

A New Record for Invasive Alien Plant *Ranunculus sardous* Crantz (Ranunculaceae) in the Republic of Korea

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Abstract - The establishment of invasive alien species management is widely recognized as a pivotal issue in the preservation of biodiversity. *Ranunculus sardous* Crantz, a species native to Europe, has been widely introduced in many other areas of the world, including the coasts of the United States, Australia, China, India, and Japan. In Korea, the first population of this plant was found growing adjacent to a wetland in Hanon, Seogwipo-si, Jeju Province, on 22 May 2018. Field observations confirmed the presences of at least two populations of this species in Jeju Province, Korea. This species is similar to *Ranunculus sceleratus* L., but can be readily distinguished by its presence of the trichomes in the whole plant, longer petioles of radical leaves, ovate-shaped leaf segments, globose to subglobose-shaped fruits and flat achenes with narrowly winged and papillae. The Invasive Alien Plant Risk Assessment (IAPRA), a system for recognizing and categorizing alien plants in Korea forests, was used to assess the invasiveness status of the species. Based on this system, *R. sardous* received a low score of 6, suggesting its potential invasion to natural forests. Although the current distribution of *R. sardous* is restricted to Jeju Province and thus far has had limited impact on local environments, local and regulatory authorities should pay close attention to this plant and take measures to prevent its further expansion.

Key words – Buttercups, Invasive alien plant, Invasiveness assessment, *Ranunculus*

Introduction

A major step in tackling invasive alien plants consists of identifying those species that represent a future threat to managed and unmanaged habitats (Brunel *et al.*, 2010). Korea National Arboretum of the Korea Forest Service reviews and organizes data on alien plants in order to build a checklist of Invasive Alien Plants (IAP). A prioritization system is being developed to select species that represent emerging threats and require the analysis of their invasiveness risk state to develop and implement preventive measures against their proliferation.

During recent field investigations carried out in the vicinity of the wetland of Jeju-do, Korea, we discovered an unusual and rather isolated population of *Ranunculus*, which appeared to be morphologically well differentiated from other *Ranunculus* taxa previously recorded in the flora of Korea.

After the examination of various floras and herbarium specimens from Korea and adjacent countries as well as the relevant literature (Kadota, 2006; Wang and Gilbert, 2001), it was concluded that the collected specimens belong to *Ranunculus sardous* Crantz, a species native to Europe that is introduced in many other areas of the world, including the United States, Australia, China, India and Japan.

Therefore, we provide a detailed description, illustrations and color photographs of this newly recorded non-native plant in the flora of Korea that can be utilized for its effective management.

Materials and Methods

Morphological observations of the new alien species were conducted on living plants and dry specimens between 2018 and 2019. The photographs in the field were captured with a Nikon Coolpix P520 camera (Tokyo, Japan). The measurements of the morphological characters were performed with a

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Table 1. Invasiveness risk assessment system of alien plant in forest (Jung *et al.*, 2015)

Invasiveness assessment standard		Score		
		3	2	1
1	Crown canopy ratio	< 20%	20-50%	> 50%
2	Spreading distance (the distance from forest edge)	> 3 km	2-3 km	< 2 km
3	Appearance frequency (forest edge of lowland to inside a forest of upland)	Over entire region (frequently)	Sporadic	Regional
4	Species richness (number of individuals in 1 ha)	> 200 individuals	100-200 individuals	< 100 individuals
5	Invasion type	Natural vegetation	Sites affected by human activity (artificial plantation forest, debris barrier, forest road, trail etc.)	Lowland of forests, forest edge

Table 2. Degree of invasion of alien plants in forest (Jung *et al.*, 2015)

Degree of Invasion	Classification	Assessment score
IV (SI)	Serious Invasion	13-15
III (CI)	Concerned Invasion	10-12
II (MI)	Minor Invasion	7-9
I (PI)	Potential Invasion	0-6

Mitutoyo 500-196-30 absolute digimatic caliper (Kanagawa, Japan) and the data were also derived from field notes. The flowering and fruiting periods are given as cited on the collector's labels. The examined material was been deposited in the Korea National Arboretum (KH). Voucher specimens of *Ranunculus sceleratus* L. deposited in the KH collection were studied. The invasiveness status was assessed by applying the Invasive Alien Plant Risk Assessment system (Jung *et al.*, 2015) (Tables 1, 2) and standardized terms for alien plants were used accordance with the classification by Jung *et al.* (2017).

