

LYGODIACEAE

海金沙科 hai jin sha ke

Zhang Xianchun (张宪春)¹; Judith Garrison Hanks²

Plants terrestrial. Stems branched, slender; fronds often more than several meters, alternately pinnate, climbing by means of a twining rachis; primary blade divisions (pinnae) pseudodichotomously forking with a dormant apical bud in axils; pinnules entire to palmately or 1- or 2-pinnate or more divided; fertile and sterile pinnae similar or fertile pinnae greatly contracted; veins free or anastomosing; sori on lobes of ultimate segments; sporangia abaxial, solitary, 1 per sorus, each sporangium covered by an antrorse indusium-like subtending flange; spores 128–256 per sporangium, tetrahedral and trilete; gametophytes green, cordate, terrestrial. $x = 29, 30$.

One genus and ca. 26 species: pantropical, extending northward to S Korea, Japan, and North America and southward to S Africa and New Zealand; nine species in China.

Ching Ren-chang, Fu Shu-hsia, Wang Chu-hao & Shing Gung-hsia. 1959. Lygodiaceae. *In*: Ching Ren-chang, ed., *Fl. Reipubl. Popularis Sin.* 2: 105–114, 345–346.

1. LYGODIUM Swartz, *J. Bot. (Schrader)* 1800(2): 7, 106. 1801, nom. cons.

海金沙属 hai jin sha shu

Cteisium Michaux; *Gisopteris* Bernhardt; *Hydroglossum* Willdenow; *Lygodictyon* J. Smith ex Hooker; *Odontopteris* Bernhardt; *Ramondia* Mirbel (1801), not *Ramonda* Richard (1805, nom. cons.); *Ugena* Cavanilles; *Vallifilix* Thouars.

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

- 1a. Pinnae simple or pseudodichotomously branched; pinnules palmately lobed, not articulate.
- 2a. Veins anastomosing 1. *L. merrillii*
- 2b. Veins free.
- 3a. Margin of pinnae entire, cartilaginous 2. *L. circinnatum*
- 3b. Margin of pinnae serrulate, not cartilaginous 3. *L. longifolium*
- 1b. Pinnae 1- or 2-pinnate; pinnules simple, pinnately or irregularly lobed, articulate or not.
- 4a. Pinnules not articulate to rachis.
- 5a. Fertile pinnae and sterile pinnae monomorphic; pinnules 1–3 cm wide 4. *L. flexuosum*
- 5b. Fertile pinnae and sterile pinnae subdimorphic; pinnules 4–6 mm wide 5. *L. japonicum*
- 4b. Pinnules articulate at base or at base of stalks.
- 6a. Pinnules articulate at base of stalks; pinnae similar to *L. flexuosum* 6. *L. yunnanense*
- 6b. Pinnules articulate at base (articulation at top of stalks).
- 7a. Pinnules small, often deltoid, obtuse at apex, 1.5–3 cm or rarely longer, herbaceous; rachis slender 7. *L. microphyllum*
- 7b. Pinnules broadly lanceolate, 8–12 cm or more, papery; rachis robust.
- 8a. Pinnae regularly 1-pinnate; rachis with dense brown long hairs; pinnules 9–13 pairs, truncate at base, not dilated 8. *L. polystachyum*
- 8b. Pinnae irregularly 1- or 2-pinnate; rachis glabrous; pinnules often 3–5 pairs, often cordate at base 9. *L. salicifolium*

1. *Lygodium merrillii* Copeland, *Philipp. J. Sci.*, C, 2: 146. 1907.

网脉海金沙 wang mai hai jin sha

Lygodium subareolatum Christ.

