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Research Article

Aethusa cynapium L. (Apiaceae), a new invasive alien plant in the Republic of Korea

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Abstract

Native to Europe, Western Asia, and the Caucasus, *Aethusa cynapium* L. is an invasive plant that has been introduced in many parts of the world, including North America, North Africa, the Russian Far East, and Japan. As for the Republic of Korea, the species is currently found in the Yangjaecheon Stream in Gaepo-dong, Gangnam-gu, in Seoul. Morphologically, it is similar to *Cicuta virosa* and *Conium maculatum* but can be distinguished from them by its striated stems, triangular or ovate leaflets, 6–25.3 mm unequal rays, three linear-lanceolate involucels, and filiform ribs on fruits. Considering that its seeds can remain viable in the soil for 10–20 years, local and regulatory authorities should pay close attention to this potentially dangerous species. Our study provides photographs, morphological description, and a geographical distribution map of *A. cynapium*.

Key words: alien species, fool's parsley, the volatile alkaloid cynopine, toxic plants, unrecorded species

Introduction

Members of the Apiaceae, comprising 440 genera and nearly 3,700 species, are mainly distributed across the northern temperate regions of the world. Species of this family usually have a characteristic pungent or aromatic odor owing to the presence of an essential oil or oleoresin (She et al. 2005a; Singh et al. 2007; Amiri et al. 2016). This family include important vegetables or medicinal crops such as carrot (*Daucus carota* L.), celery (*Apium graveolens* L.), coriander (*Coriandrum sativum* L.), fennel (*Foeniculum vulgare* Mill.), and cumin (*Cuminum cyminum* L.). Additionally, some Apiceae species are used as ornamental flowering plants such as blue lace flowers (*Trachymene caerulea* Graham) and sea holly (*Eryngium maritimum* L.) (Wang et al. 2022).

Aethusa cynapium L. (Apiaceae), commonly known as fool's parsley, is the only member of the genus *Aethusa* (Shri et al. 2010). The genus name supposedly derives from the Greek "aetein" referring to its burning taste (Power et al. 1905; Shishkin 1950). *Aethusa cynapium* is characterized by a fusiform root and a smooth, hollow, branched stem growing to approximately

20–60 cm (8–24 in), with bi- or tri-pinnate glabrous leaves and umbels composed of small white flowers (Ewing et al. 1919; Shishkin 1950; Dwivedi et al. 2021). This economically important species is a well-known annual garden weed and a traditional medicine for stomach- and intestine-related problems (Power et al. 1905; Shishkin 1950; Richa et al. 2009; Shri et al. 2010; Dwivedi et al. 2021). The species is similar to parsley (*Petroselinum crispum* Fuss) and common chervil (*Anthriscus cerefolium* Hoffm.), which are used as herbs, but differs from them because of its nauseous odor when rubbed (Castro 1958). In addition, genus *Aethusa* is distinguished from other Apiaceae genera in that the involucels have three oblong-linear leaflets, acuminate at the apex, often exceeding the umbel, and attached to one side (Shishkin 1950). This species is native to Europe, Western Asia, and the Caucasus and has been introduced into North America, North Africa, the Russian Far East, and Japan (Shishkin 1950; Mito et al. 2004; POWO 2022).

Aethusa cynapium had not been previously reported in Korea; however, it was recently detected in the Yangjaecheon Stream, Seoul (Figure 1A). To date, 45 genera and 112 species within Apiaceae have been recorded in the Korean Peninsula, six of which are cultivated and 12 are alien plants, including *A. cynapium* (Korea National Arboretum 2021a, b; Kim et al. 2022). Three species of toxic plants in Apiaceae are known, *Conium maculatum* L. (Poison Hemlock), *Cicuta* sp. (Water Hemlock), and *A. cynapium* (Lesser Hemlock, Small Hemlock), which produce the alkaloids coniine and cicutoxin and the volatile alkaloid cynopine, respectively (Dwivedi et al. 2021). The whole *A. cynapium* plant is poisonous when it is fresh, and people become sick after ingesting even small amounts (Power et al. 1905; Dwivedi et al. 2021). Conversely, the plant is not harmful after drying, because toxins such as cynopine are destroyed by drying (Salisbury 1961; Moreau 1996; Fleming 2000).