Taxon description

***Ranunculus sardous* Crantz, Stirp. Austr. Fasc. 2: 84 (1763) (Figs. 1, 2).**

syn. *R. parvulus* L., Mant. Pl.: 79 (1767)

R. pseudo-bulbosus Schur, Verh. Mitth. Siebenbürg. Vereins Naturwiss. Hermannstadt 10: 84 (1859)

Type: Austria, Europe, *coll. unknown*; holotype: probably at BP *n.v.*

Annual or biennial herbs, 15-50 cm high, sub-erect, hispid, not bulbous-based; root-stock corm like, roots fibrous. **Stem** much-branched, ribbed. **Leaves** basal and alternate, deeply lobed or compound, sparsely to densely pubescent on both surfaces; radical leaves usually present at flowering, long-petiolate, blade 3-partite, 2-5 cm long, 3-6 cm wide, ovate to heart-shaped, base rounded to cordate, terminal leaflet often short-stalked, primary leaflets (or lobes) usually again 2- or 3-lobed, segments oblong to obovate or rhombic, margins otherwise coarsely toothed, the teeth mostly rounded to bluntly pointed at their tips, petioles 3-6 cm long; cauline leaves mostly short-petiolate to sessile, progressively reduced toward the stem tip, blade progressively deeply 3-parted into narrower, less divided and toothed, more sharply pointed segments, those of the uppermost leaves linear to narrowly oblong-oblongate, midrib deeply veined, nearly glabrous or faintly long hairs. **Flowers** in cymes, 2-5 flowered, 1.2-2.5

