Tofieldia ulleungensis (Tofieldiaceae): A new species, endemic to Ulleungdo Island, Korea

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ABSTRACT: *Tofieldia ulleungensis*, a new species of the genus *Tofieldia* from the Nari Basin on Ulleungdo Island, Korea, is described and illustrated. The new species is similar to *T. yoshiiana* var. *koreana* in terms of the plant height and in that it has having a long raceme, whitish tepals, and whitish stigma, but can be readily distinguished from the latter by the presence of 1–2 linear cauline leaves, a slightly bent leaf apex, basal leaves which are twice as wide, a shorter pedicel, a revolute style, and crescent-shaped seeds.

Keywords: Tofieldiaceae, *Tofieldia ulleungensis*, endemic, Ulleungdo Island, Korea

The genus *Tofieldia* Huds. (Tofieldiaceae) comprised about 12 species distributed in the subarctic, temperate, and subtropical regions of the Northern Hemisphere (Chen and Tamura, 2000; Yamazaki, 2002; Tamura et al., 2004, 2010, 2011). The species are morphologically characterized by 2-ranked laterally flattened leaves, cupular bracteoles, raceme inflorescence (rarely a spike), actinomorphic flowers, 3 styles, and anther with two separate locules (Ohwi, 1965; Chen and Tamura, 2000). In Northeast Asia (northeastern China, Korea, Japan, and Far East Russia), seven taxa have been recognized as species level, which are mostly occurring in wetland areas of high mountains and less frequently in crevices of rocks or cliffs slopes (Chen and Tamura, 2000).

Tofieldia is currently included in the family Tofieldiaceae along with *Isidrogavia* Ruiz & Pav., *Harperocallis* McDaniel, *Pleea* Michx., and *Triantha* (Nuttall) Baker (Takhtajan, 1994, 1997; Marbberley, 2008). While the recognition of Tofieldiaceae and its placement in the Alismatales are now generally accepted, the number of distinguishable genera and species within the family still remain unresolved (Thorne, 2000; Stevens, 2001; Marbberley 2008; Takhtajan, 2009; Tamura et al., 2010; Azuma and Tobe, 2011).

In Korea, *Tofieldia fauriei* H. Lév. & Vaniot and *T. taquetii* H. Lév. & Vaniot were the first species in this genus described from Jejudo Island by Léviellé (1908). They were subsequently

recognized by Nakai (1911), but later he (Nakai, 1914) transferred *T. taquetii* to *T. fauriei*. In 1916, Nakai reported a new species, *T. nutans* Willd. ex Schult.f., from Rhobong, Pyeonganbuk-do, North Korea, and Chung (1957) recognized two species *T. fauriei* (= *T. taquetii*) and *T. nutans* in Korean Flora. Lee (2006) mentioned three species *T. coccinea* Richardson (= *T. nutans*), *T. fauriei*, and *T. nuda* Maxim. in the Coloured Flora of Korea. However, Tamura et al. (2011) treated *T. nuda* as an endemic species to Japan. More recently, the Checklist of Korean Plants (Korea National Arboretum, 2017) listed three taxa *T. coccinea* var. *coccinea*, *T. coccinea* var. *fauriei* T. Yamaz. (= *T. taquetii*), and *T. yoshiiana* Makino var. *koreana* (Ohwi) M. N. Tamura with updated species names. In addition, size of the leaf, the curvature of leaf apex, presence or absence of projection on leaf margin, the shape of inflorescence and style, and length of the pedicel are considered being the key morphological characters for species delimitation in *Tofieldia* (Chen and Tamura, 2000; Tamura et al., 2010, 2011, 2013).

During recent field investigations conducted on the Ulleungdo Island of Korea, we found an unusual and rather isolated population of *Tofieldia* that appeared morphologically different from other known taxa of the genus in Korea. After careful examination of the various flora and herbarium specimens from Korea and adjacent countries as well as the

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Fig. 1. *Tofieldia ulleungensis*. **A.** Habit. **B.** Inflorescence. **C.** Two-ranked leaves. **D.** Leaf apex. **E.** Flower (top view). **F.** Flower (abaxial view). **G.** Flower (side view). **H.** Pistil with three styles. **I.** Stamen. **J.** Tepal and stamen. **K.** Fruit (top view). **L.** Fruit (side view). **M.** Capsule. **N.** Seeds. Illustrations by Hyeryun Jo.