Plants climbing up to 5 m. Rachis of scandent fronds up to 5 mm in diam., minutely hairy; primary rachis branches very short, dormant apices prominent, covered with long dark brown hairs; secondary rachis branches unifoliate and sterile near base of a frond, upper ones pinnate; unifoliate secondary branches

6–9 cm, pinnae ca. 25 cm, palmately 5- or 6-lobed with acute sinuses to within 6 cm of base, lobes 2.5–4 cm wide, abaxial surface of lamina and veins minutely hairy or glabrous, veins oblique, anastomosing, with ca. 4 rows of elongate areoles between costa and margin, margin not thickened and shallowly and irregularly crenate-serrate (or thickened and serrate to serrulate), apex acute and acuminate; largest upper sterile secondary rachis branches pinnate, with 2–4 lateral deeply bilobed or palmate pinnae (on stalks up to 3 cm) and a terminal one; fertile secondary rachis branches pinnate (or largest bipinnate at base), in all ca. 30 cm or longer, with 5–7 pinnae 2–4-

¹ State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences, 20 Nanxincun, Xiangshan, Beijing 100093, People's Republic of China.

² Department of Natural Sciences, Marymount Manhattan College, 221 East 71st Street, New York, New York 10021, U.S.A.; Institute of Systematic Botany, New York Botanical Garden, Bronx, New York 10458-5126, U.S.A.

lobed; fertile pinnae 8–10 cm, lamina of each lobe up to ca. 1.5 cm wide, veins anastomosing, stalks 5–15 mm; sorophores 7–15 mm, somewhat contracted at base; indusia glabrous or with few pale hairs; spores very coarsely and irregularly verrucose, verrucae forming ridges with prominent laesurae and proximal equatorial ridge.

Forests, climbing on tree trunks at forest margins, often in limestone regions; 300–700 m. Guizhou, Hainan [Indonesia, Philippines, Vietnam].

2. *Lygodium circinnatum* (N. L. Burman) Swartz, Syn. Fil. 153. 1806.

海南海金沙 hai nan hai jin sha

Ophioglossum circinnatum N. L. Burman, Fl. Indica, 228. 1768; *Hydroglossum circinnatum* (N. L. Burman) Willdenow; *H. pedatum* (N. L. Burman) Willdenow; *Lygodium basilanicum* Christ; *L. conforme* C. Christensen; *L. dichotomum* (Cavanilles) Swartz; *L. pedatum* (N. L. Burman) Swartz; *O. pedatum* N. L. Burman; *Ugena dichotoma* Cavanilles; *U. macrostachya* Cavanilles.

Rhizome shortly creeping, bearing stipes very close together, apex of rhizome and bases of stipes densely covered with black hairs. Juvenile fronds once dichotomous, each branch bearing a pedate-palmatisect pinna, lobes usually ca. 4 or 5, subequal, up to ca. 25 × 3.5 cm, midrib of an outer lobe arising near base of next inner lobe, surfaces glabrous but conspicuously warty when dry (not when living), veins uniting with thickened margin, margins entire, often somewhat crisped, pale and much thickened (translucent when living), apices acute to acuminate. Rachis of climbing frond up to ca. 10 m, 2–5 mm in diam., glabrous; primary rachis branches very short, with sunken dormant apex covered with pale hairs not thickened at base; secondary rachis branches simple and 2–6 cm, or once dichotomous with each branch 1–2 cm beyond fork; sterile pinnae usually with 2–6 subequal diverging lobes separate to within ca. 2 cm from base, surfaces nearly always warty when dry, base cuneate or truncate, margin pale and thickened, entire; fertile secondary rachis branches simple or 1–3 times dichotomous (rarely subpinnate); fertile pinnae usually sessile in pairs at ends of ultimate branches, or members of a pair partly fused at base, less often 3–5-lobed (always so if secondary rachis simple), lamina ± reduced and commonly 3–6 mm wide, rarely less than ca. 2 mm or approximating in width to sterile pinna lobes; sorophores 2–5 mm, sessile; spores finely and evenly verrucose, laesura prominent.

