

## The Genus *Ramalina* (Ascomycotina: Ramalinaceae) in Taiwan

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**Abstract.** The genus *Ramalina* in Taiwan is taxonomically revised. Among the 12 species reported, *R. inclinata* is a species newly described. *Ramalina litoralis*, *R. pollinaria*, *R. subpollinaria*, and *R. shinanoana* are new to Taiwan. *Ramalina geniculata* and *R. subgeniculata* are excluded from the lichen flora of Taiwan.

**Key words:** *Ramalina*, *Ramalina inclinata*, lichens, Taiwan.

### Introduction

The *Ramalina* flora of Taiwan is in general poorly known. The first study for the genus of Taiwan was made by Zahlbruckner (1933) who reported following two species and four varieties, *R. calicaris* (L.) Röhl., *R. calicaris* var. *japonica* Hue, *R. farinacea* var. *multifida* Ach., *R. farinacea* var. *pendulina* Ach. *R. geniculata* var. *olivacea* Müll.Arg., and *R. pumila* Mont. Asahina (1938, 1939) added four species, *R. asahinana* Zahlbr., *R. geniculata* Hook. & Tayl., *R. intermediella* Vain., and *R. subgeniculata* Nyl. Kashiwadani (1986, 1987, 1988) recorded additional three species, *R. hossei* Vain., *R. nervulosa* (Müll.Arg.) des Abb., and *R. conduplicans* Vain. At present, therefore, nine species and four varieties are known from the present area.

The purpose of the present study is to provide a revision of the genus in Taiwan, with special emphasis on the morphological and chemical variations in the scope of comparison with the Japanese specimens. A key to all the species of *Ramalina* known at present in Taiwan is also provided.

### Materials and Methods

The present study is based primarily on about 300 specimens of *Ramalina* collected in Taiwan by the authors and housed in the herbarium of the National Science Museum, Tokyo (TNS). Various type specimens preserved in other herbaria were also examined. In addition, about 60 specimens loaned to H. Kashiwadani from the National Museum of Natural Science, Taichung (TNM), were also studied. The collections in Taiwan by the authors were primarily carried out during their field studies for the Natural History Researches of the Island Arcs in the Western Pacific organized by the National Science Museum, Tokyo. The secondary products of the specimens examined were determined by thin layer chromatography (TLC) using the amended procedures of Culberson and Johnson (1982). To evaluate anatomical variation within the thallus and apothecia, sections were cut by hand with a razor blade. These were mounted in GAW solution, and the anatomy and spores were examined with standard light microscopic procedures.

### Taxonomy

*Ramalina conduplicans* Vain., Ann. Soc. Zool. Bot. Fenn., 1: 35. 1921. (Fig. 1a, b)

*Ramalina conduplicans* is characterized by the corticolous habit, shrubby thallus growing from a narrow holdfast, solid flattened or canaliculated branches, punctiform and ellipsoid pseudocyphellae, cracked chondroid tissue of branches, fusiform ascospores of 12–14×4–5 μm in size, and the presence of depsides and/or depsidones such as sekikaic, homosekikaic, divaricatic, and salazinic acids.

*Ramalina conduplicans* is very variable morphologically and chemically. The holotype of this species is a fragmental specimen having dorsiventral main lobes with sparse secondary branches tapering towards the apices. Most of the specimens from Taiwan have narrow and canaliculated main branches with tapering side branches (Fig. 1a). Asahina (1939) reported such morphotype under *Ramalina calicaris* (L.) Röhl. var. *japonica* Hue. However, specimens with wider and dorsiventral lobes and flattened distal branches (Fig. 1b) are also found from Taiwan. These morphological differences found in this species are consecutive and do not seem to have a taxonomic value.

This species is widely distributed in eastern Asia, having been collected in China, Japan,

Korea, and Himalayas (Kashiwadani, 1986). Two chemical races were found in the specimens from Taiwan; the chemical race 1, containing homosekikaic acid aggregates and the race 3, containing salazinic acid as a major chemical substance (Kashiwadani, 1986). The race 3 is more common than the race 1 in this area.

This species was reported from Taiwan under *Ramalina calicaris* var. *japonica* Hue (Asahina, 1939) or *R. subcomplanata* (Ny1.) Kashiw. (Kashiwadani, 1986). In Taiwan, it usually grows on bark of trees (very rarely on rocks) in mountainous regions at elevations between 800 and 2950 m.

#### Representative specimens examined.

**Race 1.** **Prov. Chiayi:** Mt. Tsu-Tson-San, Mt. Ali, elevation about 2300–2900 m, December 31, 1963, S. Kurokawa 162 (TNS); Mt. Chien-San, Mt. Shin-Kao-San, elevation about 3100–3300 m, January 1, 1964, S. Kurokawa 273 and 274 (TNS). **Prov. Hsinchu:** 3 km E of Talulindao, Kuanwu, on bark of *Alnus formosanum*, 1950 m alt., October 18, 1994, C.K. Lin 4205 (L1079, TNM). **Prov. Hualien:** Mt. Nan-Fu-Ta-San, elevation about 1500–2400 m, January 19, 1964, S. Kurokawa 940 and 1048 (TNS); Mt. Nan-Fu-Ta-San, on twigs of *Osmanthus bioritsuensis*, elevation about 2400–2600 m, January 20, 1964, S. Kurokawa 1051 (TNS); Guaniuán, Shioulin Hshiang, on bark of *Alnus japonica*, elevation

