

THE PTERIDOPHYTA OF TAIWAN—3 SELAGINELLACEAE

by

CHARLES E. DEVOL⁽¹⁾ and HOPE H. W. CHEN⁽²⁾

INTRODUCTION

This is a continuation of the study⁽³⁾ of the Pteridophyta of Taiwan.⁽⁴⁾ The junior author, Miss Hope H. W. Chen, has been making a study of the Selaginella of Taiwan and together with the senior author have prepared descriptions of each species based on Taiwan material. Permanent slides of microspores and megaspores were prepared by Dr. T. C. Huang, C. C. Chuang and Hope Chen and are in the pollen slide herbarium of the N. T. U. Botany Department. The anatomy of the stem was studied by Miss B. Y. Shih, permanent slides were prepared by her of all available species known from Taiwan.

Henry (1896) in his "List of Plants from Formosa" cited 8 species of Selaginella from Taiwan. Since that time others have been found and we now know of 15 species. Matsumura and Hayata (1906) listed 11, Sasaki (1928) 15, and Masamune's check lists of 1936 and 1954 both give 16. But in these and other literature we find at least 40 different names used for our 15 species, some are cases of wrong identifications and some are names which have been reduced to synonyms.

The following is a list of species previously described as new from Taiwan:

- S. pseudo-involvens* Hay.
- S. subcaulescens* Hay.
- S. kelungensis* Hay. which is *S. remotifolia* Spr.
- S. morriscnensis*. Hay. which is *labordei* Hieron.
- S. somai* Hay. which is *S. bcninensis* Bak.
- S. stenostachys* Hay. which is *S. leptophylla* Bak.
- S. tarokoensis* Yam. which is *S. remotifolia* Spr.

S. biformis has been reported by Masamune (1954), we have seen no specimens of this species from Taiwan and do not know where it was collected. *S. mongholica* Rupr. as reported by Henry was examined by Tagawa and identified by him as *S. repanda* (Desv.) Spring. Tagawa also collected this species in Kaohsiung and Taitung Counties, but since we do not have any specimens of this species in our herbaria,

(1) Professor of Botany, National Taiwan University.

(2) 陳希望 Senior student in Botany Department.

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(4) *Taiwania* **10**: 89-104, **11**: 41-55.

Addendum:

To the above list of species described as new from Taiwan should be added
S. leptophylla Bak.

we are not including a description or illustration of it in this paper. True *S. mongholica* which is *S. sinensis* is not known from Taiwan.

Satake (1934, 1934a) made a study of the epidermal characters of the leaves of the Japanese species of *Selaginella*. His work closely follows that of Gibson (1897) except that Satake deals with Japanese plants. In all he studied 24 species, 15 of which are known from Taiwan. We have not repeated Satake's studies but are of the opinion that he divided the taxon more finely than necessary, and he was partly aware of this situation himself for he says regarding *S. Hayatana* "there is no clear distinction between this plant and *S. leptophylla* Baker in the characters of the epidermal layers." p. 382.

Several of the taxon which he recognized as species cannot be maintained as separate species.

For example.

His species *S. longicauda* and *S. somai* are both the same and are reduced to synonyms of *S. boninensis*.

His *S. kelungensis* and *S. japonica* are the same and are reduced to synonyms of *S. remotifolia*.

S. hayatana is the same as *S. leptophylla* and the latter name, being the older, is the correct name.

S. savatieri and *S. nipponica* are the same and *S. nipponica* is the accepted name.

Thus of the 15 taxon which he discussed several are duplicated, leaving only 10 species. This does not mean that epidermal characters are unreliable, but cannot be the sole basis for recognizing species differences.

A recent study made on the chemical constituents of *Selaginella* by Hsu, Hsiu and Wu (1963), shows that the wax found in these plants is of the estolide type and that one of the flavones present was apigenin. It is unfortunate that they misspelled the names of the *Selaginella* they investigated.

IV SELAGINELLACEAE

A family with only one genus. See description of genus for characters.

4. *Selaginella* Linn.

卷柏屬 Chuen Peh Shu

Small vascular plants usually with one or the other of the three following types of stems. (1) with weak, slender, creeping stems, rooting at intervals and bearing many leafy branches (2) with slender, erect stems, usually without branches in the lower part, rooting near base of stem (3) with a short, stout stem made up of a cluster of branches of about the same length, which roll up when dry; leaves small,⁽¹⁾

(1) Since the leaves are very small they should be examined with a magnification of at least $\times 10$ or more.

simple, with a single vein, always bearing an inconspicuous ligule on the adaxial side at its base (which is only prominent during its early development); vegetative leaves alike⁽¹⁾ or more often dimorphic and usually arranged in two median and two lateral rows on the branches, the median leaves usually smaller and of a different shape from the lateral leaves, leaves on stem may be similar or different from branch leaves; strobili usually borne on ends and sides of branches, usually made up of sporophylls quite different from the vegetative leaves, however, a few species do not have the sporophylls in compact strobili; the microsporophylls bear a single microsporangium, which contains a large number of microspores; the megasporophylls bear a single megasporangium with four megaspores; the arrangement of microsporophylls and megasporophylls in the strobilus is not always constant; microspores are very much smaller and their color is usually different from that of the megaspores; the sporangia are round or oval and open by a transverse slit.

The cross section of the stem usually shows a wide cortical region and then an aerenchyma zone connected by trabeculae with a central ectophloic protostele, but our studies show that not all species have this type of stem. The stele is usually flattened.

A KEY TO THE TAIWAN SPECIES OF SELAGINELLA

1. Main stem short, stout, made up of many branches of nearly equal length, densely tufted, curling up when dry; leaves arranged in 4 rows; lateral and median leaves much like; sporophylls uniform.....1. *S. tamariscina*
1. Main stem slender, erect or creeping.....2
2. Main stem slender, erect, rooting at base, in some species bearing rhizophores....3
2. Main stem creeping, or erect but appressed against steep banks and terraces, rooting at intervals.....10
3. Sporophylls monomorphic.....4
3. Sporophylls dimorphic.....9
4. All leaves with entire margins.....2. *S. delicatula*
4. Some or all of the leaves with ciliate or with serrulate margins.....5
5. Leaves on lower part of erect stem monomorphous, equal-sided or nearly so, directed upwards.....6
5. Leaves of basal part of erect stem dimorphous, lateral ones unequal-sided, directed outwards; lower part of stem bearing long rhizophores.....8
6. Median leaves ovate, unequal-sided, cuspidate, ciliate.....4. *S. mollendorffii*
6. Median leaves elliptical to narrowly ovate, entire or nearly so.....7
7. Basal stem leaves with auricles; rhizome very long creeping, erect stems very far apart.....3. *S. involvens*⁽²⁾

(1) This type, represented by *S. rupestris* (L.) Spr., has not been reported from Taiwan.

(2) There is a variety of *S. involvens* which has distinctly ciliate median leaves. This seems to be rare on Taiwan having only been collected from Taitung and I-lan Counties.

7. Basal stem leaves with flap below point of attachment; rhizome bearing upright stems at frequent intervals (1-4 cm) apart.....5. *S. pseudo-involvens*
8. Main branches (including leaves) 3-4 mm broad.....6. *S. subcaulescens*
8. Main branches (including leaves) 6-10 mm broad.....7. *S. doederleinii*
9. Main stem without branches at base, median stem leaves cordate at base
.....10. *S. labordei*
9. Main stem branched to base; median stem leaves not cordate at base.....
.....11. *S. leptophylla*
10. Sporophylls monomorphous.....11
10. Sporophylls dimorphous.....12
11. Plants widely creeping; leaves nearly entire, with distinct midrib; sporophylls in short compact strobili; borne on sides and ends of short leafy branches; sporophylls lanceolate, acuminate, margins very finely ciliate....8. *S. remotifolia*
11. Plants forming dense mats; all leaves distinctly ciliate, midrib absent or indistinct; sporophylls in loose strobili, borne on ends of erect stalks; sporophylls broadly ovate, margins distinctly ciliate.....9. *S. nipponica*
12. Stem including leaves 8-9 mm wide.....12. *S. boninensis*
12. Stem including leaves 3-4 mm wide13
13. Sporophylls of lower plane with long prominent cilia, sporophylls of upper plane entire or only with few short cilia; lateral branch leaves nearly entire, ciliate towards base.....13. *S. ciliaris*
13. Sporophylls of both lower and upper plane minutely and regularly ciliate, lateral branch leaves minutely ciliate along both margins.....14. *S. heterostachys*

A KEY TO THE TAIWAN SELAGINELLA

based on characters seen in the c. s. of a stem

1. Erect stems with 3 oval vascular bundles2. *S. delicatula*
1. Stems with a single vascular bundle.....2
2. Stems with no aerenchyma zone between the cortex and stele....7. *S. doederleinii*
2. Stems with a distinct aerenchyma zone.....3
3. Cortex of only thin walled cells⁽¹⁾11. *S. leptophylla*
13. *S. ciliaris*
3. Cortex with bands of both thick walled and thin walled cells.....4
4. The thick walled cells of the cortex confined to only the outer 1-3 layers of cells; stele flattened⁽²⁾6. *S. subcaulescens*
10. *S. labordei*

(1) The following two species do not differ very much in stem anatomy, but *S. leptophylla* stems are much larger and the outer and radial walls of the epidermal layer are thickened, *S. ciliaris* has an epidermis of thin walled cells.

