Allium ulleungense (Amaryllidaceae), a new species endemic to Ulleungdo Island, Korea

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ABSTRACT: *Allium ulleungense* (subg. *Anguinum*, Amaryllidaceae), from Ulleungdo Island, Korea, is described as a new species. It is clearly distinguished from its close relatives, *A. microdictyon* and *A. ochotense*, by its broader leaves and larger whitish perianth and by its diploid chromosome number, which is $2n = 2x = 16$. The lengths of the chromosomes range from 11.3 to 15.75 μm . Molecular phylogenetic analyses using nuclear and chloroplast markers also clearly indicate that *A. ulleungense* is genetically distinct from other species of the subg. *Anguinum*.

Keywords: Amaryllidaceae, *Anguinum*, *Allium ulleungense*, Ulleungdo Island, Korea

With over 900 species (Seregin et al., 2015), *Allium* L. is one of the largest genera in the Amaryllidaceae (Friesen et al., 2006; Fritsch et al., 2010; Li et al., 2010). It is characterized by bulbs enclosed in membranous (sometimes becoming fibrous) tunics, free or almost free tepals, and often a subgynobasic style (Friesen et al., 2006). Most taxa produce remarkable amounts of cysteine sulfoxides causing the well-known characteristic odor and taste (Friesen et al., 2006). *Allium* is distributed naturally in the northern hemisphere and in South Africa, mostly in regions with dry seasons (de Sarker et al., 1997; Friesen et al., 2006; Nguyen et al., 2008; Neshati and Fritsch, 2009). The classification of *Allium* by Friesen et al. (2006) based on molecular phylogenetic analyses includes 15 subgenera and 56 sections. About 19 taxa, excluding cultivated species, are known from the Korean peninsula (Choi and Oh, 2011; Shukherdorj et al., 2018).

Allium subg. *Anguinum* (G. Don. ex W. D. J. Koch) N. Friesen consists of ten species and several varieties and is part of the second of three main evolutionary lines of *Allium* (Fritsch, 2001; Fritsch and Friesen, 2002; Friesen et al., 2006; Li et al., 2010; Choi et al., 2012). The distribution area of subg. *Anguinum* reaches from southwestern Europe to eastern Asia and northeastern North America (Herden et al., 2016). Except for *A.*

victoralis L. in Europe and *A. tricoccum* Solander in North America, all the other species of subg. *Anguinum* are in Asia (Herden et al., 2016). The habitats of the species of subg. *Anguinum* are mainly mountainous, rocky places in forests, subalpine meadows and along stream banks in high mountains (Vvedenskii, 1935; Stearn, 1980; Xu and Kamelin, 2000; Fritsch and Friesen, 2002; Kawano and Nagai, 2005; Choi and Oh, 2011). Most species of subg. *Anguinum* share a basic chromosome number of $x = 8$, and $2n = 16$ or 32 (Herden et al., 2016).

In this study, we describe and illustrate a new species of *Allium* subg. *Anguinum* from Ulleungdo Island, Korea, *A. ulleungense* H. J. Choi & N. Friesen. It is readily distinguished from its closest relatives, *A. microdictyon* Prokh. and *A. ochotense* Prokh., based on morphological, cytological, and molecular characteristics.

Taxonomic Treatment

Allium ulleungense H. J. Choi & N. Friesen, sp. nov. (Figs. 1, 2).—TYPE: Korea. Gyeongsangbuk-do: Ulleung-gun, shaded slope of Seongin-bong, 37.49766N, 130.86379E, elev. 825 m, 5 Jun 2019 [fl], H. J. Choi 190605-001 (holotype: KH; isotypes: KH, KIOM).

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Fig. 1. *Allium ulleungense*. A. Habit. B. Tunic. C. Scape. D. Shape of scape in cross section. E. Inflorescence. F. Flower. G. Tepal and filament arrangement. H. Pistil. I. Capsule. J. Seed. Illustrations by Hyeryun Jo.

Herbs, hermaphroditic. Rhizomes condensed, oblique, 5–15 mm long. Bulbs solitary or clustered, cylindrically conical, 11.5–20 mm in diam.; tunic fibrous, reticulate, brown. Leaves 2 or 3; sheaths exposed above ground, 17–32 cm long, pale green; blade ascending, elliptic to oval, flat, 19.5–30 × 6.2–15 cm, solid in cross section, base pseudo-petiolate, apex obtuse to subrounded. Scape subterete, curved distally before flowering, solid in cross-section, 40–86 cm × 2.2–6.1 mm. Inflorescence umbellate, globose, 26.5–54 × 31–51 mm, without bulbils, 26–110 flowered; pedicels multiangular, subequal in length, 14.3–25 mm long; bracts 7.5–17 mm long. Flowers bisexual; perianth campanulate, white; inner tepals longer than outer ones, elliptic, apex obtuse, 6.0–8.5 × 3–3.7 mm; outer tepals oblong, apex obtuse, 5.7–7.2 × 1.6–1.8 mm; filaments exserted, 7.5–9.1 mm long, margin entire; anthers ellipsoid to oblong, yellowish, 2.3–2.6 mm long; ovary obconical, green or sometimes tinged reddish, 3.8–4.8 × 2.9–3.3 mm, ovules 1 per locule; style terete, exserted; stigma

Fig. 2. *Allium ulleungense*. A. Habit (from the holotype). B. Inflorescence. C. Underground structure and bulb tunic (r, rhizome). D. Tepal and filament arrangement. E. Flower. F. Pistil. G. Capsule. H. Seed (B–H from Fig. 8 of Choi and Oh, 2011).

