

THE GENUS *RHIZOGONIUM* BRID. (MUSCI) IN TAIWAN⁽²⁾MING-JOU LAI⁽¹⁾

Abstract: Keys, descriptions and illustrations for the four taxa, i.e., *R. dozyanum* Sande Lac., *R. spiniforme* (Hedw.) Bruch var. *spiniforme*, *R. spiniforme* var. *badakense* (Fl.) Iwats. and *R. spiniforme* var. *ryukyense* Iwats. of the genus *Rhizogonium* Brid. found in Taiwan are presented. Previous reports of Taiwanese *Rhizogonium* species are re-evaluated based on collections made chiefly by the author. *R. armatum* Sakurai is treated as a variation form of *R. spiniforme* var. *badakense*.

INTRODUCTION

Sasaoka's (1928) report of *Rhizogonium spiniforme* from Mt. Alishan, Mt. Sylvia, Mt. Tawushan, Mt. Kiraishan, and Mt. Samaushan was the first record of this genus in Taiwan. The same species was later reported by Ihsiba (1935) and Herzog & Noguchi (1955). Horikawa (1935) recorded *R. badakense* based on a collection from Mt. Morrison. *R. dozyanum* was added to the moss flora of Taiwan by Noguchi (1938). Sakurai (1941) described *R. armatum* from Taiwan and later reported it from Japan (Sakurai 1951, 1954). In 1972 Iwatsuki described *R. spiniforme* var. *ryukyense* from the Ryukyus and Taiwan.

Distribution of the synoicous species, *R. spiniforme*, has been reported from pantropical regions such as Asia, South and North America, Australia, Oceania and Africa. The distribution, differentiation and taxonomic status of the *Rhizogonium spiniforme*-complex have been discussed recently by Iwatsuki & Sharp (1967), Iwatsuki (1969, 1972) and Inoue & Iwatsuki (1976). The present study utilizes the species concepts of these authors.

RHIZOGONIUM BRID. 榆苔屬

Rhizogonium Brid., Bryol. Univ. II: 663. 1827.

Plants bright green to olive green, medium-sized, growing in large tufts, often matted together with tomentum at the base. Stems erect, sometimes branched. Leaves linear-lanceolate, patently spreading when moist, cirrate when dry; leaf margins strongly thickened with a spinose-serrate border, teeth in pairs from leaf base to apex; costa strong, ending in the pointed apex, normally toothed toward apex on abaxial side; leaf cells rounded to hexagonal, isodiametric, incrassate, smooth.

Synoicous, autoicous or dioicous. Perichaetial leaves and perigonial leaves more or less dimorphic. Paraphyses hair-like, associated with the antheridia and/or archegonia in an inflorescence. Seta elongate, originating from the middle or from near the base of stems. Capsule cylindrical, curved, horizontal to inclined, with short collum at the base. Calyptra cucullate. Operculum obliquely conic-rostrate. Peristome double; exostome consisting of 16 teeth which

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connect at the base and alternate with the pale segments of endostome; basal membrane of endostome high; cilia short, nodose.

The genus *Rhizogonium* is the only representative of the family Rhizogoniaceae in Taiwan. Species nearly 30, distributed mainly in warm regions. Two species and two varieties are known for Taiwan, common on rotting fallen logs, trunks, stumps, exposed tree roots or humus in forests from low elevation to mountainous areas (around 2,000 m elevation).

KEY TO THE SPECIES

1. Sporophytes and/or inflorescences in the middle of stems; leaves up to 1 cm long.....*R. dozyanum*
1. Sporophytes and/or inflorescences in the base of stems; leaves less than 1 cm long.....2
 2. Synoicous; perichaetial leaves ligulate, tip acuminate*R. spiniforme* var. *spiniforme*
 2. Dioicous or autoicous.....3
 3. Tip of perichaetial leaves elongate; dioicous.....*R. spiniforme* var. *badakense*
 3. Tip of perichaetial leaves only shortly tapering; autoicous*R. spiniforme* var. *ryukyuense*

1. RHIZOGONIUM DOZYANUM SANDE LAC., Ann. Musc. Bot. Lugd.-Bat. 2: 295, t. 9, f. 1, 1866-67. 大樟苔 Plate I.

Plants green to olive green, large, rigid, growing in tufts. Stems 7-9 cm in length, scarcely branched, with abundant rhizoids on lower 1/3 of stem, densely foliate above rhizoids. Leaves up to 1 cm long, 0.6-0.7 mm wide, narrowly lanceolate; border bistratose and with numerous double teeth; costa strong, with well-developed stereids in cross-section, percurrent, toothed toward apex on abaxial side; median leaf cells quadrate to hexagonal, smooth, lumen 7.5-15 μ \times 7.5-10 μ , incrassate.

