL. TAXON. 33(1): 71 (2003). (FIG. 23)**

Type: Korea. Chungbuk, Jecheon, Woraksan, slopes of rocky area, 805–810 m, 36°52'N, 128°06'E, 2 Oct 2002, H.J.Choi *et al.* 2002001 (holotype: CBU!; isotypes: CBU!, KH!; paratypes: CBU!).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 3.1–5.2 mm long. Bulbs solitary or clustered, ovoid, without bulbils, 8–19 mm in diameter; tunics consisting of linear cells, papery, brown, sometimes tinged reddish. Leaves three to 10; leaf sheaths non-exposed above ground, 4.8–13.0 cm high, striped; leaf blades spreading, linear, terete, 19.0–80.5 cm × 1.0–3.8 mm, with two rows of vascular bundles and hollow in cross section, sessile and tinged red at base, tapered at apex; leaf epidermal cells with beaded cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 23.2–45.1 cm × 0.9–2.2 mm. Inflorescences umbellate, subglobose, 20.0–48.2 × 30.0–51.8 mm, without bulbils, six to 89 flowered; pedicels terete, subequal in length, 7–20 mm long, thinner than the scapes; bracts 5.1–10.2 mm long. Flowers bisexual; perianth campanulate, purple to dark purple; inner tepals longer than outer ones, oval, obtuse to rounded at apex, 5.5–6.1 × 3.1–4.0 mm; outer tepals oval, obtuse to rounded at apex, 4.5–5.3 × 2.3–3.0 mm; filaments exserted, 5.1–11.0 mm long, entire or with two small teeth (base part of inner ones) at margin; anthers elliptical, yellowish, 1.7–1.8 mm long; ovary obovoid, greenish, with hood-like appendages at base, 2.6–4.0 × 2.4–3.5 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.5–5.4 × 4.8–6.1 mm. Seeds oval, flat in cross section, 2.8–4.2 × 1.9–3.0 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Chungbuk: Woraksan; Gyeongbuk: Hwangjansan). In sunny slopes of rocky mountains, above 700 m.

Phenology: Flowering from September to October.

Notes: This species is easily distinguished from its close relative, *A. thunbergii* by its conspicuously long (mean 43.2 cm) and markedly spreading, terete leaf blades (Fig. 23A, D and Choi & Oh, 2003: figs 1–5). Various populations of *A. linearifolium* have been observed in the Woraksan National Park and neighbouring areas of South Korea.

Specimens examined: KOREA: CHUNGBUK – Woraksan, Danyang, 22 Oct 2005, Danyang-gun(Woraksan)-

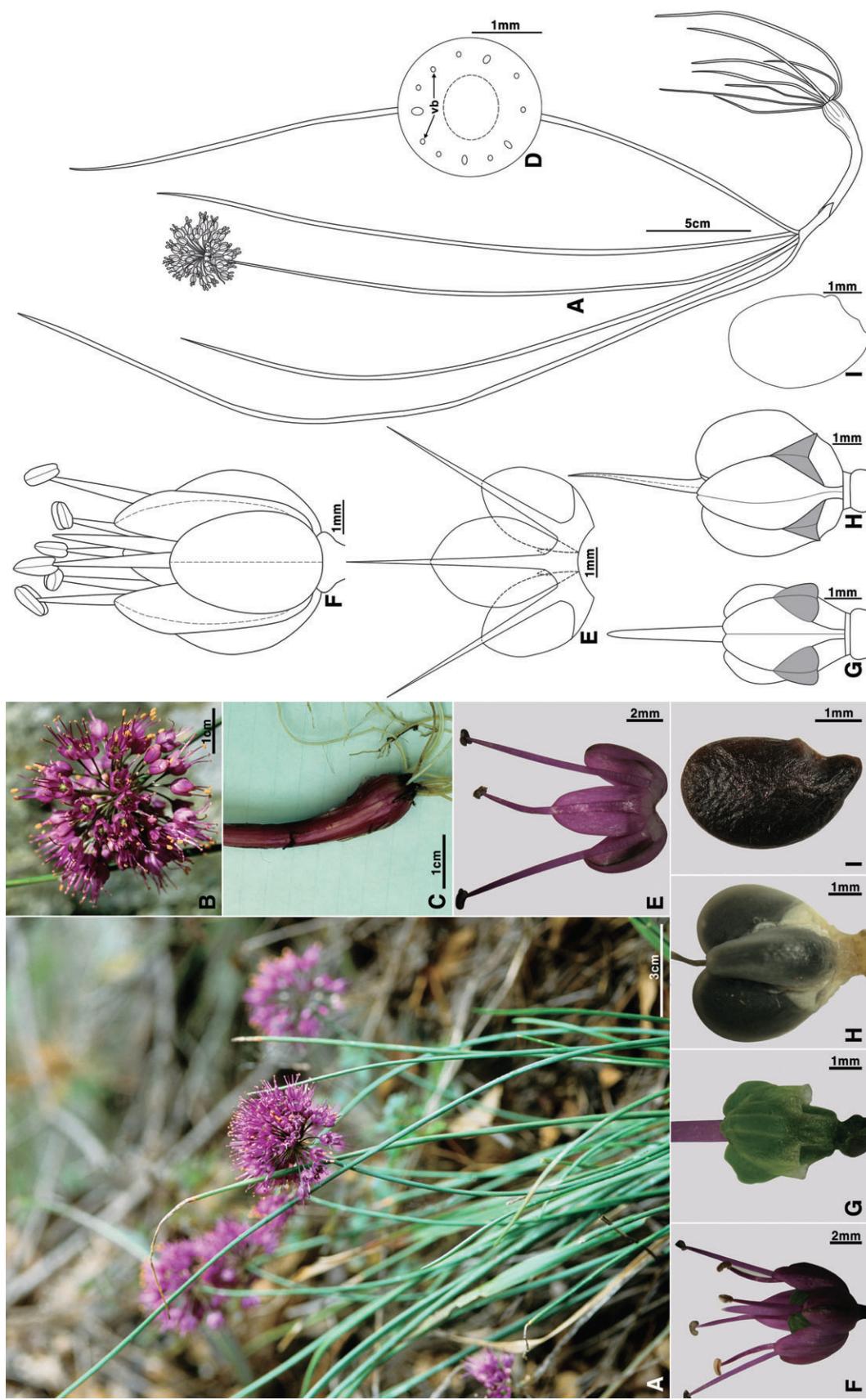


Figure 23. *Allium linearifolium*. A, habit; B, flower; C, inflorescence; D, under-ground structure; E, leaf and rhizome; F, flower; G, pistil (shading, hood-like appendage); H, capsule (shading, hood-like appendage); I, seed. E, leaf and rhizome, arrangement; F, flower; G, pistil (shading, hood-like appendage). H, capsule (shading, hood-like appendage). I, seed.

051022-040 (KH); Yeongbong, Woraksan, Jecheon, 22 Oct 2005, O 355 (KH); Yeongbong, Woraksan, Jecheon, 6 Oct 2005, ESJeon 53219 (KH). GYEONGBUK – Hwangjangsan, Mungyeong, 2 Oct 2006, Mungyeong-si(Woraksan)-061002-004 (KH).

**21. ALLIUM THUNBERGII G.DON, MEM. WERN. SOC.
6: 84 (1827). (FIG. 24)**

Type: China and Cochinchina (location in doubt). Without locality, type specimen not designated (protologue).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 2.2–6.3 mm long. Bulbs solitary or clustered, ovoid, without bulbels, 5–16 mm in diameter; tunics consisting of linear cells, papery, brown. Leaves two to five; leaf sheaths non-exposed above ground, 3.1–14.0 cm high, striped green; leaf blades ascending or curved, linear, flat, triangular or terete, 10.0–49.5 cm × 1.0–8.4 mm, with two rows of vascular bundles and solid or hollow in cross section, sessile and pale green at base, tapered to acute at apex; leaf epidermal cells with smooth or beaded cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 15.7–48.0 cm × 0.8–2.7 mm. Inflorescences umbellate, subglobose, 15.0–45.8 × 19.6–48.7 mm, without bulbils, more or less laxly six to 78 flowered; pedicels terete, subequal in length, 7.0–19.3 mm long, thinner than the scapes; bracts 3.9–8.5 mm long. Flowers bisexual; perianth campanulate, purple to dark purple; inner tepals longer than outer ones, ovately elliptical to oval, obtuse to rounded at apex, 5.1–6.4 × 2.8–3.9 mm; outer tepals elliptical to oval, obtuse to rounded at apex, 4.5–5.8 × 2.1–3.0 mm; filaments exserted, 5–10 mm long, entire or with two small teeth (base part of inner ones) at margin; anthers elliptical, yellowish, 1.6–2.0 mm long; ovary obovoid, greenish, with hood-like appendages at base, 2.6–3.8 × 2.3–3.0 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.1–5.5 × 4.7–5.8 mm. Seeds oval, flat in cross section, 3.4–4.1 × 2.0–2.9 mm.

Distribution: China, Taiwan, Korea (except Jeju) and Japan.

Notes: Varieties were considered when a group of organisms with characters of gradual variation were observed, which would indicate an incomplete segregation of the incipient species sharing the same geographical area. We followed the Suttil & Allen (1992) concept of variety used when the taxon is poorly differentiated and the variation is mostly ecotypical, not geographical.

Allium thunbergii is a very variable species, which can be divided into three varieties in Korea and north-eastern China. They can be separated using the following key.

**21A. ALLIUM THUNBERGII G.DON VAR. THUNBERGII
(FIG. 24A, C, D3–5, E–J)**

= *A. odorum* Thunb. *Fl. Jap.* 132 (1784), non L. Type not traced.

= *A. morrisonense* Hayata, *Icon. Pl. Formos.* 6, Suppl: 84 (1917). ≡ *A. bakeri* Regel var. *morrisonense* (Hayata) T.S.Liu & S.S.Ying, *Fl. Taiwan.* 5: 45 (1978). Type not traced.

= *A. stenodon* Nakai & Kitag., *Rep. 1st. Sci. Exp. Manch.* 4(1): 18 (1934). **Type:** Korea. In monte Wu-ling-shan, 2 Sept 1933, N.H.K. s.n. (holotype: TI?)