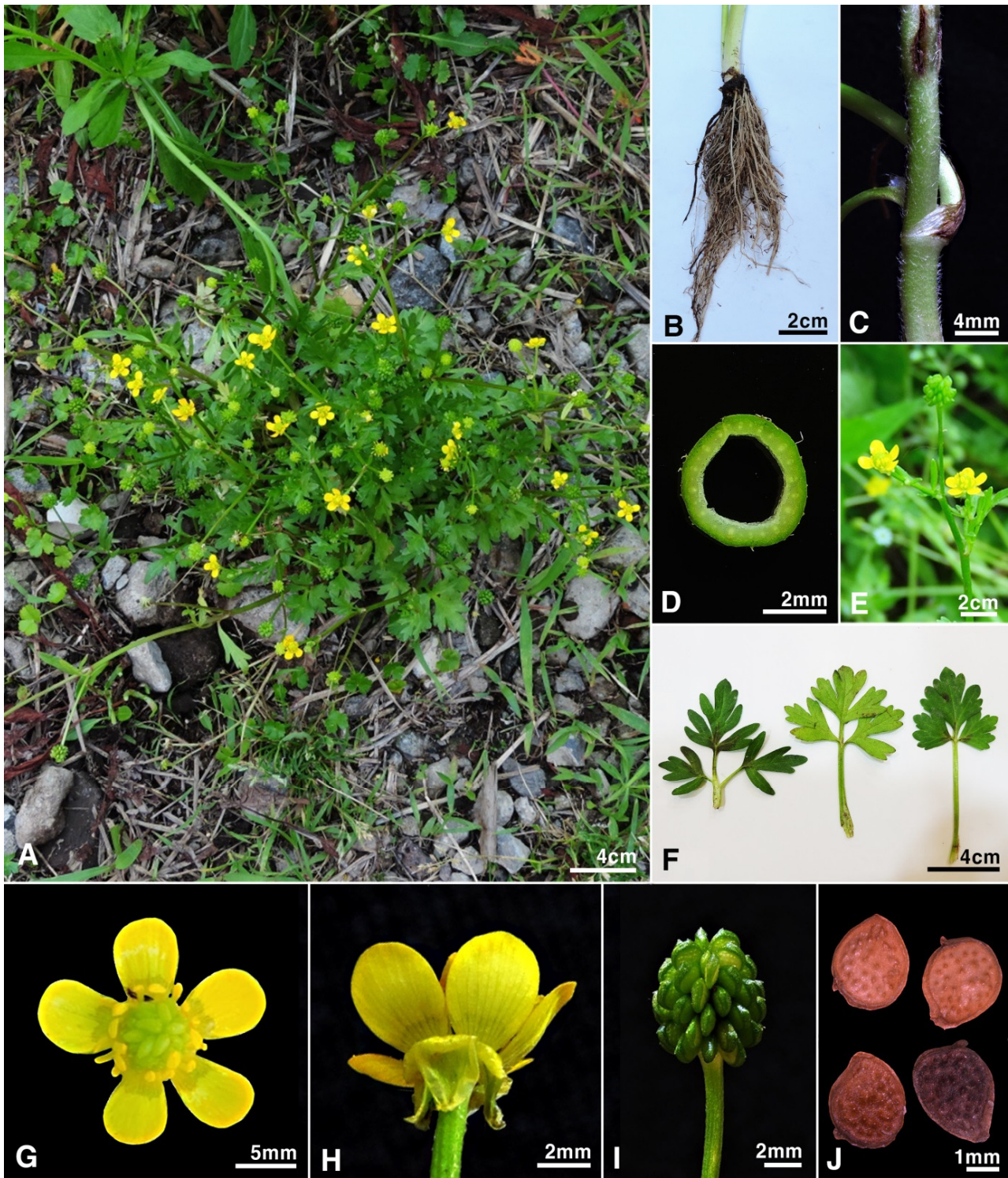


Fig. 1. Photographs of *Ranunculus sardous* Crantz. A: Habit, B: Roots, C: Stem, D: Cross section of the stem, E: Inflorescence, F: Various shapes of the leaf (adaxial surface), G: Flower (top view), H: Flower (lateral view), I: Aggregated fruit, J: Achene.



Fig. 2. Illustrations of *Ranunculus sardous* Crantz. A: Habit, B: Stem and petiole, C: Adaxial leaf surface, D: Abaxial leaf surface, E: Trichomes on peduncles, F-H: Flower, I: Sepals, J: Petal, K: Stamen, L: Aggregated fruit, M: Achene.

Table 3. Morphological comparison between *Ranunculus sardous* and its related species *Ranunculus sceleratus*

Characters	Taxon	<i>Ranunculus sardous</i>	<i>Ranunculus sceleratus</i>
Whole plant		Densely pubescent	Glabrous or sparsely pubescent
Leaf segments		Ovate	Oblanceolate
Aggregated fruits		Globose to subglobose	Ovoid-cylindrical to cylindrical
Achenes		Flat	Inflated

cm in diameter; pedicels 3-5 cm long in anthesis. **Sepals** 5, broad ovate to ovate-lanceolate, 3-8 mm long, 1.5-3 mm wide, margins membranous with densely appressed white pilose, reflexed from 1-3 mm long above the base along a well-defined transverse fold, more or less plane (the apical portion sometimes appearing somewhat folded longitudinally), early deciduous. **Petals** 5, 7-10 mm long, 4-8 mm wide, pale yellow, obovate to broadly oblong-obovate, base cuneate, longer than the sepals. **Stamens** numerous; anther oblong, pale yellow; style present. **Pistils** numerous, pale green, glabrous. **Aggregated fruits** 5-8 mm long at maturity, globose to subglobose; receptacle slightly elongated in fruit. **Achenes** 12-25 in number per fruit, broadly obovate to orbicular-obovate, 0.2-0.3 cm long, flat, reddish brown, the dorsal margin keeled and narrowly winged, the wall thick, usually pebbled or with minute papillae, occasionally smooth, glabrous, each papilla tipped with hooked bristle; beak 0.4-0.7 mm long, flattened, oblong to triangular, curved at the tip. **Seeds** obovate, 2.5-3 mm long, 1.5-2 mm wide, 0.5-1 mm in diameter.