(2) The following two species do not differ very much in stem anatomy, but in *S. subcaulescens* the stele is much longer, i. e. 3 times as long as broad, and there are less rows of thick walled cells, while in *S. labordei* the stele is only about twice as long as wide.

4. The thick walled cells of the cortex in a broad zone5
5. Cortex with first a narrow band of thin walled cells beneath the epidermis, then a wide band of sclerenchyma tissue, then an inner thin band of parenchyma cells; stele oval.....1. *S. tamariscina*
5. Cortex with the wide band of thick walled cells immediately beneath the epidermis, the parenchyma tissue constituting the innermost zone.....6
6. Stele oval⁽¹⁾.....8. *S. remotifolia*
9. *S. nipponica*
6. Stele much flattened, elongate.....7
7. Xylem band very long, uniformly narrow.....4. *S. mollendorffii*
7. Xylem not as above8
8. Xylem with a "V-shaped" widened zone in the middle3. *S. involvens*
8. Xylem with the middle and two ends swollen, somewhat dumb-belled shaped5. *S. pseudo-involvens*

SELAGINELLA SPORES

Spores of Selaginella are characterized by being triangular, flat on proximal side and rounded on distal side, the size of microspores range from 25 to 60 micron and the megaspores from 200 to 700 micron measured along one let toward its opposite side; aperture trilete; exine ornamentation various, from psilate, verrucate, gemmate, baccate, clavate to echinate, rarely covered with exospore (perine) which may be expanded as a wing in *S. involvens*; sexine obscure, rugate to reticulate. The sporoderm of Selaginella is a useful criterion for distinguishing the species.

The spore slides were prepared by both the direct and acetolysis methods. The megaspores were studied from spores mounted directly in Canada balsam while the microspores were studied from spores prepared by the acetolysis method and also from spores mounted in Canada balsam.

KEY TO SPECIES OF TAIWAN SELAGINELLA

based on spore characters

Prepared by Dr. T. C. Huang

1. Endomegaspores prominently adhering with exospores.....2
1. Endomegaspores absent or free from exospores6
2. Exospore extending over exine ornamentation as a wing.....3. *S. involvens*
2. Exospore not extending over exine ornamentation.....3
3. Sexine of megaspores obscure to rugate4. *S. mollendorffii*
3. Sexine of megaspore reticulate4

(1) The following two species do not differ very much in stem anatomy, but *S. nipponica* stems are much smaller and only has one inner layer of thin walled cells, while *S. remotifolia* has a wider band of thin walled cells.

4. Exine of megaspores psilate, scabrate, rarely mixed with short baccate.....13. *S. ciliaris*
4. Exine of megaspores echinate to long baccate.....5
5. Exine of microspores peculiar, very narrow at base, then swollen, then with a long linear apical tip; spores large, 45 μ in microspores and 700 μ in megaspores8 *S. remotifolia*
5. Exine of microspores baccate; spores small, 32.5 μ in microspores and 280 μ in megaspores.....7. *S. doederleinii*
6. Sexine of megaspores reticulate; exospore obscure.....1. *S. tamariscina*
6. Sexine of megaspores obscure or rugate; exospore absent or free7
7. Exine of microspores mostly clavate, rarely mixed with few other elements.....2. *S. delicatula*
7. Exine of microspores various except clavate.....8
8. Exine of megaspores verrucate5. *S. pseudo-involvens*
8. Exine of megaspores baccate or echinate or both9
9. Bacula of megaspores short, up to 7.5 μ long.....10
9. Bacula of megaspores long, up to 16-25 μ long.....12
10. Exine of microspores scabrate.....6. *S. subcaulescens*⁽¹⁾
10. Exine of microspores gemmate to verrucate11
11. Spores small, 30 μ in microspores and 250 μ in megaspores ...14 *S. heterostachys*⁽¹⁾
11. Spores large, 42.5 μ in microspores and 270 to 330 μ in megaspores.....10. *S. labordii*⁽¹⁾
12. Exine of microspores verrucate*S. leptophylla*⁽¹⁾
12. Exine of microspores scabrate, rarely verrucate*S. nipponica*⁽¹⁾

1. *S. tamariscina* (Beauv.) Spring

Fig. 1

Spring, 1843: 136; Koidzumi, 1935: 224; Makino, 1940; 970, fig.; DeVol, 1945: 38; Ohwi, 1957: 13; 1965: 26-27; Alston, 1934: 270; Tagawa, 1963: 19-20, pl. 5:29.

S. involvens Spring sensu Masamune 1935: 33; Baker, 1884: 22: 375; Franchet et Savatier, 1879: 200; Miquel, 1867: 349; Henry, 1896: 117; Warburg, 1900: 101, 103; Matsumura et Hayata, 1906: 553; Masamune, 1936: 33; Sasaki, 1928: 46; Hayata, 1916: 117, 1918: 98, fig. 60.

Main stem short, stout, made up of many leafy branches of nearly equal length, densely tufted, curling up when dry; basal part of stem covered with many roots; leaves all much alike, lateral and median leaves only slightly different, arranged in four rows, unequal sided, ovate, cuspidate, ciliate, margined, dark green on upper side, pale green beneath, narrowed at base, not auricled, imbricating; strobili borne on ends of leafy branches, 4-angled; sporophylls monomorphic, ovate, acuminate ciliate, keeled; microspores reddish-brown, usually borne in long strobili; megasporangia usually in very short strobili; megaspores yellow.

(1) These are not easily divided by spore characters.

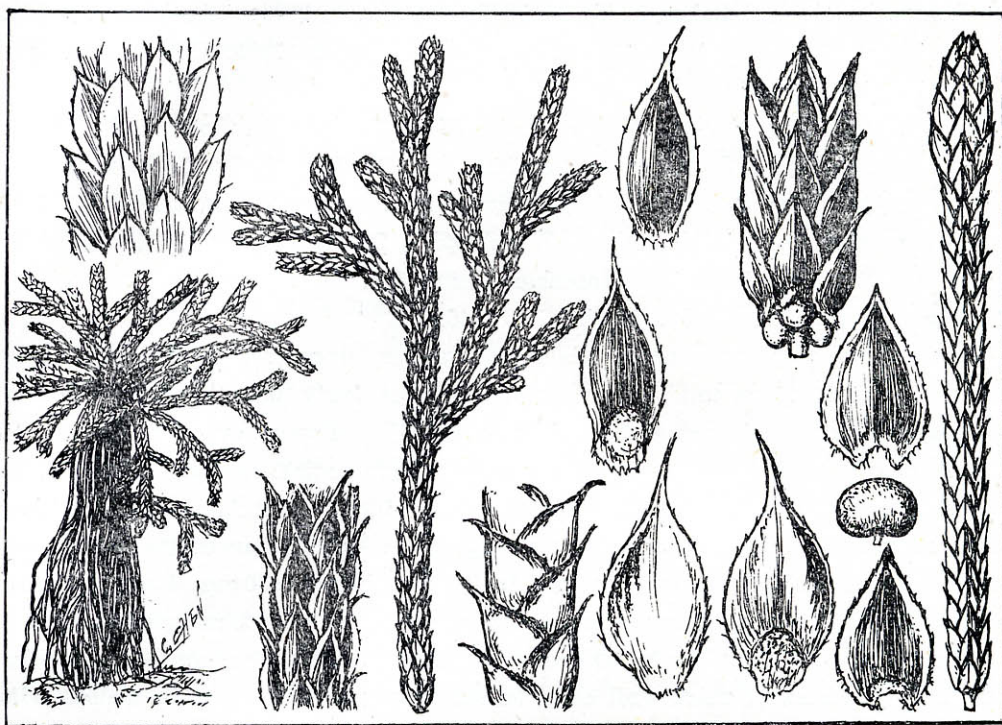


Fig. 1. *Selaginella tamariscina* (Beaur.) Spr.

C.s. of stem: Stems clustered; each stem terete; epidermis with the outer tangential and radial walls very thick; cortex of 3 zones: the outer of ± 5 cells of relatively thin walled large cells, and then a broad ring of sclerenchyma cells having very small lumen, then the innermost very narrow zone of thin walled cells (1-3 celled wide); aerenchyma region narrow; stele round or oval.

Microspores 60μ long, the exine gemmate to verrucate, the sexine coarsely granulate to rugate; megaspores 340μ long, the exine scabrate, the exospores obscure, the sexine finely reticulate.

Distribution: Eastern Siberia, Korea, Japan, Mainland China, Ryukyu, Taiwan, Philippines, Java, North India.

Taiwan: Taipei, Taichung, Nantow, Kaohsiung, Pingtung, Taitung, Hwalien, and Ilan Counties.

Habitat: Common on exposed rocks.

2. *S. delicatula* (Desv.) Alston

Alston, 1932: 282, 1934: 277; DeVol, 1945: 39.