Here, we provide information on the habitat and distribution of *A. cynapium* of Korea, a description of its morphological characteristics, and photographs to help manage this potentially invasive alien plant.

Materials and methods

Field surveys were conducted in July 2021, and the examined materials were deposited at the Korea National Herbarium (KH). An absolute digimatic caliper (500-181-30, Mitutoyo, Kanagawa, Japan) was used to measure the morphological characteristics of the new alien species, and a microscope (Carl Zeiss Microscopy GmbH, Stemi 508, Zeiss, Göttingen, Germany) with an Axiocam ERc 5s was used to capture and observe photographs. Specimens deposited in the Korea National Herbarium and the literature by Pan et al. (2005) and She et al. (2005b) were referenced to compare the new invasive alien plant with other similar species (*Cicuta virosa* and *Conium maculatum*).

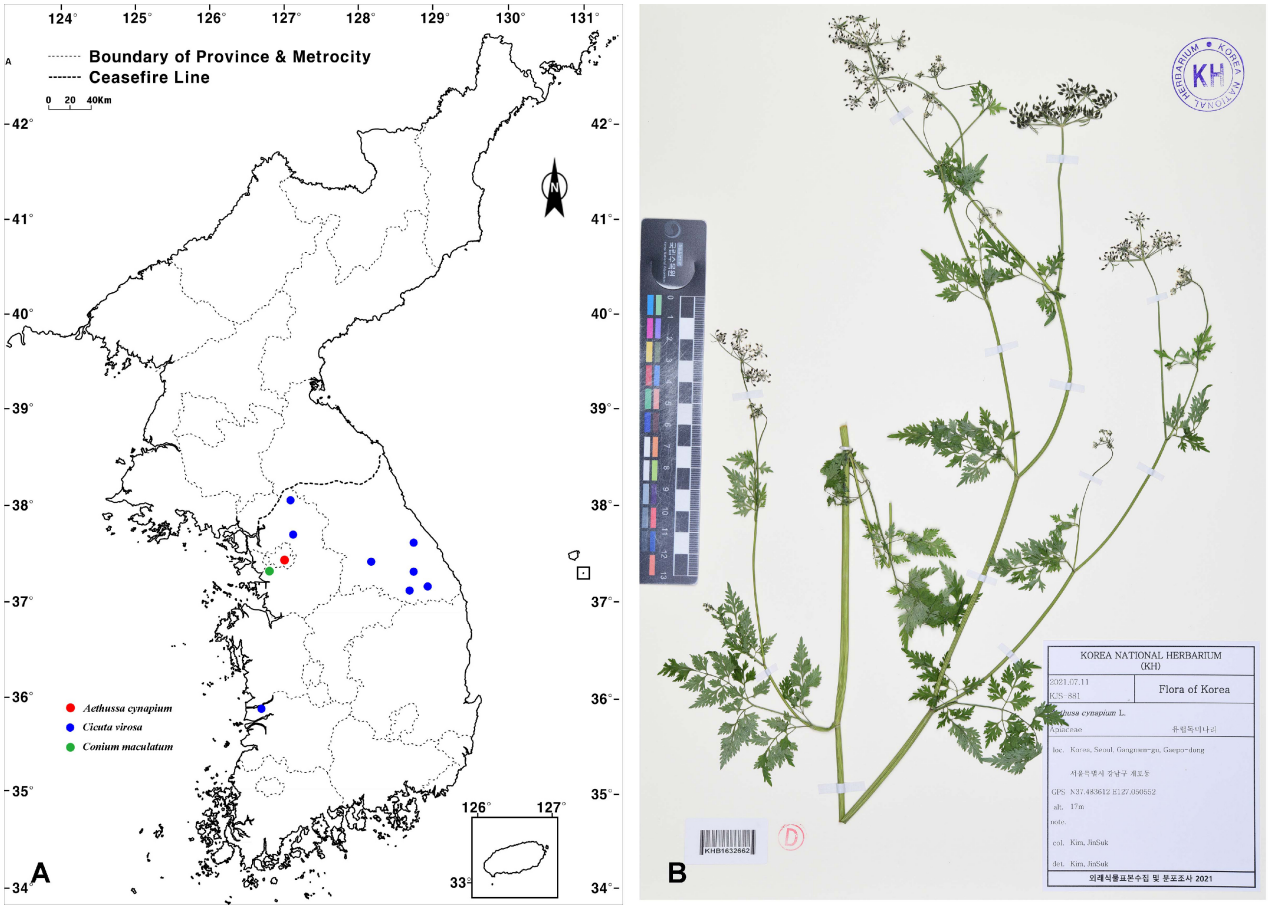


Figure 1. Distribution and specimens of *Aethusa cynapium*. A. Distribution map of *A. cynapium* and related species (*Cicuta virosa* and *Conium maculatum*) in Korea. B. Specimens examined.