Dioicous; perichaetia and perigonia (and setae) located at the middle of stem; perichaetial leaves filiform from the acuminate base, up to 5.5 mm long, margins spinose-serrate in apical region, costa percurrent; perigonial leaves much shorter, broadly ovate. Seta 3-3.5 cm in length, reddish-brown. Capsules yellowish brown, somewhat curved to an inclined position, 4 mm long; operculum rostrate.

The present species is diagnostically characterized by having both perichaetia and perigonia borne on the middle of stems. It is the tallest and most rigid species in Taiwan. Chromosome number $n=7$ (Inoue & Iwatsuki, 1976).

It has been reported from Taiwan by Noguchi (1938), Wang (1968, 1970) and Lai & Wang-Yang (1976). Chuang (1973) was doubtful of the presence of this species in Taiwan.

Habitat: On humus of forest floor.

Distribution: Taiwan, Mainland China, the Ryukyus and Japan.

Specimens examined: TAOYUEN: Mt. Peitsatienshan, *Lai* 5511, 5536, 5677, 5687, 5865. ILAN: Yuenyang Lake natural reserve, *Lai* 920, 8448.

2. RHIZOGONIUM SPINIFORME (HEDW.) BRUCH in Krauss, Flora 29: 134. 1846. VAR. SPINIFORME. 刺葉樟苔 Plate II.

Plants bright green to olive green, growing in large tufts. Stems 2-4.5 cm in length, seldom branching. Leaves linear lanceolate, 5-6 mm long, border thickened, margin with double teeth from near base to tip; costa strong, percurrent, usually toothed toward apex on abaxial side; median leaf cells round to hexagonal, lumen 10-12.5 μ \times 10-15 μ , incrassate.

Synoicous; perichaetia (and setae) originating from the base of stems; perichaetial leaves ligulate, acuminate, 1.5-2.0 mm long, margin spinose-serrate in upper part, costa ending in the apex. Seta 2.5-3.5 cm, yellowish-brown, slightly twisted toward base. Capsules 2.5-3 cm long,



Plate I. *Rhizogonium dozyanum* Sande Lac.

Fig. 1. Habit. 2. Stem. 3. Leaves. 4. Leaf apex. 5. Abaxial leaf view of paired marginal teeth and toothed costa. 6. Perichaetium and sporophyte. 7. Perichaetial leaves. 8. Perichaetial leaf with paraphyses and archegonia. 9. Archegonia and paraphyses.



Plate II. *Rhizogonium spiniforme* (Hedw.) Bruch var. *spiniforme*.

Fig. 1. Habit. 2. Leaves of upper stem. 3. Leaves of lower stem. 4. Adaxial view of leaf apex. 5. Abaxial leaf view of paired marginal teeth and toothed costa. 6, 7, 8. Perichaetial leaves. 9. Perichaetial leaf with paraphyses, antheridia and archegonia. 10. Perichaetium and sporophyte. 11. Antheridia, archegonia and paraphyses.

inclined, asymmetric; exostome of 16 teeth with distinct cross-bars, teeth brown, 0.7–0.85 mm; endostome with well-developed basal membrane, translucent yellow; operculum rostrate.

Previous reports of *Rhizogonium spiniforme* in Taiwan are now regarded doubtful (e. g. Sasaoka 1928, Ihsiba 1935, Wang 1960). Only very recently Iwatsuki (1972) and Chuang (1973) reported the synoicous condition of the present species in the collections from Taiwan and thus confirmed the occurrence of *R. spiniforme* var. *spiniforme* in Taiwan. Wang (1970) treated the dioicous *R. badakense* as conspecific with the present species.

In most cases *R. spiniforme* var. *spiniforme* is synoicous, but plants which appear autoicous are frequently found in Taiwan. Inoue & Iwatsuki (1976) have stated that this latter form is essentially synoicous, but has failed to produce male or female organs. In these plants perichaetial and perigonial leaves are similar. They may be recognized by the perichaetial leaves: lanceolate from an ovate base; leaf tips much shorter than in *R. spiniforme* var. *badakense*. Sometimes plants are found with inflorescences which contain no sex organs.

