Stachyurus praecox (Stachyuraceae), first report in Korea

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ABSTRACT: We report a previously unrecorded woody species, *Stachyurus praecox* Siebold & Zucc. (Stachyuraceae), in Korea. This species is considered to be endemic to Japan. *Stachyurus praecox* was collected for the first time in an evergreen forest on an uninhabited island of Bongsun-ri, Saengil-myeon, Wando-gun, Jeollanam-do in Korea. The inflorescence of the species was racemose and pendulous on the axils of the previous year's branches. Flowers bloomed from March to April. They were functionally dioecy but morphologically hermaphrodite. This woody species was named 'Wan-do-sul-kkot-na-mu' in Korean based on the shape of its inflorescence. Morphological characteristics and illustrations of this woody species have been provided with a distribution map and photographs of the natural habitat.

Keywords: first report in Korea, *Stachyurus praecox*, Stachyuraceae

Stachyuraceae J. G. Agardh, a family endemic to East Asia, is mainly distributed from the Himalayas across subtropical China to Taiwan Island and the Japan Archipelago (Feng et al., 2020). This family is comprised of a single genus, *Stachyurus* Siebold & Zucc. with approximately 11 species, and consists of shrubs and small trees (Keiji, 1959; Feng et al., 2020). Su et al. (2020) redefined seven species of *Stachyurus* following an integrative species concept and revised the taxonomy of Stachyuraceae based on previous reports and specimens, including the type specimens.

Stachyurus praecox Siebold & Zucc. has been regarded as an endemic species of Japan (Kitamura and Murata, 1994; Kato and Ebihara, 2011). This woody species is a pioneer shrub common in forest edges in the warm temperate zone in Japan (Abe, 2007). It is a small deciduous tree with single, alternate, and petiolate leaves (Keiji, 1959). Inflorescence is racemose, pendulous, located on axils of the previous year's branches, and 3–10 cm in length. The flowers are hermaphrodite or sometimes plant dioecious, with four each of sepals and petals (Abe, 2007). Fruit is a berry with a coriaceous pericarp that are broadly ellipsoid to ovoid, 0.7–1.2 cm in diameter, and green and brownish yellow when mature (Feng et al., 2020;

Su et al., 2020).

Recently, a natural population of the species was discovered on the uninhabited island of Wando-gun, Jeollanam-do in Korea. This is the first report of *S. praecox* in a natural habitat in Korea. We provide the morphological characteristics, illustrations, photographs, and a distribution map of this woody species.

Materials and Methods

DNA extraction

Two accessions of *S. praecox* collected in Wando-gun were included in phylogenetic analysis. Voucher specimens (*C. J. Oh* OCJ80118 and OCJ80119) were deposited in the herbarium of Korea National Arboretum (KH). Specific information of the specimens are described in the Specimens examined section below. Total DNA from leaves was isolated using Exgene Plant SV (GeneAll Co., Seoul, Korea) following the manufacturer's protocol. Isolated DNA was stored at -20°C.

Primer design and polymerase chain reaction

PCR was performed using the internal transcribed spacer (ITS) 1 and ITS4 primers (White et al., 1990) for amplification

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of the ribosomal ITS regions. The PCR reactions were conducted with a final reaction volume of 30 µL containing EmeraldAmp GT PCR Master Mix (Takara, Tokyo, Japan), each primer (10 pM) and template DNA (50–100 ng/µL).

The PCR reactions were carried out with an initial denaturation for 5 min at 94°C, followed by 35 cycles of denaturation for 30 s at 96°C, annealing for 30 s at 57°C, extension for 1 min at 72°C, and with a final extension for 10 min at 72°C. PCR products were electrophoresed on a 1.5% agarose gel, and then the DNA band was confirmed using UV transilluminator. Amplified PCR products were purified using AccuPrep PCR Purification Kit (Bioneer Co., Daejeon, Korea), and sequenced using the same primers at Macrogen Co., Seoul, Korea

Phylogenetic analysis

To determine the phylogenetic position of newly collected plants in this study, we conducted maximum likelihood analysis using the nucleotide sequences of the ITS regions of six species of *Stachyurus*. Also, for phylogenetic analysis, *Staphylea bumalda* DC. (GenBank accession number: MH808363) was included as an outgroup. The newly obtained ITS sequences were edited by Geneious Prime (Kearse et al., 2012), and

multiple sequence alignment was conducted by using the MAFFT program (Kato, 2013). Maximum Likelihood analysis of the ITS data was performed in RAxML 8.2.11 (Stamatakis, 2006) with the following settings. Nucleotide model was used GTR-GAMMA; algorithm was used Rapid Bootstrapping and search for best-scoring maximum likelihood tree; the number of starting trees or bootstrap replicates were performed 100 times; and parsimony random seed was performed.