Lycopodium delicatulum Desv. ex. Poir. Encycl, Supple. 1814, 3: 584.

S. plana Hieron. sensu Sasaki, 1928: 47; 1930: 50; Satake, 1934: 369; Masamune, 1936: 33.

Fig. 2

S. canaliculata (L.) Baker, 1885: 21, 1887: 91; Henry, 1896: 177; Warburg, 1900: 107 et 122; Diels, 1901: 211; Matsumura et Hayata, 1906: 552; Hayata, 1916: 117, 1918: 98, fig. 61.

S. flabellata (L.) Spring; Baker, 1885: 47, 1887: 98; Bentham, 1887, 7: 678; Henry, 1896: 117; Matsumura et Hayata, 1906: 553; T. Ito, 1928: pl. 2.

S. philippica Spring (misspelled by Japanese authors) sensu Sasaki, 1928: 47, 1930: 50; Masamune, 1936: 33; see *S. philippina* Spring; Baker, 1884: 298, 1887: 83; Warburg, 1900: 104; Rosenburg, 1915: 180.

S. pouzoliana (Gaud.) Spr. Spring 1843:145.

Main stem erect, stramineous, glabrous, angular, decumbent and bearing roots near the base, 30-50 cm tall, lower portion without leafy branches, or with very short leafy branches; leaves at base of stem all alike, distant, ovate, acute, auricled at base, nearly equal sided, pointing upwards, margin entire; median leafy branches 4-5 mm broad (including leaves) lateral leaves oblong, apiculate, unequal sided, entire, narrowed at base; median leaves very unequal sided, lanceolate, shortly cuspidate, entire; strobili terminal on the leafy branchlets, 5-30 mm long, 4-angled; sporophylls all of one type, ovate-acuminate, equal sided, keeled, margins entire.

C. s. of stem: Stems terete, epidermal cells very small, thickened on all sides; outer half of cortex of thick wall cells, lumen large, inner half of thin walled cells;

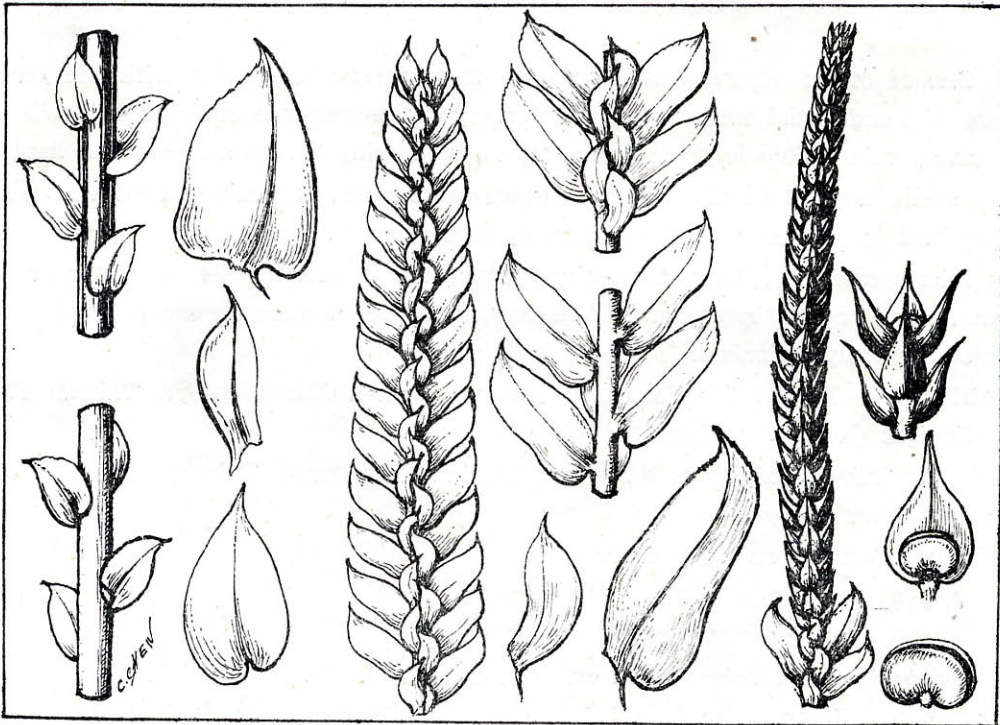


Fig. 2. *Selaginella delicatula* (Desv.) Alston

with three separate vascular bundles in the erect stems, these are oval or oblong, and each is surrounded by a narrow aerenchyma zone.

Microspores 37.5μ long, the exine clavate, the sexine coarsely granulate; megaspores 270μ long, the exine short clavate, the sexine rugate. **Fig. 14, 6.**

Distribution: Mainland China, Taiwan, Hainan, Philippines, Malaya, Burma, India, Nepal, New Guinea, Polynesia.

Taiwan: Known from nearly every county.

Habitat: Forest floor.

3. *S. involvens* (Sw.) Spring

Fig. 3

Spring, 1843: 136; Alston, 1945: 220; Tagawa, 1963: 19, pl. 5: 28.

Lycopodium involvens Sw., 1806: 182.

S. caulescens (Wall) Spring, 1843: 137; Baker, 1885, 23: 24, 1887, 94; Franchet et Savatier, 1879: 199; Henry, 1896: 117; Diels, 1901: 221; Matsumura et Hayata, 1906: 552; Hayata, 1911: 410, 1916: 117, 1918: 99. fig. 63; T. Ito, 1928: pl. 1; Sasaki, 1928: 46, 1930: 50, Alston, 1934: 285, 1935: 441; Masamune, 1936: 32.

S. japonica Moore ex MacNab, 1868, 9: 8; Koidzumi, 1935: 226.

S. pachystachys Koidz., 1935: 226; Ohwi, 1957: 13; 1965: 27.

Main stem terete, erect, without branches on the lower half; from a very wide creeping, shallowly subterranean, branching rhizome; scales on rhizome without

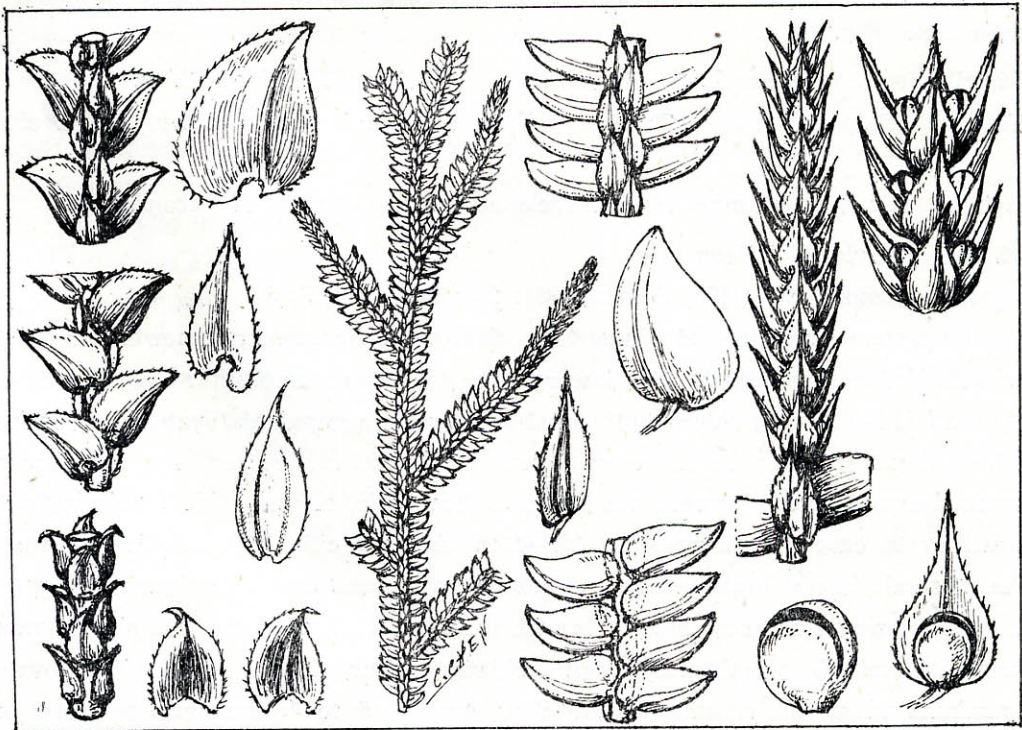


Fig. 3. *S. involvens* (Sw.) Spr.

chlorophyll, pinkish-yellow to orange, ovate, ciliate, attached by broad base, acute, apex appressed or recurved; plants up to 40 cm tall; leaves on lower part of stem monomorphous, ovate, clasping, auricled, nearly equal-sided, with a definite midrib, apex appressed or recurved, margins erose and long ciliate towards apex; leafy branches 5 to 12 cm long, lower ones longest; lateral leaves of leafy branches unequal-sided, ovate-lanceolate to broadly ovate, pointing outwards, ciliate near base, otherwise entire, apex acute, often slightly falcate, with indistinct midrib; median leaves elliptical, nearly equal sided, acuminate, entire or minutely ciliate, pointing towards apex, with two longitudinal grooves reaching from base to apex; axillary leaves unequal-sided, ovate, acute, minutely ciliate; strobili tetragonal, terminal on branches, sporophylls monomorphous, ovate, acuminate, shortly awned, minutely ciliate.