Comparison of Taiwan specimens with a specimen from Hawaii (OAHU: S. Koolau Mountains, Honolulu, leg. W. J. Hoe 3332, Bryophyta Hawaiica Exsiccata, ser. I, decade 2, no. 18) have been made. Taiwan plants match perichaetial leaf shape and synoicous inflorescence type of this specimen. Chromosome number $n=12$ (Inoue & Iwatsuki 1976).

Habitat: Common on trunks, rotten fallen logs or humus.

Distribution: Taiwan, Mainland China, Japan, the Ryukyus, the Philippines, Malay Peninsula, Java, Sumatra, Borneo, Celebes, Nepal, Sikkim, Assam, Ceylon, Africa, Madagascar, North and South America, Hawaii, Tahiti, New Guinea, New Caledonia, New Zealand, Tasmania and Australia.

Specimens examined: TAIPEI: Huangtitién, *Lai* 1988. Wulai, *Lai* & Lewis 129, *Lai* 1896. Wulai to Paling, *Lai* 6947, 6970. Yangmingshan, *Shimada* 41. TAICHUNG: Mt. Pahsienshan, *Lai* 3311. NANTOU: Chitou, *Lai* 575, 961, 1036, 1564, 2339, 2661, 8189, *Koponen* 17470, *Lin* 28, 66, 87, 91, *Kao & Feung* 1653a. CHIAYI: Mt. Alishan, *Lai* 189, 10118, *Lai* s. n. Oct. 13, 1970, *Koponen* 17223, 17236, 17259, *Iwatsuki & Sharp* 129, 700a. Hungchihu, *Lin* s. n. Feb. 5, 1973. HWALIEN: Hoping forest station, *Lai* 2027, 2064. TAITUNG: Sinkang, *T. Suzuki* 19932. KAOHSIUNG: Chishan, *T. Suzuki* 20812. Tunchih, *Lai* 7927. PINGTUNG: Mt. Tawushan, *Matsuda* s. n. Jan. 1917.

3. RHIZOGONIUM SPINIFORME (HEDW.) BRUCH VAR. BADAKENSE (FLEISCH.)

IWATS., Journ. Hatt. Bot. Lab. 41: 400. 1976.—*Rhizogonium badakense* Fleisch., Musc.

Fl. Buit. 2: 595. 1904.—*Rhizogonium armatum* Sak., Bot. Mag. Tokyo 55: 207. f. 5. 1941.

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Plate III.

Plants bright green to olive green, medium-sized, growing in large tufts. Stems 3–5 cm high, simple or sometimes branching, more or less densely foliate, rhizoids confined to the base. Leaves 3–6 mm long, 0.5–0.6 mm wide, linear-lanceolate, more or less ciliate when dry; border thickened, margin with numerous spinose double teeth from basal region to apex; costa strong, percurrent, usually toothed toward apex on abaxial side; median leaf cells quadrate to hexagonal, smooth, lumen 10–12.5 $\mu \times$ 10–15 μ , incrassate.

Dioicous; perichaetia and perigonia (and setae) originating from the base of stems; tips of inner perichaetial leaves elongate, 4–5 mm long, margin spinose-serrate in upper part, costa percurrent; perigonia bud-like, perigonial leaves shorter, 2–3 mm long, acuminate, margins nearly entire. Seta 3–4.5 cm long, reddish-brown. Capsules yellowish-brown, sub-horizontal, 3 mm long; operculum rostrate.

Rhizogonium badakense has been reported from Taiwan by Horikawa (1935, 1939), Chuang (1973), Lai & Wang-Yang (1976) and Lai (1977). Wang (1970) treated the present plant as a synonym of *R. spiniforme*, disregarding the differences between the dioicous and synoicous

conditions which serve to distinguish these plants.

Rhizogonium spiniforme var. *badakense* is closely related to its typical variety. It may, however, be separated from the latter by having much narrower and longer, i.e. filiform, perichaetial leaves. Normally, *R. spiniforme* var. *badakense* has a dioicous inflorescence. *R. spiniforme* var. *spiniforme* has a synoicous one. Chromosome number is $n=6$ (Inoue & Iwatsuki 1976).