Fig. 2. *Tofieldia ulleungensis*. **A.** Plant habit. **B.** Plant. image of the holotype. **C.** Inflorescence. **D.** Basal leaf. **E.** Basal leaf margin. **F.** Cauline leaf. **G.** Flower. **H.** Pistil, stamen, and tepal. **I.** Capsule. **J.** Seed. Photographs by Kang-Hyup Lee and Hyeryun Jo.

review of relevant literature, we concluded that the collected specimens represent a new taxon in the genus, *Tofieldia ulleungensis*.

Materials and Methods

Morphological observations of the new species were conducted based on living plants as well as dry specimens collected between 2018 and 2020. The photographs in the field were captured by using a Nikon Coolpix P510 camera (Tokyo, Japan). The measurements of morphological characters were obtained by using a digital vernier caliper and from data derived from field notes. The flowering and fruiting period is given as cited on the collector's labels. Type material has been deposited in the Korea National Arboretum (KH). The voucher specimens of Korean *Tofieldia* taxa deposited in the KH collections were studied.

Taxonomic Treatment

Tofieldia ulleungensis H. Jo, sp. nov. (Figs. 1, 2).—**TYPE:**

KOREA. Gyeongsangbuk-do, Ulleung-gun, Mireukbong of Nari Basin, 37°51'10.0"N, 130°84'98.5"E, elev. 800 m, 22 Aug. 2019 [fl], JHR 190822-001 [holotype: KH (KHB-1584584), Fig. 3; isotype KH 1 sheet (KHB-1584585), Fig. 4].

Herbs perennial, 10–17 cm tall, with short ascending rhizome. Leaves basal or nearly so, 2-ranked, flattened, 7–15 cm × 5–7 mm, rather rigid, margin scabrous, apex acuminate, 3–5 inconspicuous veins, tip slightly bent. Scape oblique, slender, 12–15 cm long, with 1 or 2 linear leaves in the proximal part. Racemes ca. 3–5 cm × 8–13 mm, densely many-flowered. Flowers bisexual, arising from axils of bracts, ascending or nearly so; bracts lanceolate; pedicel 2–3 mm long at anthesis; bracteole 1, cupular, apically 2- or 3-lobed. Tepals 6, white, narrowly oblanceolate-oblong, 3–3.5 mm × ca. 0.7–1 mm. Stamens 6, nearly equaling tepal length; filaments 2.5–3 mm long; anthers ca. 0.7 mm long, light brown to brown. Ovary superior, ca. 1.5–2 mm long, oblong-ovoid, white; styles 3, revolute, ca. 0.5–0.7 mm long, nearly as long as anthers; stigma white. Capsule suberect, ca. 4 mm × 3–4 mm, obovoid-ellipsoid; carpels 2–3.5 mm × 2–2.5 mm, with persistent styles 0.5–1 mm long and stigmas scarcely thickened. Seeds crescent-

Fig. 3. Holotype of *Tofieldia ulleungensis*.

Fig. 4. Isotype of *Tofieldia ulleungensis*.

Fig. 5. Comparative illustration of *Tofieldia ulleungensis*, *T. yoshiiana* var. *koreana*, *T. coccinea* var. *coccinea*, and *T. coccinea* var. *fauriei*. **A.** Flower. **B.** Ovary, stamen and tepal. **C.** Capsule and seeds. **D.** Leaf apex. Illustrations by Hyeryun Jo.

shaped, ca. 1–1.2 mm × 0.2–0.3 mm, without a white longitudinal band on either side.

Etymology: The specific epithet “*ulleungensis*” refers to the geographic location Ulleungdo Island, where the species was discovered.

Local name: Ul-leung-kkot-jang-po (울릉꽃장포; new Korean name).

Phenology: Flowering mid-July to late-August.

Distribution and ecology: Republic of Korea, Ulleungdo Island, endemic. Grows in wet rocky areas at high elevations (Fig. 2). Currently, the new species is known only from the type locality and the population is composed of about 50 mature individuals.

Note: Three taxa of *Tofieldia* (*T. yoshiiana* var. *koreana*, *T. coccinea* var. *coccinea*, and *T. coccinea* var. *fauriei*) have been described in Korea so far. The leaves of *T. coccinea* var.

Table 1. Comparison of major characters of *Tofieldia ulleungensis* with related species.