Fig. 3. Metaphase chromosomes (A) and idiogram (B) of *Allium ulleungense* ($2n = 16$). Scale bars = 10 μ m.

smooth. Capsules cordiform, trigonous, 6–6.5 × 6.5–7.5 mm. Seeds globose or nearly so, 2.6–4.1 × 2.5–3.5 mm.

Etymology: The specific epithet, “*ulleungense*,” is based on the name of the location, Ulleungdo Island, where *Allium ulleungense* was discovered.

Local name: Ul-leung-san-ma-neul (Choi and Oh, 2011).

Phenology: Flowering late May to mid-June.

Karyology: Chromosome number $2n = 2x = 16$, diploid (Fig. 3) (Choi and Oh, 2011). The chromosomes range from 11.3 to 15.75 μm in length. The chromosome complement comprises five pairs (1, 3, 5, 6 and 8 of Fig. 3) of metacentric chromosomes

and three pairs (2, 4 and 7 of Fig. 3) of submetacentric chromosomes based on Levan et al. (1964).

Distribution and ecology: South Korea, Ulleungdo Island, endemic (Fig. 4). Rare in natural habitats, but widely cultivated in Korea as an edible plant named ‘Myeong-i-na-mul’ or ‘San-ma-neul.’

Fig. 4. Distribution map of the species of *Allium* subg. *Anguinum* in Europe and Asia (supplemented from Fig. 3 of Herden et al., 2016).

Table 1. Comparison of major characters of *Allium ulleungense*, *A. microdictyon*, and *A. ochotense* (measurements from a minimum of 30 specimens of each).

Character		<i>A. ulleungense</i>	<i>A. microdictyon</i>	<i>A. ochotense</i>
Leaf blade	Shape	Elliptic to oval	Oblong to elliptic	Oblong to elliptic
	Apex	Obtuse to subrounded	Acute	Acute
	Length (cm)	19.5–30.0	11.5–21.5	12.5–25.0
	Width (cm)	6.2–15.0	2.8–6.0	3.0–10.0
Perianth	Color	White	Pale yellow	White to pale yellow
Inner tepal	Length (mm)	6.0–8.5	5.2–6.5	5.0–6.5
	Width (mm)	3.0–3.7	2.4–3.0	2.2–3.0
Outer tepal	Length (mm)	5.7–7.2	4.0–5.5	4.0–5.6
	Width (mm)	1.6–1.8	1.2–1.5	1.2–1.8
Anther	Length (mm)	2.3–2.6	1.6–1.9	1.9–2.3
Ovary	Color	Green or tinged reddish	Green	Green
Seed	Length (mm)	2.6–4.1	2.0–2.3	2.2–3.0
	Width (mm)	2.5–3.5	2.1–2.3	2.2–2.8
Chromosome number ($2n$)		$2x = 16$	$2x = 16$	$4x = 32$

Fig. 5. Comparative photographs of inflorescences, flowers, tepal and filament arrangement, and leaf blades of *Allium ulleungense* (A–D), *A. microdictyon* (E–H), and *A. ochotense* (I–L).

Additional specimens examined: KOREA. Gyeongsangbuk-do: Seonginbong, Ulleungdo Isl., 18 May 2002 [fl], *H.J. Choi 020056* (CBU); Seonginbong, Ulleungdo Isl., 20 May 1989 [fl], *S. G. March et al. s.n.* (SNUA); Seonginbong, Ulleungdo Isl., 28 Jul 1961 [fr], *T. B. Lee s.n.* (SNUA); Albong, Ulleungdo Isl., 37°31'02.3"N, 130°51'56.5"E, elev. 420 m, 14 May 2004 [fl], *S. H. Park 40940* (KH); Chusan, Ulleungdo Isl., 37°31.447'N, 130°51.236'E, 21 May 2002 [fl], *S. H. Park 21587* (KH); Anpyeongjeon to Nari, Ulleungdo Isl., 3 Jun 2001 [fl], *E. S. Jeon s.n.* (KH); Naribunji to Seonginbong, Ulleungdo Isl., 37°29'46.5"N, 130°51'46.3"E, elev. 739 m, 12 May 2003 [fl], *S. H. Park 30602* (KH).

Note: *Allium ulleungense* was previously identified as *A. victorialis* (Yu et al., 1981) or *A. ochotense* (Choi and Oh,

2011) in Korea, but is also morphologically similar to *A. microdictyon* (Choi and Oh, 2011). However, it is clearly distinguished from *A. microdictyon* and *A. ochotense*, particularly by its relatively broader leaves (mean 110 mm wide) and larger whitish perianth (Fig. 5, Table 1). Additionally, *A. ulleungense* is diploid ($2n = 2x = 16$) (Fig. 3) along with *A. microdictyon* (Herden et al., 2016), whereas *A. ochotense* has been reported to be tetraploid ($2n = 4x = 32$) (Kawano and Nagai, 2005; Probatova et al., 2006) or rarely pentaploid (Probatova et al., 2006). Molecular phylogenetic analyses using nuclear ITS and chloroplast markers (*rps16*, *rbcL-atpB*, *rpl32-trnL*) also clearly indicate that *A. ulleungense* is genetically distinct from other species of subg. *Anguinum* (Fig. 6).

A. ITS

B. Combined

(*rbcL-atpB*, *rpl32-trnL*, *rps16*)

Fig. 6. Phylogenetic trees resulting from Bayesian analyses of the internal transcribed spacer (ITS) sequences (A) and combined cpDNA sequences (B) of subgenus *Anguinum*. Bayesian posterior probabilities (>0.5) above branches, bootstrap support (>50%) below branches. All sequence data are from Herden et al. (2016), but accessions *Gb-19* and *Am165* were reidentified as *Allium ulleungense* in this study.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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