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OPHIOGLOSSACEAE

瓶尔小草科 ping er xiao cao ke

Zhang Xianchun (张宪春)[1], Liu Quanru (刘全儒)[2]; Norio Sahashi[3]

Plants perennial, mostly terrestrial, rarely epiphytic, usually small and fleshy, lacking sclerenchyma. Roots lacking root hairs, unbranched or with a few narrow lateral branches [rarely dichotomously branched], fibrous or fleshy, sometimes producing vegetative buds. Rhizome mostly erect, less often horizontal, rarely branched, eustelic, glabrous or hairy. Fronds 1 to few per plant, monomorphic, vernation nodding (not circinate), erect or folded, stipe base dilated, clasping, forming open or fused sheath surrounding successive leaf buds; buds glabrous or with long, uniseriate hairs; common stipe usually dividing into sterile, laminate, photosynthetic portion (trophophore) and fertile, spore-bearing portion (sporophore); sterile lamina ternately or pinnately compound to simple, rarely absent, glabrous or with scattered, long, uniseriate hairs, especially on stipe and rachis; veins anastomosing or free, pinnate, or palmate. Sporophores 1 per frond [rarely more], spikelike or pinnately branched; sporangia exposed or embedded, sometimes clustered on very short lateral branches, wall 2 cells thick, annulus absent; spores many (> 1000) per sporangium, globose-tetrahedral, trilete, thick-walled, surface rugate, tuberculate, baculate (with projecting rods usually higher than wide), sometimes joined in delicate network, mostly with ± warty surface. Gametophytes subterranean, usually fleshy, mycorrhizal, non-photosynthetic, orbicular or linear. x = 30, (44), 45, (46), 94.

Four(–nine) genera and ca. 80 species: nearly worldwide; three genera and 22 species (two endemic) in China.

Ching Ren-chang, Fu Shu-hsia, Wang Chu-hao & Shing Gung-hsia. 1959. Ophioglossaceae, Botrychiaceae, and Helminthostachyaceae. *In:* Ching Ren-chang, ed., Fl. Reipubl. Popularis Sin. 2: 6–26, 329–330.

1a. Fertile lamina simple, rarely forked; sporangia sunken in 2 rows on sides of a single linear spike; sterile lamina mostly simple, rarely absent or forked at apex, veins reticulate ..... 3. *Ophioglossum*
1b. Fertile lamina regularly pinnately or radially branched; sporangia exposed on branchlet tips, not sunken; sterile lamina mostly pinnately or ternately lobed or divided, veins free.
2a. Fertile lamina mostly in one plane, branches pinnate; rhizome erect; sporangia solitary and lacking associated sterile projections; sterile lamina mostly pinnately lobed ..... 1. *Botrychium*
2b. Fertile lamina cylindrical, spikelike, branches very short, radially arranged; rhizome horizontal; sporangia ± clustered in clumps of several, with sterile projections; sterile lamina ternate ..... 2. *Helminthostachys*

1. BOTRYCHIUM Swartz, J. Bot. (Schrader) 1800(2): 8, 110. 1801.

阴地蕨属 yin di jue shu

Zhang Xianchun (张宪春); Norio Sahashi

Botrypus Michaux; *Japanobotrychum* Masamune; *Sceptridium* Lyon.

Plants terrestrial or in rocky crevices, evergreen or winter-green. Rhizome short, erect, dictyostelic, glabrous or hairy, hairs long, non-septate; gemmae absent or minute, spherical, apex hairy. Roots occasionally laterally branching, yellowish to black, smooth or with corky ridges, not proliferous. Fronds 1(or 2) per stem. Common stipe thick, fleshy, glabrous or hairy. Sterile lamina ascending or perpendicular to common stipe, sessile or stalked; lamina [simple or] 1–4[or 5]-pinnate, linear, oblong, or deltoid; pinnae (reduced to segments in many species) spreading to ascending, fan-shaped to lanceolate or linear, margin entire to dentate or lacerate, apex rounded or acute; veins free, arranged like ribs of fan or pinnate. Sporophores normally 1 per frond, 1–3-pinnate, long stalked, borne at ground level to high on common stipe. Sporangia sessile to shortly stalked, almost completely exposed, large, globose, glabrous, dehiscing by 2 valves, borne in 2 rows along pinnate branches (except in very small plants). Spore surface rugate, tuberculate, baculate, sometimes joined in delicate network. Gametophytes not green, broadly ovate, unbranched. x = (44), 45, (46).

Between 50 and 60 species: nearly worldwide; 12 species in China.

Botrychium has been separated into four genera, often treated as subgenera: *Botrychium*, *Botrypus* (=*B.* subg. *Osmundopteris* (Milde) R. T. Clausen), *Japanobotrychum*, and *Sceptridium*; here, all the species are treated in a single genus.

Classification mainly follows Zou and Wagner (Amer. Fern J. 78: 122–135. 1988). Reviewer Don Farrar notes that many additional species in *Botrychium* subg. *Botrychium* have been described since the Zou and Wagner treatment and since Wagner and Wagner's treatment in Flora of North America (2: 86–101. 1993), resulting in 14 diploid species (n = 45), 16 tetraploid species (n = 90), and one hexaploid species (n = 135) in North America, plus one additional diploid and one additional tetraploid in Europe for a total of 32 species worldwide. In North America, Farrar also accepts

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Botrychium, *Botrypus*, and *Sceptridium* as distinct genera, following the recommendations of Kato (Gard. Bull. Singapore 40: 1–14. 1987) and Hauk et al. (Molec. Phylogen. Evol. 28: 131–151. 2003).