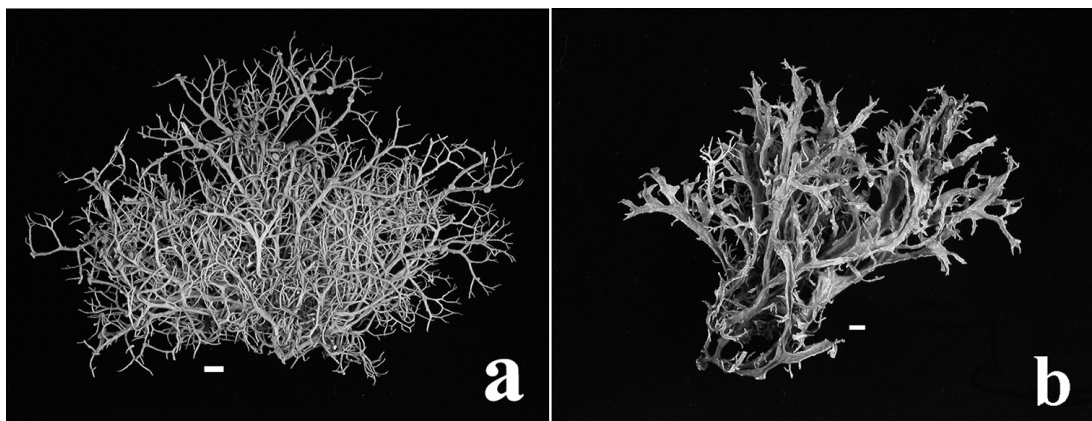


Fig. 1. Morphological variation of *Ramalina conduplicans* Vain. a, Narrow and canaliculated main branches with tapering side branches (H. Kashiwadani no. 45535, TNS); b, dorsiventral lobes with flattened distal branches (H. Kashiwadani 43901, TNS). Scale bars=2 mm.

about 2300 m, March 12, 2004, H. Kashiwadani 46935 (TNS). **Prov. Nantou:** en route from Tungpushe to Lolo, on bark of *Quercus* sp., elevation 1605 m, March 16, 1963, S. Nakanishi 12655 (TNS); Keitau, October 30, 1933, H. Masuda s.n. (TNS); Tayuling, Jenai, on rock, elevation about 2600 m, August 2, 1985, K. Yoshida 7056 (TNS); the same locality, on bark of *Prunus yedoensis*, elevation about 2540 m, March 5, 1991, H. Kashiwadani 43967 (TNS); along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on bark, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45535 (TNS); ca 10 km SE from Lishan, along route 8, Hohuanshan Mts., Jen-Ai Hsiang, on rock along road, elevation about 2100 m, March 10, 2003, H. Kashiwadani 45692 (TNS); ca 3 km W of Kueniynag, Jen-Ai Hsiang, on bark of *Salix* sp., elevation about 2780 m, March 8, 2003, H. Kashiwadani 45561 and 45556 (TNS). **Prov. Taichung:** en route from Suyen to Mt. Nanhutashan, Hopin, on bark of *Salix* sp., elevation about 2000 m, Nov. 9, 1989, K. Yoshida 9888 (TNS); en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, on bark of *Salix* sp., elevation 1900–2250 m, November 9, 1989, H. Kashiwadani 35766 and 35763 (TNS); en route from Tochiatun Shan to Sheen-ma-jenn Shan, Mt. Nanhuta Shan, Hoping, elevation 2500–2900 m, November 11, 1989, H. Kashiwadani 35908 and 35948 (TNS); Guguan Hot Spring, Hopen Hsiang, on rock, elevation 800–900 m, March 6, 2003, H. Kashiwadani 45604 (TNS); Tashueshan Forest Park, above Hsiaoshuehshan Hostel (upper parking lot), on road to summit of Mt. Tashueshan, Hopen, on branch of *Acer* sp., elevation 2800 m, November 29, 2002, H. Kashiwadani 45318 (TNS); the same locality, on branch of *Berberis* sp., elevation 2600–2800 m, November 29, 2002, H. Kashiwadani 45308 and 45064 (TNS).

*Race 3.* **Prov. Chiayi:** Mt. Alisan. July 14, 1935, M. Ogata 928 (TNS); Mt. Tsu-Tson-San, Mt. Ali, elevation about 2200–2600 m, January 4, 1964, S. Kurokawa 497 (TNS). **Prov. Hualien:** Mt. Nan-Fu-Ta-San, on twigs of *Osmanthus bitoritsuensis*, elevation about 2400–2600 m, Jan-

uary 20, 1964, S. Kurokawa 1052 (TNS); Tayuling, Hsiulin-gun, elevation about 2700 m, August 2, 1985, H. Shibuichi 8069 (TNS); Yangtoushan, Hsiulin, on rotten log, 2025–3035 m alt., Nov. 19, 2000, C.K. Lin 7019 (L 2543, TNM). **Prov. Taichung:** Anmashan, Tungshih, on tree, alt. 2665 m, June 1, 2001, C.K. Lin 7257 (L2742, TNM); en route from Suyen to Mt. Nanhutashan, Hopin, on bark of *Salix* sp., elevation about 2000 m, Nov. 9, 1989, K. Yoshida 9884 and 9891 (TNS); Keitau, 1935, Y. Asahina s.n. (TNS); en route from Ssu-yuan to Tochiatun Shan, Mt. Nanhuta Shan, Hoping, elevation 1900–2250 m, November 13, 1989, H. Kashiwadani 35762 and 35803 (TNS); Hoping, on *Salix* sp., elevation about 2250 m, November 14, 1989, H. Kashiwadani 35737 (TNS). **Prov. Nantou:** en route from Lolo to Tuikuan, on bark, elevation 1870 m, March 7, 1963, S. Nakanishi 12749 and 12938 (TNS); Lisan, January 17, 1964, S. Kurokawa 882 (TNS); Tayuling, Jenai, on rock, elevation about 2600 m, August 2, 1985, K. Yoshida 7155 (TNS); along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on bark, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45536 (TNS); ca 3 km W of Kueniynag, Jen-Ai Hsiang, on bark of *Salix* sp., elevation about 2780 m, March 8, 2003, H. Kashiwadani 45554 and 45563 (TNS). **Prov. Taitung:** Mt. Lachialachiaerh, elevation about 1800 m, January 22, 1965, S. Kurokawa 2496 (TNS); Mt. Wunitoparu, elevation about 1900 m, January 23, 1965, S. Kurokawa 2596 (TNS); Raisha, January 5, 1926, Y. Asahina F 288 and F 290 (TNS); ca 2 km E of Kwansan Yako, Haituan-gun, on bark of *Alnus* sp., elevation about 2350 m, March 1, 1991, H. Kashiwadani 43940 (TNS); en route from Tentzu to Kwansan Yako, Haituan-gun, on bark of *Pinus* sp., elevation about 2580 m, February 28, 1991, H. Kashiwadani 43901 and 43909 (TNS).

*Ramalina dilacerata* (Hoffm.) Hoffm., *Herbarium vivum, sive collection plantarum siccarum, caesareae universitatis Mosquensis*: 451. 1825.