C. s. of stem: Stem terete; epidermal cells with small round lumen, thickening circular; outer half of cortex of sclerenchyma tissue and inner half of parenchyma; aerenchyma zone very narrow; stele very much flattened and elongated, with a "v" shaped bulge in the middle.

Microspores $30\ \mu$ long, the exine verrucate, the sexine coarsely granulate to rugate, the tetraspores present after acetalysis; megaspores $340\ \mu$ long, the exine baccate, the exospores extending over exine ornamentation, the sexine sometimes reticulate. **Fig. 14. 4.**

Distribution: Southern Korea, Japan, Ryukyu, Taiwan, Mainland China.

Taiwan: Taipei, Hsinchu, Taichung, Nantow, Chiayi, Ilan Counties and Orchid Island.

Habitat: Growing on moss covered rocks and trunks of trees or stream banks.

4. *S. mollendorffii* Hieron.

Fig. 4

Hieronymous, 1902: 178; Alston, 1934: 283; DeVoi, 1945: 38.

Main stem erect, up to 55 cm tall, glabrous, stramineous, somewhat angular, without leafy branches on the lower part, decumbent at base; leaves at base of stem all alike, lacking chlorophyll, equal sided, pointing upwards, ovate, acute, entire, midrib distinct, leaves on the stem below the branches directed upward, distant, green, leaves on stem between the branches dimorphic, unequal sided, pointing outward, ovate, cuspidate, margined, auricled on one side, ciliate, the median narrower than lateral; lateral branch leaves unequal sided, ovate, acute, contiguous, minutely ciliate, pointing outwards; median branch leaves smaller, very unequal sided, ovate, cuspidate, midrib prominent, margins ciliate, axillary leaves, equal sided, ovate, acuminate, margined, ciliate, not auricled; strobili 5 to 15 mm long, terminal on branchlets; sporophylls monomorphous, ovate, acuminate, margined, ciliate.

Median leaves	<i>S. involvens</i>	<i>S. mollendorffii</i>
Midrib	absent or indistinct; but with 2 longitudinal grooves.	prominent, ending in an aristate tip.
Margins	entire	ciliate
Shape	elliptical, nearly equal sided.	ovate very unequal sided.
c. s. of median leaf	2 deep grooves on upper side, outer cutin layer thick on both upper & lower sides, thin walled cells in grooves round, with apiculate tip.	median region raised, no grooves on upper side, cutin layer thin.
c. s. of stem	stele elongate, xylem with "V-shaped" central bulge.	stele elongate, xylem band of uniform width.
rhizome	very long creeping.	short; erect stems decumbent at base.

5. *S. pseudo-involvens* Hayata

Fig. 5

Hayata, 1918: 100, fig. 65; Sasaki, 1928: 47, 1930: 50; Masamune, 1936: 33.

Main stem (rhizome) widely creeping, rooting at intervals, the scale-like leaves appressed, imbricating, equal sided, sub-entire, acuminate; erect aerial stems usually 2 to 3 cm apart, 8 to 20 cm tall, lower half without branches, terete, often brown or purplish; leaves at base of stem monomorphous, equal sided, pointing upward, ovate-acuminate, with dark marginal lines, scarios border and fimbriate base; leafy branches 2 to 7 cm long, spreading, lowest largest; lateral leaves on branches contiguous, pointing outwards, broadly ovate, sharply pointed, minutely serrulate along upper margin; median leaves nearly equal sided, narrowly ovate, acuminate-aristate; strobili 1 to 3 cm long, borne on ends of branchlets; sporophylls monomorphous, ovate, acuminate, margins scarios, erose.

C. s. of stem: Stem terete or oval; outer cutin layer thick; the wide cortex mostly composed of thick walled cells, only the innermost one of two layers of parenchyma, aerenchyma zone very narrow, stele flattened, elongate, with the two ends and central region swollen.

Microspores 47.5μ long, the exine verrucate, the sexine coarsely granulate; megaspores 430μ long, the exine verrucate, the sexine verrucate.

Distribution: Taiwan.

Taiwan: Nantow, Pingtung, Taichung, Taitung, Hwalien, and Ilan Counties.

Habitat: Growing on exposed rocky cliffs.

Type: Isotype: *B. Hayata* and *S. Sasaki* 2521 Hwalien, Buiegan (TAIF)

6. *S. subcaulescens* Hayata

Fig. 6

Hayata, 1918: 99, fig. 64; Sasaki, 1928: 47, 1930: 50; T. Ito, 1928: pl. 4; Masamune, 1936: 33.

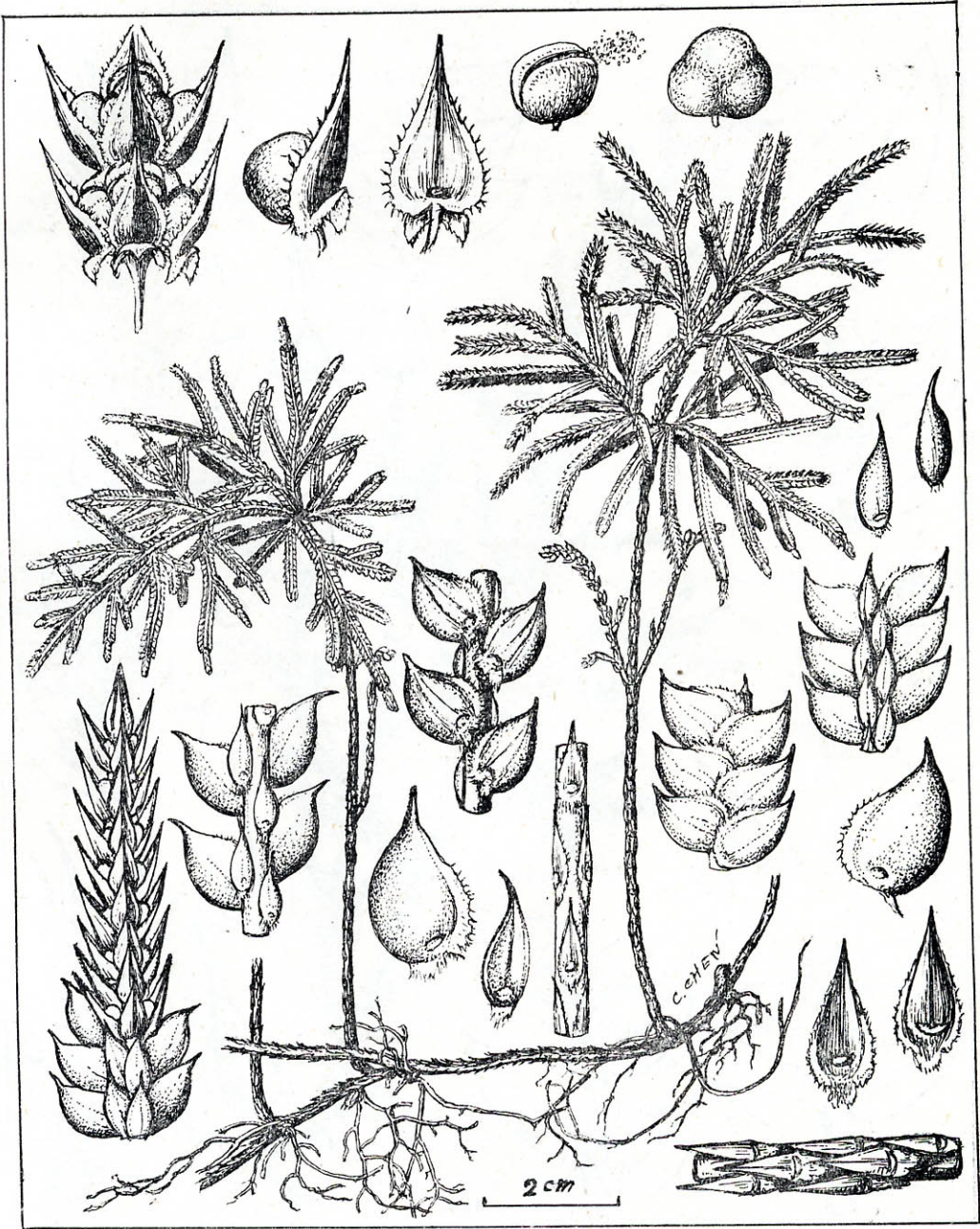


Fig. 5. *Selaginella pseudo-involvens* Hay.



Fig. 6. *Selaginella subcaulescens* Hay.

Main stem erect, 8 to 30 cm tall, stramineous, decumbent and rooting at base, bearing rhizophores, with leafy branches borne almost to base, lowest ones shortened, median leafy branches to 10 cm long; leaves at base of stem dimorphous, those on the lower plane pointing outwards, ovate, acute, with the cilia near base of leaf longer than at tip; those of the upper plane ovate, cuspidate, nearly equal sided, ciliate, margined; leaves on the lateral branches similar to those at base of stem; strobili borne on ends and sides of leafy branchlets, 3 to 12.5 mm long, 4-angled; sporophylls uniform, lanceolate, acuminate, margined, serrulate, keeled; megaspores whitish, microspores orange.