Ching et al. (FRPS 2: 22–23. 1959) accepted *Botrychium multifidum* (S. G. Gmelin) Ruprecht (Beitr. Pflanzenk. Russ. Reiches 11: 40. 1859; *Osmunda multifida* S. G. Gmelin, Novi Comment. Acad. Sci. Imp. Petrop. 12: 517. 1768; *Botrychium matricariae* (Schrank) Sprengel; *O. matricariae* Schrank) for NE China; however, Zou and Wagner (loc. cit.: 133) noted that no Chinese specimens of *B. multifidum* were cited and that true *B. multifidum* occurs in N North America and NW Asia–NE Europe.

Japanobotrychum arisanense Masamune (J. Soc. Trop. Agric. Formosa 3: 246. 1931), the type of *Japanobotrychum*, was described from Taiwan.

1a. Plants small, 3–15 cm; frond primordium glabrous; sterile lamina pinnate or ternate, 1- or 2-pinnate.
  2a. Pinnae fan-shaped, midribs absent ..... 1. *B. lunaria*
  2b. Pinnae elongate, midribs present.
    3a. Pinnae rounded at apex, often overlapping; frond primordium erect ..... 2. *B. boreale*
    3b. Pinnae pointed at apex, usually well separated; frond primordium pendulous ..... 3. *B. lanceolatum*
1b. Plants medium-sized to large, mostly more than 10 cm; frond primordium usually hairy; sterile lamina ternately 2–4-pinnate.
  4a. Sporophore stalk joined to sterile lamina stalk at or above base of sterile lamina.
    5a. Sporophore stalk joined to rachis above base of sterile lamina; frond very hairy to essentially glabrous ..... 4. *B. lanuginosum*
    5b. Sporophore stalk joined to base of sterile lamina; frond nearly to entirely glabrous.
      6a. Ultimate segments contracted at base, deeply divided; sporangia on 2- or 3-pinnate fertile lamina; sporangial cluster deltoid ..... 5. *B. virginianum*
      6b. Ultimate segments not contracted, shallowly lobed; sporangia on 1-pinnate fertile lamina; sporangial cluster narrowly linear ..... 6. *B. strictum*
  4b. Sporophore stalk joined to sterile lamina stalk below base of sterile lamina.
    7a. Plants sparsely hairy; frond primordium with many fine hairs; sterile lamina mostly large, 10–25 cm.
      8a. Sporophore stalk joined to sterile lamina stalk near base of frond ..... 7. *B. japonicum*
      8b. Sporophore stalk joined to sterile lamina stalk 1/3–2/3 from base to sterile lamina.
        9a. Sterile lamina up to 3-pinnate, papery; sporophore stalk arising 1/2–2/3 from base to sterile lamina ..... 8. *B. daucifolium*
        9b. Sterile lamina up to 4-pinnate, herbaceous; sporophore stalk arising 1/3–2/3 from base to sterile lamina ..... 9. *B. formosanum*
    7b. Plants mostly glabrous; frond primordium glabrous or only upper part hairy; sterile lamina mostly smaller, 5–15 cm.
      10a. Terminal pinnules large, differentiated from lateral pinnules, 8–15 × 5–10 mm, elongate, acute at apex, margin finely serrate; fronds mostly turning reddish in winter ..... 10. *B. nipponicum*
      10b. Terminal pinnules smaller, ± conform with lateral pinnules, 3–10 × 2–9 mm, rounded to truncate at apex, margin subentire to finely dentate; fronds mostly green in winter.
        11a. Segments blunt, rounded, or subacute, margin entire to shallowly and coarsely crenate or dentate; sterile lamina leathery ..... 11. *B. robustum*
        11b. Segments mostly acute, margin shallowly to deeply denticulate; sterile lamina herbaceous .... 12. *B. ternatum*

1. Botrychium lunaria (Linnaeus) Swartz, J. Bot. (Schrader) 1800(2): 110. 1801.

扇羽阴地蕨 shan yu yin di jue

Osmunda lunaria Linnaeus, Sp. Pl. 2: 1064. 1753; *Botrypus lunaria* (Linnaeus) Richard.

Rhizomes short, erect, annually producing 1 frond 5–15 (–25) cm tall. Common stipe greenish, cylindrical, 4–12 cm, 2–3 mm in diam., hollow, succulent. Sterile lamina pinnate, sessile, broadly lanceolate or oblong, 3–8 × 1.5–2.5 cm, fleshy, leathery, glabrous, apex rounded or blunt; pinnae 4–6 pairs, approximate, often overlapping, opposite or almost opposite, flabellate (fan-shaped), lunate, or reniform, 1–1.5(–2) cm long and wide, shortly stalked to almost sessile, lowest 1 or 2 pairs 1–2 cm apart, margin entire, crenate, or incised; veins free, flabellately forked, glabrous. Sporophore with stalk 4–7 cm, glabrous; panicle 2- or 3-pinnate, racemose, 3–6 × 1.5–2 cm, glabrous; sporangia sessile, large, 0.5–1 mm in diam. Spores yellowish, surface verrucose. $2n = 90$.

Grasslands, meadows, forests; 1300–4000 m. Gansu, Hebei, Heilongjiang, Henan, Hunan, Jilin, Liaoning, Nei Mongol, Qinghai, Shaanxi, Shanxi, Sichuan, Taiwan, Xinjiang, Xizang, Yunnan [Asia, Australia, N Europe, North America, Pacific islands].

Throughout the range of *Botrychium lunaria*, sporadic plants have been found with incised sterile pinnae and which have been named as forms or varieties, such as *B. lunaria* f. *subincisum* Roeper and *B. lunaria* var. *onondagense* (Underwood) House.