Character		<i>T. ulleungensis</i>	<i>T. yoshiiana</i> var. <i>yoshiiana</i>	<i>T. yoshiiana</i> var. <i>koreana</i>	<i>T. coccinea</i> var. <i>coccinea</i>	<i>T. coccinea</i> var. <i>fauriei</i>
Stolons		Absent	Present	Absent	Absent	Absent
Leaf	Length (cm)	7–15	3.2–13.5	10–14	2.5–5	2.5–5
	Width (mm)	5–7	–	1.7–3	2–3	2–4
	Vein number	3–5	3	3	3	3
	Margin	Scabrous	Smooth	Scabrous	Scabrous	Smooth
Cauline leaf	Number	1–2	1–2	3–6	1–2	1–2
	Length (cm)	0.5–3	–	0.2–3.5	0.2–2.5	0.5–2.5
Scape	Length (cm)	12–15	5.3–18	14–30	5–16	6–21
Raceme	Length (cm)	3–5	1.4–7.8	3–7	0.7–1.5	0.7–1.5
	Width (cm)	0.8–1.3	5–22	1.5–2.5	0.6–1.3	0.7–1
Pedicel	Length (mm)	2–3	5–25	6–8	1–3	1–3
Tepals	Color	White	White or grayish white	White	Purplish white	Purplish white
	Length (mm)	3–3.5	–	2.5–3	1–2	1–2
	Width (mm)	0.7–1	–	0.7–1	ca. 0.7	ca. 0.7
	Ratio of tepal and stamen	Nearly equaling stamen	–	Shorter than stamen	Shorter than stamen	Shorter than stamen
Anther	Color	Light brown to brown	Whitish cream	Cream to light yellow	Purple	Brown
Ovary	Color	White	White or grayish white	White	Purplish white	Light purple
Style	Shape	Revolute	–	Erect	Revolute	Revolute
	Length (mm)	0.5–0.7	1.5–2	1–1.2	0.3–0.5	0.5–0.7
Stigma	Color	White	White or grayish white	White	Purple	Purple
Seed	Shape	Crescent	-	Linear-semicircular	Linear-semicircular	Linear-semicircular

Characters of *T. yoshiiana* var. *yoshiiana* are based on the description in the Flora of Japan (Tamura, 2016).

coccinea and *T. coccinea* var. *fauriei* are wide and flattened and style is revolute (Fig. 5). Although, these characters are also common in the new species, the whole plants of *T. coccinea* var. *coccinea* and *T. coccinea* var. *fauriei* can be easily distinguished from the new species by their small size. The tepal and ovary are purplish white in *T. coccinea* var. *coccinea* and *T. coccinea* var. *fauriei* but yellowish-white in the new species (Table 1). The new species shows a close morphological similarity with *T. yoshiiana* var. *koreana* but differs in the morphology of leaves, pedicels, styles, anthers, and seeds. The leaves of *T. ulleungensis* are wide, rigid, and spreading out like a fan, but they are narrow, showing a drooping shape in *T. yoshiiana* var. *koreana*. The pedicel is shorter in *T. ulleungensis* than in *T. yoshiiana* var. *koreana* and racemes are cone-like (vs. broad cone in the latter). The styles are revolute and the anthers are light brown to brown in the new species (vs. styles erect and anthers cream to light yellow in *T. yoshiiana* var. *koreana*). In addition, the seeds are crescentic in *T. ulleungensis* but linear-semicircular in *T. yoshiiana* var. *koreana* (Fig. 5, Table 1). Meanwhile, the new species differs from *T. yoshiiana* var. *yoshiiana* which is endemic to Japan by its stolon (vs. absent in *T. ulleungensis*), smooth leaf margin (vs. scabrous in *T. ulleungensis*), 5–25 mm long pedicel (vs. 2–3 mm in *T. ulleungensis*) (Table 1).

Key to *Tofieldia ulleungensis* and its related taxa in Korea

1. Leaves shorter than 5 cm; flowers in a dense raceme, raceme length less than 1.5 cm; tepals 1–2 mm long, purplish white; ovary purplish white; stigma purple ... 2
1. Leaves longer than 5 cm; flowers in a loose raceme, raceme length more than 3 cm; tepals 2.5–3.5 mm long, white; ovary white; stigma white 3
2. Leaf margin scabrous; scape oblique; anther purple; ovary orbicular, purplish white *T. coccinea* var. *coccinea*
2. Leaf margin smooth; scape erect; anther brown; ovary ovoid, light purple *T. coccinea* var. *fauriei*
3. Leaves narrow, less than 3 mm wide; pedicel 6–8 mm long; stamen obviously longer than tepals, anther cream to light yellow; styles erect; seeds linear-semicircular *T. yoshiiana* var. *koreana*
3. Leaves wide, more than 5 mm wide; pedicel 2–3 mm long; stamen nearly equaling tepals, anther light brown to brown; styles revolute; seeds crescentic *T. ulleungensis*

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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