C. s. of stem: Stem oval to round; epidermal cells very small and thick walled, outer cutin layer very thick; one or two layers of subepidermal cells with somewhat thickened walls, remaining part of cortex of large, thin-walled cells, aerenchyma zone wide; stele much flattened, elongate.

Microspores 48μ long, the exine scabrate, the sexine coarsely granulate; megaspores 310μ long, the exine short baccate, the sexine granulate.

Distribution: Ryukyu, Taiwan

Taiwan: Hsinchu, Nantow, Taichung, Changhwa, Chiayi and Pingtung Counties.

Type: Isosyntye *Shimada 2546* Tainan Co. Nantow (TAIF)

Note: We do not know enough about the circumstances to explain why Alston reduced *S. subcaulescens* to be a synonym of *S. mollendorffii*. No one knew the Selaginellas better than Alston. Perhaps someone sent him a specimen or specimens of *S. mollendorffii* which had been wrongly identified as *S. subcaulescens* and he concluded that the two species were the same. We have one specimen in our Herbarium of *S. mollendorffii* collected by E. Matuda *H. 356*, Dec. 30, 1948, which he identified as *S. subcaulescens* and for some reason called "Type". It may be that this is the plant which Alston saw and for this reason reduced *S. subcaulescens* as a synonym of *S. mollendorffii*.

7. *S. doederleinii* Hieron.

Fig. 7

Hieronymus, 1904: 41; Alston, 1932: 62, 1934: 279; Koidzumi, 1935: 225; DeVol, 1945: 39; Ohwi, 1957: 13-14, 1965: 27; Tagawa, 1963: 19, fig. 7-3, pl. 5-27.

S. atroviridis Spr. sensu Matsumura et Hayata, 1906: 552; Henry, 1896: 117; Hayata, 1911: 410, 1916: 117, 1918: 99, fig. 62; Rosenberg, 1915: 77 et 79; Makino, 1917: 124; T. Ito, 1928: pl. 3.

S. springiana Rosenb. sensu Masamune; Rosenberg, 1915: 77; Sasaki, 1928: 47, 1930: 50; Masamune, 1936: 33.

S. plumosa Baker, 1883(21): 144; Henry, 1896: 117; Matsumura et Hayata, 1906: 554.

Main stem 12 to 35 cm tall, erect, decumbent at base, bearing long rhizophores, glabrous, terete; branches widely spreading, alternate, distant, 5 to 16 cm long, 8 to 10 mm wide, lower and median branches longest; leaves at base of stem dimorphic,

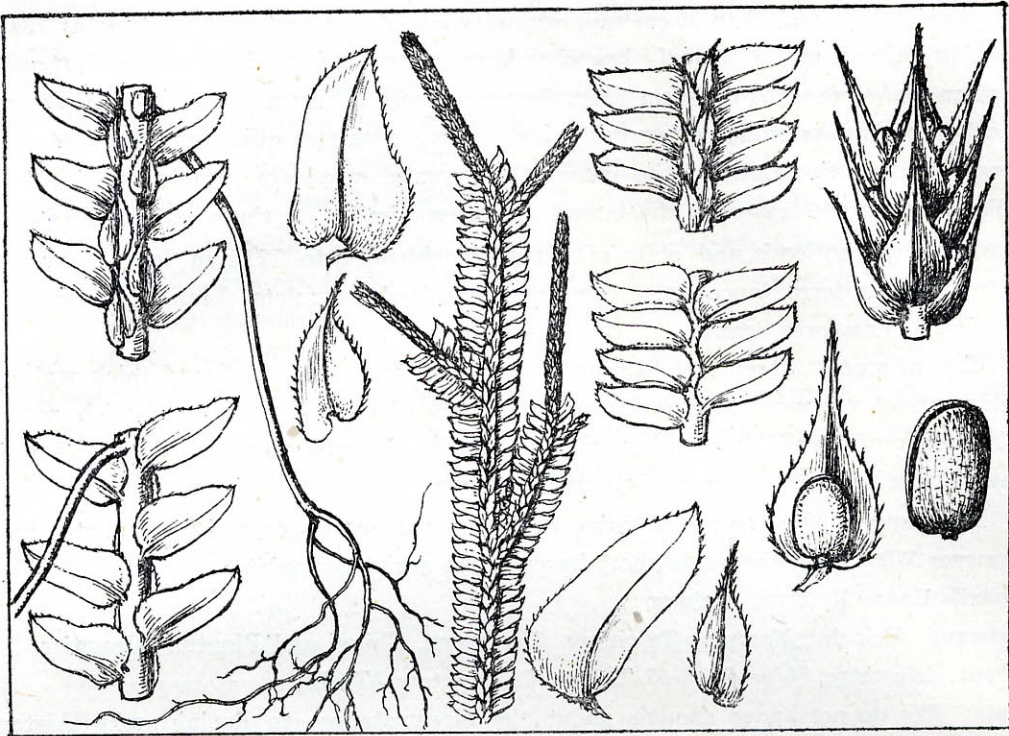


Fig. 7. *Selaginella doederleinii* Hieron

lateral leaves pointing outwards, unequal sided, oblong, margins almost entire, ciliate on adaxial side, median leaves unequal sided, ovate, aristate, pointing upwards, lowest ones not auricled, lateral branch leaves contiguous, similar in form to the lateral leaves on the stem; median leaves imbricating, ovate, equal sided, aristate, ciliate, midrib raised; leaves in axils of branches equal sided, ovate, ciliate; strobili 5 to 12 mm long, borne on tips and sides of the lateral branches, 4-angled; sporophylls monomorphic, ovate, aristate, keeled, margins ciliate.

C.s. of stem. Stems strictly terete; epidermal and subepidermal cells much alike, cutin not very thick; cortex nearly all of thick walled cells only inner layers of parenchyma, no aerenchyma area; stele oval or slightly flattened.

Microspores 32.5μ long, the exine baccate, the sexine coarsely granulate to rugate, the tetraspores present after acetolysis; megaspores 280μ long, the exine echinate, the exospore extending to exine ornamentation, the sexine reticulate.

Distribution: Japan, Mainland China, Ryukyu, Taiwan, Hongkong, Hainan, Vietnam, Malaya, Indo-China, South India.

Taiwan: Known from nearly every county.

Habitat: Forest shade.

8. *S. remotifolia* Spring

Spring, 1854: 276; Alston, 1934: 274, 1935: 363, 1937: 177; DeVol, 1945: 42, Tagawa, 1941: 193, 1963: 18, fig. 7-2, pl. 4-26.

Fig. 8

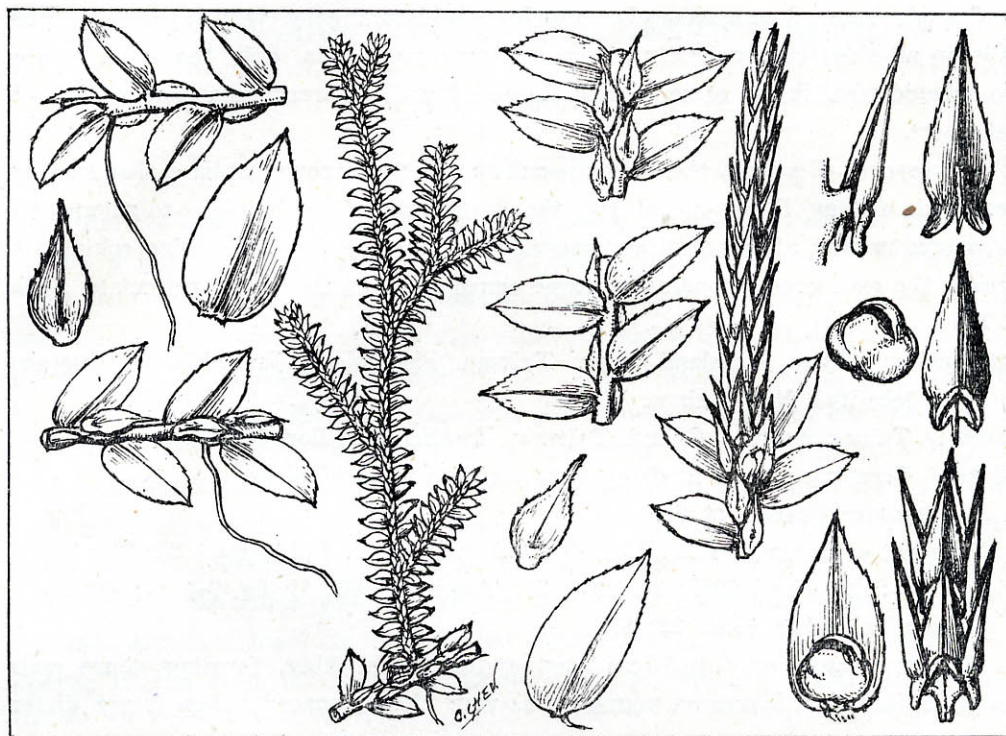


Fig. 8. *Selaginella remotifolia* Spr.