Reviewer Don Farrar notes that North American authors recognize five taxa within the *Botrychium lunaria* complex, nearly all of which extend into the Aleutian Islands and thus could extend into Asia. As well, the reported spore size of up to 48 microns might suggest that *B. lunaria* belongs to the allotetraploid species *B. yaaxudakeit* Stensvold & Farrar.

The following taxon is excluded from the present treatment, pending further research: *Botrychium lunaria* var. *przevalskii* Tzvelev (Novosti Sist. Vyssh. Rast. 36: 17. 2004).

2. Botrychium boreale J. Milde, Bot. Zeitung (Berlin) 15: 880. 1857.

北方阴地蕨 bei fang yin di jue

Rhizomes suberect, shortly cylindrical, annually producing 1 frond 5–10 cm tall. Common stipe 3–8 cm. Sterile lamina sessile or nearly so, lamina 2-pinnate at base, pinnate above, shiny, green, ovate-deltoid, 1–4 × 1–3 cm, fleshy, base cordate; pinnae 3–5 pairs, ascending, mostly overlapping; basal pinnae largest, ovate, up to 2 cm wide, base subtruncate, apex obtuse; upper pinnae and segments of basal pinnae elliptic, up to 5 mm wide; veins free. Sporophore arising at or near top of common stipe, with stalk 1.5–5 cm, 2-pinnate. Spore surface verrucose. $2n = 180$.

Forests; ca. 1000 m. Nei Mongol [Japan, Korea; N Europe, North America (Greenland)].

According to reviewer Don Farrar, North American authors recognize three species from within the original concept of *Botrychium boreale*: *B. boreale* s.s. in Europe and *B. pinnatum* H. St. John and *B. alaskense* W. H. Wagner & J. R. Grant in North America, including Alaska and the Aleutian Islands. The correct placement of Asian material has not yet been critically examined but could prove to belong to one or other of the American species rather than *B. boreale* s.s.

3. Botrychium lanceolatum (S. G. Gmelin) Angström, Bot. Not. 1854: 68. 1854.

长白山阴地蕨 chang bai shan yin di jue

Osmunda lanceolata S. G. Gmelin, Novi Comment. Acad. Sci. Imp. Petrop. 12: 516. 1768; *Botrychium manshuricum* Ching; *B. ramosum* Wang Wei et al. (1958), not (Roth) Ascherson (1864); *B. ramosum* var. *manshuricum* (Ching) Kitagawa.

Rhizomes shortly cylindrical, annually producing 1 frond 5–20 cm tall. Common stipe green, 4–15 cm. Sterile lamina subternate, 2-pinnatifid, medium green to yellow-green, somewhat shiny, broadly ovate-deltoid, 1–4 × 1–3 cm; pinnae lanceolate, up to 1 cm wide, deeply pinnatifid, apex acute; upper pinnae and segments of basal pinnae oblong, up to 2 cm wide; veins pinnate, free. Sporophore arising at top of common stipe, narrowly deltoid, 1–6 cm, 2-pinnate; sporangia exposed and not immersed, mostly approximate or slightly separated and covering midrib of pinnae. Spore surface tuberculate to irregularly verrucose. $2n = 90$.

Rocky places; high elevations. Jilin (Changbai Shan), Nei Mongol [Japan; Asia, Europe, North America].

4. Botrychium lanuginosum Wallich ex Hooker & Greville, Icon. Filic. 1: t. 79. 1828.

绒毛阴地蕨 rong mao yin di jue

Botrychium arisanense Masamune; *B. decurrens* Ching; *B. lanuginosum* var. *leptostachyum* (Hayata) Nakai; *B. leptostachyum* Hayata; *B. modestum* Ching; *B. parvum* Ching; *B. virginianum* (Linnaeus) Swartz var. *lanuginosum* (Wallich ex Hooker & Greville) T. Moore; *B. yunnanense* Ching; *Botrypus decurrens* (Ching) Ching & H. S. Kung; *B. lanuginosus* (Wallich ex Hooker & Greville) Holub; *B. tibeticus* Ching; *Japanobotrychum lanuginosum* (Wallich ex Hooker & Greville) M. Nishida ex Tagawa; *Osmundopteris lanuginosa* (Wallich ex Hooker & Greville) M. Nishida.

Rhizomes erect, short, apex hairy; hairs long, light brown. Common stipes stramineous to light brown, 12–30 cm, 3–6 mm in diam., fleshy, woolly-hairy; hairs sparse, whitish, long. Sterile lamina 3- or 4-pinnate, deltoid to subpentagonal, 14–45 × 10–38 cm, thin and herbaceous, degree of pubescence variable; pinnae 5–8 pairs, alternate, long stalked, 2–6 cm apart, lowest pair largest, 7–20 × 5–10 cm; pinnules 6–10 pairs, alternate, stalked, basiscopic pinnules larger than acroscopic ones, basal pinnule largest; ultimate lobes acute or obtuse; veins free, simple or forked. Sporophore with stalk 2–10 cm, hairy, arising at various points between lowest two pairs of pinnae of sterile lamina, usually close to base of second lowest pinnae; spikes 2- or 3-pinnate, paniculate, 7–12 × 5–7 cm, hairy. Spores yellowish, surface reticulate, finely striate on ridges. $2n = 180$, 270, 360.

Evergreen broad-leaved forests; 1000–3000 m. Guangxi, Guizhou, Hunan, Sichuan, Taiwan, Xizang, Yunnan [Bhutan, India, Indonesia (Java, Sumatra), Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Thailand, Vietnam].

C. B. Clarke (Trans. Linn. Soc. London, Bot. 1: 588. 1880) treated material of *Botrychium lanuginosum* as the following species, *B. virginianum*.