Slightly shaded places in primary or secondary forests, never where ground becomes seasonally very dry; near sea level to 1500 m. Guangdong, Guangxi, Guizhou, Hainan, Yunnan [Cambodia, E India, Laos, Malaysia, Sri Lanka, Vietnam; Australia, W Pacific islands].

3. *Lygodium longifolium* (Willdenow) Swartz, J. Bot. (Schrader) 1801(2): 305. 1803.

掌叶海金沙 zhang ye hai jin sha

Hydroglossum longifolium Willdenow, Abh. Kurfüstl.-Mainz. Akad. Nützl. Wiss. Erfurt 2(4): 22. 1802; *Lygodium derivatum* Alderwerelt; *L. digitatum* C. Presl; *L. teysmannii* Alderwerelt.

Rhizome shortly creeping, apex of rhizome and bases of stipes covered with shiny black hairs. Juvenile fronds once or twice dichotomous, pinnae palmately divided with 4–7 subequal lobes, base often ± cordate, lobes up to ca. 18 × 1.8 cm, acuminate, margins shallowly serrate, with a vein ending in each tooth. Scandent fronds up to ca. 4 m, rachis up to ca. 2 mm in diam.; primary rachis branches very short, with a dormant apex covered with brown hairs having small swollen multicellular bases; secondary rachis branches 1–3 times dichotomous or subpinnate (lowest ones sometimes simple and bearing large 6-lobed pinnae); sterile pinnae composed of 2–4 subequal lobes ca. 15 cm or longer and ca. 15 mm wide, sinuses between lobes reaching up to 15 mm from base of pinna, surfaces glabrous and usually not warty when dried, base cuneate to cordate, margins regularly serrate, not or slightly thickened; fertile secondary branches 1–3 times dichotomous or (if dichotomies unequal) ± distinctly pinnate with 2 dichotomous tertiary branches (tertiary branches rarely with 3 separate pinnae); fertile pinnae simple or more often usually consisting of 2 subequal lobes united at base, lamina 3–10 mm wide, sorophores commonly 2–3 mm, less often up to 6 mm; spores coarsely and irregularly verrucose with prominent laesura and equatorial ridge on proximal face.

Forest margins, probably in more exposed places than *Lygodium circinnatum*. Hainan, Taiwan [S India, Indonesia, Malaysia, Philippines].

4. *Lygodium flexuosum* (Linnaeus) Swartz, J. Bot. (Schrader) 1800(2): 106. 1801.

曲轴海金沙 qu zhou hai jin sha

Ophioglossum flexuosum Linnaeus, Sp. Pl. 2: 1063. 1753; *Hydroglossum flexuosum* (Linnaeus) Willdenow; *H. scandens* (Linnaeus) Willdenow; *Lygodium altum* (C. B. Clarke) Alderwerelt; *L. flexuosum* var. *accidens* R. C. Y. Chou; *L. flexuosum* var. *alta* C. B. Clarke; *L. pilosum* Desvoux; *L. scandens* (Linnaeus) Swartz; *L. semibipinnatum* R. Brown; *Odontopteris scandens* (Linnaeus) Bernhardt; *Ophioglossum scandens* Linnaeus; *Ramondia flexuosa* (Linnaeus) Mirbel; *R. scandens* (Linnaeus) Mirbel.

Rhizome shortly creeping and densely covered with roots, stipes very close together; apex of rhizome covered with dark brown to nearly black hairs. Juvenile fronds once or twice dichotomous, each branch bearing a single pinna deeply palmately 3–7-lobed, lobes almost equal, base of whole pinna cordate, margins serrate and sometimes crenately lobed. Rachis of scandent fronds narrowly winged, flattened and puberulent on adaxial surface between wings; primary rachis branches up to 3 mm (lower ones longest), dormant apex covered with pale brown hairs; secondary rachis branches pinnate to somewhat bipinnate, narrowly ovate to deltoid in outline, commonly ca. 15 × 8 cm; sterile pinnae of lower branches palmate, often 5-lobed, base strongly cordate; higher secondary branches bearing 3–5 (sometimes up to 7) pinnae on each side and an apical one, apical and lower pinnae asymmetrical or ± lobed at base, lowest of branches with 2 or 3(–6) separate quaternary pinnae at base; sterile pinnae 3–10 cm × 8–15 mm above lobed base, margin serrate, apex subacute, lower pinnae stalked, upper pinnae sessile, lamina rather thin; costae usually with scattered long hairs, less often with dense short hairs, veins often with scattered