*Ramalina geniculata* var. *globiformis* Räsänen, *J. Jpn. Bot.*, 16:88. (1940). Type collection:

Japan, Honshu, Prov. Rikuzen, Matsushima, April 20, 1919, E. Ochiai s.n (herb. A. Yasuda 623)–holotype in H!, isotype in TNS! (*tlc*: usnic acid, sekikaic acid, and 4'-O-demethylsekikaic acid). **Syn. nov.**

*Ramalina dilacerata* is characterized by the corticolous habit, shrubby and fistulose thallus growing from a narrow holdfast, inflated and more or less pellucid thalli with sparse side branches tapering towards the apices, sparse and small fenestrations, discontinuous medullary hyphae with isolated bundles of hyphae (Kashiwadani & Moon 2002), shortly fusiform ascospores of 12–14(16)×4–5 μm in size, and the presence of sekikaic acid without accompanying homosekikaic or divaricatic acids as major chemical substances.

Historical review for this species has been well arranged by Krog and James (1977). The type specimen of this species from Germany (MW) was not studied by the present authors. However, specimens from Taiwan have characteristic features as written above, which coincide well with those of the lectotype of *R. calicaris* f. *minuscula* Nyl. (= *R. dilacerata*; Type: Fellman, Lich. Arct. 57, BM!) or exsiccata specimens by Räsänen (Lich. Fenn. Exs. 34, TNS) and Santesson (Lich. Sel. Scand. Exs. 189, TNS).

Räsänen (1940), when he studied Japanese lichens mainly collected by A. Yasuda, described one variety, *Ramalina geniculata* var. *globiformis*. The type specimen of this taxon preserved in H and TNS are well fertile and have fistulose thalli without soredia, terminal apothecia, discontinuous medullary hyphae, ascospores of 12–15×4–5 μm, and produces sekikaic and 4'-O-demethylsekikaic acids as major chemical substances. Therefore, the name is now reduced to a synonym of the present species, belonging to the chemical race 1.

As reported by Kashiwadani and Inoue (1993) for Japanese specimens, two chemical races, the sekikaic acid and norstictic acid (±) containing race (Race 1) and the divaricatic acid containing race (Race 2), are found also in Taiwan, where the race 2 is apparently more common than the

race 1.

This species is widely distributed in the Northern Hemisphere, having been reported from Canada, Nordic countries in Europe, Japan, and Korea. The distribution now includes Taiwan, where it grows on bark in mountainous regions at a elevation from 1600 to 2900 m.

**Representative specimens examined.** *Race*

*1. Prov. Tainan:* Toroyen, Mt. Arisan, July 14, 1935, M. Ogata s.n. (TNS).

*Race 2. Prov. Ilan:* Piyanan Pass, elevation 1600–1900 m, January 16, 1964, S. Kurokawa 844 (TNS). **Prov. Taichung:** en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, on bark of *Alnus japonica*, elevation 1900–2250 m, November 9, 1989, H. Kashiwadani 35822 (TNS); en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, on bark of *Pinus* sp., elevation about 2500 m, November 10, 1989, H. Kashiwadani 35987 (TNS); en route from To-chia-tun Shan to Sheen-majenn Shan, Mt. Nanhuta Shan, Hoping, elevation 2500–2900 m, November 11, 1989, H. Kashiwadani 35946 (TNS); Tashueshan Forest Park, above Hsiaoshuehshan Hostel, on road to summit of Mt. Tashueshan, Hopen, on branch of *Acer* sp., elevation 2800 m, November 29, 2002, H. Kashiwadani 45317 and 45319 (TNS); the same locality, on branch of *Berberis* sp., elevation 2600–2800 m, November 29, 2002, H. Kashiwadani 45066 (TNS). **Prov. Nantou:** along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on bark, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45533 and 45537 (TNS); ca 3 km W of Kueniynag, Jen-Ai Hsiang, on bark of *Salix* sp., elevation about 2780 m, March 8, 2003, H. Kashiwadani 45559 and 45560 (TNS).

*Ramalina hossei* Vain., Ann. Soc. Zool.-Bot. Fenn. Vanamo, 1: 36. 1921.

*Ramalina hossei* is characterized by solid and narrow (up to 1.5 mm wide) branches growing from a common holdfast, punctiform pseudocyphephae, finely divided terminal branches forming nodular branchlets, absence of soredia, cracked chondroid tissue, shortly fusiform as-



cospores of  $14\text{--}16 \times 4\text{--}5 \mu\text{m}$  in size, and the presence of divaricatic acid as major chemical substances (for specimens in Taiwan).

*Ramalina hossei* might be confused with *R. conduplicans*, because they both have similar solid branches, punctiform pseudocyphellae, and produce homosekikaic or divaricatic acids as chemical substances. However, it can be distinguished from the latter by the common holdfast and the presence of terminal branches with nodular and isidioid branchlets. For distinctions between *R. hossei* and *R. shinanoana*, see under the latter species.

When Kashiwadani (1988) first reported this species from Taiwan, he recognized homosekikaic acid containing race from the present area. Re-examination of specimens, however, reveals that the chemical data cited by him came from fragments of *R. conduplicans* mixed in the herbarium packets. All the specimens of this species in Taiwan so far studied belong to the divaricatic acid containing race.

This species has been reported from Bhutan, Thailand, and Taiwan. In Taiwan, it is very common on tree trunks (*Alnus*, *Salix*, *Tsuga*, etc.) or rarely on rocks along trail in mountainous regions at elevations between 1500 and 2900 m.

**Representative specimens examined.** **Prov. Taichung:** en route from Tochiatun Shan to Sheenmajenn Shan, Mt. Nanhuta Shan, Hoping, elevation 2500–2900 m, November 11, 1989, H. Kashiwadani 35912 (TNS); the same locality, on rock, 2500 m, November 10, 1989, H. Kashiwadani 35986 (TNS). **Prov. Nantou:** Along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on rock, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45528 and 45534 (TNS); ca 10 km SE from Lishan, along route 8, Hohuanshan Mts., Jen-Ai Hsiang, on rock along road, elevation about 2100 m, March 10, 2003, H. Kashiwadani 45687 and 45698 (TNS). **Prov. Chiayi:** Mt. Tsutson-san, Mt. Ali, elevation 2300–2900 m, December 31, 1963, S. Kurokawa 161 and 170 (TNS). **Prov. Hualien:** Guaniuian, Shioulin Hshian, on bark of *Alnus japonica*, elevation about 2300 m, March 12, 2004, H. Kashiwadani