5. Botrychium virginianum (Linnaeus) Swartz, J. Bot. (Schrader) 1800(2): 111. 1801.

蕨萁 jue qi

Osmunda virginiana Linnaeus, Sp. Pl. 2: 1064. 1753; *Botrypus virginianus* (Linnaeus) Michaux; *Japanobotrychum virginianum* (Linnaeus) M. Nishida ex Tagawa.

Rhizomes erect, short, cylindrical, fleshy, having many fleshy roots and annually producing 1 frond 25–70 cm tall. Sterile lamina: stalk 15–35 cm, subglabrous; lamina subternate, tri- or quadripinnatifid, pale green, broadly pentagonal or subdeltoid, 5–28 × 7–30 cm, thinly herbaceous, soft, abaxially lanuginose on midrib, base subtruncate or slightly cordate, apex acute or obtuse; pinnae broadly ovate, with basal pinnules small and middle ones large, oblong or ovate-lanceolate; ultimate segments elliptic or oblong, margin deeply lobed or dentate, apex acuminate; veins pinnate, free. Sporophore arising at top of common stipe; stalk 10–30 cm; lamina ovate-deltoid, 10–20 cm, 3- or 4-pinnate; pinnae stalked; sporangia globose or elliptic, each on tip of very short, sometimes obscure axes. Spore surface coarse and distantly verrucose. $2n = 184$.

Forests; 1600–3200 m. Anhui, Chongqing, Gansu, Guizhou, Henan, Hubei, Hunan, Shaanxi, Shanxi, Sichuan, Xizang, Yunnan, Zhejiang [temperate Asia: Himalaya, Japan, Korea, Russia; temperate regions within the N Hemisphere; Central and South America].

6. Botrychium strictum Underwood, Bull. Torrey Bot. Club 30: 52. 1903.

劲直阴地蕨 jin zhi yin di jue

Botrypus strictus (Underwood) Holub; *Japanobotrychum strictum* (Underwood) M. Nishida ex Tagawa; *Osmundopteris stricta* (Underwood) M. Nishida.

Plants summer-green. Rhizomes erect, short, cylindrical. Fronds 30–70 cm tall. Sterile lamina: stalk 15–25 cm, up to 1 cm in diam., fleshy; lamina subternate, bi- or tripinnatifid, dull green, broadly pentagonal; pinnules sessile, narrowly oblong, base decurrent to costal wing; ultimate segments elliptic, dentate, apex rounded; costae and costules beneath sparsely lanuginose. Sporophore arising at top of common stipe, as long as sterile lamina; lamina bipinnate, spikelike; pinnae short; sporangia ellipsoid-globose, each on tip of short but distinct ultimate axes or veins. Spore surface coarsely verrucose. 2*n* = 88, ca. 90.

Forests. Chongqing, Gansu, Heilongjiang, Henan, Hubei, Jilin, Liaoning, Nei Mongol, Shaanxi, Sichuan [Japan, Korea].

7. Botrychium japonicum (Prantl) Underwood, Bull. Torrey Bot. Club 25: 538. 1898.

华东阴地蕨 hua dong yin di jue

Botrychium daucifolium Wallich var. *japonicum* Prantl, Jahrb. Königl. Bot. Gart. Berlin 3: 340. 1884; *Sceptridium japonicum* (Prantl) Lyon.

Rhizomes erect, shortly cylindrical, having many fleshy roots and annually producing 1 frond (15–)30–50(–70) cm tall. Sterile lamina: stalk 12–26(–36) cm, 3–4 mm in diam., glabrous; lamina subternate, tripinnatifid, subpentagonal, 10–25 × 15–25 cm, apex acute; basal pinnae much larger than upper ones, broadly deltoid-elliptic, 8–15 × 5–8 cm, with stalk 1.5–3 cm; pinnules broadly lanceolate, gradually narrowed toward acute apex; pinnule segments narrowly elliptic, margin sharply serrate or crenulate, apex acute or acuminate; basal segments fan-shaped, deeply lobed; stalks and costae sparsely lanuginose; veins pinnate, free. Sporophore arising 2–6(–10) cm above base of common stipe (or much below middle of common stipe), taller than sterile lamina, subdeltoid, bipinnate, 25–50 cm (stalk 20–40 cm, lamina 5–10 cm); sporangia globose, attached on both sides of axes. Spore surface with dense spinules or papillae forming reticulate pattern with fine granules. 2*n* = 270.

Forests by streams; ca. 1200 m. Anhui, Fujian, Guangdong, Guizhou, Hunan, Jiangsu, Jiangxi, ?Taiwan, Zhejiang [Japan, Korea].

8. Botrychium daucifolium Wallich ex Hooker & Greville, Icon. Filic. 2: t. 161. 1830.

薄叶阴地蕨 bao ye yin di jue

Sceptridium daucifolium (Wallich ex Hooker & Greville) Lyon; *Botrychium officinale* Ching; *B. subcarnosum* Wallich ex Beddome; *S. officinale* (Ching) Ching & H. S. Kung.

Rhizomes erect, shortly cylindrical, bearing many fleshy roots. Frond 30–40 cm tall with stalk 10–12 cm. Sterile lamina: stalk 7–8 cm, glabrous; lamina bipinnate to tripinnatifid, subpentagonal, 15–20 × 16–24 cm, herbaceous; pinnae 6 or 7 pairs, alternate, shortly stalked; basal pinnae largest, triangular, 12–14 × 6–10 cm, bipinnatifid; pinnules 4 or 5 pairs, narrowly ovate to broadly lanceolate, lower basal pinnule largest, up to 8 × 3 cm, pinnatifid, ultimate segments sharply serrate, apex acute or acuminate; veins obvious, rachis and costae with sparse, white, long hairs. Sporophore arising from above middle of common stipe, as long as sterile lamina, with stalk 14–16 cm, bi-tripinnate, 10–12 cm, with long soft hairs. Spore surface with dense papillae often forming reticulate pattern with minute granules. 2*n* = 180.