Results

Taxonomic Treatment

***Aethusa cynapium* subsp. *cynapium* L. sp. Pl. 1: 256, 1753.**
(Figures 2, 3)

The lectotype (designated Rechinger Fl. Iran. 162: 345, 1987). Anonymous *s.n.* (LINN-362.1, Photograph!)

Korean name: Yu-reop-dok-mi-na-ri (유럽독미나리)

Description: **Herbs** are annual, rarely biennial, hermaphroditic, 30–100 cm tall. **Root** taproot, fusiform, yellowish-white. **Stem** erect, branched, hollow in cross section, glabrous. **Leaves** alternate, bi- or tripinnate, 5.4–10.6 × 3.9–7.9 cm, adaxial surface green, abaxial surface pale green, both surfaces glabrous; petioles in lower leaves, sessile on dilated sheath in the upper; leaflets triangular or ovate, deeply cut or parted. **Inflorescence** terminal and lateral, compound umbels, 3.3–7.3 cm in diam.; peduncle 6.1–14.2 cm long; involucre absent or rarely one or two leaflets; rays 10–20, 6.0–25.3 mm, unequal; involucels asymmetrical, three leaflets, linear-lanceolate, acuminate at apex, 4.51–6.39 mm long, reflexed, scarious at base and margins; pedicel 10–20, 2.6–5.5 mm long, unequal. **Flowers** bisexual, actinomorphic; petals, five;