short hairs on abaxial surface, lamina sometimes similarly hairy; fertile pinnae smaller than sterile pinnae, sorophores 3–5 mm (rarely up to 10 mm), at apices of small triangular lobes; indusia glabrous or with a few hairs like those of abaxial surface of lamina; spores finely evenly verrucose.

Open places, climbing on shrubs, in teak (*Tectona grandis*) and bamboo forests, not in shaded evergreen forests; near sea level to 1000 m. Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hunan, Yunnan [Bhutan, India, S Japan, Malaysia, Nepal, Philippines, Sri Lanka, Thailand, Vietnam; E Australia].

In very dry or exposed places, the veins and lamina of *Lygodium flexuosum* are often rather copiously hairy.

One of us (Garrison Hanks) notes that differences between *Lygodium flexuosum* and *L. japonicum* based on pinnule size are problematic, but the taxa are difficult to distinguish in many collections.

5. *Lygodium japonicum* (Thunberg) Swartz, J. Bot. (Schrader) 1800(2): 106. 1801.

海金沙 hai jin sha

Ophioglossum japonicum Thunberg in Murray, Syst. Veg., ed. 14, 926. 1784; *Hydroglossum japonicum* (Thunberg) Willdenow; *Lygodium chaerophylloides* Desvaux; *L. cochinchinense* Desvaux; *L. dissectum* Desvaux; *L. japonicum* var. *microstachyum* (Desvaux) C. Christensen & Tardieu; *L. microstachyum* Desvaux; *L. microstachyum* var. *glabrescens* Nakai; *L. pubescens* Kaulfuss.

Rhizome widely creeping, dichotomously branched, 2–5 mm in diam., densely clothed with dark brown hairs, fronds commonly 5–10 mm apart. Juvenile fronds erect, first branching an unequal dichotomy (?always), two main branches of large fronds bipinnate, deltoid in outline, with palmatisect pinnae, pinna margins doubly serrate. Rachis of climbing fronds hardly ca. 2 mm in diam., glabrous except for minute hairs on flattened adaxial surface between narrow wings; primary rachis branches 3–10 mm, dormant apex covered with pale hairs; secondary branches of fronds on young or stunted plants pinnate, on well-grown fronds bipinnate or tripinnate, deltoid in outline, commonly ca. 12 cm long and wide, rachises densely shortly hairy on adaxial surface and with fewer longer hairs elsewhere; sterile tertiary pinnae of lower rachis branches palmate with 5–7 lobes, middle lobe much longer than lateral lobes, tertiary pinnae higher up frond 3-lobed with an elongate middle lobe or pinnate with small oblique and often lobed quaternary pinnae and a usually deltoid-pinnatisect terminal pinna ca. 3 cm, margins acutely biserrate, apex obtuse or subacute; stalks of pinnae up to 3 mm, never articulate or thickened at apex; costae usually with long scattered hairs, veins and surfaces usually glabrous but sometimes shortly hairy; fertile secondary branches tripinnate, pinnae smaller than sterile pinnae, sorophores 2–12 mm; indusia glabrous or with few hairs if lamina hairy; spores finely low tuberculate to verrucose with prominent laesurae.

Climbing in secondary vegetation; sea level to ca. 500 m (in Taiwan). Anhui, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shanghai, Sichuan, Taiwan, Xizang, Yunnan, Zhejiang [Bhutan, India, Indonesia (Java), Japan, Kashmir, Korea, Nepal, Philippines, Sri Lanka; tropical Australia, North America].