Results and Discussion

To determine whether the samples of *Stachyurus* collected from Wando-gun, Jeollanam-do are the same taxon as *S. praecox*, Maximum likelihood analysis based on the ITS dataset of regions of six taxa of *Stachyurus* was performed. The results suggested two accessions representing male and female plants collected on Wando-gun, denoted as “*Stachyurus-wando_Male*” and “*Stachyurus-wando_Female*” formed a clade with *S. praecox* with strong bootstrap support (Fig. 1). Therefore, *Stachyurus* collected from Wando-gun, Jollanam-do in the present study was considered to be in the same taxon as *S. praecox* distributed in Japan. This is the first report not

Fig. 1. Phylogenetic position of newly collected materials in Korea denoted with *Stachyurus-wando* from the analysis of nucleotide sequences from the internal transcribed spacer regions. The maximum likelihood tree is shown with bootstrap values above branches. GenBank accession number is indicated in each taxon.

only of *Stachyurus praecox* in Korea but of Stachyuraceae in the Korean flora. We suggest Wan-do-sul-kkot-na-mu-gua (완도술꽃나무과) for the Korean name of the family.

Taxonomic Treatment

Stachyurus praecox Siebold & Zucc., Fl. Jap. (Siebold) 1: 43, 1836.

Stachyurus praecox var. *rotundifolius* Tuyama, J. Jap. Bot. 16: 504, 1940; *S. praecox* f. *rotundifolius* (Tuyama) Tuyama ex H. Hara, Enum. Sperm. Jap. 3. 229, 1954.

Stachyurus praecox var. *microphyllus* Nakai Bull. Nat. Sci. Mus. Tokyo no. 27: 31, 1949; *S. praecox* f. *microphyllus* (Nakai) H. Hara, Enum. Sperm. Jap. 3. 229, 1954.

Stachyurus praecox var. *parviflorus* Makino ex H. Hara, Enum. Sperm. Jap. 3. 229, 1954.

Stachyurus praecox f. *marginatus* Hiyama, J. Jap. Bot. 36: 127, 1954.

Korean name: Wan-do-sul-kkot-na-mu (완도술꽃나무).

Deciduous usually small trees, stems 3–9 m tall, ca. 5–10 cm in diam., bark dull purplish-brown. Leaves alternate, petiole 1–3 cm long; blade chartaceous, usually elliptic to ovoid, 12–

19 × 5.5–8 cm, apex acute to acuminate, base rounded to truncate, margins serrate, lower surfaces glabrous or sometimes pubescent on or along veins, lateral veins 5–7 pairs. Inflorescences racemose, pendulous, on axils of previous year's branches, 10–18 cm long (usually shorter in female); flowers functionally dioecious (but morphologically hermaphrodite), campanulate, 7–9 mm long; pedicel less than 0.5 mm long; bract triangular, 1.5–2 mm long; sepals 4; petals 4, greenish-yellow in pistillate flowers; stamens 8, slightly shorter than petals, rudimentary in female flowers; pistil 1, slightly longer than stamens in staminate flowers; ovary narrowly ovoid; style shorter than ovary. Fruit berry, broadly ellipsoid to narrowly ovoid, 8–10 mm in diam., green, brownish-yellow when mature. Seeds 80–105 in a fruit, 1.5–3 mm long, 0.9–1.6 mm in diam., yellowish red (Figs. 2, 3).

Flowering: March to April.

Distribution: Korea (Wando-gun), Japan (Hokkaido, Honshu, Shikoku, Kyushu).

Specimens examined: KOREA. Jeollanam-do: Wando-gun, Saengil-myeon, Bongsun-ri, 4 Apr 2018, C. J. Oh OCJ80118, OCJ80119 (KH); 26 Mar 2021, C. J. Oh OCJ210088, OCJ210089, OCJ210090 (KH).