Description: Rhizomes 2.3–6.3 mm long. Bulbs 5.3–16.0 mm in diameter. Leaves three to five; leaf sheath 3.1–13.5 cm high; leaf blades curved, nearly flat, 11.5–49.5 cm × 1.1–8.4 mm, solid in cross section, tapered to acute at apex; leaf epidermal cells with smooth cuticles. Scapes 22.4–48.0 cm × 0.8–2.7 mm. Inflorescences 15.0–45.8 × 19.6–48.7 mm, seven to 78 flowered; pedicels 7.0–19.3 mm long; bracts 4.2–8.0 mm long. Inner tepals 5.1–6.1 × 2.8–3.6 mm; outer tepals 4.5–5.0 × 2.1–2.9 mm; filaments 5–10 mm long; anthers 1.6–2.0 mm long; ovary 3.0–3.8 × 2.5–2.7 mm. Capsules 4.1–5.5 × 4.7–5.8 mm. Seeds 3.4–4.1 × 2.0–2.9 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: China (Hebei; Henan; eastern Hubei; Jiangsu; southern Shaanxi; Shandong; Shanxi; eastern Nei Mongol; Heilongjiang; Jilin; Liaoning), Taiwan, Korea (except Jeju) and Japan. In sunny slopes of rocky mountains.

KEY TO THE VARIETIES OF *ALLIUM THUNBERGII* IN KOREA AND NORTH-EASTERN CHINA

- | | |
|--|-----------------------------|
| 1. Leaf blades flat, solid in cross section..... | a. var. <i>thunbergii</i> |
| 1*. Leaf blades angular or terete, hollow in cross section..... | 2 |
| 2. Leaf blades curved, angular, epidermal cells with smooth cuticles..... | b. var. <i>deltoides</i> |
| 2*. Leaf blades ascending, terete, epidermal cells with beaded cuticles..... | c. var. <i>teretifolium</i> |

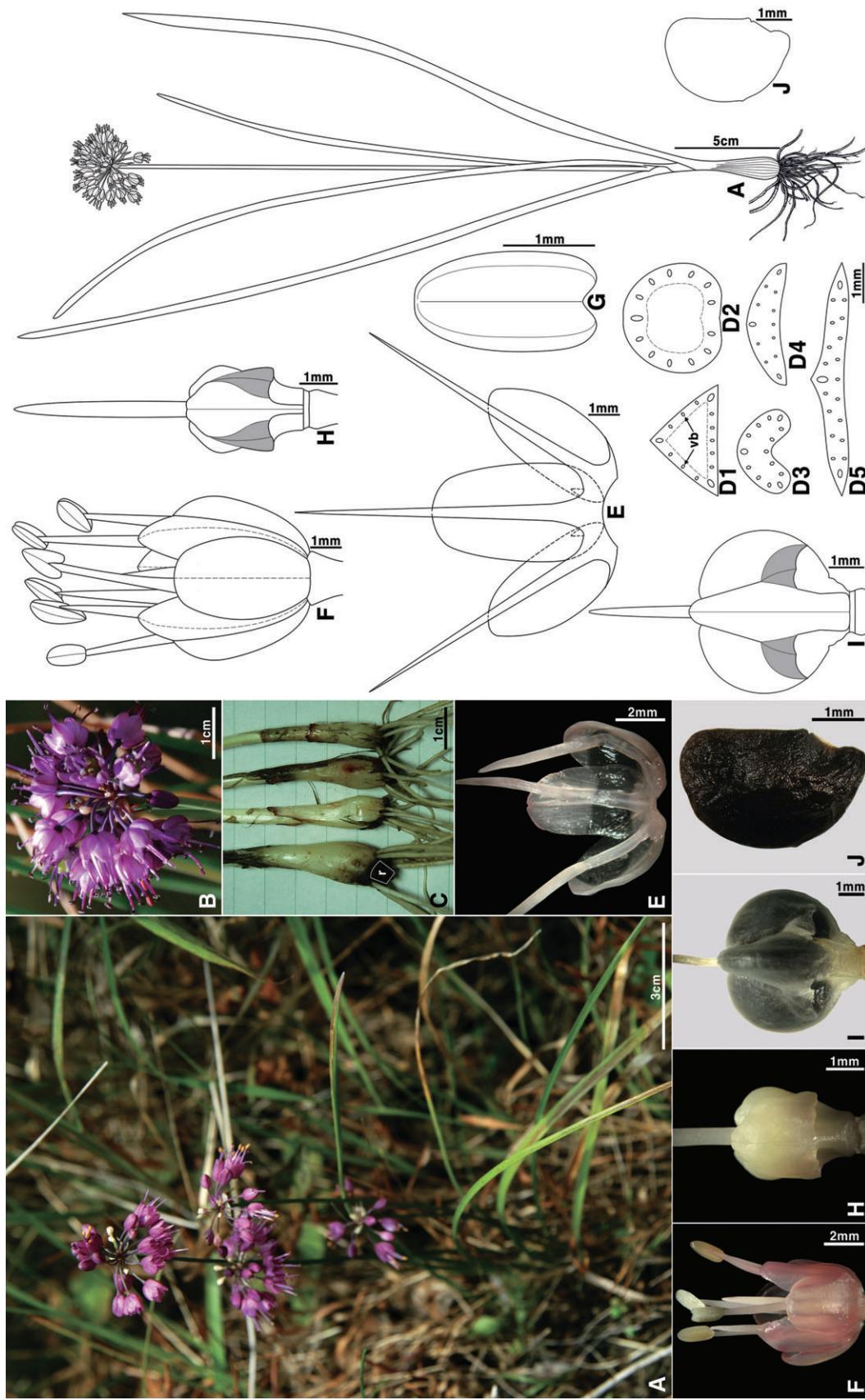


Figure 24. *Allium thunbergii* var. *thunbergii* (A, C, D3–5, E–J), var. *deltoides* (B, D2). A, habit. B, inflorescence. C, rhizome. D, shape of leaf in cross section (a, axial; b, vascular bundles). E, tepal and filament arrangement. F, flower. G, anther. H, pistil (stigma, hood-like appendage). I, capsule (shading, blood-like appendage). J, seed.

Phenology: Flowering from late August to October in north-eastern China and September to October in Korea.

Notes: This typical variety of *A. thunbergii* is relatively common in Korea and north-eastern China together with *A. sacculiferum* Maxim. It is characterized by the combination of nearly flat leaf blades growing curved (Fig. 24D3–5; Choi & Oh, 2003: figs 1–3), condensed leaf sheaths that are non-exposed above ground (Fig. 24A) and relatively short scapes (*c.* 7.4 cm in the protologue). In addition, *A. thunbergii* var. *thunbergii* proved to be diploid in chromosome number ($2n = 2x = 16$) together with var. *deltoides*, var. *teretifolium* and *A. longistylum*, whereas its relatives, *A. sacculiferum* (except *H.J.Choi & Y.Y.Kim 010011*; see ‘Notes’ for *A. sacculiferum* below) and *A. pseudojaponicum*, were tetraploid ($2n = 4x = 32$) (Table 1).

Specimens examined: CHINA: HEILONGJIANG – Saertu,?, Chang et al. 751 (PE); Saertu, Andal, 13 Sept 1951, Cho 751 (PE). JILIN – Dafangtun to Wusongyan, 14 Sept 1959, Tongwha 284 (PE). KOREA: GANGWON – Hyangrobong, Inje, 3 Oct 2000, S-1921 (KH); Geonbongsan, Inje, 4 Oct 2000, Gwang 10749 (KH); Mangyeongbong, Taebaeksan, Taebaek, 10 Sept 2002, Oh et al. s.n. (KH); Osaek to Daecheongbong, Seoraksan, Yangyang, 4 Sept 2006, NGH 60700 (KH); Misiryeong, Seoraksan, 23 Sept 2001, H.J.Choi et al. 010017 (CBU); Yukdam falls, Seoraksan, 31 Aug 2001, B.U.Oh et al. 010018 (CBU); Daecheongbong to Jungcheongbong, Sokcho, 25 Sept 2002, ParkSH 23948 (KH); Hangyeryeong, Sokcho, 9 Oct 2001, ParkSH s.n. (KH); Gongjaksan, Hongcheon, 4 Sept 1979, W.T.Lee 0022841 (KNU); Garisan, 2 Oct 1977, W.T.Lee 0022835 (KNU); Yonghwasan, 8 Sept 1976, B.G.Yoon 0022827 (KNU); Gachilbong, 26 Sept 1987, W.T.Lee 0022861 (KNU); Jeongkoksan, Yangyang, 11 Oct 1987, W.T.Lee 0022866 (KNU); Jeombongsan, 23 Sept 1998, J.S.Chang s.n. (SNUA); Daeryongsan, Chuncheon, 13 Sept 2002, ESJeon s.n. (KH); Yonghwasan, Hwacheon, 8 Sept 2002, L-60626 (KH); Deoghangsan, Samcheok, 24 Sept 2005, KTAPS 20050825 (KH); Seonam village, Yeongwol, 15 Sept 2006, ESJeon 61605 (KH). GYEONGGI – Bukhansan, Seoul,?, W.T.Lee 0022851 (KNU); Gwanaksan, Seoul, 17 Oct 1966, T.B.Lee & M.Y.Cho 9303 (SNUA); Manisan, Ganghwado, Incheon, 13 Oct 2002, H.J.Choi & Y.Y.Kim 020066 (CBU); Cheonbosan, Uijeongbu, 31 Aug 2001, ESJeon s.n. (KH); Suraksan, Uijeongbu, 4 Oct 2003, ParkSH 32728 (KH); Yongmunsan, Yangpyeong, 30 Sept 2002, Y.Y.Kim 020065 (CBU); Cheonmasan, Namyangju, 8 Sept 1978, J.G.Ham 0022837 (KNU); Gwangneung, Sept 1957, T.B.Lee s.n. (SNUA); Chilbosan, 12 Oct 1966, T.B.Lee