Forests, shaded wet places. Chongqing, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, ?Taiwan, Yunnan, Zhejiang [Bhutan, NE and S India, Indonesia (Sumatra), Myanmar, Nepal, Philippines, Sri Lanka, Vietnam].

9. Botrychium formosanum Tagawa, Acta Phytotax. Geobot. 9: 87. 1940.

台湾阴地蕨 tai wan yin di jue

Sceptridium formosanum (Tagawa) Holub.

Rhizomes erect, cylindrical, ca. 2 cm, annually producing 1 or 2 fronds 15–60 cm tall. Sterile lamina: stalk (4–)13–35 cm, sparsely lanuginose; lamina subternate, tripinnate, deltoid-pentagonal, 8–35 × 8–40 cm, thickly herbaceous; pinnules broadly lanceolate, apex acute; ultimate segments elliptic, irregularly roughly serrate, apex obtuse or subacute; veins pinnate, free. Sporophore arising (2–)6–15 cm below top of common stipe (or near middle of common stipe); stalk 7–20 cm; lamina deltoid, 5–18 cm, bipinnate; sporangia globose, attached on both lateral sides of axes. Spore surface with dense papillae often uniting in reticulate pattern, with minute granules. 2*n* = 180.

Guangdong, Guangxi, Guizhou, Jiangxi, Taiwan, Yunnan [Himalaya, Japan].

Reviewer Ralf Knapp suggests that records of *Botrychium japonicum* and *B. daucifolium* from Taiwan might have been based on misidentifications of material of *B. formosanum*.

10. Botrychium nipponicum Makino, J. Jap. Bot. 1(2): 5. 1916.

日本阴地蕨 ri ben yin di jue

Sceptridium nipponicum (Makino) Holub.

Plants small, winter-green. Rhizomes erect, short, cylindrical, annually producing 1 frond 20–50 cm tall. Sterile lamina: stalk 4.5–19 cm, glabrous; lamina subternate, tripinnate, ca. 10 cm long and wide, herbaceous or membranous, reddish in winter; lower pinnae broadly ovate, long stalked, upper ones much narrower; ultimate segments large, differentiated from lateral pinnules, elongate, 8–15 × 5–10 mm, margin finely serrate, apex acute; veins pinnate, free. Sporophore arising 1.5–6 cm above base of common stipe (or distinctly below middle of common stipe), much taller than sterile lamina, deciduous after spore dispersal; stalk ca. 40 cm; lamina smaller than sterile lamina; sporangia globose, attached on both lateral sides of axes. Spore surface irregularly reticulate with fine granules. 2*n* = 90.

Forests. Guangxi [Japan, Korea].

11. Botrychium robustum (Ruprecht ex Milde) Underwood, Bull. Torrey Bot. Club 30: 51. 1903.

粗壮阴地蕨 cu zhuang yin di jue

Botrychium rutifolium A. Braun var. *robustum* Ruprecht ex Milde, Nova Acta Regiae Soc. Sci. Upsal., ser. 3, 26: 763. 1858; *B. longipedunculatum* Ching; *B. multifidum* (Gmelin) Ruprecht var. *robustum* (Ruprecht ex Milde) C. Christensen ex Hultén; *B. sutchuanense* Ching.

Plants small, hardy. Rhizomes erect, short, cylindrical. Fronds 35–40 cm tall. Sterile lamina: stalk 2–7 cm or more, up to 1 cm in diam., fleshy; lamina bi- or tripinnatifid, dull green, pentagonal, 6–11 × 7–11 cm; pinnae 4–6 pairs, subopposite, lower ones stalked; basal pinnae largest, ovate to triangular, 4–6 × 2.5–4.5 cm, bipinnate to tripinnatifid; pinnules 3 or 4 pairs, narrowly oblong or lanceolate, lower basal pinnule longest, 2.5–4 × 1.5–2 cm; ultimate segments ovate or oblong, margin dentate; costae and costules beneath sparsely lanuginose, lateral veins obscure. Sporophore arising from middle or lower part of common stipe, with longer stalk, up to 10–25 cm, lamina 4–11 cm, bipinnate to tripinnate, spikelike; pinnae short; sporangia ellipsoid-globose, each on tip of short but distinct ultimate axes or veins. Spore irregularly reticulate with minute granules. 2*n* = 90.

Forests, grasslands; 1000–2000(–4000) m. Chongqing, Heilongjiang, Jilin, Liaoning, Sichuan, Yunnan [Japan, Korea, Russia].

12. Botrychium ternatum (Thunberg) Swartz, J. Bot. (Schrader) 1800(2): 111. 1801.

阴地蕨 yin di jue

Osmunda ternata Thunberg in Murray, Syst. Veg., ed. 14, 927. 1784; *Sceptridium ternatum* (Thunberg) Lyon.

Plants small, winter-green. Rhizomes erect, short, annually producing 1 frond (10–)15–55 cm tall. Sterile lamina: stalk 5–12 cm or longer, ca. 2 mm in diam.; lamina ternate, tri- or quadripinnatifid, dull green, subpentagonal, 5–10 × 8–12 cm, somewhat thickly herbaceous, glabrous, apex acute; pinnae subdeltoid, basal ones stalked; segments broadly elliptic or broadly ovate, sparsely crenate, apex rounded; veins pinnate, free. Sporophore arising 2–4 cm above base of common stipe (or below middle of common stipe), much taller than sterile lamina; stalk 12–25 cm; lamina bi- to tripinnate, subdeltoid, 4–10 cm; sporangia globose, attached on both lateral sides of axes. Spore surface irregularly reticulate with minute granules. 2*n* = 90.