6. *Lygodium yunnanense* Ching, Fl. Reipubl. Popularis Sin. 2: 345. 1959.

云南海金沙 yun nan hai jin sha

Lygodium giganteum Tagawa & K. Iwatsuki.

Rhizome very shortly creeping, bearing fronds close together, apices and bases of stipes densely covered with dark brown hairs. Fronds very large, climbing to more than 2 m; stipes at most 20 cm, stramineous to dark, densely pubescent throughout, very narrowly winged; rachis like upper part of stipes, 2–4 mm in diam., densely pubescent; primary rachis branches 8–15 mm, apex dormant, covered with dense brown hairs; secondary rachis branches pinnate to bipinnate, up to 25 cm long and wide; in larger ones tertiary rachis branches with few pinnae, forming a pentagonal outline, tertiary pinnae palmately 5-lobed to hastate, with large central lobes, deeply cordate at base, rounded or very moderately acute at apex; axes of branches of secondary and of higher orders stramineous, densely pubescent with pale unicellular hairs, with distinct articulation at every junction; ultimate lobes larger, oblong-subdeltoid to oblong, up to 20 × 4 cm, herbaceous to soft papery, irregularly and slightly dentate at margin, rounded at apex; stalks very narrowly winged, articulate at base of lamina, up to 15 mm; veins forked 3–4 times, all free; both surfaces of lamina as well as veins hairy. Sporangia-bearing lobes protruding at margin of ultimate lobes, 2–8 × ca. 1.2 mm; indusia hairy.

Among shrubs, dry slopes in thickets, usually in deciduous forests at low to middle elevations; 300–1300 m. Guangxi, Guizhou, Yunnan [Myanmar, Thailand].

In hairiness and articulation at base of ultimate segments (without an actual function as an abscission zone), *Lygodium yunnanense* is similar to *L. salicifolium* and rather difficult to distinguish from the latter in the Myanmar-Yunnan region. The pattern of division of the fronds is like that of *L. flexuosum*, but *L. yunnanense* is a much larger species.

7. *Lygodium microphyllum* (Cavanilles) R. Brown, Prodr. 162. 1810.

小叶海金沙 xiao ye hai jin sha

Ugena microphylla Cavanilles, Icon. 6: 76. 1801; *Lygodium scandens* (Linnaeus) Swartz var. *microphyllum* (Cavanilles) Luerssen.

Rhizome long creeping, ca. 3 mm in diam., branching, covered with multicellular hairs 2–3 mm, lustrous black changing to reddish brown on fronds. Fronds 3–10 mm apart, climbing to 10–15 m. Stipes dark brown at base becoming stramineous, covered with reddish brown multicellular hairs, sparse distally, ca. 14 cm to first pinnae. Rachis ca. 1 mm in diam., narrowly grooved, glabrous to randomly hairy. Pinna stalk 3–6 mm, grooved, glabrous to sparsely hairy, hairs short, acicular extending onto pinna branch for a short distance. Dormant pinna bud prominent, covered with golden to reddish brown multicellular hairs. Primary pinna branches grooved, glabrous, pinnate, bearing 4(–7) alternate pairs of segments, terminal segments bifid or dichotomous. Segment stalk 2–4(–7) mm, articulate (segment deciduous leaving persistent stalk),

articulation zone prominent at base of segment. Segments deltoid to lanceolate, rarely lobed, 1.5–2.5(–5.5) × 0.9–1.5(–2) cm, truncate to cuneate at base, rounded to acute at apex. Veins free, prominent abaxially, 2 or 3 times forked, ascending at 30°–40° from costa, ending at margin. Margins minutely crenulate-serrulate to subentire, slightly thickened. Fertile and sterile segments monomorphic to slightly dimorphic. Fertile segments smaller, 1–3 × 1–1.5 cm, articulation zone of stalk less prominent, hairs more common abaxially close to sorophores which extend from veins at margins, 4–6(–10) sporangial pairs per sorophore; indusia glabrous, margins crenulate; spores reticulate, laesurae not prominent.