& M.Y.Cho 9270 (SNUA); Myeonjisan, Gapyeong, 14 Aug 1997, KSS & LYM s.n. (KH); Gamaksan, Yangju, 20 Oct 2007, SemyeongUni-729 (KH); Haehyeopsan, Gwangju, 12 Oct 2007, HNBM-B-301 (KH); Guksabong, Seongnam, 16 Oct 2007, HNBM-B-275 (KH); Chungnyeongsan, Namyangju, 3 Sept 1998, S-0831 (KH). CHUNGBUK – Geumsusan, Danyang, 30 Sept 2006, Danyang-gun(Woraksan)-060930-004 (KH); Guksabong, Danyang, 4 Oct 2001, ESJeon s.n. (KH); Munsubong, Songnisan, 28 Sept 2001, H.J.Choi 010019 (CBU); Songnisan, Boen, 11 Oct 2002, L-60044 (KH); Domyeongsan, Goesan, 16 Oct 2002, H.J.Choi s.n. (CBU); Gunjasan, Goesan, 17 Oct 2001, ParkSH s.n. (KH); Mayeokbong, Woraksan, Jecheon, 16 Sept 2006, Chungju-si(Woraksan)-060916-002 (KH). CHUNGNAM – Seodaesan, Geumsan, 3 Oct 2002, Y.Y.Kim et al. 020067 (CBU); Chilgapsan, Cheongyang, 17 Oct 2004, ESJeon 42771 (KH). JEONBUK – Sebong, Buan, 8 Oct 2004, Buan-gun(Sebong)-041008-036 (KH); Naejangsan, Jeongeup, 8 Oct 2004, Jeongeup(Naejangsan)-041008-433-2 (KH). JEONNAM – Bonghwangsan, Dolsando, Yeosu, 10 Oct 2003, ESJeon 33244 (KH); Heuksando,?, W.T.Lee 0022850 (KNU); Wolchulsan,?, W.T.Lee 0022847 (KNU); Baekunsan, Gwangyang, 5 Aug 2003, Yeosu 2-30508-064-1 (KH); Gubonghwasan, Gwangyang, 8 Oct 2004, Gwangyang-si(Gubonghwasan)-041008-085 (KH); Palyeongsan, Goheung, 28 Sept 2003, Goheung 2-030928-021 (KH). GYEONGBUK – Juheulsan, 4 Oct 1985, S.C.Ko & I.T.Im 003840 (HNHM); Biseulsan, 13 Sept 1958, S.Y.Oh s.n. (KNU); Geumosan, 16 Sep, 1999, J.H.Kim s.n. (CBU); Guksabong, Yeocheon, 25 Sept 2006, Yeocheon-gun(Guksabong)-060925-003 (KH). GYEONGNAM – Georyongsan, Geoje, 23 Oct 2004, J.O.Hyun & H.K.Park 2004231 (KH); Gajasan, Geoje, 23 Oct 2004, J.O.Hyun & H.K.Park 2004228 (KH); Bango, Ulsan, 2 Nov 2007, ParkSH 71927 (KH).

21B. *ALLIUM THUNBERGII* G.DON VAR. *DELTOIDES* (S.YU, W.LEE & S.LEE) H.J.CHOI & B.U.OH, KOREAN J. PL. TAXON. 33(4): 351 (2003). (FIG. 24D1)

Basionym: *A. cyaneum* Regel var. *deltoides* S.Yu, W.Lee & S.Lee, Korean J. Pl. Taxon. 11: 29 (1981). **Type:** Korea. Gyeongnam, Gayasan, grassland and soil on the rocks *c.* 1300–1400 m, along the trail to the peak, Yoo 5920 (holotype: Wonkwang University herbarium; isotypes: KNU!, JNU, SNU).

Description: Rhizomes 2.2–5.1 mm long. Bulbs 5.0–11.5 mm in diameter. Leaves two to five; leaf sheath 4.1–14.0 cm high; leaf blades curved, triangular, 10.0–45.5 cm × 1–3 mm, hollow in cross section, tapered at apex; leaf epidermal cells with smooth cuticles. Scapes

20.2–35.0 cm × 0.8–1.5 mm. Inflorescences 17.0–29.9 × 23.3–43.2 mm, six to 45 flowered; pedicels 7.1–13.0 mm long; bracts 3.9–8.5 mm long. Inner tepals 5.8–6.3 × 3.2–3.9 mm; outer tepals 4.8–5.2 × 2.5–2.9 mm; filaments 7.0–9.5 mm long; anthers 1.6–1.9 mm long; ovary 2.6–3.8 × 2.3–3.0 mm. Capsules 4.2–5.3 × 4.9–5.8 mm. Seeds 3.5–3.7 × 2.4–2.7 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Gyeongnam: Gayasan). In sunny and rocky slopes of high mountains, above 1300 m.

Phenology: Flowering from September to October.

Notes: This taxon was originally described as a variety of *A. cyaneum* by Yu *et al.* (1981). However, this led to a taxonomic problem because *A. cyaneum* (section *Sikkimensia*) is not taxonomically related to this variety (section *Sacculiferum*) as now understood. Yu *et al.* (1981) had misidentified *A. taquetii* as *A. cyaneum*, which is not found in Korea (Xu & Kamelin, 2000; Choi & Oh, 2003; Choi *et al.*, 2004c; see 'Notes' for *A. taquetii* above). In addition, the closest relative of var. *deltoides* is not *A. taquetii*, but *A. thunbergii* with respect to phytogeography and general morphology, including shape and growing pattern of the leaf, inflorescence size and perianth shape, as well as karyotype (Choi & Oh, 2003; Ko *et al.*, 2009). Indeed, it is distinguishable from typical *A. thunbergii* only by its triangular and hollow leaf blades (Fig. 24D1). Consequently, this taxon was renamed as *A. thunbergii* var. *deltoides* by Choi & Oh (2003). It has a restricted distribution, which is one of the important conditions for recognizing infraspecific taxa (Radford *et al.*, 1974): it is found so far only in the type locality (Gayasan) and neighbouring areas.

Specimens examined: KOREA: GYEONGNAM – Gayasan, Hapcheon, 21 Oct 2001, H.J.Choi & Y.Y.Kim s.n. (CBU); Gayasan, Hapcheon, 23 Sept 2003, H.J.Choi 030007 (CBU); Gayasan, Hapcheon, 2 Sept 1991, W.T.Lee *et al.* 0022799 (KWNU); Sangwangbong, Gayasan, Seongju, 26 Oct 2001, ESJeon s.n. (KH); Gayasan, Hapcheon, 20 Oct 2005, ESJeon 53516 (KH).

21C. *ALLIUM THUNBERGII* G.DON VAR.
TERETIFOLIUM H.J.CHOI & B.U.OH, *KOREAN J. PL. TAXON.* 34(2): 79 (2004). (FIG. 24B, D2)

Type: Korea. Jeonbuk, Muju, Deogyusan, Hyangjeokbong, slope of rocky area, 1600–1610 m, 7 Oct 2002, H.J.Choi 020068 (holotype: CBU!; isotypes: CBU!, KH!).

= *A. thunbergii* var. *teretifoliosum* H.J.Choi & B.U.OH, *Korean J. Pl. Taxon.* 39(3): 179 (2009), nom. superfl. Type: same as *A. thunbergii* G.Don var. *teretifolium* H.J.Choi & B.U.OH.

Description: Rhizomes 2.3–5.0 mm long. Bulbs 6.0–10.7 mm in diameter. Leaves two to five; leaf sheath 4.5–13.8 cm high; leaf blades ascending, terete, 17.7–45.5 cm × 1.2–3.1 mm, hollow in cross section, tapered at apex; leaf epidermal cells with beaded cuticles. Scapes 15.7–38.7 cm × 1.0–2.1 mm. Inflorescences 18.0–29.8 × 20.6–41.6 mm, eight to 43 flowered; pedicels 8.4–14.9 mm long; bracts 4.1–8.3 mm long. Inner tepals 5.9–6.4 × 3.4–3.8 mm; outer tepals 5.0–5.8 × 2.5–3 mm; filaments 7.5–9.8 mm long; anthers 1.6–1.8 mm long; ovary 3.3–3.7 × 2.5–3.0 mm. Capsules 4.2–5.5 × 4.8–5.7 mm. Seeds 3.5–3.8 × 2.4–2.7 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: Endemic to Korea (Jeonbuk: Deogyusan; Jeonnam: Jirisan; Gyeongnam: Jirisan). In sunny and rocky slopes of high mountains, above 1500 m.

Phenology: Flowering from September to October.

Notes: This taxon has frequently been misidentified as *A. cyaneum* with *A. taquetii* in Korea (Choi *et al.*, 2004a; see 'Notes' for *A. taquetii* above). However, Choi *et al.* (2004a) described it as a variety of *A. thunbergii* based on phytogeography and morphological characters such as shape and size of the perianth. Ko *et al.* (2009) also confirmed it as belonging to *A. thunbergii* instead of *A. taquetii* by means of karyotype analyses. This variety is easily distinguished from its relatives, var. *thunbergii* and var. *deltoides* by terete and hollow leaf blades (Fig. 24D2). Various populations of *A. thunbergii* var. *teretifolium* have been observed in two localities of South Korea, one in the Deogyusan National Park (type locality) and one in the Jirisan National Park.

Specimens examined: KOREA: JEONBUK – Deogyusan,?, W.T.Lee 0022801 (KWNU); Deogyusan,?, s.n. (KNM); Deogyusan, Muju, 21 Oct 2005, ESJeon 53532 (KH); Deogyusan, Muju, 8 Sept 2002, J.H.Kim *et al.* 2002-0383 (KH). JEONNAM – Jirisan,?, W.T.Lee 0022802 (KWNU); Nogodan to Banyabong, Jirisan, 29 Sept 1966, T.B.Lee & M.Y.Cho s.n. (SNUA). GYEONGNAM – Jungbong, Jirisan, 1 June 2007, C.S.Jang 49475 (CBU); Jungbong, Jirisan, 1 Oct 2008, H.J.Choi s.n. (KH).

22. *ALLIUM LONGISTYLOM* BAKER, J. BOT.

12: 294 (1874). (FIG. 25)

Type: China. Hubei (holotype: BM, probably destroyed).

= *A. jeholense* Franch., *Nouv. Arch. Mus. Hist. Nat.*, II, 7: 113 (1884). Type not traced.