In shaded shrubs; 400–1000 m. Anhui, Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Shaanxi, Shandong, Sichuan, Taiwan, Zhejiang [temperate and warm regions of E Asia including within the Himalaya, India, Japan, Korea, Nepal, and Vietnam].

2. HELMINTHOSTACHYS Kaulfuss, Enum. Filic. 28. 1824.

七指蕨属 qi zhi jue shu

Zhang Xianchun (张宪春); Norio Sahashi

Ophiala Desvaux.

Plants medium-sized, terrestrial, evergreen. Rhizomes shortly creeping, dorsiventral with fronds in 2 rows on dorsal side; buds glabrous; roots thick. Fronds solitary, sterile lamina perpendicular to common stipe, ternate with large basal pinnae divided into few pinnules, thus appearing palmately dissected as a whole; veins free, forked into parallel close veinlets. Sporophore attached at base of sterile lamina, spikelike, cylindrical; sporangia globose, born in pseudowhorls on radially arranged stalked clusters interspersed with small sterile projections. Spores trilete, globose, surface reticulate, with delicate projections ± fused baculate. *n* = 94.

One species: widely distributed in tropics and subtropics of the Old World.

1. Helminthostachys zeylanica (Linnaeus) Hooker, Gen. Fil. t. 47. 1840.

七指蕨 qi zhi jue

Osmunda zeylanica Linnaeus, Sp. Pl. 2: 1063. 1753; *Botrychium zeylanicum* (Linnaeus) Swartz; *Helminthostachys dulcis* Kaulfuss, nom. illeg. superfl.; *Ophiala zeylanica* (Linnaeus) Desvaux.

Rhizome 4–8 mm in diam. Fronds usually single at rhizome apex, 20–60 cm tall; stipe base sheath ca. 1 cm; common stipe fleshy, 10–55 cm, 2–8 mm in diam., glabrous; sterile lamina ternate with basal pinnae divided into 3 or 4 pinnules; pinnules lanceolate, 6–20 × 1.5–3 cm, base decurrent, margin irregularly toothed, apex acute or rounded. Spikelike sporophore arising at top of common stipe; stalk 4–10 cm, spike 4–20 cm, 5–12 mm in diam., branches divided 1 or 2 times, each consisting of stalk bearing a pseudowhorl of sporangia and 1–4 forked sterile apical appendages. 2*n* = 188.

Forests, edges of marshes; low elevations. Guangdong, Hainan, Taiwan, Yunnan [widespread: Cambodia, India, Japan, Laos, Philippines, Sri Lanka, Thailand, Vietnam; tropical Australia, W Pacific islands].

Helminthostachys zeylanica is a rare, endangered species in China because of over-collecting for use in traditional medicine and because of habitat change.

3. OPHIOGLOSSUM Linnaeus, Sp. Pl. 2: 1062. 1753.

瓶尔小草属 ping er xiao cao shu

Liu Quanru (刘全儒); Norio Sahashi

Ophioderma Blume.

Plants terrestrial, rarely epiphytic, generally small, erect, rarely large and pendulous. Rhizome erect, rarely creeping, short,

glabrous or long hairy. Fronds often solitary, occasionally 2, rarely more; sterile lamina with stipe, usually simple, lanceolate, ovate, or ribbon-shaped, rarely dichotomously divided, with entire or wavy margin; midrib indistinct; veins reticulate; sporophore arising from base, near base, or middle part of sterile lamina, with long stalk. Sporangia embedded in 2 rows along margin of linear spike; spore surface irregularly reticulate, foveolate, or subsmooth.

About 28 species: mainly in the N Hemisphere; nine species (two endemic) in China.

1a. Plants epiphytic; sterile lamina large, ribbon-shaped, pendulous; rhizome with long hairs; sporophore arising from near base or middle part of sterile lamina ..... 1. *O. pendulum*
1b. Plants terrestrial; sterile lamina small, ovate or lanceolate, erect; rhizome glabrous; sporophore arising from base of sterile lamina.
2a. Plants usually 2–10 cm tall; sterile lamina usually less than 3 cm.
3a. Fronds consisting of sterile and fertile portions; sterile lamina elliptic or elliptic-ovate; spike bearing 10–18 pairs of sporangia ..... 8. *O. nudicaule*
3b. Fronds usually consisting of sporophore only, or rarely with both sterile and fertile portions; sterile lamina elliptic or ovate-rhombic; spike bearing 3–12 pairs of sporangia ..... 9. *O. yongrenense*
2b. Plants more than 10 cm tall, sometimes up to 35 cm; sterile lamina more than 3 cm.
4a. Sterile lamina cordate at base; margin ± wavy; areoles of veins evident.
5a. Spores coarsely reticulate ..... 5. *O. austroasiaticum*
5b. Spores subreticulate ..... 6. *O. reticulatum*
4b. Sterile lamina not cordate at base; margin entire.
6a. Sterile lamina narrow, lanceolate or oblanceolate, narrowly cuneate at base ..... 7. *O. thermale*
6b. Sterile lamina broad, oblong to ovate, broadly cuneate, truncate, or rounded at base.
7a. Sterile lamina oblong, rounded at apex ..... 4. *O. oblongum*
7b. Sterile lamina elliptic or narrowly to broadly ovate, rounded or acute at apex.
8a. Sterile lamina elliptic or narrowly ovate, 6–10 cm or longer ..... 2. *O. vulgatum*
8b. Sterile lamina ovate to broadly ovate, 3–6 cm ..... 3. *O. petiolatum*

1. Ophioglossum pendulum Linnaeus, Sp. Pl. 2: 1518. 1763.

带状瓶尔小草 dai zhuang ping er xiao cao

Ophioderma pendula (Linnaeus) C. Presl; *O. pendula* f. *ramosa* Nakai.