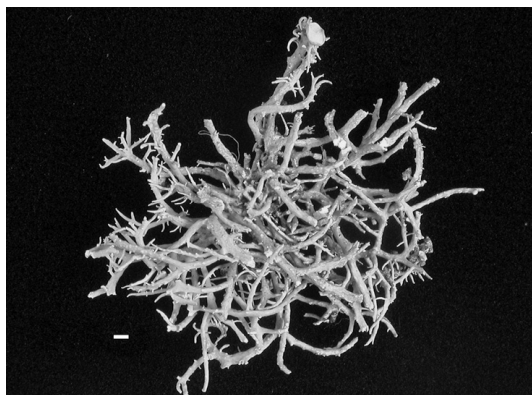


Fig. 2. Holotype of *Ramalina inclinata* Kashiw., K. H. Moon & M. J. Lai [H. Kashiwadani (46998) & K. H. Moon, TNS]. Scale bar=2 mm.

46938 (TNS). **Prov. Taitung:** en route from Tentzu to Kansan, Haituan-gun, on bark of *Salix* sp., elevation about 2450 m, February 28, 1991, H. Kashiwadani 43880 (TNS).

***Ramalina inclinata*** Kashiw., K.H.Moon & M.-J.Lai, **sp. nov.** (Figs 2, 3a)

Thallus ut in *Ramalina litoralis* sed ramis subcylindricis, sorediis et isidiis destitutis et acidiiis sekikaicis et norsticticis continentibus differt.

**Type collection.** Taiwan, Prov. Pingtung (Pingtung Co.), Mt. Da Jian Shu Shan, Hengchung ( $21^{\circ}57'N$ ,  $120^{\circ}48'E$ ), on rocks, elevation about 300 m, March 8, 2004, H. Kashiwadani (no. 46998–holotype in TNS) and K.H. Moon.

**Chemistry (TLC).** Usnic and sekikaic, 4'-O-demethylsekikaic and norstictic acids.

**Description.** Thallus saxicolous, up to 3 cm long, decumbent, sparingly and irregularly branched, growing from a narrow holdfast. Lobes greenish yellow, solid, up to 1.2 mm wide, cylindrical, slightly flattened near base, main branches with tapering side branches. Soralia absent. Pseudocyphellae rare, narrowly ellipsoid, flat. Cortex of lobes indistinct,  $10\text{--}12 \mu\text{m}$  thick; chondroid tissue smooth, continuous; medulla loose, with embedded strands of chondroid tissue. Apothecia rare, lateral; disc more or less convex, without white margin; thalloid exciple smooth,

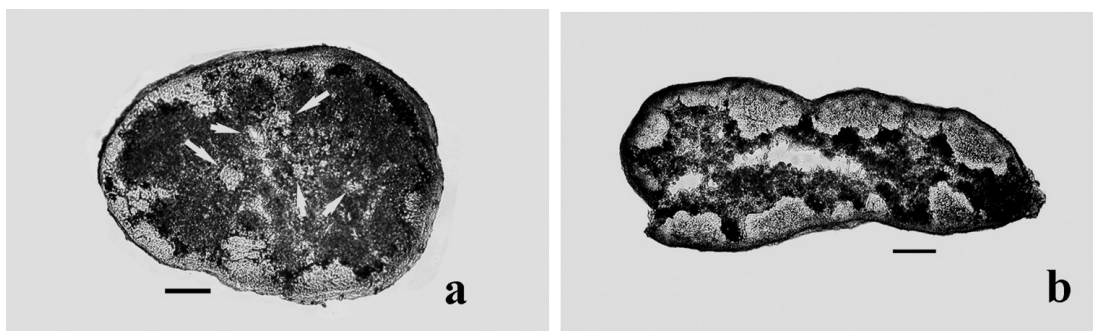


Fig. 3. Cross section of branches. a, Medulla with separated chondroid tissue without cracks of *R. inclinata*; b, medulla with separated chondroid tissue with cracks of *R. litoralis*. Scale bars=100  $\mu\text{m}$ .

lacking pseudocyphellae; ascospores short-fusiform,  $12\text{--}15 \times 3.5\text{--}4.5 \mu\text{m}$ . Pycnidia not seen.

*Ramalina inclinata* resembles *R. litoralis*, a saxicolous species growing on seaside rocks in eastern Asia, as both species have similar branches with ellipsoid pseudocyphellae. However, it can be distinguished from the latter by the absence of soralia and the presence of norstictic acid together with sekikaic acid as major chemical substances. In addition, the chondroid tissue of this species is smooth and the medulla has separated chondroid tissue (Fig. 3a); whereas the chondroid tissue of the latter is distinctly cracked and does not spread into the medullary hyphae (Fig. 3b).

A similar anatomy for branches was reported by Østhaugen and Krog (1976) from *Ramalina pluviariae* Krog & Østh. and *R. scopulorum* var. *nematodes* Nyl., both the Canary Islands' taxa, which differ in having striate pseudocyphellae and distinct cortex and in producing protocetraric or salazinic acids.

At present this species is known only from several places nearby the type locality near the top of steep conglomeratic rocks together with *R. pollinaria*.

**Specimens examined.** **Prov. Pintung:** Mt. Da Jian Shu Shan, Henchung, on rocks, elevation 200–300 m, March 8, 2004, H. Kashiwadani (46813, 16816, 46824, TNS) and K.H. Moon; the same locality, K. Yoshida 9557 and 9558 (TNS).

*Ramalina litoralis* Asahina, J. Jpn. Bot., 15: 220. 1939. (Fig. 3b)

*Ramalina litoralis* is distinguished from allied species by the saxicolous habit, caespitose thallus, more or less dorsiventral and solid branches with irregularly thickened branchlets ending in nodules, absence of soredia, sparse shortly linear pseudocyphellae, fusiform ascospores,  $10\text{--}13 \times 3\text{--}4(5) \mu\text{m}$ , and the presence of sekikaic (never accompanying homosekikaic acid) or divaricatic acids as major chemical substances.

When Kashiwadani (1987) revised this species for Japanese specimens, he reported two chemical races in this species. In Taiwan only the divaricatic acid containing race is found.

This species might be confused with dwarf form of *R. peruviana*. However, it can be easily distinguished from the latter by the absence of soredia. In addition, *R. litoralis* lacks homosekikaic acid which is constantly produced in the latter species.