= *A. hopeiense* Nakai, *J. Jap. Bot.* 19(11): 316 (1943). *Type*: China. Hebei, in monte Xiao-Wu-Tai-Shan, Aug 1938, *Takenaka-Yo* 187 (holotype: TI?).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 2.2–7.0 mm long. Bulbs solitary or clustered, cylindrically ovoid, without bulbels, 5.0–13.5 mm in diameter; tunics consisting of linear cells, papery, brown. Leaves three to five; leaf sheaths exposed above ground, 5.1–16.0 cm high, striped green; leaf blades curved, linear, terete, 10.5–41.0 cm × 1.0–3.6 mm, with two rows of vascular bundles and hollow in cross section; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 21.5–54.5 cm × 1.1–2.5 mm. Inflorescences umbellate, subglobose, 10.6–36.0 × 29.9–37.0 mm, without bulbils, 11–82 flowered; pedicels terete, subequal in length, 7.0–15.6 mm long, thinner than the scapes; bracts 4.9–10.1 mm long. Flowers bisexual; perianth campanulate, reddish purple to purple; inner tepals longer than outer ones, ovately elliptical, obtuse at apex, 5.4–6.5 × 2.6–3.3 mm; outer tepals elliptical, obtuse at apex, 4.2–5.0 × 2.0–2.5 mm; filaments exserted, 8.0–9.5 mm long, entire or with two small teeth (base part of inner ones) at margin; anthers elliptical, yellowish, 1.6–1.7 mm long; ovary obovoid, greenish, with hood-like appendages at base, 3.0–3.4 × 2.5–2.8 mm. Capsules cordiform, trigonous, 5.4–5.5 × 4.8–5.0 mm. Seeds oval, flat in cross section, 3.0–3.9 × 2.0–2.6 mm.

Chromosome number: $2n = 16$ (Table 1).

Distribution and habitat: China (Hebei; Nei Mongol; Shanxi) and Korea (Gangwon: Hwacheon, Jeongseon; Gyeonggi: Paju, Yeouju, Yeoncheon; Chungbuk: Danyang). In slopes, plains and sunny meadows of riversides.

Phenology: Flowering from September to October.

Notes: *Allium longistylum* had been known to be distributed only in China (Hebei, Nei Mongol and Shanxi; Xu & Kamelin, 2000), but Choi, Jang & Oh (2003) also reported it from the central part of Korea. This species is morphologically similar to *A. thunbergii* var. *teretifolium*, but the former can be distinguished by the combination of leaf sheaths exposed

above ground with leaf blades growing curved (Choi & Oh, 2003: figs 1–6). In addition, although they share terete and hollow leaf blades, the former have smooth cuticular layers on the epidermal cells contrary to the latter with the clearly beaded type (Choi *et al.*, 2004b).

Specimens examined: CHINA: HUBEI – Beijing, 1 Oct 2007, KH-hubei-021 (KH). KOREA: GANGWON – Bukhangang, Hwacheon, 8 Oct 2002, B.U.Oh *et al.* 020038 (CBU); Hwacheon, 27 Sept 1994, ParkGW s.n. (KH); Donggang, Jeongseon, 1 Oct 2007, E.S.Jeon & H.J.Chi 070001 (KH). GYEONGGI – Hantangang, 23 Oct 1974, T.B.Lee 4294 (SNUA); Hantangang, Yeoncheon, H.J.Chi s.n. (KH); Imjingang, Paju?, H.J.Chi s.n. (CBU); Silreuksa, Yeouju, 5 Oct 2004, ESJeon 42525 (KH). CHUNGBUK – Gagok, Danyang, 2 Nov 2004, ESJeon 42875 (KH).

23. *ALLIUM SACCULIFERUM* MAXIM., PRIM. FL.
AMUR. 281 (1859). (FIG. 26)

Type: Russia. On south Amur, one day travel over the Chinganskoi Piket, 21 Aug 1856, K.I.Maximowicz s.n. (lectotype: LE!, designated by N. Friesen, 8 Aug 1996, photograph CBU!).

= *A. japonicum* Regel, *Trudy Imp. S.-Peterburgsk. Bot. Sada* 3(2): 133 (1875), nom. illeg. Type not traced.

= *A. ophiopogon* H.Lév., *Repert. Spec. Nov. Regni Veg.* 12: 184 (1913). *Type*: Korea. Quelpaert, in Parva insula Mounseum, in herbidis, 9 Aug 1911, Taquet 5213 (lectotype: TI!, here designated, photographs: KWNU!, CBU!).

= *A. komarovianum* Vved., *Bull. Univ. As. Centr.* 19: 119 (1934). *Type*: Russia. By village Faddeevka on the river Suifun, 11 Sept 1931, V.L.Komarov s.n. (holotype: LE!, photograph: CBU!).

= *A. yuchuanii* Y.Z.Zhao & J.Y.Chao, *Acta Sci. Nat. Univ. Intramongolicae* 20: 241 (1989). Type not traced.

= *A. sacculiferum* Maxim. var. *viviparum* Sakata, *Bull. Nat. Sci. Mus. Tokyo* 7: 16 (1938). *Type*: Japan. Keiki, pede Reikisan, Suigen, 6 Oct 1935, T.Sakata s.n. (holotype: TI?).

= *A. deltoidefistulosum* S.Yu, W.Lee & S.Lee, *Korean J. Pl. Taxon.* 11: 30 (1981). *Type*: Korea. Jeonbuk, Namwon, Unbong, wet open grassland around pine forest at 600 m c. 800 m toward Segeolsan of Gongan, Yoo 6012 (lectotype: KWNU!, here designated; isolectotypes: KWNU!, JNU?, SNU?).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 2.9–6.8 mm long. Bulbs solitary or clustered, cylindrically ovoid to ovoid, without bulbels, 7.0–22.8 mm in diameter; tunics consisting of linear

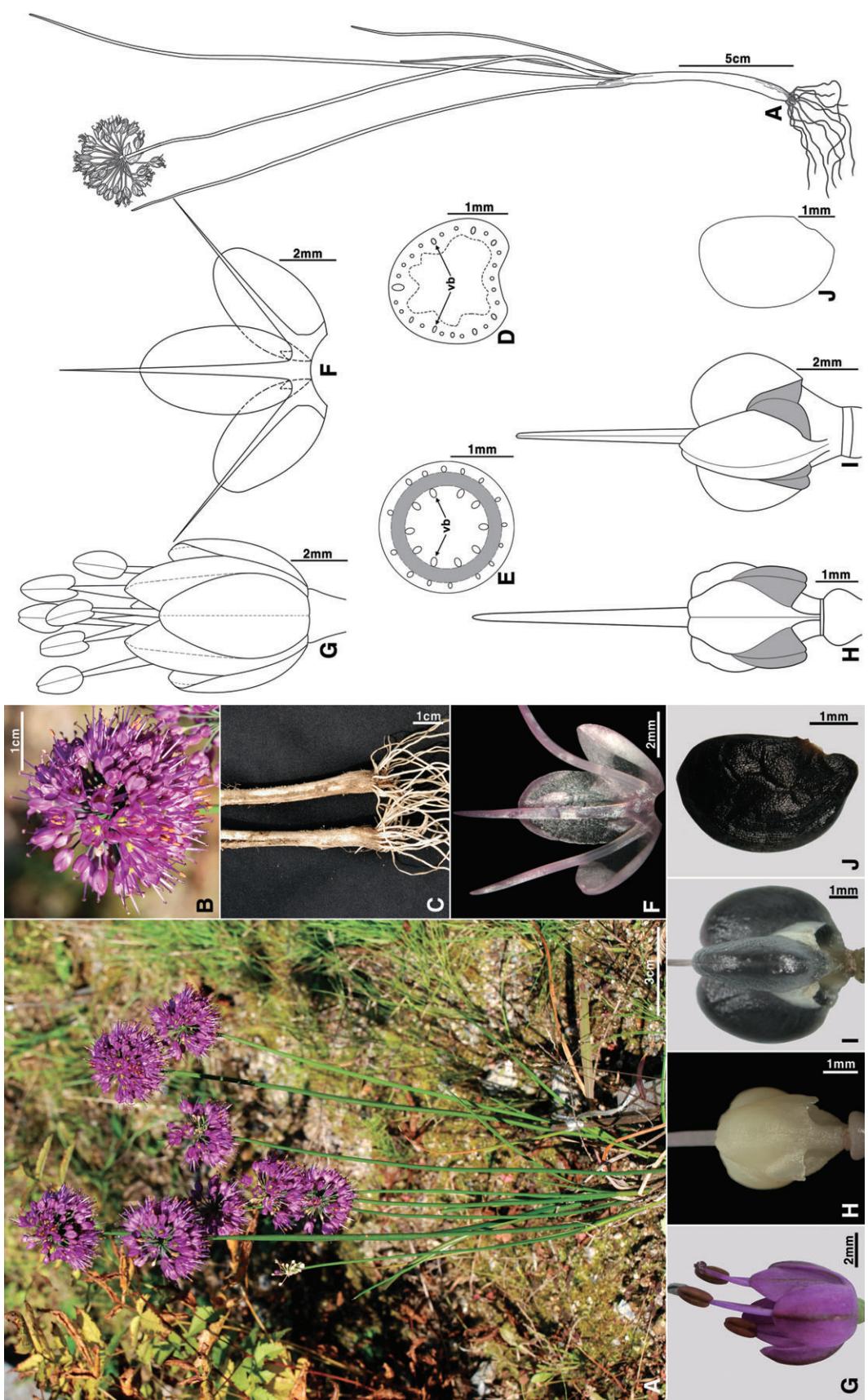
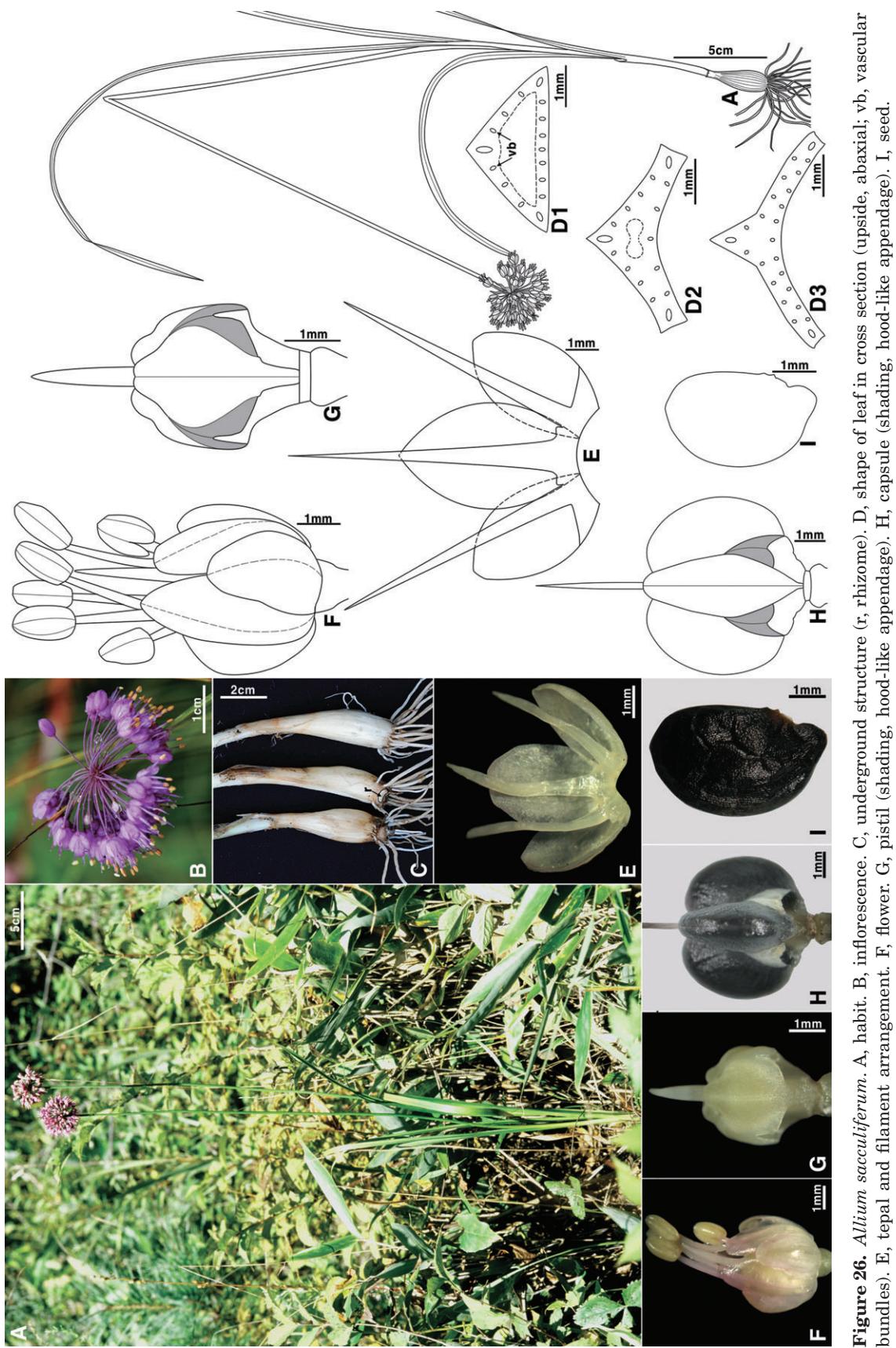