Fronds 1–3 or more. Sterile lamina sessile, pendulous and ribbonlike, usually lanceolate, sometimes dichotomously divided, up to 30–50(–100) × 1–3 cm; veins reticulate, without distinct midrib, forming diagonal and hexagonal areoles; veinlets ± visible. Sporophore arising from near base or middle part of sterile lamina and never longer than sterile lamina, pendent; stalk to 7 cm, spike 5–30 cm; sporangia 40–200 on each side. Spores colorless or light yellow, quadrangular, surface foveolate. $2n = 740–960$.

On tree trunks in tropical rain forests. Hainan, Taiwan, Yunnan [India, Indonesia, Japan, Korea, Malaysia, Philippines, Sri Lanka; W Africa, Australia, Pacific islands (Hawaiian Islands)].

Ophioglossum pendulum is sometimes placed in a separate genus, *Ophioderma*.

2. Ophioglossum vulgatum Linnaeus, Sp. Pl. 2: 1062. 1753.

瓶尔小草 ping er xiao cao

Plants 10–30 cm tall. Rhizomes erect, bearing a cluster of fleshy roots; roots extending horizontally and stolonlike. Fronds usually single; common stalk pale at lower part, 6–9 cm, slightly robust, deeply buried underground. Sterile lamina sessile, elliptic or narrowly ovate, rarely ovate, 6–10 × 1.5–4 cm, slightly fleshy to herbaceous, base cuneate, truncate, or rounded, sometimes abruptly narrowed, margin entire, apex obtuse or abruptly acute; veins distinctly reticulate. Sporophore arising from base of sterile lamina, 9–18 cm or longer; spike 2.5–3.5 cm, ca. 0.2 mm in diam., apex acute, exceeding sterile lamina. Spore surface obviously and coarsely reticulate. $2n = 240–1140$.

Shaded forests, wet meadows; below 3000 m. Anhui, Fujian, Guangdong, Guizhou, Henan, Hubei, Hunan, Jiangxi, S Shaanxi, Sichuan, Xizang, Yunnan, Zhejiang [India, Japan, Korea, Sri Lanka; Australia, Europe, North America].

3. Ophioglossum petiolatum Hooker, Exot. Fl. 1: t. 56. 1823.

柄叶瓶尔小草 bing ye ping er xiao cao

Plants 15–25 cm tall. Rhizomes erect, bearing a cluster of thick fleshy roots; roots extending horizontally like stolons, producing a new plant from apical bud. Fronds simple; common stalk 9–15 cm. Sterile lamina sessile, ovate to broadly ovate, 3–6 × 2–3 cm, herbaceous, base ± elongated and rounded, apex acute or obtuse; veins fairly distinct, reticulate. Sporophore arising from base of sterile lamina, 6–9 cm; linear spike 2.5–3 cm. Spore surface obviously subreticulate with fine granules. $2n = 960–1100$.

Open shrubby hillsides; 200–3300 m. Fujian, Guizhou, Hainan, Hubei, Sichuan, Taiwan, Yunnan [W India, Indonesia, Japan, Nepal, Philippines, Sri Lanka, Thailand; Australia, North America, Pacific islands (New Zealand)].

Specimens described as *Ophioglossum pedunculosum* Desvaux in FRPS (2: 9–10. 1959) and some provincial floras (e.g., floras of Anhui, Fujian, Guangdong, Guizhou, Jiangxi, and Yunnan) should be included in *O. petiolatum*. According to the studies by Clausen (Mem. Torrey Bot. Club 19(2): 1–177. 1938), *O. pedunculosum* was described as having a lamina with a prominent pale median band, but this character

is very different in Chinese specimens. Whether *O. pedunculosum* is really distributed in China needs further study. Chinnock (Fl. Australia Online: http://www.anbg.gov.au/abrs/online-resources/flora; accessed 18 Jul 2012) includes *O. petiolatum* within *O. reticulatum*.

4. Ophioglossum oblongum H. G. Zhou & H. Li, Guihaia 11: 40. 1991.

矩圆叶瓶尔小草 ju yuan ye ping er xiao cao

Plants 20–25 cm tall. Rhizomes erect, bearing few fleshy roots. Fronds caespitose, ca. 23 cm; common stalk 6–8 cm, greenish or pale at lower part from being buried underground. Sterile lamina simple, sessile, light green when dried, oblong, 2–8 × ca. 1.5 cm, herbaceous, base broadly cuneate, shortly decurrent, margin entire, apex rounded; reticulate veins indistinct. Sporophore 6–14 cm, slender, arising from base of sterile lamina; spike linear, 1.5–4 cm, bearing 17–34 pairs of sporangia.

● Guangxi (Fengshan).

5. Ophioglossum austroasiaticum M. Nishida, Bull. Natl. Sci. Mus., Tokyo, n.s., 4: 329. 1959 [*"austro-asiaticum"*].

高山瓶尔小草 gao shan ping er xiao cao

Plants 10–20 cm tall. Rhizomes erect, cylindrical. Common stalk 6.5–7.5 cm. Sterile lamina sessile, suborbicular or broadly ovate, ca. 3.5 × 3 cm, base cordate, apex rounded; areoles with included veinlets and smaller areoles. Sporophore arising from near base of sterile lamina. Spore surface coarsely reticulate.

Taiwan [Indonesia (Borneo)].

Ophioglossum austroasiaticum resembles *O. reticulatum* but differs from the latter in having coarsely reticulate spores only. This species needs further study.