This species has been known from Japan and Korea (Kashiwadani, 1987; Kashiwadani *et al.*, 2002). The distribution range now includes Taiwan where only two collections are made on seaside rocks.

**Specimens examined.** **Prov. Taipei:** Shermen, Shermen-gun, on rock along coast, elevation about 5 m, March 11, 2005, H. Kashiwadani 47387 (TNS). **Prov. Taitung:** Landao, Lanyu Island, on rock along the coast, October 26, 1989, H. Kashiwadani 35731 (TNS); the same locality, on rock, elevation 20 m, October 26, 1989, K.

Yoshida 9463 (TNS); Hongtuo-cun, Lanyu, on rocks along the coast, October 24, 1989, H. Kashiwadani 35688 (TNS); Lanyi Island, June, 1936, S. Sasaki s.n. (TNS).

***Ramalina nervulosa*** (Müll.Arg.) des Abb., Bull. Inst. Fr. Afr. Noire, 14: 25. 1952.

This species is characterized by the corticolous habit, shrubby or subpendulous branches from a narrow holdfast, dorsiventral and sparingly branched thallus often with fenestrations, striate pseudocyphellae, marginal farinose soralia, cracked chondroid tissue, broadly fusiform ascospores of  $12\text{--}16 \times 4\text{--}5 \mu\text{m}$ , and the presence of homosekikaic or divaricatic acids as major chemical substances.

When Kashiwadani (1986) revised this species from Japan and Taiwan, he reported two chemical races, the homosekikaic and sekikaic acids containing race and the divaricatic acid containing race. In Taiwan, the former is apparently more common than the latter (specimen with an asterisk in the following list). The specimen (Asahina F291, pr. p., TNS) reported under *Ramalina farinacea* var. *multifida* Ach. by Zahlbruckner (1933) is now identified with the homosekikaic acid containing race of *R. nervulosa*.

*Ramalina nervulosa* resembles *R. peruviana* in having similar branches with soredia. However, this species can be distinguished from the latter by having wider branches (1.5–3.0 mm wide) with farinose soredia and occasional fenestrations and by shortly fusiform ascospores. *Ramalina peruviana* has narrower branches (less than 1.2 mm wide) with granular soredia, isidioid branchlets, and narrowly fusiform ascospores. In addition, the latter species never forms fenestration on branches.

This species is widely distributed in tropical and subtropical regions in the world including Japan and Taiwan (Kashiwadani, 1986; Stevens, 1987). In Taiwan, however, it is rather rare, being collected on twigs of shrubs in the lowland south of Chiayi Province at a elevation below 300 m.

**Representative specimens examined.** **Prov.**

**Chiayi:** Kagi, December 30, 1933, Y. Asahina s.n.\* (TNS); the same locality and date, Y. Asahina F291 (pr. p., TNS). **Prov. Kaohsiung:** Kural, elevation 250 m, S. Kurokawa (TNS); the same locality, December 30, 1933, Y. Asahina s.n. (TNS). **Prov. Pintung:** Mt. Dajianshu-shan, Henchung, on branches of *Berberis* sp., elevation 300 m, March 8, 2004, H. Kashiwadani 46824 (TNS); the same locality, May 12, 1985, M.J. Lai 17031 (TNS).

***Ramalina pertusa*** Kashiw., Mem. Natn. Sci. Mus., 18: 102. 1985.

*Ramalina pertusa* is easily distinguished from other corticolous species of Taiwanese *Ramalina* by shrubby and fistulose thallus with orbicular to elongate openings on the lower surface, more or less continuous medullary hyphae tightly attached onto chondroid layer, broadly ellipsoid ascospores of  $12\text{--}15 \times 4\text{--}5(6) \mu\text{m}$  in size, and the production of evernic and obtusatic acids as major chemical substances.

*Ramalina pertusa* is a polymorphic species. Even in a single specimen, fertile branches usually have sparse side branches whereas most of the sterile branches frequently form cylindrical and tapering side branches. This species resembles *R. dilacerata*, which differs in having discontinuous clusters of medullary hyphae together with embedded strands of chondroid tissue (Kashiwadani & Moon, 2002).

*Ramalina pertusa* was described from Japan and has not been recorded from other countries. The present study, however, reveals that this species is also common in Taiwan, where it grows on bark of trees in mountainous regions from 800 to 2900 m high. Asahina (1938) first reported this species from Taiwan under *R. subgeniculata* Nyl.

**Representative specimens examined.** **Prov. Ilan:** Taipingshan, along the road to Santieh waterfall, on tree, elevation 1800 m, August 2, 1997, C.K. Lin 6089 (L 1942, TNM). **Prov. Hualien:** Guaniuian, Shioulin Hshiang, on bark of *Alnus japonica*, elevation about 2300 m, March 12, 2004, H. Kashiwadani 46988 and 46939 (TNS);

Tayuling, Hsiulin-gun, on rocks, elevation about 2700 m, August 2, 1985, H. Shibuichi 8069b (TNS); Mt. Nan-Fu-Ta-San, elevation about 2400–2600 m, January 20, 1964, S. Kurokawa 1045 and 1046 (TNS); the same locality, on bark, elevation 1500–2400 m, January 19, 1964, S. Kurokawa 941 (TNS); Yangtoushan, Hsiulin, on rotten log, 2025–3035 m, Nov. 19, 2000, C.K. Lin 7040 (L2564, YNM). **Prov. Taichung:** en route from Suyen to Mt. Nanhutashan, Hopin, on bark of *Salix* sp., elevation about 2200 m, Nov. 9, 1989, K. Yoshida 9885 (TNS); the same locality, on bark of *Alnus japonica*, elevation 1900–2250 m, November 9, 1989, H. Kashiwadani 35870 (TNS); the same locality, on bark of *Pinus* sp., elevation about 2500 m, November 10, 1989, H. Kashiwadani 35989 (TNS); en route from Tochia-tun Shan to Sheen-ma-jenn Shan, Mt. Nanhuta Shan, Hoping, on bark of *Salix* sp., elevation 2500–2900 m, November 11, 1989, H. Kashiwadani 35911 (TNS); Mt. Wunitoparu, elevation about 1900 m, January 23, 1965, S. Kurokawa 2594 (TNS); Tashueshan Forest Park, above Hsiaoshuehshan Hostel (upper parking lot), on road to summit of Mt. Tashueshan, Hopen, on branch of *Prunus* sp, elevation 2600–2800 m, November 29, 2002, H. Kashiwadani 45316 (TNS); the same locality, on bark of *Pinus morrissonicola*, elevation 2550–2580 m, November 30, 2002, H. Kashiwadani 45324 (TNS). **Prov. Nantou:** Along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on rock, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45529 (TNS). **Prov. Kaohsiung:** Mt. Nanfong, elevation 800–1300 m, February 7, 1965, S. Kurokawa 2839 (TNS). **Prov. Taitung:** en route from Tentzu to Kwansan Yako, Haituan-gun, on bark, elevation about 2580 m, March 1, 1991, H. Kashiwadani 43921 (TNS).