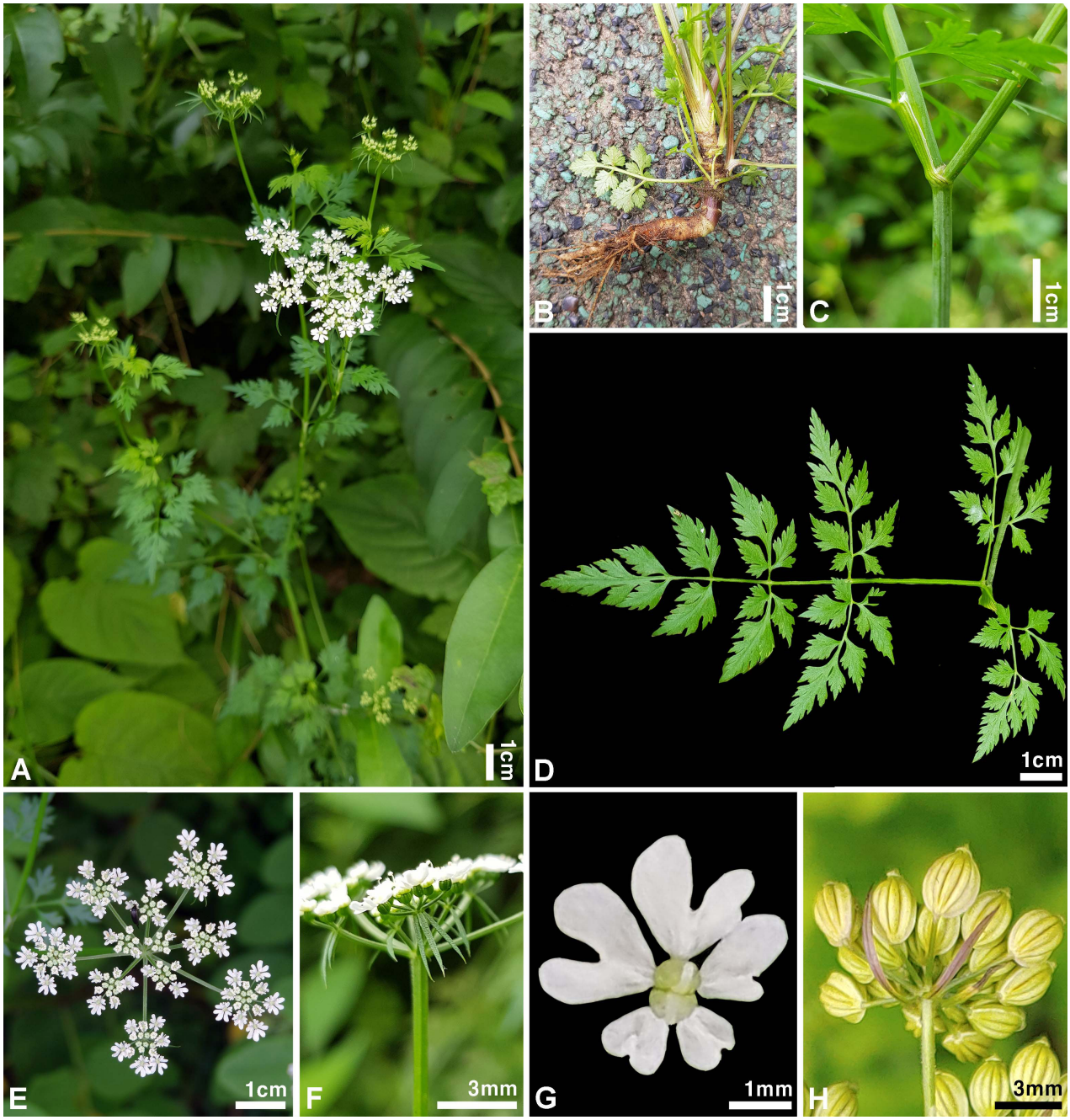


Figure 2. Photographs of *A. cynapium:* A. Habit B. Root, C. Stem, D. Leaf, E. Inflorescence, F. involucels, G. Flower, H. Schizocarp. Photographs by Jin Suk Kim.

asymmetrical, obcordate, cuneate at base, 0.8–1 ×1.1–1.3 mm, white; stamens, five, alternating with petals; filaments, filiform, 1–1.8 mm; pistil, two carpellate; ovary, inferior, syncarpous, two locular; stylopodium, conical; styles, two, 0.5–0.6 mm, free, ascending, reflexed in fruit. **Fruit** a dry schizocarp composed of two mericarps, ovate-ellipsoid, 3.2–3.8 × 2.0–2.5 mm; mericarps dorsally compressed, glabrous; dorsal ribs, three, filiform, prominent, not winged; marginal ribs, winged.

Phenology: June to October.

Chromosome number: $2n$ = 20 (Arohonka 1982; Buttler 1984; Uotila 1985; Probatova et al. 2006).

