

## ISOËTACEAE

水韭科 shui jiu ke

Zhang Libing (张丽兵)<sup>1</sup>; W. Carl Taylor<sup>2</sup>

Plants grasslike, heterosporous, perennial lycophytes growing as submerged aquatics or emergent and amphibious [or seasonal terrestrials]. Rhizome brown, cormlike, corky, (2 or)3(–5)-lobed, nearly globose [or horizontally spindle-shaped and proliferous]. Roots arising along central groove separating each rootstock lobe, dichotomously branched [or unbranched], containing eccentric vascular strand and surrounding lacuna. Microphylls tufted, several to many, erect to spreading, straight to recurved, (1–)5–50(–100) cm, spirally [or distichously] arranged, simple, linear with membranous margins toward base, dilated and spatulate basally, tapering to apex, semiterete in cross section with adaxial surface flattened and abaxial surface rounded, containing 4 transversely septate longitudinal lacunae with septa apparent on adaxial microphyll surface, 1 central collateral vascular strand, and frequently several peripheral fibrous bundles at microphyll angles. Ligules deltoid to cordate, 1–2(–6) mm, membranous, inserted above sporangium; sclerified scales and phyllopodia occasionally surrounding microphylls. Megasporephylls and microsporephylls usually borne in alternating cycles. Megasporeangia often at adaxial side of external microphyll bases. Microsporeangia at adaxial side of internal microphyll bases. Sporangia solitary, adaxial, embedded in basal cavity of sporophyll, ellipsoid to subglobose, 2–7(–15) mm, walls unpigmented [or brown streaked to completely brown], traversed internally by septae; velum membranous, rudimentary [or partly to completely covering adaxial surface of sporangium wall]; megasporangium containing several to hundreds of megaspores; microsporangium containing thousands of microspores. Megaspores white when dry, gray when wet [or black], globose, 300–500(–900) µm in diam., trilete with an equatorial ridge dividing proximal and distal hemispheres and 3 radial ridges converging at pole of proximal hemisphere, surfaces smooth or textured with spines, tubercles, or ridges. Microspores gray or brown en masse, ellipsoid, 15–30(–50) µm, monolete, surfaces smooth or textured with spines, granules, or tubercles. Megagametophyte achlorophyllous, endosporic, exposed when megaspore wall opens along proximal ridges; archegonia apparent as quartets of brown neck cells. Microgametophyte 9-celled, endosporic, antheridium releasing 4 multiflagellate spermatozooids.  $x = [10], 11$ .

One genus and more than 250 species: nearly worldwide on islands and all continents except Antarctica; five species (all endemic) in China.

Zhang Libing. 2004. Isoëtaceae. In: Zhang Xianchun, ed., *Fl. Reipubl. Popularis Sin.* 6(3): 220–223.

### 1. ISOËTES Linnaeus, Sp. Pl. 2: 1100. 1753

水韭属 shui jiu shu

Morphological characters and geographic distribution are the same as those of the family.

- 1a. Plants emergent; microphylls 3–4.5 cm, ca. 1 mm wide; megaspores smooth ..... 5. *I. hypsophila*  
1b. Plants submerged or emergent; microphylls longer than (10–)15 cm, 1–10 mm wide; megaspores textured with spines, tubercles, or ridges.  
2a. Plants emergent; microphylls 1–2 mm wide; sporangia with white membranous velum cover.  
3a. Roots without reddish sheathing mantle; cross section of microphylls more circular; microphylls with 3 or more intrastelar canals; lucunae thick-walled; megaspore proximal hemisphere spinulose to spinulose-cristate, distal hemisphere cristate ..... 1. *I. sinensis*  
3b. Roots with reddish sheathing mantle; cross section of microphylls oval; microphylls with 1 intrastelar canal; lucunae thin-walled; megaspore proximal hemisphere cristate, with muri irregularly anastomosing, distal hemisphere cristate-reticulate ..... 2. *I. orientalis*  
2b. Plants submerged or emergent; microphylls 5–10 mm wide; sporangia without velum cover.  
4a. Plants submerged or emergent; microphylls 10–60 cm; megaspore proximal hemisphere rugulate-cristate with muri irregularly anastomosing, distal hemisphere cristate-reticulate ..... 3. *I. yunguiensis*  
4b. Plants emergent; microphylls 7–25 cm; megaspore proximal hemisphere tuberculate, distal hemisphere rugulate with rounded muri irregularly anastomosing ..... 4. *I. taiwanensis*

1. *Isoëtes sinensis* Palmer, Amer. Fern J. 17: 111. 1927.