*Ramalina peruviana* Ach., Lich. Univ.: 1599. 1810.

*Ramalina peruviana* is characterized by tufted thallus growing from a common holdfast, narrow (less than 1.5 mm wide) branches becoming terete or irregularly thickened at the distal

branches, narrowly elongated pseudocyphellae, marginal or laminal soralia with granular soredia and tiny branchlets, smooth chondroid tissue, narrowly fusiform ascospores of  $15\text{--}20 \times 3\text{--}4 \mu\text{m}$  in size, and the presence of homosekikaic and sekikaic acids together with ramalinoric acid.

This species might be confused with *R. nervulosa* in Taiwan, because these species have similar branches with soralia. However, it can be distinguished from the latter by the narrow and irregularly thickened branches, soralia with granular soredia and branchlets, and narrowly fusiform ascospores; the lobes are dorsiventral even in the distal branches and soralia does not produce branchlets in *R. nervulosa*. In addition, specimens kept in the herbarium for long time turn into reddish brown in *R. peruviana*, whereas they turn into ochre yellow in the latter species. It also resembles *R. dissecta* which differs in having punctiform pseudocyphellae and shortly fusiform ascospores.

This species was reported under *R. farinacea* var. *pendulina* Ach. by Zahlbruckner (1933) and *R. intermediella* Vain. by Asahina (1939). A specimen (Asahina F291, pr. p., TNS) reported under *Ramalina farinacea* var. *multifida* Ach. by Zahlbruckner (1933) is also identified with *R. peruviana*.

*Ramalina peruviana* is occasionally collected elevations below ca 1000 m in Taiwan, but it is locally abundant especially on the trunks of planted *Cocos nucifera* in southern Taiwan (Hualien and Taitung Provinces).

**Specimens examined.** **Prov. Taipei:** Okaseki, June 1903, U. Faurie 295 (TNS). **Prov. Hualien:** Taroko Gorge, Shioulin Hsiang, on bark of *Zelkova serrata*, elevation about 720 m, March 11, 2004, H. Kashiwadani 46972 (TNS); Tienhsiang, Shulin-gun, on bark of *Prunus persica*, elevation about 950 m, March 3, 1991, H. Kashiwadani (43961 and 44005, TNS) and K.H. Moon. **Prov. Taichung:** Keitau, 1935, T. Masuda s.n. (TNS). **Prov. Chiayi:** Kagi, December 30, 1933, Y. Asahina F 291 and Asahina s.n. (TNS). **Prov. Kaohsiung:** Kural, December 30, 1933, Y. Asahina s.n. (TNS). **Prov. Taitung:** ca 5 km N of



Tai Yuan, Dongho Hshiang, on bark of *Cocos nucifera*, elevation about 270 m, March 11, 2004, Kashiwadani (46997, TNS) and K.H. Moon.

***Ramalina pollinaria*** (Westr. ex Ach.) Ach., Lich. Univ.: 608. 1810.

*Ramalina pollinaria* is easily distinguished from other species of *Ramalina* in Taiwan by the saxicolous habit, shrubby and solid thallus with terminal or laminal soralia with granular soredia, and the production of evernic and obtusatic acids as chemical substances.

This is one of the well known species of *Ramalina* widely distributed in the world. Although this species has been reported from China, Japan, and Korea in eastern Asia (Kashiwadani & Moon, 2003), it has never been known from Taiwan. In fact, only one collection was made during our field study, but it must have been overlooked in Taiwan, since it is very common like weeds in other areas.

**Specimen examined.** **Prov. Hualien:** Taroko Gorge, Shioulin Hshiang, on rock, elevation about 720 m, March 11, 2004, H. Kashiwadani 46976 (TNS).

***Ramalina pumila*** Mont., Ann. Sci. Nat. Bot. Ser. 2, 20: 356. 1843.

*Ramalina pumila* is characterized by the corticolous habit, hollow thallus with a narrow holdfast, partly flattened to more or less inflated branches with sparse cylindrical branchlets on main branches, sparse smaller perforations (up to 1–2 × 1 mm in size), continuous medullary hyphae without forming bundles of hyphae, shortly fusiform ascospores of 12–14(1–15) × (3.5)4–5 μm in size, and the production of sekikaic acid (Race 1) or divaricatic acid (Race 2) as a major chemical substance.

*Ramalina pumila* might be confused with *R. dilacerata* in having similar branches and in producing same chemical substances. However, it can be distinguished from the latter by the continuous medullary hyphae tightly attached to the chondroid layer of thallus. In addition, *R. pumila* is a lowland species whereas *R. dilacerata* grows

in montane forests higher than 1500 m in Taiwan. *Ramalina pumila* resembles *R. pertusa* which differs in having larger perforations (up to 3–6 × 2–4 mm in size) and in producing evernic and obtusatic acids.

Specimens of this species from Taiwan had been misidentified with *R. geniculata* var. *olivacea* Müll.Arg. (Zahlbruckner, 1933) or *R. geniculata* Hook.f. & Tayl. (Asahina, 1938).

**Specimens examined.** **Race 1.** **Prov. Hualien:** Taroko Gorge, Shioulin Hshiang, on branches of *Ficus* sp., elevation about 150 m, March 11, 2004, H. Kashiwadani 46995 and 46996 (TNS); Tienhsiang, Shulin-gun, on branches of *Malus torringo*, elevation about 950 m, March 3, 1991, H. Kashiwadani 4402 (TNS). **Prov. Kaohsiung:** Pongari-sha, January 7, 1926, Y. Asahina F289 (TNS); Shanping, elevation about 750 m, February 6, 1965, S. Kurokawa 2735 (TNS).