S. japonica Miquel, 1867: 185, 1866-1867: 349 et 390; Nakai, 1925: 202; Makino, 1940: 969, fig.

S. kelungensis Hayata, 1918: 97-98, fig. 59; Sasaki, 1928: 46, 1930: 50; Masamune, 1936: 33.

S. kraussiana (Kunze) A. Br. sensu Matsumura et Hayata, 1906: 553; Franchet et Savatier, 1879: 200-201; Baker, 1884(22): 87.

S. remotifolia var. *japonica* (Miq.) Koidz., 1935: 228; Ohwi, 1957: 14, 1965: 27.

S. tarokoensis Yamamoto, 1931: 237.

Main stem creeping, greenish-stramineous, angular, glabrous, 5 to 30 cm long, rooting at intervals; leaves of stems and branches dimorphous, midrib present, more clearly visible on underside; stem leaves spaced farther apart than their width; lateral leaves unequal sided, ovate, acute, pointing outwards, with margins nearly entire or minutely ciliate at base; median leaves very unequal sided, pointing towards apex, ovate, auricled on one side, apex caudate, margined, spreading; lateral leaves along branches contiguous, leaves at ends of branches imbricating; leaves in axil of branches ovate, equal sided, acute, entire; strobili 5 to 10 mm long, borne on the sides and ends of lateral branches; sporophylls monomorphic, narrowly ovate, acuminate, keeled, ciliate.

C. s. of stem: Stems somewhat angular; epidermal cells very small with thick walls on all side; cortex mostly of large parenchyma cells, only the outer one or two subepidermal layers of cells with thickened walls; aerenchyma zone wide, stele oval, short.

Microspores $45\ \mu$ long, the sexine peculiar: shortly narrowed at base, then swollen, then with a long linear apical tip, the sexine coarsely granulate to rugate, the tetraspores present after acetolysis; megaspores $540\text{--}700\ \mu$ long, the exine echinate to baccate, the exospores extending to exine ornamentation, the sexine reticulate. **Fig. 14. 1.**

Distribution: Japan, Mainland China, Taiwan, Philippines, Java, Malaya, Sumatra (type locality), New Guinea.

Taiwan: Taipei, Nantow, Chiayi, Taitung, Hwalien and Ilan Counties.

Habitat: Creeping on soil in damp woods and exposed hillsides.

9. *S. nipponica* Franch. et Sav.

Fig. 9

Franchet et Savatier, 1879: 199, 615; Baker, 1884: 88; Koidzumi, 1935: 227; DeVol, 1945: 40; Ohwi, 1957: 14, 1965: 27; Tagawa, 1963: 17, fig. 7-1, pl; 4-24.

S. savatieri Baker, 1884: 22: 87.

Main stem creeping, 5 to 15 cm long, angular, branching, forming dense mats, rooting at intervals, leaves on young stems very closely spaced; stem leaves dimor-

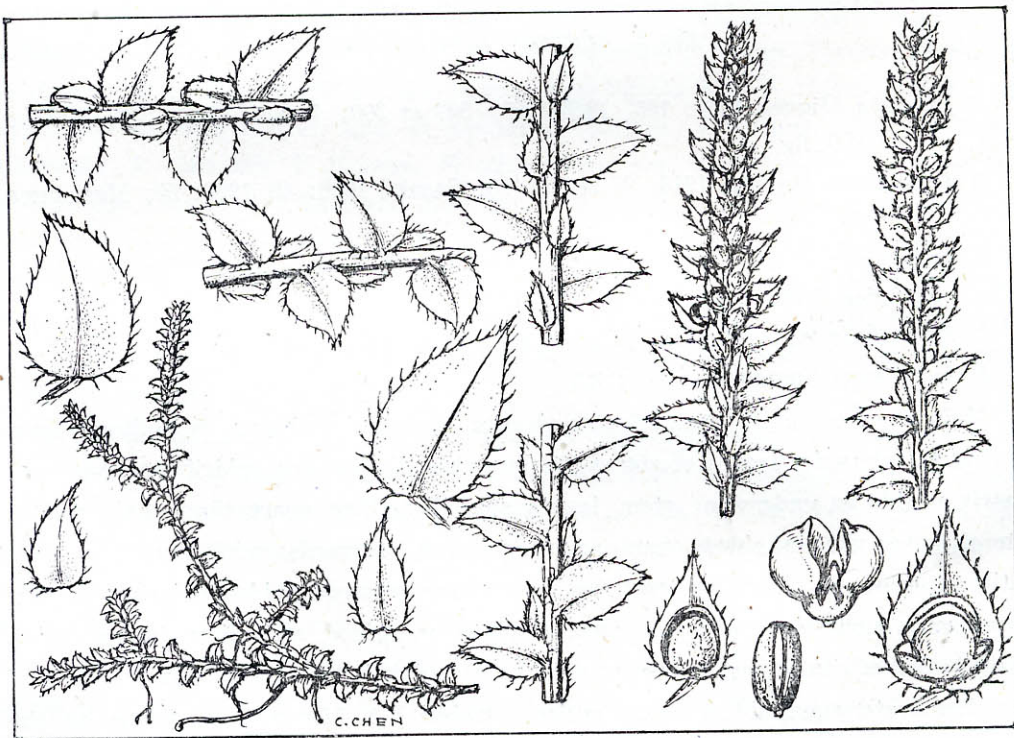


Fig. 9. *Selaginella nipponica* Fr. et Sav.

(Note: The midrib of these leaves is not so distinct as shown in this drawing.)

Main stem erect, 12 to 30 cm tall, stramineous, glabrous, angular, decumbent and rooting at base; lower third of stem without or with very short leafy branches; branches 2 to 3 pinnate; stem leaves dimorphous, spaced farther apart than their width, those on the lower plane unequal sided, oblong-ovate, acute, auricled on one side, margined, ciliate, pointing outward; those on the upper plane nearly equal sided, ovate, acuminate, ciliate, median leafy branches 4 to 12 cm long, spreading, alternate, distantly spaced; lateral branch leaves unequal sided, oblong-ovate, acute, margined, ciliate, pointing outward; median leaves unequal sided, ovate, long cuspidate, margined, ciliate, auricled on one side, pointing upward; leaves in axil of branches nearly equal sided, ovate, acute, margined, ciliate; strobili borne on sides of leafy branchlets, 3 to 7 mm long, sporophylls dimorphous, those on the lower plane nearly equal sided, ovate-lanceolate, acuminate, keeled; those on the upper plane lanceolate, acuminate, ciliate; median leafy branches longest; microspores orange; megaspores pale yellow.

C. s. of stem: Stem oval and somewhat angular, epidermal cells small, thickened on all sides; 2 or 3 outer layers of the cortex have thick walled cells, parenchyma zone wide, aerenchyma wide; stele flattened.

Microspores 42.5μ long, the exine gemmate, the sexine dense, coarsely granulate; megaspores $270-350 \mu$ long, the exine verrucate to short baccate, the sexine rugate.

Distribution: Mainland China, Taiwan.

Taiwan: Taipei, Nantow, Chiayi, Tainan, Pingtung, Taitung, Hwalien and Ilan counties.

Habitat: Damp soil, shaded or exposed hillside.

11. *S. leptophylla* Baker

Fig. 11

Baker, 1885(23): 157, 1887: 109; Warburg, 1900: 109; Matsumura et Hayata, 1906: 553; Hayata, 1911: 410, 1916: 117; T. Ito, 1928: pl. 6; Sasaki, 1928: 46, 1930: 50; Masamune, 1936: 33; Tagawa, 1941: 194.

S. stenostachya Hayata, 1914: 129, fig. 68; 1916: 117, 1918: 102, fig. 69; T. Ito, 1928: pl. 5; Sasaki, 1928: 47; Tagawa, 1941: 194.

S. proniflora Baker, sensu Matsumura et Hayata, 1906: 554; Baker, 1885(23): 156, 1887: 108; Henry, 1896: 117; Hayata, 1916: 117; Sasaki, 1928: 47, 1930: 50; Masamune, 1936: 33; Tagawa, 1941: 194.

S. wichurae Warb., 1900: 110 et 127; Matsumura et Hayata, 1906: 554; Sasaki, 1928: 47; Masamune, 1936: 33; Tagawa, 1941: 194.