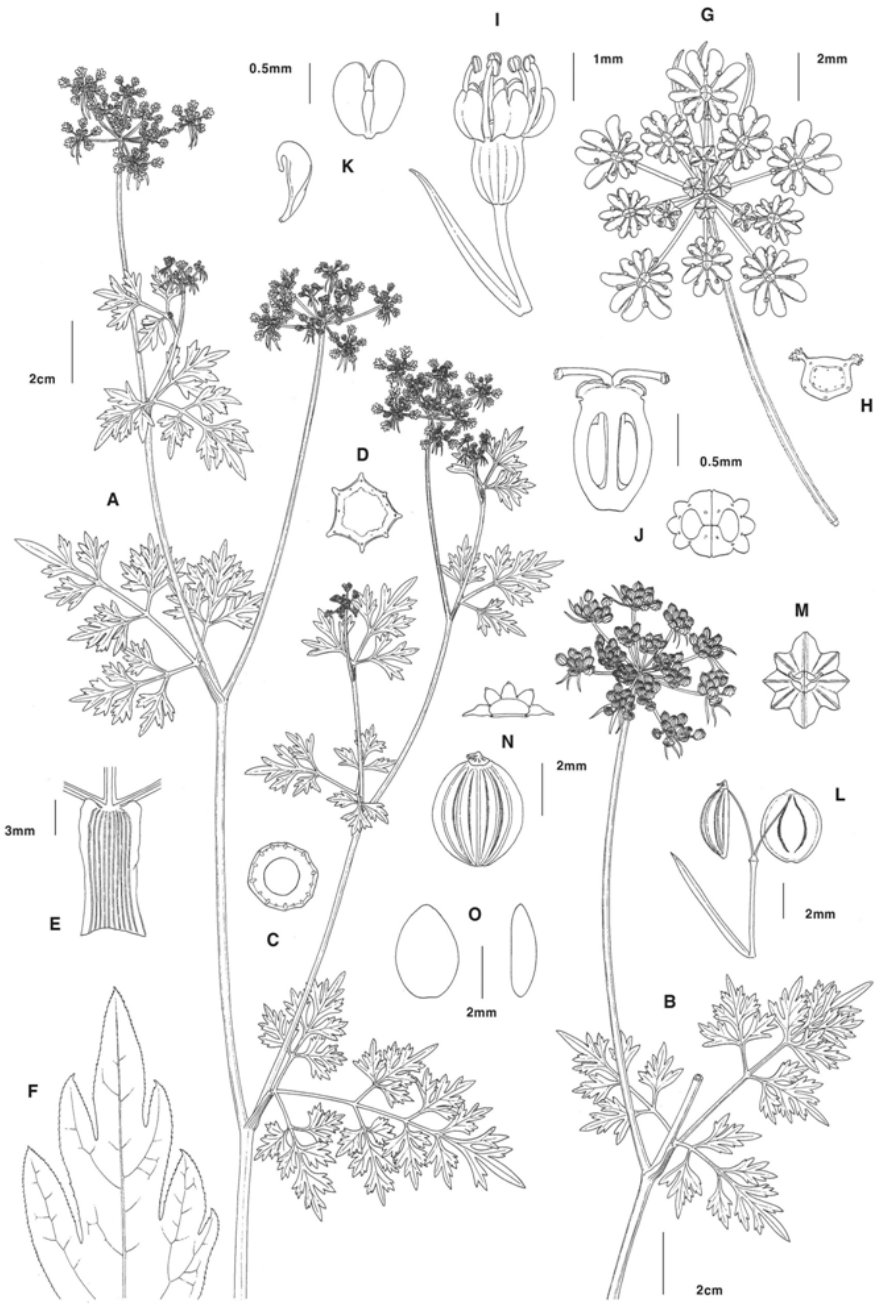


Figure 3. Illustrations of *A. cynapium*. A–B. Habit, C. Stem cross-section, D. Peduncle cross-section, E. Petiole, F. Leaf margin, G. Inflorescence, H. Ray cross-section, I. Flower, J. ovary, K. Petal, L–N. Fruit, O: Seed. Illustrations by Kyungsoo Eo.

Habitat and distribution: This species is found in felled areas and floodplain forests of the Republic of Korea (Seoul), Europe, Western Asia and the Caucasus, North America, North Africa, the Russian Far East, and Japan.

Specimens examined: Gaepo-dong, Gangnam-gu, Seoul, Republic of Korea, 11 Jul 2021, *KJS-881* (KHB1632662, Figure 1B); Gaepo-dong, Gangnam-gu, Seoul, Republic of Korea, 11 Jul 2021, *KJS-881* (KHB1632663).

Taxonomic note: *Aethusa cynapium* is a very variable species, which can be divided into three subspecies: *A. cynapium* subsp. *cynapium*, *A. cynapium*

Table 1. Comparison of the major characteristics of *Aethusa cynapium*, *Cicuta virosa*, and *Conium maculatum*.