Among shrubs by streams; low elevations (near sea level to 700 m in Taiwan). Fujian, Guangdong, Guangxi, Hainan, Taiwan, Yunnan [India, Indonesia, Malaysia, Myanmar, Nepal, Philippines; Africa, Australia, North America, S Pacific islands].

8. *Lygodium polystachyum* Wallich ex T. Moore, Gard. Chron. 671. 1859.

羽裂海金沙 yu lie hai jin sha

Hydroglossum pinnatifidum Willdenow; *Lygodium colaniae* Tardieu & C. Christensen.

Rhizome shortly creeping, 3–5 mm in diam., densely clothed with spreading black hairs. Juvenile fronds once or twice dichotomous; stipes up to 30 cm to first dichotomy, brown, with short very slender hairs mixed with thick longer multicellular ones; ultimate branches leafy like secondary rachis branches of climbing fronds. Rachis of climbing fronds ca. 2.5 mm in diam., shortly hairy, not winged; primary rachis branches very short, ending in a dormant apex covered with brown hairs (apices of lower primary branches sometimes proliferous); secondary rachis branches 20–30 cm, not winged, shortly hairy, bearing 10–15 pinnae on each side and a similar terminal pinna; sterile pinnae 3.5–7.5 × 1.5–2 cm, apex rather abruptly narrowed and rounded, base truncate or cordate, jointed to a hairy stalk 1–4 mm, sides lobed halfway to costa or

more, lobes 4–5 mm wide, oblong with rounded apex, each lobe with a sinuous costule with scattered stiff hairs on both surfaces, costa also with shorter hairs, segment stalks strongly articulate; fertile pinnae like sterile pinnae but distal half or more of each lobe narrowed to ca. 2 mm wide, narrow part (sorophore) 4–10 mm, bearing sporangia on abaxial surface; indusia with scattered stiff hairs; spores finely and evenly verrucose.

Lowland forests, climbing trees to a considerable height. Guangxi, Yunnan [India, Malaysia, Myanmar, Thailand, Vietnam].

9. *Lygodium salicifolium* C. Presl, Suppl. Tent. Pterid. 102. 1845.

柳叶海金沙 liu ye hai jin sha

Rhizome and juvenile fronds as in *Lygodium flexuosum*, except rachis thickened at junction of rachis with midribs of lobes of pinnae. Rachis of climbing fronds up to 10 m, up to 2 mm in diam.; primary rachis branches always very short (hardly measurable), ending in a dormant apex covered with brown hairs; secondary rachis branches normally pinnate, rarely somewhat bipinnate and then tertiary branches bearing 1 or more pairs of short spreading lateral pinnae (jointed at base) and a large terminal one; secondary branch system usually consisting of ca. 4(–6) pinnae on each side, and a terminal deeply bilobed pinna (or a pair of pinnae), all pinnae of ± equal size and all stalked, stalks 2–10 mm and thickened at junction with lamina, most often articulate (old pinnae sometimes deciduous but not regularly so as in *L. microphyllum*); pinnae 4–15 × 0.5–2 cm, base truncate to cordate, margins of sterile pinnae finely crenate-serrate, apex acute and attenuate or subobtusate; lamina thicker than in *L. flexuosum*; adaxial surface of costae ± hairy especially toward base, abaxial surface often glabrous, veins usually glabrous; sorophores 2–5 mm, usually constricted at base; indusia glabrous; spores finely verrucose.

Mixed forests; 800–1200 m. Hainan, Taiwan, Yunnan [Bhutan, India, Indonesia, Myanmar, Nepal, Thailand, Vietnam].