S. hayatana Satake, 1934: 261; Masamune, 1936: 32; Tagawa, 1941: 194.

S. satakana Koidz., 1936: 40; Tagawa, 1941: 104.

Main stem erect, 5 to 10 cm tall, angular, stramineous, glabrous, rooting at base, bearing rhizophores; branched to base, stem leaves dimorphous, those of the lower plane unequal sided, ovate, acute or obtuse, minutely ciliate, distant, pointing outwards; those of the upper plane nearly equal sided, acuminate, distant, ciliate, point-

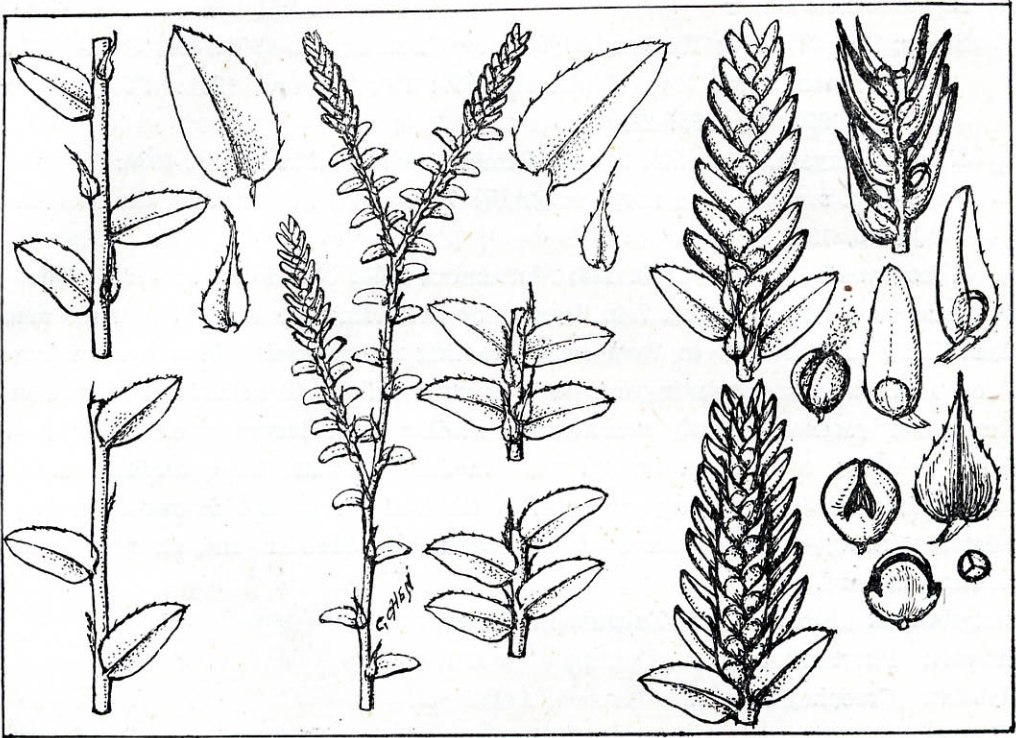


Fig. 11. *Selaginella leptophylla* Bak.

ing upwards; lateral branch leaves similar to stem leaves of lower plane, median leaves similar to stem leaves of upper plane; leaves in axil of branches equal sided, ovate, acute, ciliate; strobili borne on ends of leafy branchlets, 3 to 10 mm long; sporophylls dimorphous, those of the upper plane unequal sided, oblong, acute, minutely ciliate, pointing outward; those of the lower plane nearly equal sided, ovate, cuspidate, ciliate, keeled, pointing upwards; microsporophylls terminal, microspores orange; megasporophylls basal, megaspores yellow.

C. s. of stem: Stems angular; epidermal cells large, isodiametric in c. s. view, heavily cutinized on outer and radial walls; cortex composed entirely of large parenchyma cells, aerenchyma zone wide; stele small, oval.

Microspores 32.5μ long, the exine verrucate, the sexine coarsely granulate; megaspores 200μ long, the exine short baccate, the sexine rugate.

Distribution: Mainland China, Taiwan, India, Ceylon, Malaya, North Australia.

Taiwan: Taipei, Hsinchu, Chiayi, Hwalien and Ilan counties.

Habitat: Shaded hillsides.

Type: *Oldham 79* (at Kew) from Tamsui, Taiwan. Topotype *Tanalsa 10966* Tamsui (NTUF)

Addendum:

On the underside of the sporophylls of the upper plane, there is a broad prominent wing borne along the midrib.

12. *S. boninensis* Baker**Fig. 12**

Baker, 1885(23): 178; Warburg, 1900: 109; Matsumura, 1904: 361; Sasaki, 1930: 49; Alston, 1935: 370; Koidzumi, 1935: 230; Tagawa, 1941: 275, 1963: 20; Ohwi, 1957: 15, 1965: 27.

S. somai Hayata, 1918: 101, fig. 66; Sasaki, 1928: 47; Masamune, 1936: 33.

Type of *S. somai*: Iso-syntype in TAIF: *T. Somai*, 2523, Pingtung Co. Kusukusu, Jan. 3, 1912.

S. longicauda Warburg 1900: 123; Matsumura 1904: 362; Koidzumi, 1935: 229.

Main stem long creeping, 7 to 8 mm wide (including the leaves), bearing many short leafy branches (2 to 3 cm long), rooting at intervals; lateral stem leaves oblong, unequal sided, pointing outwards, minutely ciliate, apex acute, base of leaves almost contiguous or slightly overlapping; median stem leaves ovate, nearly equal sided, pointing towards apex, ciliate, acuminate-aristate, base cordate; strobili appressed; sporophylls slightly dimorphous, those of the upper side ovate-acuminate, ciliate, pointing outward; those of the lower side broader and strongly keeled, pointing upward.

Distribution: Bonin Island, Taiwan, Philippines.

Taiwan: Pingtung County.

Habitat: Creeping on soil.

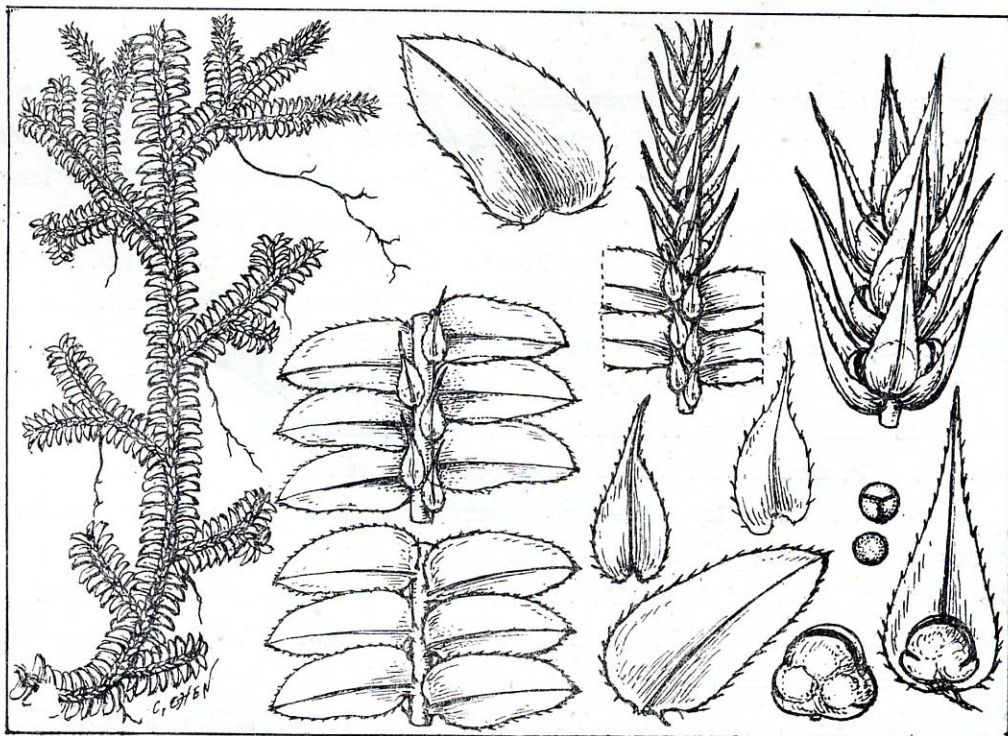


Fig. 12. *Selaginella boninensis* Bak.

13. *S. ciliaris* (Retz.) Spring

Fig. 13

Spring, 1843: 231; Baker, 1885(23): 121; Alston, 1934: 291-292; 1935: 370; 1945: 227.

Main stem creeping, 3 to 10 cm long, stramineous, glabrous, angular, rooting at intervals but mostly near base; all leaves dimorphous; leafy branches 3 to 5 cm long; lateral leaves unequal sided, ovate-lanceolate, acute or obtuse, margined, ciliate, pointing outward; median leaves nearly equal sided, narrowly ovate, with prominent midrib, cuspidate, margined, ciliate, pointing upwards; leaves in axil of branches equal sided, ovate, acute, ciliate at base; strobili terminal on short branches, 5 to 10 mm long, sporophylls dimorphous, those of the upper plane lanceolate, acuminate, ciliate, margined: those of the lower plane ovate, acuminate, with long conspicuous cilia, margined; microsporophylls borne near apex, megasporophylls at base of strobili, megaspores pale yellow.

C. s. of stem: Stems small oval; epidermal cells thin walled, cutin layer thin; cortex of only thin walled cells, about 3 cells wide; aerenchyma zone broad, stele oval.

Microspores $25\ \mu$ long, the exine baccate, the sexine coarsely granulate to rugate; megaspores $240\text{--}260\ \mu$ long, the exine psilate, scabrate to short baccate, the exospore extending to exine ornamentation, the sexine finely reticulate. Fig. 14. 2.