Dixon (1935) treated *R. badakense* as a synonym of *R. longiflorum* (Mitt.) Jaeg. (Ber. S. Gall. Naturw. Ges. 1873-74: 223. 1875). Noguchi (1967) reported the latter as distributed in Taiwan, Japan, the Philippines and Indonesia, excluding any mention of *R. badakense* from Japan. However, Iwatsuki (1969) found the two species to be distinct after examining the type and other specimens of *R. longiflorum*. Based on these examinations he suggested that *R. longiflorum* be excluded from Japan's moss flora. Chuang (1973) excluded it from Taiwan, believing it to be restricted to North Borneo. Distribution of this species has been recorded from North Borneo and the Philippines (Bartram 1939, Iwatsuki & Tan 1977). A sterile specimen (Yuenyang Lake natural reserve, Ilan County, leg. M. J. Lai & J. E. Lewis no. 139) has been collected which exhibits strong gametophytic characteristics of *R. longiflorum*: leaves widest in the middle, narrowed to insertion; costa distinctly widest at the base, occupying nearly whole basal area. However, fertile material is necessary before the presence of *R. longiflorum* can be confirmed for Taiwan.

A new species of *Rhizogonium*, *R. armatum*, had been described in 1941 by Sakurai after being separated from other *Rhizogonium* species only on the basis of its profusely branching habit. Wang (1960, 1970) also listed this variation as a distinct species. This species was later reduced to *R. spiniforme* (Shin, 1965) based on similarities of gametophytic habit. Many *Rhizogonium* specimens with this same profusely branching habit have been examined by the author. On clear evidence of perichaetial and perigonal leaves they are herein considered to be *R. spiniforme* var. *badakense*.

Habitat: Common on humus, stumps, trunks or rotten fallen logs in temperate forests.

Distribution: Taiwan, Mainland China, Japan, the Ryukyus, Java, Sumatra and Vietnam.

Specimens examined: TAIPEI: Yangmingshan, Iwatsuki & Sharp 83. Mt. Chisingshan, Nakamura 14. Chutsehu, Yeh s.n. May 22, 1964. Wulai, T. Suzuki s.n. Sept. 18, 1938, Shimada 267, 268. TAOUYUEN: Paling, Husingshan, Lai 7168. ILAN: Yuenyang Lake natural reserve, Lai 6127, Lai & Lewis 140, 159. Mt. Taipingshan, Kao s.n. Mar. 4, 1967. Mt. Nanhutashan, Jeng 1968. HSINCHU: Chutung, Kwangwu forest station, Lai 9114, M. Y. Lin s.n. Mar. 12, 1976. MIAOLI: Nankonchi, ca. 1700 m, Kao 1500, 1501, 1502. TAICHUNG: Mt. Sylvia, Shimada 269. Mt. Pahsienshan, Lai 3251, 3311. Mt. Tahsheshan, Iwatsuki & Sharp 875. Mt. Anmahshan, Lai 10044, Iwatsuki & Sharp 1189, 1203. CHIAYI: Mt. Alishan, Koponen 16800, Iwatsuki & Sharp 660a, Matsuyama & Sho s.n. June 1943. NANTOU: Hosheh, Lai 1735. HWALIEN: Mt. Muhiwashan, Nakamura 121. Mt. Kiraishan, Shimada 263. KAOHSIUNG: South Cross High Way, Kuo s.n. Dec. 21, 1972. PINGTUNG: Mt. Lilungshan, Lai 7857. PINGTUNG: Mt. Peitawushan, Lai 9859, 9867.

4. RHIZOGONIUM SPINIFORME (HEDW.) BRUCH VAR. RYUKYUENSE IWATS., Journ. Hatt. Bot. Lab. 35: 134. 1972. 琉球檜苔 Plate IV.

Stems 2-2.5 cm high, simple. Leaves 4.5-5 mm long, 0.4-0.6 mm wide, linear-lanceolate, border thickened, margin double serrate, median leaf cells rounded to hexagonal, $7.5-15 \mu \times 7.5-12.5 \mu$.

Autoicous; perigonia and perichaetia (and setae) on the base of same stem; perichaetial leaves ovate ligulate with shortly tapering tip, 1.5-2 mm long, margin serrate in the upper part of leaf, costa ending in the apex; perigonal leaves ovate, acuminate, 1.5 mm long. Seta