Figure 25. *Allium longistylum*. A, habit. B, inflorescence. C, underground structure. D, shape of leaf in cross section (upside, abaxial; vb, vascular bundle). E, shape of sepal in cross section (vb, vascular bundle; sb, shading, fl��re). F, tepal and filament arrangement. G, shape of leaf in cross section (upside, abaxial; vb, vascular bundle). H, flower. I, capsule (shading, hood-like appendage). J, seed.



cells, papery, brown. Leaves three to five; leaf sheaths clearly exposed above ground, 7.5–42.0 cm high, striped green; leaf blades ascending, linear, angular, 26.8–63.2 cm × 1.5–10.3 mm, with two rows of vascular bundles and solid to hollow in cross section, sessile and pale green at base, tapered to acute at apex; leaf epidermal cells with smooth cuticles, amphistomatic. Scapes central from bulbs, not slender, terete, erect before flowering, solid in cross section, 33–103.5 cm × 1.0–4.1 mm. Inflorescences umbellate, subglobose, 18.7–58.6 × 25–65 mm, without bulbils, usually densely 10–163 flowered; pedicels terete, subequal in length, 8.1–26.0 mm long, thinner than the scapes; bracts 4.3–12.7 mm long. Flowers bisexual; perianth campanulate, reddish lilac to purple; inner tepals longer than outer ones, elliptical, obtuse at apex, 5.3–6.3 × 2.8–3.4 mm; outer tepals elliptical, obtuse at apex, 4.3–5.1 × 2.0–2.6 mm; filaments exserted, 5.1–11.0 mm long, entire or with two small teeth (base part of inner ones) at margin; anthers elliptical, yellowish, 1.6–2.2 mm long; ovary ovoid, greenish, with hood-like appendages at base, 2.5–3.8 × 2.2–2.7 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.5–5.5 × 4.6–5.5 mm. Seeds oval, flat in cross section, 3.2–3.5 × 2.2–3.0 mm.

Chromosome number: $2n = (16)$, 32 (Table 1).

Distribution and habitat: Russia (Far East), China (north-eastern Nei Mongol; Heilongjiang; Jilin; Liaoning), Korea (except Jeju) and northern Japan. In sunny lowland meadows, forest margins, riversides, lakesides, wetlands and mountain foothills.

Phenology: Flowering from September to October.

Notes: There has been much confusion between *A. sacculiferum* and *A. thunbergii* var. *thunbergii*. These species exhibit a wide range of morphological variation, even among individuals of the same ecological locality (Yu *et al.*, 1981; Hao *et al.*, 2002; Choi *et al.*, 2004c). However, the former differs consistently from the latter in the clearly elongated leaf sheath (7.5–42.0 cm vs. 3.1–13.5 cm), which is exposed above ground, and the longer scape (33.0–103.5 cm vs. 15.7–48.0 cm), together with a tetraploid chromosome number ($2n = 4x = 32$) (Choi *et al.*, 2004c; Ko *et al.*, 2009). In addition, *A. sacculiferum* usually occurs in lowland meadows, forest margins and riversides, but *A. thunbergii* var. *thunbergii* is found on sunny slopes of rocky mountains in Korea and north-eastern China.

Allium deltoidefistulosum was described as a Korean endemic species on the basis of its distinguishing triangular and hollow leaf blades nearly

ascending (Yu *et al.*, 1981; Choi & Oh, 2003; Choi *et al.*, 2004c). It has been reported to be a diploid ($2n = 2x = 16$), unlike tetraploid *A. sacculiferum* (Choi & Oh, 2003; Ko *et al.*, 2009). Nevertheless, all taxonomic observations of *A. deltoidefistulosum* are overlapping (included in) the variation of *A. sacculiferum*, and we could not find any diagnostic character of the taxon in this study. Indeed, Seo & Kim (1989) reported tetraploid *A. deltoidefistulosum* from its syntype locality, Gokseong in South Korea. There are some tetraploid plants, such as H.J.Chi & J.W.Han 070052 (Table 1), which have triangular and hollow leaf blades and might be identified as *A. deltoidefistulosum*. Consequently, we propose *A. deltoidefistulosum* as an additional synonym of *A. sacculiferum*.

Specimens examined: CHINA: HEILONGJIANG – Gyeongaekho, Mokdangang, 21 Aug 2001, S-2023 (KH); Saertu, 12 Sept 1951, Zhang *et al.* 751 (PE); Saertu, Anda, 13 Sept 1951, Zhao 751 (PE). JILIN – Jangchun, 11 Sept 1975, So 75519 (PE); Hwaryong, 11 Sept 1959, Yenji2 719 (PE); Ando, 23 Aug 1959, Yenji2 209 (PE); Idobaekha, Ando, 4 Sept 1959, Pu *et al.* 1860 (PE); Peimalukow, O-muhsien, 15 Sept H.W.Kung 2305 (PE); Ipbeopsan, Gyoha, 2 Sept 2006. Jilin23-060902-008 (CBU); Idobaekha, Ando, 20 Aug 2001, B.U.Oh *et al.* s.n. (CBU); Idobaekha, Ando, 8 Sept 2007, H.J.Chi & J.W.Han 070052 (KH); Gunhamsan, Hwaryong, 8 Sept 2007, B.U.Oh *et al.* s.n. (CBU). LIAONING – Cheonsan, Ansan, 9 July 2007, B.U.Oh *et al.* s.n. (CBU); Senyang, 4 Sept 2007, Liaoning1-070703-001 (CBU); Gerenxian, 2 Sept 1959, Wang *et al.* 4281 (PE); Qianshan, 25 Sept 1963, Liu *et al.* 549 (PE); Baiyinshan, Daeryeon, 5 Oct 1925, J.Sato 9240 (PE); Tiehling, 23 Sept 1925, J.Sato 9195 (PE); Qianshan, 10 Oct 1955, Liu *et al.* 6932 (PE); Qianshanbeigou, 25 Sept 1963, Lim 461 (PE). KOREA: HAMNAM – Sinpo, 3 Oct 2002, B.U.Oh 020061 (CBU). GANGWON – Cheongtaesan, Hoengseong, 3 Oct 2003, K.Heo & K.T.Yeo 1471 (KH); Taegisan, Pyeongchang, 22 Sept 2001, H.J.Chi *et al.* 010012 (CBU); Samaksan, Chuncheon, 8 Oct 1988, W.T.Lee 0022889 (KNU); Gariwangsan, Jeongseon, 16 Oct 1996, W.T.Lee 0022886 (KNU); Mulno, Chuncheon, 14 Sept 2002, ESJeon s.n. (KH); Sonjiho, Goseong, 17 Oct 2006, JOH 20060667 (KH); Mindungsan, Jeongseon, 5 Oct, 2001, ESJeon s.n. (KH); Duwibong, Jeongseon, 25 June 2008, H.J.Chi 080167 (KH). GYEONGGI – Yeongjongdo, Incheon, 4 Oct 1975, W.T.Lee 0022822 (KNU); Yeonpyeondo, Incheon, 19 Oct 2007, ESJeon 74647 (KH); Gyodong, Ganghwado, Incheon, 20 Sept 1975, T.B.Lee 4312 (SNUA); Guksabong, Daemuido, Incheon, 13 Sept 2001, ESJeon s.n. (KH); Baengnyeongdo, Incheon, 5 Oct 2007, ESJeon 74236 (KH); Unaksan, Pocheon, 14 Sept 1991, W.G.Baek 0022877 (KNU); Gwangdeok,