Phenology: Flowering and fruiting time: April to June

Distribution: Europe, Australia, United States, India, China (Shanghai), Japan (Kōchi Prefecture) and Korea (Jeju Province)

Vernacular (Korean) name: Teol-gae-gu-ri-ja-ri (털개구리자리; new Korean name)

Habitat and ecology: Based on field observations, at least two populations of this species were observed growing adjacent to a wetland in Hanon, Jeju Province, Korea. This habitat is located in a sunny paddy field. They formed dense mono-species stand of 20 × 30 m in size and sporadic individual along the edges and waterways of paddies, stands mixed with native plants such as a large populations of *R. cantoniensis* DC., *Hydrocotyle maritima* Honda, *Poa annua*

L. and *Erigeron annuus* (L.) Pers. etc. in herbaceous layer.

Invasiveness risk assessment in forest: *R. sardous* origin in Europe, recently it has been managed as an invasive alien plant in Japan and China. In the study, it was assigned a low score of 6, suggesting its potential for invasion in forest according to the classification by Jung *et al.* (2015). *R. sardous* is a casual alien plant mainly distributed in forest edge of lowland, forming small populations with regional and low frequency of occurrence in Korea (Jung *et al.*, 2017). The population size is less 100 mature individuals. It is difficult to trace how this species was introduced from the location of native to Korea, but considering the environment of habitat, we can be assumed that it immigrated long ago. Although the current distribution of *R. sardous* is restricted to Hanon Wetlands in Jeju Province because this location are paddy fields, which are removed for paddy farming in June (weeding season). So, Thus far has limited impact on local environments, But wetlands and coastal areas are prone to invasion of alien plant species owing to their frequent exposure to stress and disturbance (Cho and Cho, 2015; Kim *et al.*, 2019). Besides, there is strong case for the spread dramatically of *R. sardous* in many other areas of the world (USDA, NRCS, 2019). Therefore, local and regulatory authorities should pay close attention to this plant and take measures to stop its expansion.

Taxonomic note: *R. sardous* shows morphological similarities with *R. sceleratus* L. in being annual, 3-partite leaf blades and reflexed sepals etc. Despite these similarities, there are clear differences between these two species in the presence of trichomes and the shape of leaf segments, aggregated fruits and achenes (Figs. 1, 2; Table 3). Furthermore, *R. sardous* is characterized by longer petioles of basal leaves and middle leaf segments abruptly contracted into a stalk when compared with those of *R. sceleratus* (Srivastava, 2010).

Key for identification of the genus *Ranunculus* L. in Korea

1. Plants annuals or biennial.
 2. Rarely pubescent to glabrous; aggregate fruit ovoid-cylindric to cylindric *R. sceleratus* (개구리자리)
 2. Pubescent; aggregate fruit globose to sub-globose *R. sardous* (털개구리자리)
1. Plants perennial.
 3. Aggregate fruit ovoid-cylindric to cylindric *R. chinensis* (젓가락나물)
 3. Aggregate fruit globose to sub-globose.
 4. Plants sparsely pubescent; achenes persistent stigma hooked at apex *R. quelpaertensis* (왜젓가락나물)
 4. Plants hirsute; achenes persistent stigma straight at apex.
 5. Leaves 2-ternate, leaflet narrowly oblanceolate *R. tachiroei* (개구리미나리)
 5. Leaves 1-ternate, leaflet ovate to obovate *R. cantoniensis* (털개구리미나리)

Additional specimens examined: Hanon wetland, Hogeundong, Seogwipo-si, Jeju-do, Korea, 22 May 2018, *K.H.Lee* 201800522-001 (KH); 23 May 2019, *K.H.Lee* 201900523-001, 201900523-002 (KH).

Conflicts of interest

Authors declare that there is no conflict of interests.

Acknowledgments

This study was supported by the Korea National Arboretum, project No. 'KNA1-2-27, 16-5'. We would like to thank the

anonymous reviewers for their valuable comments and suggestions.

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(Received 22 July 2019 ; Revised 4 September 2019 ; Accepted 26 September 2019)