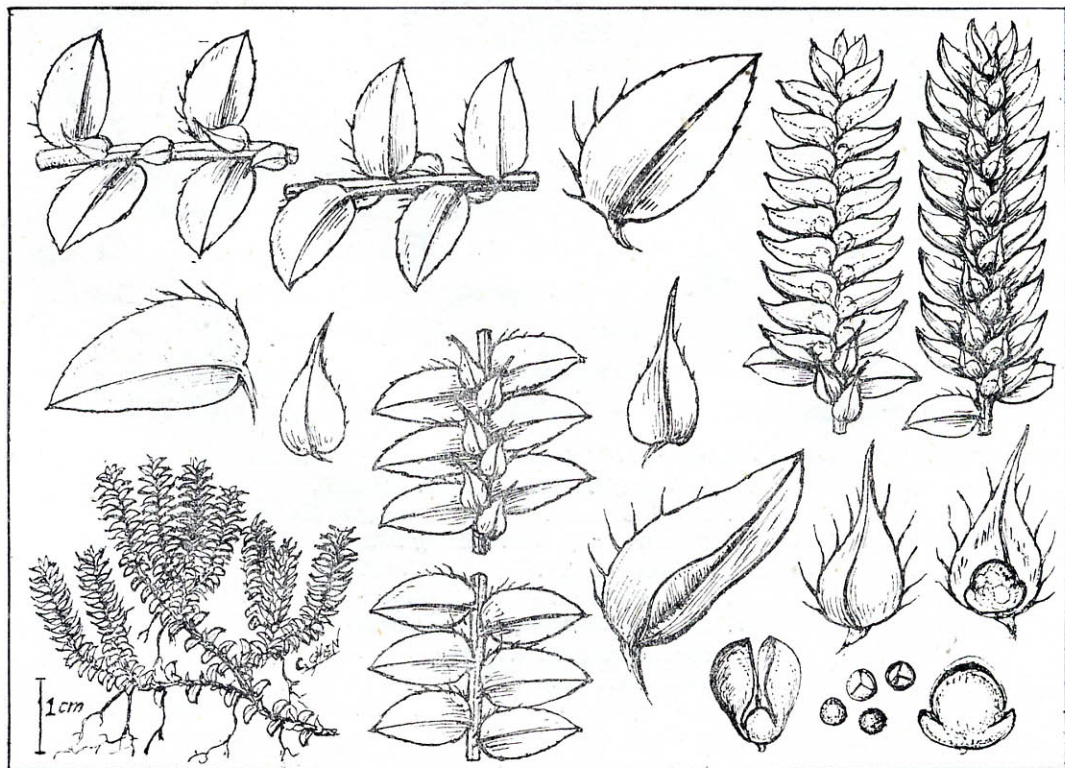


Fig. 13. *Selaginella ciliaris* (Retz.) Spr.

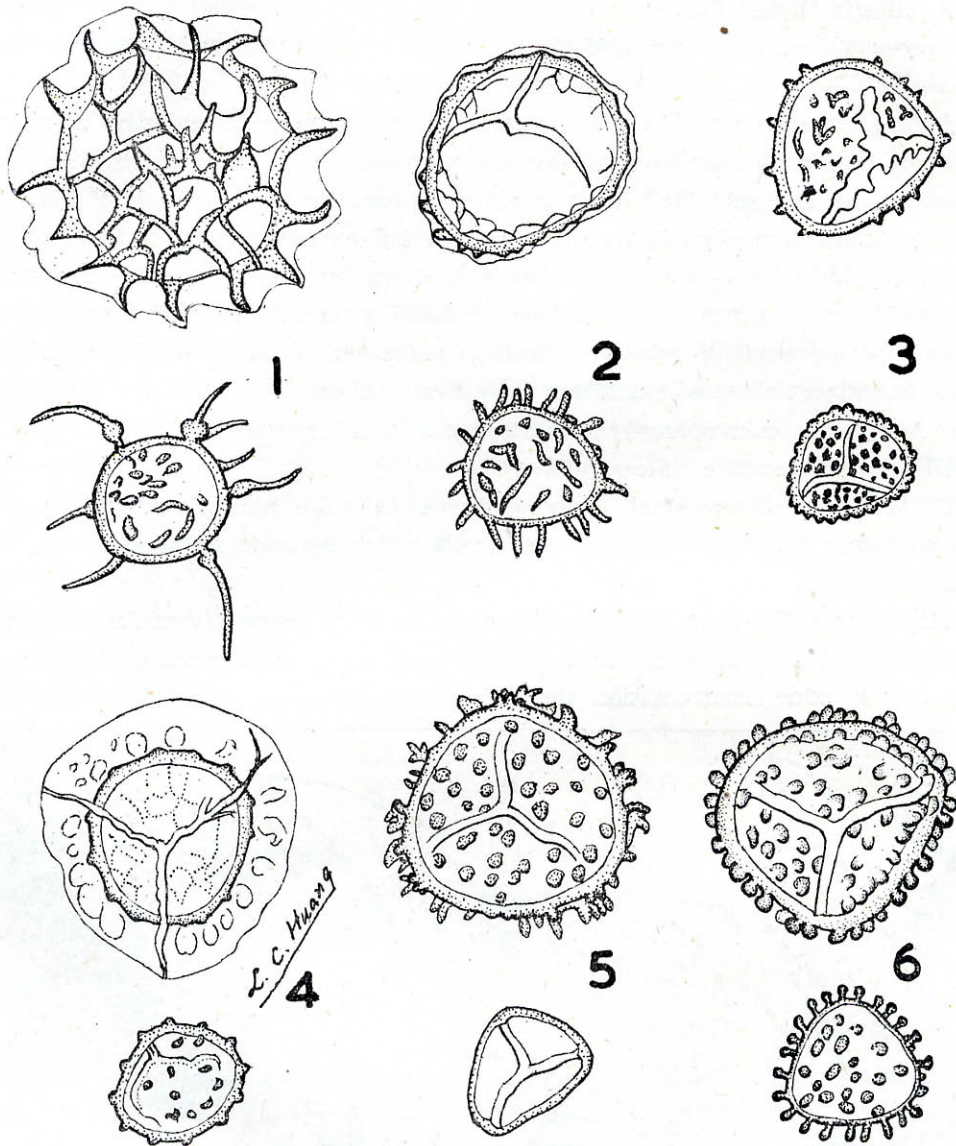


Fig. 14. Palynogram of *Selaginella*

1. *S. remotifolia* Spring (*Sasaki 380155*)
2. *S. ciliaris* (Retz.) Spring (*Chuang & Kao 4679*)
3. *S. heterostachys* Bak. (*Huang 931*)
4. *S. involvens* (Sw.) Spring (*Kao 6756*)
5. *S. nipponica* Fr. & Sw. (*Chuang & Kao 6613*)
6. *S. delicatula* Alston (*Chuang 3428*)

Upper rows: megaspores c. $\times 100$

Lower rows: microspore (2) c. $\times 400$, (1, 5, 6) c. $\times 520$,

(3, 4) c. $\times 640$.

Distribution: Taiwan, Mainland China, Philippines, India, New Guinea, Northern Australia.

Taiwan: Taipei, Hsinchu, Nantow, Kaohsiung and Pingtung counties.

Type: Ceylon, Keening (in Lund Herbarium and with a fragment at Kew)

Note: Most of our specimens are much smaller than described by Baker (1885: 121).

He says "stems trailing, reaching $\frac{1}{2}$ ft. in length,....". Ours are only from 3 to 10 cm long. The stems are weak and usually grow erect, appressed against embankments and terraces, they root mostly at and near the base. Our plants seem to be annuals. During January we find many small plants about 5 mm long with bright green leaves and in healthy condition, but all the older larger plants appear dead.

14. *S. heterostachys* Baker

Baker, 1885, 23: 177, 1887: 110; Alston, 1932, 70: 62, 1934: 290; DeVol, 1945: 40; Koidzumi, 1935: 230; Ohwi, 1957: 14-15, 1965: 27; Tagawa, 1963: 20, fig. 7-5, pl. 5-31; Warburg, 1900: 109.

S. recurvifolia Warb., 1900: 125; Matsumura, 1904: 363.

Main stem creeping to semi-erect, stramineous, glabrous, angular, 6-12 cm long; leaves dimorphous throughout, those of the lower plane unequal sided, ovate, obtuse or acute, minutely ciliate, pointing outward; those of the upper plane nearly equal sided, narrowly ovate to lanceolate, acuminate or nearly aristate, ciliate, pointing upward; axillary leaves narrowly ovate, acute, equal sided, entire; leaves on creeping stems very crowded, those on semi-erect branches more distantly spaced; strobili borne on ends of leafy branches, 5-10 mm long, sporophylls dimorphic, those on the upper plane unequal sided, lanceolate, acute, minutely ciliate, those on the lower plane nearly equal sided, ovate acuminate, ciliate; megasporophylls basal, microsporophylls towards apex, megaspores pale yellow, microspores orange-yellow.

Microspores 30μ long, the exine gemmate to verrucate, the sexine coarsely granulate; megaspores 250μ long, the exine verrucate to short baccate, the sexine rugate. **Fig. 14. 3.**

Distribution: Japan, Mainland China, Ryukyu, Taiwan, Vietnam.

Taiwan: Nantow County.

Habitat: Creeping on soil in moist woods, bamboo grooves and grassy hillsides.

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