Yangju,?, W.T.Lee 0022852 (KNU); Kkotji beach, Anmyeondo, Nov 1998, J.H.Do s.n. (CBU); Siheung, 18 Oct 1998, J.H.Kim et al. s.n. (CBU); Chilbosan, 26 Sept 1996, C.S.Chang 4304 (SNUA); Nogosan, Pocheon, 10 Nov 2005, KJY 05110035 (KH); Yumyeonsan, Gapyeong, 27 Sept 2003, K.Heo & K.T.Yeo 1379 (KH); Jugeumsan, Gapyeong, 1 Oct 2005, san 171 (KH); Gomo, Pocheon, 24 Oct 2003, JM 03100125 (KH); Sihwaho, 16 Oct 2002, L-60742 (KH); Yeoju, 4 Oct 2006, ESJeon 61817 (KH). CHUNGBUK – Mulhan, Yeongdong, 8 Oct 2001, H.J.Choi & Y.Y.Kim 010013 (CBU); Hwanghaksan, Yeongdong, 30 Oct 2005, YC 159 (KH); Sangdangsan, Cheongju, 13 Oct 2001, H.J.Choi 010014 (CBU); Cheonghwasan, Goesan, 6 Oct 2005, Goesan-gun(Cheonghwasan)-051006-061 (KH); Deogseongsan, Jincheon, 31 Aug 2005, Y 255 (KH); Gukmangbong, Sobaeksan, Yeongju, 24 Sept 2006, Sobaeksan(Gukmangbong)-060924-013 (KH); Woraksan, Jecheon, 10 Oct 2002, L-60045 (KH). CHUNGNAM – Sikjangsan, Daejeon, 13 Oct 2005, P 565 (KH); Seodaesan, Geumsan, 3 Oct 2002, Y.Y.Kim 020062 (CBU); Jinaksan, Geumsan, 15 Oct 2006, CB 60299 (KH); Mukbangsan, Cheongyang, 29 Oct 2000, B.U.Oh et al. s.n. (CBU); Daedeokbong, Cheongyang, 29 Oct 2000, B.U.Oh et al. s.n. (CBU); Baejaesan, Boryeong, 5 Oct 1999, S.C.Ko & H.Y.Bae 024902 (HNHM); Palbongsan, Seosan, 26 Oct 2007, HNU 1808 (KH); Amisan, Dangjin, 8 Oct 2005, K 252 (KH); Wonsubong, Yeongi, 12 Oct 2005, J.O.Hyun & H.G.Park 20060807 (KH); Gwangdeoksan, Asan, 28 Oct 2007, Jeon 11838 (KH); Eunbongsan, Dangjin, 9 Oct 2005, Dangjin-gun(Eunbongsan)-051009-073 (KH); Sinjindo, Taean, 1 Oct 2007, ParkSH 71328 (KH). JEONBUK – Cheonhwangbong, Namwon, 27 Sept 1999, B.U.Oh et al. s.n. (CBU); Seonunsa, Gochang, 5 Sept 2004, Gochan-04905-629 (KH); Deogyusan, Muju, 24 Oct 2004, Mujugun(Deogyusan)-041024-003 (KH); Segeolsan, Namwon, 20 Oct 2001, H.J.Choi & Y.Y.Kim 010011 (CBU); Janggye, Jangsu, 4 Nov 2005, ESJeon 53576 (KH); Palgongsan, Jangsu, 14 Oct 2005, CH 0187 (KH); Deogyusan, Muju, 24 Oct 2004, Mujugun(Deogyusan)-041024-004 (KH). JEONNAM – Wolgaksan, Gwangju, 2 Oct 2004, ESJeon 42337 (KH); Deogrimsan, Yeounggwang, 19 Nov 2001, H.J.Choi & S.J.Ji 010015 (CBU); Haenam, 26 Oct 2002, Y.Y.Kim s.n. (CBU); Sonji, Haenam, 18 Oct 2004, H.T.Im s.n. (KH); Bogildo, Wando, 18 Oct 2001, J.H.Kim et al. s.n. (CBU); Gokseong,?, W.T.Lee 0022804 (KNU); Unsan, Hwasun, 13 Oct 2005, LYM & NGH 50182 (KH); Dalmasan, Haenam-gum, 27 Oct 2005, LYM & NGH 50466 (KH); Wolbongsan, Damyang, 4 Nov 2001, ESJeon s.n. (KH); Seonchisanseon, Sinan, 24 Oct 2007, WR-071024-023 (KH); Tongmyeonsan, Gokseong, 26 Oct 2006, ESJeon 53542 (KH); Obongsan, Suncheon, 16 Oct 2004, Suncheonsi(Obongsan)-041016-095 (KH); Illimsan,

Boseong, 28 Oct 2005, ParkSH 54420 (KH); Nogodan, Jirisan, Gurye, 29 Sept 1986, KJY s.n. (KH); Bukmyeon, Hwasun, 3 Oct 2004, ESJeon 42394 (KH). GYEONGBUK – Hyodong, Gyeongju, 4 Nov 2000, H.J.Choi et al. 000004 (CBU); Andong, 31 Oct 1971, S.Y.Oh 002578 (KNU); Geumosan, 17 Oct 1965, I.S.Yang s.n. (KNU); Dokyongsanseong, Seongju, 16 Oct 2007, H.J.Choi 70312 (KH); Daemisan, Mungyeong, 2 Oct 2006, Mungyeong-si(Woraksan)-061002-012 (KH); Seongjae, Cheongsong, 14 Oct 2006, Cheongsong-gu(Andeok-myeon)-061014-014 (KH); Cheonghwasan, Gumi, 23 Sept 2006, CBU-070661 (KH); Hwanghaksan, Uiseong, 24 Sept 2006, CBU-070659 (KH); Okgye, Juwangsan, 8 Oct 2002, L-60076 (KH). GYEONGNAM – Gijang, Busan, 13 Oct 2006, H.J.Choi 050512 (KH); Ganwoljae, Ulsan, 12 Sept 2007, ParkSH 73970 (KH); Sancheong, 27 Oct 2002, Y.Y.Kim 020064 (CBU); Mujechineup, Ulsan, 16 Sept 2005, ESJeon 52956-1 (KH); Gayasan, Hapcheon, 19 Oct 1973, H.R.Do s.n. (KNU); Gayasan, Hapcheon, 25 Oct 2005, TUT 17602 (KH); Geumosan, Hadong, 10 Oct 2002, J.O.Hyun & H.K.Park 2002522 (KH); Hwangseoksan, Hamyang, 5 Nov 2004, ESJeon 43003 (KH); Georyongsan, Geoje, 24 Aug 2003, H.J.Choi et al. 030186 (CBU).

24. *ALLIUM PSEUDOJAPONICUM* MAKINO, BOT. MAG. (TOKYO) 24: 30 (1910). (FIG. 27)

Type: Japan. Tsushima Island, 27 Oct 1901, K.Hirata 91 (holotype: TI, photographs KNU!, CBU!).

= *A. amamianum* Tawada, J. Geobot. 22(4): 56 (1975). *Type:* Japan. Kagoshima, Amamioshima, Ayamaru-misaki, K.Kamei s.n. (holotype: RYU).

Description: Herbs hermaphroditic. Rhizomes condensed, erect, 3–8 mm long. Bulbs solitary or clustered, ovoid, without bulbils, 10–27 mm in diameter; tunics consisting of linear cells, papery, brown. Leaves two to six; leaf sheaths exposed above ground, 3–18 cm high, striped green; leaf blades curved, lustrous, linear, flat, 8–40 cm × 3–10 mm, with two rows of vascular bundles and solid in cross section, sessile and pale green at base, acute at apex; leaf epidermal cells with beaded cuticles, amphistomatic. Scapes usually lateral from bulbs, not slender, terete, erect before flowering, solid in cross section, 15–72 cm × 1.5–4.0 mm. Inflorescences umbellate, subglobose, 15–41 × 25–48 mm, without bulbils, densely 20–75 flowered; pedicels terete, subequal in length, 7–17 mm long, thinner than the scapes; bracts 6.5–13.0 mm long. Flowers bisexual; perianth campanulate, pale purple to purple; inner tepals longer than outer ones, ovately elliptical to oval, obtuse to rounded at apex, 5.5–7.0 × 3.8–4.2 mm; outer tepals elliptical to oval, obtuse to rounded at apex, 5–6 × 2–