中华水韭 zhong hua shui jiu

Plants helophytic, 15–30 cm tall. Rhizome slightly 2- or 3-lobed, bearing numerous forked roots. Microphylls 20–90 tufted, erect to spreading, imbricate adaxially, bright green, linear, 15–30 cm, 1–2 mm wide, succulent, herbaceous, apex

acuminate, base broadly sheathlike, membranous, yellowish white, concave adaxially; peripheral fibrous bundles present; central intrastelar canals 3 or more. Ligules triangular, 2–3 mm, acuminate. Sporangia with white membranous velum cover. Megasporeangia ca. 9 mm, ca. 3 mm in diam.; megaspores few, white, granular, tetrahedral, 330–475 µm in diam., proximal hemisphere spinulose to spinulose-cristate, distal hemisphere

<sup>1</sup> Missouri Botanical Garden, P.O. Box 299, Saint Louis, Missouri 63166-0299, U.S.A.; Chengdu Institute of Biology, Chinese Academy of Sciences, P.O. Box 416, Chengdu, Sichuan 610041, People's Republic of China.

<sup>2</sup> Department of Botany, Smithsonian Institution, P.O. Box 37012, District of Columbia 20560-0166, U.S.A.

cristate. Microspores numerous, gray, powdery, dihedral, 25–30  $\mu\text{m}$ , spinulose. Spores mature late May to end of Oct.  $2n = 44^*$ .

- Shallow water, beside ponds, sludge in gullies, intertidal zones along rivers and in streams; 100–300 m. Anhui (Dangtu, Tunxi, Xiuning), Guangxi (Guilin), Jiangsu (Nanjing), Zhejiang (Hangzhou, Jiande, Lishui, Zhuji).

Molecular, cytological, and morphological evidence shows that *Isoëtes sinensis* may be allotetraploid, originating via hybridization between *I. yunguiensis* and *I. taiwanensis*.

**2. *Isoëtes orientalis*** H. Liu & Q. F. Wang, *Novon* 16: 164. 2005.

东方水韭 dong fang shui jiu

Plants aquatic, emergent. Rhizome 3-lobed. Microphylls 20–40 tufted, widely spreading, white at base, green above, spirally arranged, 10–20 cm, ca. 2 mm wide at middle, flattened on adaxial side, rounded on abaxial side, base alate; peripheral fibrous bundles present; central intrastelar canal 1. Ligules ovate-subtriangular, 1.5–2  $\times$  2–3 mm. Sporangia basal, obovate, 5–6  $\times$  3.8–4.5 mm; velum rudimentary, covering only distal edge of sporangium. Megaspores white when dry, gray when wet, 350–450  $\mu\text{m}$  in diam., proximal hemisphere cristate with muri irregularly anastomosing, distal hemisphere cristate-reticulate. Microspores gray en masse, elliptic, 19–29  $\mu\text{m}$  in diam., spinulose-verrucate and granular. Spores mature Jun–Oct.  $2n = 66^*$ .

- Swampy and loamy meadows between hills; ca. 1200 m. Zhejiang (Songyang).

*Isoëtes orientalis* is an allohexaploid. It occurs within the range of *I. sinensis*, and it appears to be a hybrid between *I. sinensis* and *I. yunguiensis* or a closely related taxon.