Stachyurus praecox was newly recorded from an inhabited island of Saengil-myeon, Wando-gun, Jeollanam-do in Korea

Fig. 2. Photographs of *Stachyurus praecox* Siebold & Zucc. in Korea. **A.** Natural habitat. **B.** Flowering branch. **C.** Fruiting branch. **D.** Root collar. **E.** Female inflorescence. **F.** Male inflorescence. **G.** Diameter at basal height. **H.** Leaves. **I.** Fruits. **J.** Longitudinal section of fruit. **K.** Seeds.

Fig. 3. Illustrations of *Stachyurus praecox* Siebold & Zucc. **A, B.** Habit. **C.** Leaf. **D.** Male inflorescence. **E.** Female inflorescence. **F.** Fruits. **G.** Male flower. **H.** Stamens. **I.** Longitudinal section of male flower. **J.** Female flower. **K.** Pistil. **L.** Longitudinal section of female flower. **M.** Fruit. **N.** Arrangement of seed in fruit. **O.** Seeds.

Fig. 4. Distribution map of *Stachyurus praecox* Siebold et Zucc. in Korea and Japan.

(Fig. 4). Over 200 trees were distributed along the coastline on the island. The tallest tree was 8 m high and 23 cm in basal diameter. Most of the trees had two to 6 branches (Fig. 2).

Stachyurus praecox, distributed in Wando-gun, Jeollanam-do in Korea, is presumed to have migrated approximately 40 to 50 years ago via bird dispersal of seeds that originated from Japan archipelago (Abe and Matsunaga, 2007; Sakai et al., 2010).

Vegetation analysis of the population showed that the tree layer was comprised of *Neolitsea aciculata* (Blume) Koidz., *Dendropanax trifidus* (Thunb.) Makino ex H. Hara and *Ilex integra* Thunb., and other species, and was dominated by *Cinnamomum yabunikei* H. Ohba. In the subtree layer, *S. praecox* was the dominant species and *Machilus thunbergii* Siebold & Zucc. ex Meisn., *Ligustrum japonicum*, *Camellia japonica* L., *Litsea japonica* (Thunb.) Juss., *Ficus erecta* Thunb., *Neolitsea sericea* (Blume) Koidz., *Prunus serrulata* Lindl. f. *spontanea* (E. H. Wilson) Chin S. Chang, *Neolitsea aciculata* (Blume) Koidz., and *Eurya japonica* Thunb. were

the major species. The shrub layer was composed of *Litsea japonica* (Thunb.) Juss., *Camellia japonica* L., *Dendropanax trifidus* (Thunb.) Makino ex H. Hara, *Stauntonia hexaphylla* (Thunb.) Decne., *Trachelospermum asiaticum* (Siebold & Zucc.) Nakai, *Sinomenium acutum* (Thunb.) Rehder & E. H. Wilson, *Hedera rhombea* (Miq.) Siebold & Zucc. ex Bean, *M. thunbergii* Siebold & Zucc. ex Meisn., *Osmanthus insularis* Koidz., *Aucuba japonica* Thunb., *N. sericea* (Blume) Koidz. and *Callicarpa japonica* Thunb., including *S. praecox*. The major species in the herb layer were *Farfugium japonicum* (L.) Kitam., *Cyrtomium falcatum* (L.f.) C. Presl, *Ophiopogon jaburan* (Siebold) Lodd., and *Arisaema thunbergii* Blume.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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한국 미기록종 식물: 완도솔꽃나무 (완도솔꽃나무과)

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적 요: 전남 완도군 섬지역에서 발견된 *Stachyurus praecox* Siebold & Zucc.를 우리나라 미기록 식물로 보고한다. 이 수종은 일본의 난·온대지역에 넓게 분포하고 있으며, 특산수종으로 알려져 왔다. 꽃은 총상화서에 달리며, 형태적으로는 양성화지만, 기능적으로는 자웅이주로 관찰되었다. 화관은 흰색 또는 연한 보라색 꽃잎과 꽃받침은 각각 4개이다. 국명은 최초 발견지 지역명과 꽃차례 모양이 장식용으로 달리는 여러 가닥의 실을 의미하는 뜻으로 쓰이는 “술”을 고려하여 “완도솔꽃나무”로 신청하였으며, 이에 대한 기재문과 도해, 사진을 제시하였다.

주요어: 한국 미기록, 완도솔꽃나무, 완도솔꽃나무과