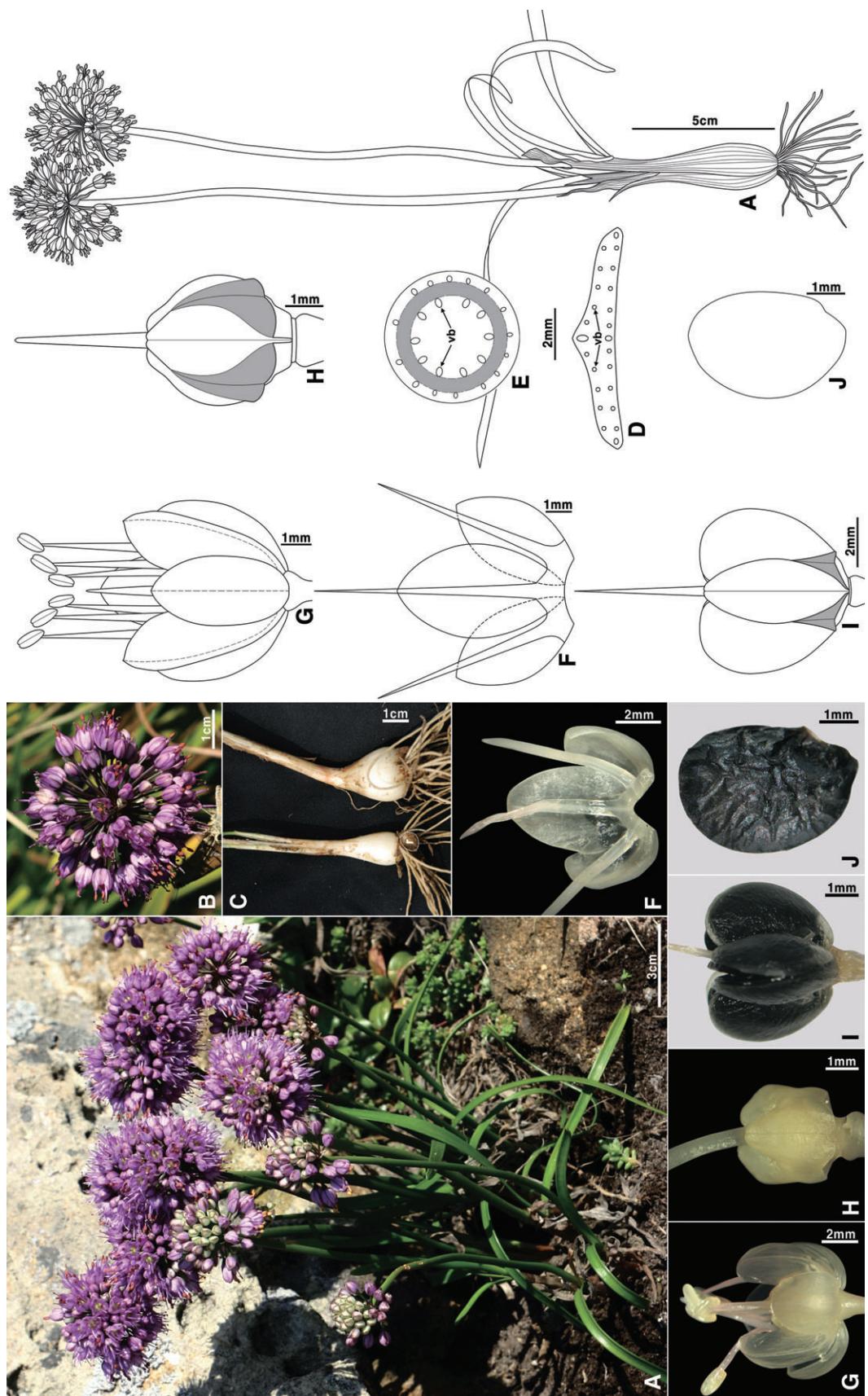


Figure 27. *Allium pseudojaponicum*. A, habit. B, inflorescence. C, underground structure (rhizome). D, shape of leaf in cross section (rhizome). E, filament arrangement. F, staminal bundle; staminal, three. G, flower. H, pistil (shading, abaxial; white, adaxial). I, capsule (shading, hood-like appendage). J, seed. Vascular bundle. E, shape of stipe in cross section (vb, vascular bundle; staminal, three). F, staminal, three. G, flower. H, pistil (shading, abaxial; white, adaxial). I, capsule (shading, hood-like appendage). J, seed.

3 mm; filaments exserted, 7–10 mm long, entire at margin; anthers elliptical, yellowish, 2.0–2.2 mm long; ovary obovoid, greenish, with hood-like appendages at base, 3–4 × 2.5–3.2 mm, ovules two per locule; style terete, exserted; stigma smooth. Capsules cordiform, trigonous, 4.5–5.8 × 4.8–6.1 mm. Seeds oval, flat in cross section, 4.0–4.6 × 2.5–3.0 mm.

Chromosome number: $2n = 32$ (Fig. 3F; Table 1; Hotta, 1998).

Distribution and habitat: Southern Korea (Jeonnam: Geomundo; Jeju) and southern Japan. In dry slopes and grasslands facing towards the sea.

Phenology: Flowering from September to October.

Notes: Since *A. pseudojaponicum* was originally described from Tshushima Island of Japan, this species has been identified by botanists as *A. thunbergii* var. *thunbergii* (Hotta, 1998; Choi *et al.*, 2006). However, Hotta (1998) and Choi *et al.* (2006) concluded it was a biologically distinct species on the basis of morphological and cytological characters. In fact, this taxon can be clearly distinguished from *A. thunbergii* var. *thunbergii* in having lustrous broad leaves (Fig. 27A, D), relatively short and thick scapes which are usually lateral from bulbs, and entire inner filaments (Fig. 27F), together with chromosome numbers of tetraploid ($2n = 4x = 32$) (Fig. 3F; Table 1; Hotta, 1998; Choi *et al.*, 2006). In addition, the microstructure of leaf epidermal cells can distinguish between these two related taxa: although they share flat leaf blades growing curved, *A. pseudojaponicum* has beaded cuticles (Fig. 2P), whereas *A. thunbergii* var. *thunbergii* has smooth ones (Fig. 2O). Phytogeographically, this species is only found in islands of southern Korea and southern Japan.

Specimens examined: KOREA: JEONNAM – Geomundo, Yeosu, 24 Sept 2005, Oh *et al.* s.n. (CBU); Geomundo, Yeosu, 1 Oct 2005, Oh *et al.* s.n. (CBU); Suwolsan, Geomundo, Yeosu, 16 Oct 2005, H.J.Chi 50377 (KH); Seomyeon, Geomundo, Yeosu, 25 Oct 2006, ESJeon 61913 (KH). JEJU – Pyoseon beach, Seogwipo, 24 June 2007, H.J.Chi 070040 (KH). JAPAN: HUKUOKA – Cheuchejaki beach, Ishara-cho, Tsushima, 4 Apr 2004, Oh & Jang-Tsushima-040404-001 (CBU).

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REFERENCES

- APG III.** 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society* **161**: 105–121.
- Bang JW.** 2004. *Chromosome index to Korean native plants*. Daejeon: Korea Plant Chromosome Research Center, Chungnam National University.
- Barkalov VJU.** 1987. *Allium* L. In: Charkevich SS, ed. *Plantae vasculares orientis extremi Sovietici*, vol. 2. Lenigrad: Nauka, 376–393 [in Russian].
- Bentham G, Hooker JD.** 1883. Ordo CLXXVIII Liliaceae. In: Bentham G, Hooker JD, eds. *Genera plantarum*, vol. 3. London: Lovell Reeve & Co, 748–804.
- Blattner FR, Friesen N.** 2006. Chapter 10. Relationship between Chinese chive (*Allium tuberosum*) and its putative progenitor *A. ramosum* as assessed by random amplified polymorphic DNA (RAPD). In: Zeder MA, Bradley DG, Emshwiller E, Smith BD, eds. *Documenting domestication: new genetic and archaeological paradigms*. Berkeley, CA: University of California Press, 133–141.
- Chase MW, Reveal JL, Fay MF.** 2009. A subfamilial classification for the expanded asparagalean families Amaryllidaceae, Asparagaceae and Xanthorrhoeaceae. *Botanical Journal of the Linnean Society* **161**: 132–136.
- Choi HJ.** 2009. *Systematics of the genus Allium (Alliaceae) in Korea and northeastern China*. PhD Thesis. Cheongju, Chungbuk, Korea: Chungbuk National University [in Korean].
- Choi HJ, Cota-Sánchez JH.** 2010. A taxonomic revision of *Allium* (Alliaceae) in the Canadian prairie provinces. *Botany* **88**: 787–809.
- Choi HJ, Oh BU.** 2003. Taxonomy of the *Allium* sect. *Sacculiferum* in Korea: with a special reference to the morphology. *Korean Journal of Plant Taxonomy* **33**: 339–357 [in Korean].
- Choi HJ, Oh BU.** 2010. A new species and a new combination of *Allium* sect. *Rhizirideum* (Alliaceae) from northeastern China and Korea. *Brittonia* **62**: 199–205.
- Choi HJ, Jang CG, Oh BU.** 2003. An unrecorded species of *Allium* (Alliaceae) in Korea; *A. longistylum* Baker. *Korean Journal of Plant Taxonomy* **33**: 259–301 [in Korean].
- Choi HJ, Jang CG, Ko SC, Oh BU.** 2004a. Two new taxa of *Allium* (Alliaceae) from Korea; *A. koreanicum* H.J.Chi et B.U.Oh and *A. thunbergii* var. *teretifolium* H.J.Chi et B.U.Oh. *Korean Journal of Plant Taxonomy* **34**: 75–85.
- Choi HJ, Jang CG, Ko SC, Oh BU.** 2004b. Leaf epidermal structure of the *Allium* L. and its taxonomic significance. *Korean Journal of Plant Taxonomy* **34**: 97–118 [in Korean].
- Choi HJ, Jang CG, Ko SC, Oh BU.** 2004c. A taxonomic review of Korean *Allium* (Alliaceae). *Korean Journal of Plant Taxonomy* **34**: 119–152 [in Korean].