**Race 2.** **Prov. Taipei:** Tamsui (Tansui), June 1903, U. Faurie (KYO, TNS).

***Ramalina shinanoana*** Kashiw., Bull. Natn. Sci. Mus. Ser. B, 12: 122. 1986. (Fig. 4)

When Kashiwadani (1986) described this species, he reported two chemical races, the homosekikaic acid race (Race 1) and the acid deficient race (Race 2). However, all specimens listed below have divaricatic acid and can be regarded as a new chemical race for *R. shinanoana*. These three chemical races are indistinguishable regarding the morphology of thalli, apothecia, and ascospores. The Race 2 was not found among the collections from Taiwan.

*Ramalina shinanoana* resembles *R. hossei*, a commonly found species in mountainous regions of Taiwan. However, it can be distinguished from the latter by the thallus growing from a narrow holdfast and the presence of soralia. Although this species was reported from Japan and China (Kashiwadani, 1986), the distribution now includes Taiwan, where it grows on barks or twigs of trees at elevations between 2300 m and 2800 m.

**Specimens examined.** **Prov. Hualien:** Mt. Nan-Fu-Ta-San, on bark, elevation about 2400–

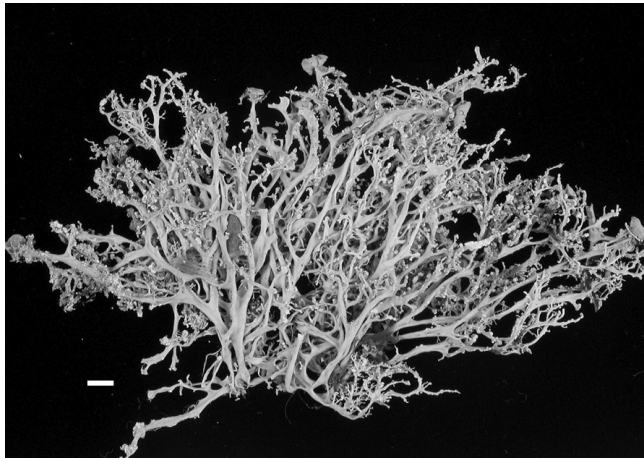


Fig. 4. *Ramalina shinanoana* Kashiw. (H. Kashiwadani 45531, TNS). Scale bar=3 mm.

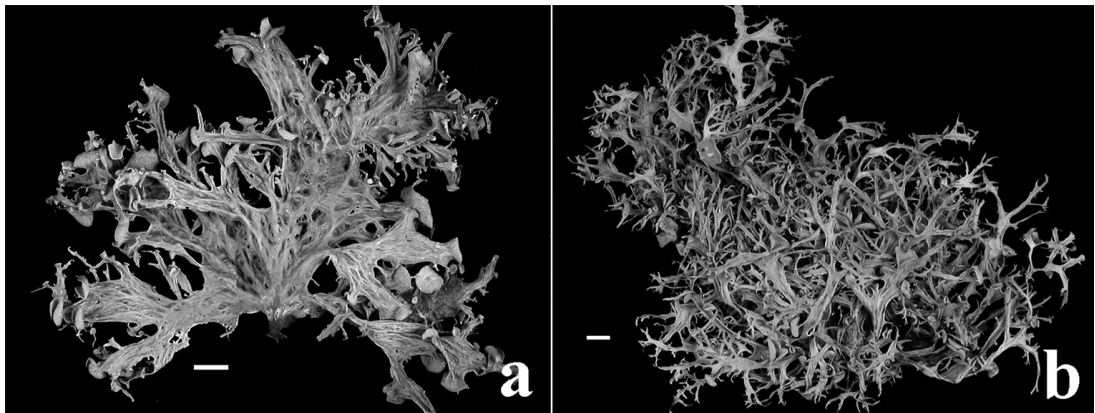


Fig. 5. Morphological variations of *Ramalina sinensis* Jatta. a, Palmate and loosely tufted lobes (H. Kashiwadani 46933, TNS); b, elongate, marginally outgrown lobes (H. Kashiwadani 46940, TNS). Scale bars=10 mm for a; 3 mm for b.

2600 m, January 20, 1964, S. Kurokawa 1047c and 1115 (TNS). **Prov. Taichung:** Tashueshan Forest Park, above Hsiaoshuehshan Hostel (upper parking lot), on road to summit of Mt. Tashueshan, Hopon, on branch of *Berberis* sp., elevation 2600–2800 m, November 29, 2002, H. Kashiwadani 45067, 45307, and 45309 (TNS). **Prov. Nantou:** along route 820, Hohuanshan Mts., Jen-Ai Hsiang, on rock, elevation about 2590 m, March 9, 2003, H. Kashiwadani 45531 (TNS).

*Ramalina sinensis* Jatta, *Nouv. G. Bot. Ital.*, 9: 462. 1902. (Fig. 5a, b)

*Ramalina sinensis* is characterized by the cor-

ticulous habit, palmate and flattened lobes with distinctly dorsiventral appearance, absence of soredia, longitudinally orientated anastomosing ridges of chondroid tissue, depressed and reticulately arranged pseudocyphellae on the lower surface of lobes, straight, fusiform ascospores of  $13\text{--}15(17)\times 5\text{--}6(7)\mu\text{m}$  in size, and the absence of chemical substances in the medulla, although small amount of salazinic acid is occasionally found.

*Ramalina sinensis* is very variable in lobe shape and branching. Although specimens with palmate and loosely tufted lobes (Fig. 5a) are commonly found in Taiwan, those forming elon-