Character		*Aethusa cynapium*	*Cicuta virosa*	*Conium maculatum*
Habit	Length (cm)	30–100	70–120	150–200
Stem	Surface	striate	striate	conspicuously purple-spotted
Leaves	Shape	2-3 pinnate	(1-)2-3 pinnate	2-3 pinnate
	Length (cm)	5.4–10.6	12–30	10–30
	Width (cm)	3.9–7.9	10–25	6–28
	Shape of leaflet	triangular or ovate	linear-lanceolate or lanceolate	oblong or ovate-lanceolate
	Margin	parted	serrate or dentate	incised or pinnatifid
Peduncles	Length (cm)	6–15	2.5–20	2–7 cm
rays	Number	10–20	6–25	10–20
	Length (mm)	6.0–25.3	2–6	1.5–4
Pedicels	number	10–20	15–35	10–20
	Length (mm)	2.6–5.5	4–8	1–5
Involucres	Number	absent	absent or 1	2–6
	Shape		linear	ovate-lanceolate
	Length (mm)		ca. 8	2–5
Involucels	Number	3	numerous	2–6
	Shape	linear-lanceolate	linear-lanceolate	ovate
	Length (mm)	4.5–6.5	3–5	1.5–3
Petals	shape	obcordate, having enlarged petals on the outer edge in an umbellet	obovate or suborbicular, apex incurved	obovate or obcordate, apex incurved
Fruit	shape	ovate-ellipsoid	ovoid-globose	ovoid or ovoid-globose
	ribs	filiform	filiform	narrowly sinuate-winged
Phenology		Jun.–Oct.	Jul.–Sep.	May–Aug.
Chromosome number (2n)		2n = 20	2n = 22	2n = 22

subsp. *elata* (Hoffm.) Schübl. & G.Martens, and *A. cynapium* subsp. *segetalis* (Boenn.) Schübl. & G.Martens (POWO 2022). They can be distinguished by the following morphological features. *A. cynapium* subsp. *elata* often exceeds 100 cm in height and has oblong to linear leaf-lobes, while two subspecies are shorter than 100 cm and have ovate leaf-lobes. Moreover, *A. cynapium* subsp. *segetalis* can be separated from *A. cynapium* subsp. *cynapium* by its involucels shorter or equal than the partial umbels and outer pedicels usually shorter than their fruits (Tutin 1968; Fabri 1989). As a result of examining these characteristics, the species discovered in Korea is *A. cynapium* subsp. *cynapium*.

Aethusa cynapium is morphologically similar to *Cicuta virosa* and *Conium maculatum* in the Korean Peninsula. However, the former can be clearly distinguished from the latter by the surface of the stem, shape of the leaves, shape of the involucre, number and shape of involucels, and shape of the ribs on the fruits. *Aethusa cynapium* has a striate stem, triangular or ovate leaflets, 6–25 mm unequal rays, three linear-lanceolate involucels, and filiform ribs on fruits, whereas *Cicuta virosa* has a striate stem but linear-lanceolate or lanceolate leaflets, 2–6 cm subequal rays, numerous linear-lanceolate involucels, and filiform ribs on fruits. In turn, *Conium maculatum* has a conspicuously purple-spotted stem, oblong or ovate-lanceolate leaflets, 1.5–4 cm unequal rays, 2–6 ovate involucels, and narrowly sinuate-winged ribs on fruits (Table 1, Figure 4). Furthermore, we found additional differences among these three species in terms of phenology and somatic chromosome number. Thus, flowering and fruiting periods of