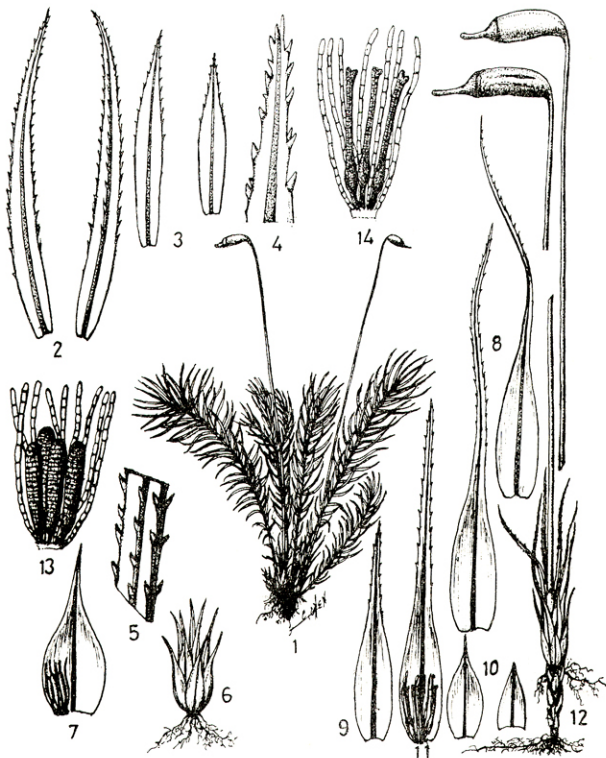


Plate III. *Rhizogonium spiniforme* (Hedw.) Bruch var. *badakense* (Fleisch.) Iwats.

Fig. 1. Habit. 2. Leaves of upper stem. 3. Leaves of lower stem. 4. Leaf apex. 5. Abaxial leaf view of paired marginal teeth and toothed costa. 6. Perigonium. 7. Perigonial leaf with antheridia. 8, 9, 10. Perichaetial leaves. 11. Perichaetial leaf with archegonia. 12. Perichaetium and sporophytes. 13. Antheridia and paraphyses. 14. Archegonia and paraphyses.

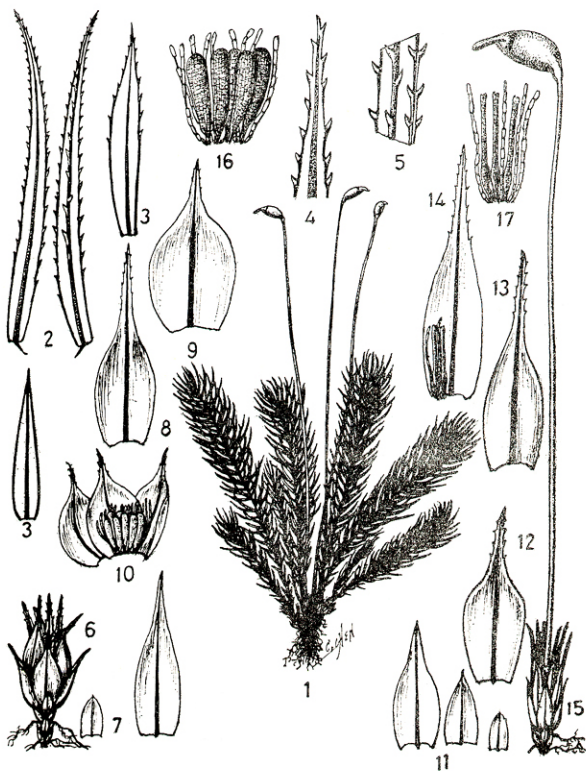


Plate IV. *Rhizogonium spiniforme* (Hedw.) Bruch var. *ryukyense* Iwats.

Fig. 1. Habit. 2. Leaves of upper stem. 3. Leaves of lower stem. 4. Leaf apex. 5. Abaxial leaf view of paired marginal teeth and toothed costa. 6. Perigonium. 7, 8, 9. Perigonial leaves. 10. Perigonial leaves with antheridia and paraphyses. 11, 12, 13. Perichaetial leaves. 14. Perichaetial leaf with archegonia. 15. Perichaetium and sporophyte. 16. Antheridia and paraphyses. 17. Archegonia and paraphyses.

3-3.5 cm long. Capsules inclined, 4 mm long; operculum rostrate.

The shape of perigonial leaves and autocious condition make the present variety diagnostically distinct. The chromosome number is $n=12$ (Inoue & Iwatsuki 1976). This variety is rare in Taiwan.

Distribution: Taiwan, the Ryukyus and Japan.

Specimens examined: TAIPEI: Wulai, *Lai 8153, 9183, Lai & Lewis 87*. Mt. Tatumshan, *Lai 1282*. CHIAYI: Mt. Alishan, *Koponen 17212, Lai 10091*. TAITUNG: Sinkang, *T. Suzuki 19963*.

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