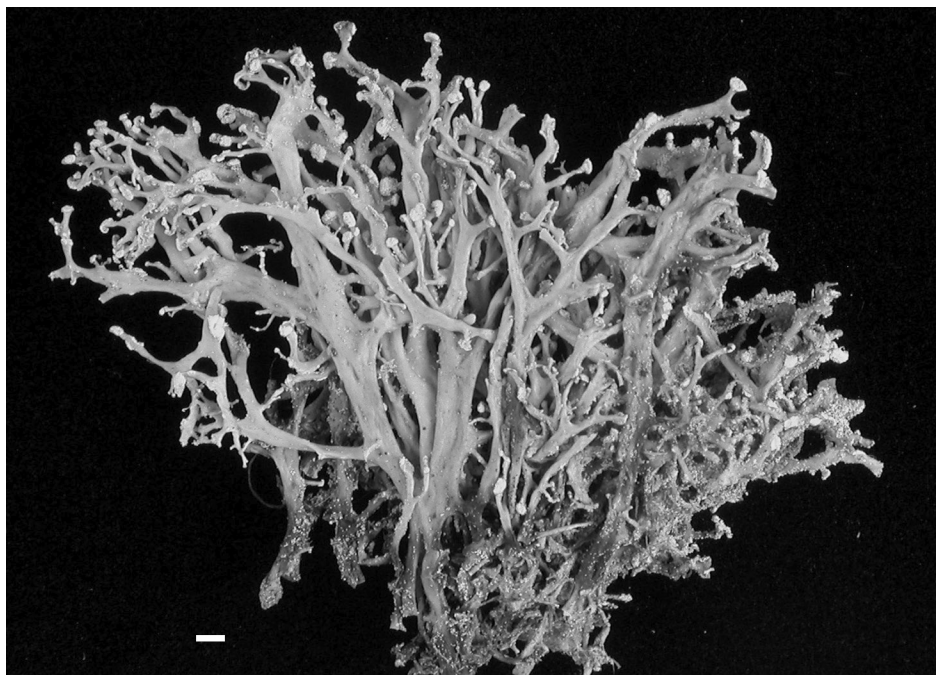


Fig. 6. *Ramalina subpollinaria* Nyl. (H. Kashiwadani 35761, TNS). Scale bar=1 mm.

gate, marginally outgrown lobes are also found (Fig. 5b). In the latter case, it can be confused with *R. fraxinea*, a species widely distributed in boreal regions, which differs in having branches without dorsiventral appearance, the ellipsoid pseudocyphellae, and the distinctly curved ascospores.

This cosmopolitan species was first reported from Taiwan by Asahina (1939) under the name *Ramalina asahinana* Zahlbr. It is rather commonly found on trees in mountainous regions in Taiwan.

**Specimens examined.** **Prov. Chiayi:** Mt. Anfuta-shan, on bark, elevation 1500–2400 m, January 19, 1964, S. Kurokawa 939 (TNS); the same locality, on twigs of *Osmanthus bioritsuensis*, 2400–2600 m, January 20, 1964, S. Kurokawa 1049 (TNS). **Prov. Hualien:** Guanian, Shioulin Hshiang, on bark of *Alnus japonica*, elevation about 2300 m, March 12, 2004, H. Kashiwadani 46933 and 46940 (TNS). **Prov. Nantou:** Tantalindao, Hsini, on branch of *Alnus formosana*, alt. 2200 m, September 25,

1993, C.K. Lin 3289 (L 0708, TNM); Tayuling, Jenai, on rock, elevation about 2600 m, August 2, 1985, K. Yoshida 7158 (TNS).

*Ramalina subpollinaria* Nyl., Bull. Soc. Linn. Normand. Ser. 2, 4: 125. 1870. (Fig. 6)

*Ramalina subpollinaria* is recognized by its small solid thallus growing from a narrow holdfast, terminal soralia with farinose soredia, and the presence of homosekikaic and sekikaic acids, or salazinic acid.

Kashiwadani (1987) reported two chemical races of this species from Brazil, the plants from the present area are the homosekikaic acid aggr. race lacking salazinic acid. This is the first report for the species outside South America.

**Specimens examined.** **Prov. Taichung:** en route from Su-yuan to Tochiatun Shan, Mt. Nanhuta Shan, Hoping, on rock, elevation about 2000 m, November 9, 1989, H. Kashiwadani 35865 (TNS); the same locality, on bark of *Salix* sp., elevation about 1900 m, November 9, 1989, H. Kashiwadani 35761 (TNS).

**Key to the *Ramalina* species of Taiwan**

1. Thallus hollow.....2
  - Thallus solid.....4
2. Perforations common, conspicuous, more than 1/2 of branches in width; evernic and obtusatic acids present .....*R. pertusa*
  - Perforations rare, small, less than 1/3 of branches in width; sekikaic acid or divaricatic acid present.....3
3. Medullary hyphae dense, continuous, tightly attached to the cortex; coastal lowland species.....*R. pumila*
  - Medullary hyphae sparse, discontinuous, forming bundles of chondroid tissue in medulla; montane species.....*R. dilacerata*
4. Soralia present.....5
  - Soralia absent .....10
5. Thallus less than 3 cm long, sparingly branched .....6
  - Thallus more than 3 cm long, repeatedly branched.....7
6. Soredia granular; evernic and obtusatic acids present.....*R. pollinaria*
  - Soredia farinose; homosekikaic and sekikaic acids present .....*R. subpollinaria*
7. Main branches up to 1.5 mm wide, growing from a common holdfast .....8
  - Main branches 1.5–3.0 mm wide, growing from a narrow holdfast.....9
8. Pseudocyphellae punctiform; distal branches finely divided, ending in nodular isidioid branchlets.....*R. hossei*
  - Pseudocyphellae shortly linear; distal branches tapering but never forming isidioid branchlets.....*R. peruviana*
9. Soredia farinose, marginal; pseudocyphellae shortly linear; maritime species .....*R. nervulosa*
  - Soredia granular, terminal or laminal; pseudocyphellae ellipsoid; montane species . .....*R. shinanoana*
10. Thallus corticolous, branches more or less canaliculated to flat; pseudocyphellae distinct, punctiform to ellipsoid .....*R. conduplicans*
  - Thallus saxicolous, branches cylindrical or terete; pseudocyphellae indistinct, shortly linear.....11
11. Branches more or less cylindrical, tapering, never producing nodules; center of medulla (in cross section) with strands of chondroid tissue .....*R. inclinata*
  - Branches irregular in thickness, often with isidioid nodules; center of medulla (in cross section) with interwoven hyphae ...*R. litoralis*

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## 台湾のカラタチゴケ属（子囊菌亜綱，カラタチゴケ科）

柏谷博之・文 光喜・頼 名洲

台湾産カラタチゴケ属の分類学的研究を行った。同地域からは12種が報告され、そのうち *Ramalina inclinata* は新種であり、*R. litoralis*, *R. pollinaria*, *R. subpollinaria* および *R. shinanoana* は台湾新産である。*Ramalina geniculata* と *R. subgeniculata* は台湾産地衣相からは除外された。