- Choi HJ, Kim YY, Ko EM, Jang CG, Oh BU.** 2006. An unrecorded species of *Allium* (Alliaceae) in Korea: *A. pseudojaponicum* Makino. *Korean Journal of Plant Taxonomy* **36**: 53–59.
- Choi HJ, Jang CG, Lee YM, Oh BU.** 2007. A taxonomic study of Korean *Allium* L. based on the morphological characters. *Korean Journal of Plant Taxonomy* **37**: 275–308 [in Korean].
- Dahlgren RMT, Clifford HT, Yeo FT.** 1985. *The families of the monocotyledons*. Berlin; Heidelberg; New York; Tokyo: Springer Verlag.
- Friesen N.** 1987. The genera *Allium* L. and *Calostordum* Herbert. In: Malyshev L, Peshkova G, eds. *Flora of Siberia*, vol. 4. Novosibirsk: Nauka Sib. Otdel, 55–97, 177–195.
- Friesen N.** 1995. The genus *Allium* L. in the flora of Mongolia. *Feddes Repertorium* **106**: 59–81.
- Friesen N, Fritsch RM, Pollner S, Blattner FR.** 2000. Molecular and morphological evidence for an origin of the aberrant genus *Milula* within Himalayan species of *Allium* (Alliaceae). *Molecular Phylogenetics and Evolution* **17**: 209–218.
- Friesen N, Fritsch RM, Blattner FR.** 2006. Phylogeny and new intrageneric classification of *Allium* (Alliaceae) based on nuclear ribosomal DNA ITS sequences. *Aliso* **22**: 372–395.
- Fritsch RM.** 1992. Septal nectaries in the genus *Allium*. In: Hanelt P, Hammer K, Knupffer H, eds. *The genus Allium – taxonomic problems and genetic resources (Proceedings of an International Symposium held at Gatersleben, June 11–13, 1991)*. Gatersleben: IPK, 77–85.
- Fritsch RM, Keusgen M.** 2006. Occurrence and taxonomic significance of cysteine sulphoxides in the genus *Allium* L. (Alliaceae). *Phytochemistry* **67**: 1127–1135.
- Fritsch RM, Kruse J, Adler K, Rutten T.** 2006. Testa sculptures in *Allium* L. subg. *Melanocrommyum* (Webb & Berth.) Rouy (Alliaceae). *Feddes Repertorium* **117**: 250–263.
- Gregory M, Fritsch RM, Friesen N, Khassanov FO, McNeal DW.** 1998. *Nomenclator Alliorum: Allium names and synonyms—a world guide*. Kew: Royal Botanic Gardens.
- Gurushidze M, Fritsch RM, Blattner FR.** 2008. Phylogenetic analysis of *Allium* subg. *Melanocrommyum* infers cryptic species and demands a new sectional classification. *Molecular Phylogenetics and Evolution* **49**: 991–1007.
- Hanelt P, Schulze-Motel J, Fritsch RM, Kruse J, Maass H, Ohle H, Pistrick K.** 1992. Infrageneric grouping of *Allium* – the Gatersleben approach. In: Hanelt P, Hammer K, Knupffer H, eds. *The genus Allium – taxonomic problems and genetic resources (Proceedings of an International Symposium held at Gatersleben, June 11–13, 1991)*. Gatersleben: IPK, 107–123.
- Hao G, Lee DH, Lee JS, Lee NS.** 2002. A study of taxonomical relationship among species of Korean *Allium* sect. *Sacculiferum* (Alliaceae) and related species using intersimple sequence repeat (ISSR) markers. *Botanical Bulletin of Academic Sinica* **43**: 63–68.
- Hotta M.** 1998. The *Allium thunbergii* group (Liliaceae) distributed in southern Kyushu and Ryukyu Island. *Acta Phytotaxonomica et Geobotanica* **49**: 57–66 [in Japanese].
- Hultén E.** 1927. Flora of Kamtchatka and the adjacent islands, I. *Kungliga Vetenskapsakademiens Handlingar* **5**: 1–346.
- Jensen W.** 1962. *Botanical histochemistry: principles and practice*. San Francisco, CA: W. H. Freeman and Company.
- Jing WC, Xu JM, Yang L.** 1999. A study on cytotaxonomy of sect. *Anguinum* of *Allium*. *Acta Phytotaxonomica Sinica* **37**: 20–34 [in Chinese].
- Kamelin RV.** 1973. *Florogeneticheskij analiz estestvennoj flory gornoj Srednej Azii*. Leningrad: Nauka.
- Kawano S, Nagai Y.** 2005. Life-history monographs of Japanese plants. 4: *Allium victorialis* L. ssp. *platyphyllum* (Makino) Hultén (Alliaceae) Syn. *Allium victorialis* L. var. *platyphyllum* Makino; *A. latissimum* Prokh. *Plant Species Biology* **20**: 219–225.
- Kawano S, Nagai Y, Hayashi K.** 2005. Life-history monographs of Japanese plants. 3: *Allium monanthum* Maxim. (Alliaceae). *Plant Species Biology* **20**: 155–165.
- Keusgen M.** 2002. Health and alliums. In: Rabinowitch HD, Currah L, eds. *Allium crop science: recent advances*. New York: CABI Publishing, 357–378.
- Ko EM, Choi HJ, Oh BU.** 2009. A cytotaxonomic study of *Allium* (Alliaceae) sect. *Sacculiferum* in Korea. *Korean Journal of Plant Taxonomy* **39**: 170–180 [in Korean].
- Korean Ministry of Environment.** 2006. *The investigation guide for specially designed species by floristic region*. Seoul: 3rd National Natural Environment Survey [in Korean].
- Kovtonyuk NK, Barkalov VJU, Friesen NV.** 2009. Synopsis of the family Alliaceae Borkh. (Onions) of Asian part of Russia. *Turczaninowia* **12**: 31–39 [in Russian].
- Kruse J.** 1992. Variability of testa sculptures in the genus *Allium* L. In: Hanelt P, Hammer K, Knupffer H, eds. *The genus Allium – taxonomic problems and genetic resources (Proceedings of an International Symposium held at Gatersleben, June 11–13, 1991)*. Gatersleben: IPK, 181–182.
- Lawrence GHM.** 1951. *Taxonomy of vascular plants*. New York: Macmillan Publishing Co.
- Lee YM, Lee WY.** 1997. *Illustrated rare and endangered species in Korea*. Seoul: Korea Forest Service [in Korean].
- Li RJ, Shang ZY, Cui TC, Xu JM.** 1996. Studies on karyotypes and phylogenetic relationship of *Allium* sect. *Calostordum* (Liliaceae) from China. *Acta Phytotaxonomica Sinica* **34**: 288–295 [in Chinese].
- Linnaeus C.** 1753. *Allium*. In: Linnaeus C, ed. *Species plantarum*, vol. 1. Stockholm: Laurentii Salvii, 294–302.
- McNeal DW.** 1992. Taxonomy of North American species of *Allium*. In: Hanelt P, Hammer K, Knupffer H, eds. *The genus Allium – taxonomic problems and genetic resources (Proceedings of an International Symposium held at Gatersleben, June 11–13, 1991)*. Gatersleben: IPK, 195–204.
- McNeal DW, Jacobsen TD.** 2002. *Allium* L. In: Editorial Committee of Flora of North America, ed. *Flora of North America*, vol. 26. New York: NYBG Press, 224–276.
- van der Meer QP.** 1997. Old and new crops within edible alliums. *Acta Horticulturae* **433**: 17–31.
- Neshati F, Fritsch RM.** 2009. Seed characters and testa sculptures of some Iranian *Allium* L. species (Alliaceae). *Feddes Repertorium* **120**: 322–332.

- Nguyen NH, Driscoll HE, Specht CD.** 2008. A molecular phylogeny of the wild onions (*Allium*; Alliaceae) with a focus on the western North American center of diversity. *Molecular Phylogenetics and Evolution* **47**: 1157–1172.
- Noda S, Kawano S.** 1988. The biology of *Allium monanthum* (Liliaceae) I. Polyploid complex and variation in karyotype. *Plant Species Biology* **3**: 13–26.
- Ohwi J.** 1984. *Flora of Japan*. Washington, DC: Smithsonian Institution.
- Rabinowitch HD, Currah L.** 2002. *Allium crop science: recent advances*. New York: CABI Publishing.
- Radford AE, Dickinson WC, Massey JR, Bell CR.** 1974. *Vascular plant systematics*. New York: Harper & Row.
- Rahn K.** 1998. Alliaceae. In: Kubitzki K, ed. *The families and genera of vascular plants*, vol. 3. Berlin and Heidelberg: Springer Berlag, 70–76.
- Regel E.** 1875. Alliorum adhuc cognitorum monographia. *Trudy Imperatorskago S.-Peterburgskago Botanicheskago Sada* **3**: 1–266.
- de Sarker D, Johnson MAT, Reynolds A, Brandham PE.** 1997. Cytology of the highly polyploid disjunct species, *Allium dregeanum* (Alliaceae), and of some Eurasian relatives. *Botanical Journal of the Linnean Society* **124**: 361–373.
- Seo BB, Kim HH.** 1989. Giemsa C-banded karyotypes in two diploid and two tetraploid *Allium* species. *Korean Journal of Botany* **32**: 181–188 [in Korean].
- Shang ZY, Li RJ, Cui TC, Xu JM.** 1997. Studies on chromosomes of eight species of *Allium* from China. *Acta Phytotaxonomica Sinica* **35**: 434–444 [in Chinese].
- Suttil TA, Allen GA.** 1992. Morphological and chromosomal variation in *Dodecatheon pulchellum* (Primulaceae). *Botany* **70**: 2476–2483.
- Takhtajan A.** 1997. *Diversity and classification of flowering plants*. New York: Columbia University Press.
- Tolgor, Zhao YT, Xu JM.** 1994. A chromosomal study of eight species in *Allium* sect. *Rhizirideum* G.Don in China. *Acta Phytotaxonomica Sinica* **32**: 165–172 [in Chinese].
- Traub HP.** 1968. The subgenera, sections and subsections of *Allium* L. *Plant Life (Stanford)* **24**: 147–163.
- Vvedensky AI.** 1935. *Allium* L. In: Komarov VL, ed. *Flora of the USSR*, vol. 4. Leningrad: Botanical Institute of Academy of Science, 112–280.
- Wu ZG, Raven PH, Hong DY.** 2002. *Flora of China illustrations*, vol. 24. Beijing and St Louis: Science Press and Missouri Botanical Garden Press.
- Xu JM, Kamelin RV.** 2000. *Allium* L. In: Wu ZY, Raven PH, eds. *Flora of China*, vol. 24. Beijing and St Louis: Science Press and Missouri Botanical Garden Press, 165–202.
- Yang L, Xu JM, Zhang XL, Wan HQ.** 1998. Karyotypical studies of six species on the genus *Allium*. *Acta Phytotaxonomica Sinica* **36**: 36–46 [in Chinese].
- Yoo KO, Kim WB, Park HJ, Lim HT.** 1998a. Investigation on the ultrastructure of epidermis, anatomical, palynological, and cytological characteristics of *Allium victorialis* var. *platyphyllum* collected from three different habitats. *Journal of the Korean society for Horticultural Science* **39**: 260–265 [in Korean].
- Yoo KO, Kim WB, Park HJ, Lim SC, Jang HT.** 1998b. External morphology and numerical taxonomy among habitat of *Allium victorialis* var. *platyphyllum*. *Korean Journal of Plant Resources* **11**: 210–216 [in Korean].
- Yu SO, Lee ST, Lee WT.** 1981. A taxonomic study on the *Allium* species in Korea. *Korean Journal of Plant Taxonomy* **11**: 21–41 [in Korean].
- Zhou SD, He XJ, Yu Y, Xu JM.** 2007. Karyotype studies on twenty-one populations of eight species in *Allium* section *Rhizirideum*. *Acta Phytotaxonomica Sinica* **45**: 207–216 [in Chinese].
- Zhu SM, Xu JM.** 1999. Karyotypic differentiation in *Allium macrostemon* Bunge. *Acta Phytotaxonomica Sinica* **37**: 269–278 [in Chinese].