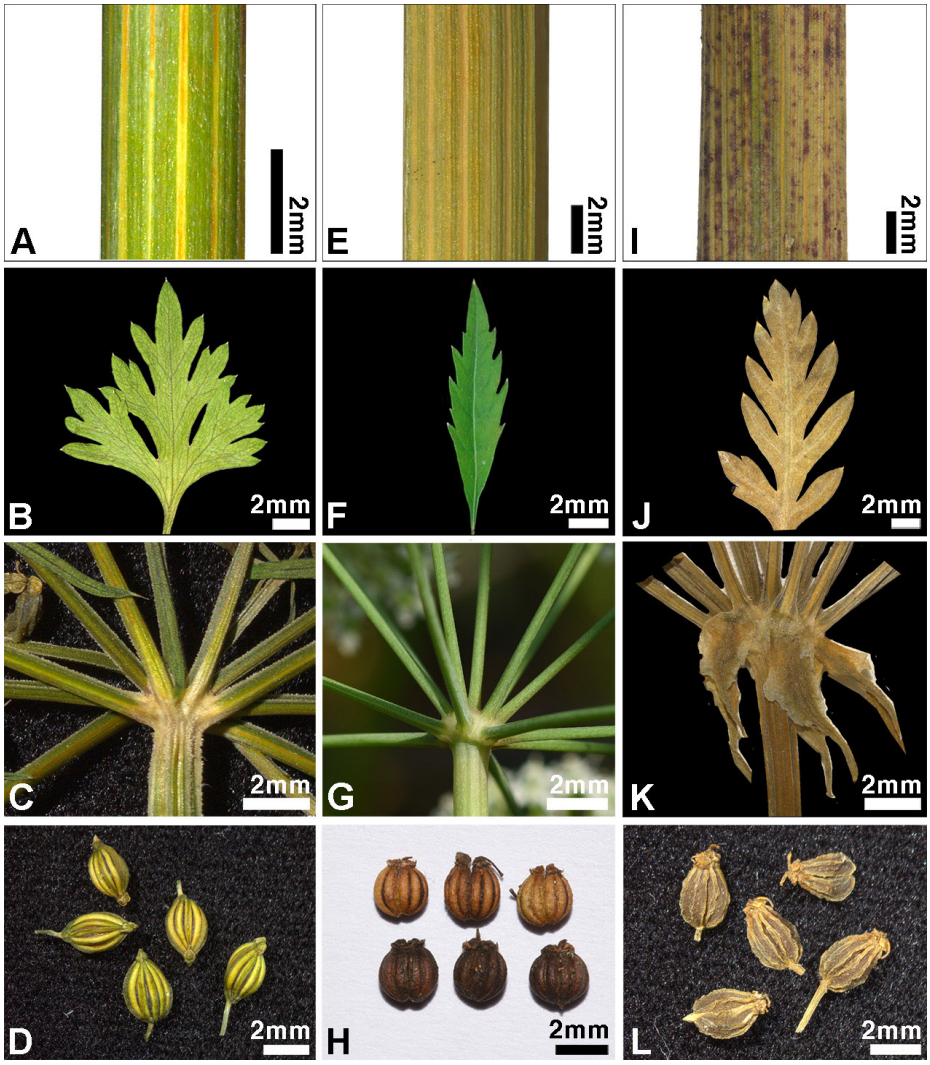


Figure 4. Comparative photographs of the stem, leaflet, involucre, and schizocarp of *A. cynapium* (A–D), *Cicuta virosa* (E–H), and *Conium maculatum* (I–L). Photographs by Ju Eun Jang.

Aethusa cynapium, *Cicuta virosa*, and *Conium maculatum* were from June to October, July to September, and May to August, respectively. Meanwhile, the number of chromosomes in *A. cynapium* is 2n = 20, whereas *C. virosa* and *C. maculatum* reportedly have 2n = 22 (Rostovtseva 1976; Silvestre 1978; Spooner et al. 1987; Krasnikov et al. 1990).

Discussion

The species is morphologically different from *C. virosa*, a rare plant with a northern distribution limit, and *C. maculatum*, which was recorded as an alien plant (Park 1999; Supplementary material Appendix 1). *Aethusa cynapium* is an annual weed native to Europe (particularly the United Kingdom), Western Asia, and the Caucasus (Bond et al. 2007; Richa et al. 2009). It was introduced to North America, North Africa, the Russian Far East, Japan, and Korea (Shishkin 1950; Mito et al. 2004; POWO 2022). In North America, it is widely naturalized in the northeastern United States and southeastern Canada (Nelson et al. 2007; Dwivedi et al. 2021).

Furthermore, it has been reported as an invasive alien plant in Japan to prevent adverse effects on ecosystems, human safety, and agriculture (Mito et al. 2004). This genus is mainly found in floodplain forests with nutrient-rich loams, and we found it in the vicinity of the Yangjae stream (Hanf 1974). Considering that the seeds of this species can remain in the soil for 10–20 years, and although *Aethusa* species formed a small population in this study, local and regulatory authorities should pay attention to this plant to prevent wide spreading (Brenchley et al. 1936; Long 1938; Chancellor 1986). Therefore, it is necessary to monitor the invasive alien plant to determine the rate of expansion and the pattern of spread.

Authors' contribution

SDC designed the study and revised the manuscript. KJS and YYO have collected the data and conducted field work. KJS and GHY revised the manuscript. JJE conducted the investigation and wrote the original draft. All authors have read and agreed to the submitted version of the manuscript.

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Supplementary material

The following supplementary material is available for this article:

Appendix 1. A list of the representative specimens of *Cicuta virosa* and *Conium maculatum* examined in this study.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2024/Supplements/BIR_2024_Jang_etal_SupplementaryMaterial.pdf