6. Ophioglossum reticulatum Linnaeus, Sp. Pl. 2: 1063. 1753.

心叶瓶尔小草 xin ye ping er xiao cao

Ophioglossum cordifolium Roxburgh; *O. pedunculosum* Dunn & Tutcher (1912), not Desvaux (1811).

Plants 10–30 cm tall. Rhizomes erect, slender, bearing a few thick fleshy roots. Common stalk 4–8 cm, light green, gradually pale toward base. Sterile lamina with a short stalk or almost sessile, ovate or orbicular-ovate, 3–4 × 2.6–3.5 cm, herbaceous, base deeply cordate, margin ± wavy, apex rounded or subobtuse; veins distinct, reticulate. Sporophore arising from base of sterile lamina, slender, 10–15 cm; spike 3–3.5 cm, slender. Spore surface regularly or irregularly subreticulate. 2*n* = 240–1280.

Shaded forests; 1100–4000 m. Fujian, Gansu, Guizhou, Henan, Hubei, Jiangxi, Shaanxi, Sichuan, ?Taiwan, Xizang, Yunnan [Korea; Africa, Madagascar, South America].

For a discussion on the unconfirmed status in Taiwan, see Knapp (Ferns Fern Allies Taiwan, 469–470. 2011).

7. Ophioglossum thermale Komarov, Repert. Spec. Nov. Regni Veg. 13: 85. 1914.

狭叶瓶尔小草 xia ye ping er xiao cao

Ophioglossum angustatum Maxon, nom. illeg. superfl.; *O. japonicum* Prantl (1883), not Thunberg (1784); *O. nipponicum* Miyabe & Kudô; *O. savatieri* Nakai, nom. illeg. superfl.; *O. thermale* var. *nipponicum* (Miyabe & Kudô) M. Nishida ex Tagawa; *O. vulgatum* Linnaeus var. *thermale* (Komarov) C. Christensen.

Plants 10–20 cm tall. Rhizomes erect, slender, bearing a cluster of unbranched fleshy roots; roots stolonlike, producing new plants at apices. Fronds simple or 2 or 3 together. Common stalk green or pale when lower part buried underground, 3–6 cm, slender. Sterile lamina simple, sessile, light green, oblanceolate or oblong-oblanceolate, 2–5 cm × 3–10 mm, herbaceous, base narrowly cuneate, margin entire, apex slightly acute or obtuse; veins reticulate, indistinct, but visible under light. Sporophore arising from base of sterile lamina; stalk 5–7 cm, overtopping sterile lamina; spike narrowly linear, 2–3 cm, acute at apex, with 15–28 pairs of sporangia. Spores pale, surface subreticulate or subsmooth. 2*n* = 240–960.

Grassy hillsides, near thermal springs; 200–1800 m. Anhui, Guizhou, Hebei, Heilongjiang, Henan, Jiangsu, Jiangxi, Jilin, Liaoning, Shaanxi, Shandong, Sichuan, E and SE Taiwan, Yunnan [Japan, Korea, Russia (Kamchatka)].

8. Ophioglossum nudicaule Linnaeus f., Suppl. Pl. 443. 1781.

裸茎瓶尔小草 luo jing ping er xiao cao

Ophioglossum parvifolium Greville & Hooker.

Plants 3–8 cm tall. Rhizomes erect, very thick, with numerous fibrous roots, usually bearing 2 or 3 fronds. Common stalk grayish green on most parts from being buried underground, 1.5–3 cm. Sterile lamina elliptic or elliptic-ovate, 1–3 × ca. 1 cm, subfleshy, base shortly cuneate, margin entire, apex acute or rounded; veins indistinct. Sporophore 4–5 cm, arising from base of sterile lamina; spike short and thick, 1–2 cm, surpassing sterile lamina 1–2 times, apex acute; sporangia 10–18 pairs. Spore surface coarsely reticulate. 2*n* = 240–480.

Slopes, meadows; 1800–4300 m. SW Sichuan, Xizang, C and NW Yunnan [N India, Nepal].

The spore ornamentation of *Ophioglossum parvifolium* from Yunnan (sample in K) is minutely reticulate. More detailed palynological studies are required. Very recent collections from SE Taiwan may represent the Japanese species *O. parvum* M. Nishida & Kurita (see Knapp, Web Albums Pteridophytes Gymnosperms Taiwan; https:// picasaweb.google.com/116136418529949606360?feat=email; accessed 17 Jul 2012). This will key out as *O. nudicaule* but differs by the smaller sterile lamina, 0.5–1.5 × 0.3–0.7 cm, shorter spike, 7–9 mm, and minutely reticulate spores.

9. Ophioglossum yongrenense Ching ex Z. R. He & W. M. Chu, Acta Bot. Yunnan. 23: 43. 2001.

永仁瓶尔小草 yong ren ping er xiao cao

Plants 2–9 cm tall. Rhizomes erect, cylindrical, with fleshy roots, 1 or 2 new fronds arising every year. Common stalk 2–10 mm, ca. 0.5 mm in diam. Fronds usually consisting only of sporophore, rarely with both sterile and fertile lamina portions.

Sterile lamina sessile, adpressed to ground, elliptic or ovate-rhomboid, 0.5–1.5 × 0.2–0.7 cm, apex abruptly acute. Sporophore: spike simple, rarely forked, 0.3–1.5 cm, ca. 0.1 mm in diam.; stalk 0.5–6 cm, bearing 3–12 pairs of sporangia.

● Dry slopes, grasslands; ca. 2000 m. Yunnan (Yongren).

The Japanese endemic *Ophioglossum kawamurae* Tagawa (Acta Phytotax. Geobot. 8: 134. 1939) is very similar to *O. yongrenense*. Further studies of the latter are needed.