**3. *Isoëtes yunguiensis*** Q. F. Wang & W. C. Taylor, *Novon* 12: 587. 2002.

云贵水韭 yun gui shui jiu

Plants submerged or emergent, 10–52 cm tall. Rhizome slightly 3-lobed. Microphylls 20–70 tufted, widely spreading, spirally arranged, semitransparent, green, linear, 10–60 cm, 5–10 mm wide, cross section triangular-semicircular, herbaceous, base enlarged on both sides, broadly sheathlike, membranous, concave adaxially; peripheral fibrous bundles absent. Ligules triangular, cuspidate, 1–2.5 mm. Sporangia oblong, 2–7 mm, concave, without membranous velum cover. Megaspores globe-tetrahedral, 340–430  $\mu\text{m}$  in diam., proximal hemisphere rugulate-cristate with muri irregularly anastomosing, distal hemisphere cristate-reticulate. Microspores numerous, gray, powdery, 20–25  $\mu\text{m}$ , smooth to granular. Microphylls Apr–May, sporangia Jul–Aug, spores mature Sep–Oct.  $2n = 22^*$ .

- Marshy soil and small ponds along streams; 1300–1900 m. Guizhou, Yunnan (Kunming, Xundian).

Specimens of *Isoëtes yunguiensis* have long been identified as *I. japonica* A. Braun, but the megaspores of *I. yunguiensis* have cristate-reticulate ornamentation with rough ridges and are 360–450  $\mu\text{m}$  in diam. and the chromosome number is  $2n = 22$ ; while megaspores of *I. japonica* have regular reticulate ornamentation with flattened ridges and are 390–550  $\mu\text{m}$  in diam. and the chromosome number is  $2n = 66$ .

**4. *Isoëtes taiwanensis*** De Vol, *Taiwania* 17: 1. 1972.

台湾水韭 tai wan shui jiu

Plants emergent. Rhizome 2–4-lobed, upper part flat, lower part terete, base margin with thinly membranous materials. Microphylls 15–90 tufted, spreading, spirally arranged, bright green, linear, 7–25 cm, succulent, herbaceous, with cavities, with single vein; peripheral fibrous bundles absent. Ligules triangular and elongate, 1–2.5 mm. Sporangia yellow. Megaspores gray when wet, white when dry, broadly elliptic, 325–425  $\mu\text{m}$  in diam., proximal hemisphere tuberculate to rugulate, distal hemisphere rugate-rugulate with rounded muri irregularly anastomosing. Microspores gray, elliptic, 20–25  $\mu\text{m}$ , spinulose. Spores mature Jul–Oct.  $2n = 22^*$ .

- Wetlands and drier places; 100–800 m. Taiwan (Quemoy (Jinmen), Taibei).

The population in Taibei has slightly longer and broader microphylls than that in Jinmen. Molecular data have not yet supported their separation into two species.

**5. *Isoëtes hypsophila*** Handel-Mazzetti, *Symb. Sin.* 6: 13. 1929.

高寒水韭 gao han shui jiu

Plants helophytic, small, less than 5 cm tall. Rhizome fleshy, tuberous, ca. 4 mm, 2- or 3-lobed. Microphylls (4–)6–10 tufted, spreading, bright green above base, linear, 3–4.5 cm, ca. 1 mm wide, succulent, herbaceous, apex acuminate, base broadly sheathlike, membranous, ca. 4 mm wide; peripheral fibrous bundles absent. Ligules cordate-ovate, ca. 1 mm. Megaspore ca. 3 mm, ca. 2 mm in diam.; megaspores 300–400  $\mu\text{m}$  in diam., proximal and distal hemispheres glabrous. Microsporangia ca. 2.5 mm, ca. 1.5 mm in diam.; microspores 18–22  $\mu\text{m}$ , glabrous. Spores mature Jul–Aug.  $2n = 22^*$ .

- Shallow water in intermittent pools, margins of waters in drying pools in grazed or ungrazed meadows on sandy soil; 3500–4300 m. SW Sichuan (Daocheng, Hongyuan, Jiulong), NW Yunnan (Zhongdian).

The type of *Isoëtes hypsophila* was collected on the way from Lijiang, Yunnan, to Xuyong, Sichuan, without accurate locality. This species could occur in Qinghai and Xizang.

This species has glabrous megaspores. Based on molecular data (Hoot et al., *Syst. Bot.* 31: 449–460. 2006), the Chinese species form a monophyletic clade with other E Australian/New Zealand/E Asian/New Guinean species, and *Isoëtes hypsophila* is the first diverging lineage within this Chinese clade.