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Japanese Species of *Parmelia* Ach. (sens. str.), Parmeliaceae (1)

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Seventeen species of *Parmelia* sens. str. are recognized as Japanese members of the genus and the distribution range of each species is discussed in detail. Among them, two species, *P. marmorophylla* and *P. praesquarrosa*, are new to science and a new combination, *P. angustifolia* (Asah.) Kurok., is proposed. Two species, *P. omphalodes* and *P. saxatilis*, are added to the Japanese lichen flora. *P. subdivaricata* is considered as a distinct species in this paper, though it was reduced as a synonym of *P. fertilis* by Hale (1987). Three Asian species with punctate pseudocyphellae are classified under the new subgenus Nipponoparmelia. They are *P. isidioclada*, *P. laevior*, and *P. pseudolaevior*.

Introduction In his monumental manual of Japanese *Parmelia* (sens. lat.), Asahina (1952) cited seven important characters to separate species, viz. 1) presence or absence of cilia, 2) presence or absence of soredia, 3) presence or absence of isidia and isidial lobules, 4) presence or absence of white maculae including pseudocyphellae on the upper surface, 5) shape and size of spores, 6) shape and size of conidia, and 7) chemical ingredients. Even in current years, these characters are used in separating species and some of them in separating even genera.

As widely known at present, *Parmelia* sens. lat. has been divided into more than 30 genera. In his monograph of *Parmelia* sens. str., Hale (1987) delimited the genus by the following characters; adnate sublinear to subirregular lobes without cilia, upper surface effigurate-pseudocyphellate, less commonly punctate-pseudocyphellate, lower surface black and rhizinate, rhizines simple, furcate, or squarrosely branched, microconidia cylindrical or weakly bifusiform, less than 8.0 μm long, spores simple, 8 per ascus. Chemically it is distinguished by the presence of atranorin and chloroatranorin and lack of usnic acid in the cortex. He (Hale 1987) included 38 species in the genus, most of which were well typified.

In his manual, Asahina (1952) recognized 11 species with some varieties and forms as Japanese members of *Parmelia* of the present sense. He described *P. submarmariza* and *P. ontakensis* in 1953 and 1954, respectively. Kurokawa added *P. sulcata* and *P. erumpens* to the lichen flora of Japan in 1968 and 1969. In his monograph of *Parmelia*, Hale (1987) recognized 12 species of *Parmelia* from Japan. They were *P. adaugescens, P. cochleata, P. erumpens, P. fertilis, P. isidioclada, P. laevior, P. marmariza, P. pseudolaevior, P. pseudoshinanoana, P. shinanoana, P. squarrosa,* and *P. sulcata.* Unfortunately, however, he was not familiar with most Japanese species and had a few chances to observe them in the field. In addition, distribution range of each Japanese species was not fully studied in his monograph. In the present paper, the author intends to characterize each Japa-

nese species of *Parmelia* especially based on close observation in the field and to clarify the distribution range of each species in Japan and the adjacent area.

In the present study, *P. omphalodes* and *P. saxatilis* will be added to the Japanese flora and *P. marmorophylla* and *P. praesquarrosa* will be described as new to science. In addition, *P. subdivaricata* is recognized as a distinct species and a new combination, *P. angustifolia* (Asah.) Kurok. will be proposed. On the other hand, *P. cochleata* is reduced as a synonym of *P. fertilis*. Consequently, 17 species will be reported as Japanese members of *Parmelia*.

The present study is principally based on specimens preserved in TNS, unless otherwise stated. In order to reduce the space, specimens examined are not fully cited in this study, excepting for the cases of the critical species. In this opportunity, the author expresses his sincere thanks to the curators of G, H, KYO, TNS, TUR, and W for the loan of type specimens.

Vegetative structures Upper cortex of *Parmelia*, as delimited by Hale (1987), is perforated by pseudocyphellae. Pseudocyphellae of foliose lichens such as *Parmelia, Cetrelia, Platismatia,* etc. develop close to the growing tissue, probably within the latest year's growth, and reach their maximum size in 2–3 years (Hale 1981). Consequently, the thallus surface becomes sprinkled with pores (pseudocyphellae) of various size with the largest toward the central older parts. Pseudocyphellae are formed as cortex disintegrates or small pores that could act in gas exchange in their initial stages (Hale 1981). These cortex disintegrates form angular or linear aggregates or punctate perforations as observed as pseudocyphellae in surface view. The actual sizes and the densities of pseudocyphellae on mature lobes seem to be species specific. For example, Kurokawa (1964) examined the sizes and densities of punctate or more or less angular pseudocyphellae on mature lobes in *Cetrelia braunsiana, C. cetrarioides, C. chicitae, C. nuda,* and *C. olivetorum* (Table 1) and showed that *C. braunsiana, C. chicitae*, and *C. nuda* were different not only in the presence and absence of isidia and soredia but also in the density and size of pseudocyphellae and that *C. cetrarioides* and *C. olivetorum* could be distinguished not only by the chemical products but also by the density and size of pseudocyphellae. Kurokawa (1964) concluded that the density and size of pseudocyphellae were species specific and could be considered to reflect the speciation of lichens. In the taxonomy of *Parmelia*, the density and size of pseudocyphellae can be similarly used to separate the species.

In *Parmelia*, most frequent type of pseudocyphellae appears as an irregular effigurate white marking under a low power microscope. These markings are aggregates of numerous cortex disintegrates, which appear angular or linear in surface view as mentioned above. According to Hale (1981), they are covered with a thin persistent, densely pored polysaccharide epicortex acting as a roof over the disintegrating pore area below. These maculate markings have been called pseudocyphellae and are found in most species

Table 1. Densities and sizes of pseudocyphellae in species of *Cetrelia* (after Kurokawa 1964)

	C. chicitae	*C. braunsiana*	*C. nuda*	*C. cetrarioides*	*C. olivetorum*
Number of pseudocyphellae in a circle of 4.5 mm across	7–130	33–142	6–55	15–96	6–38
Maximum size of pseudocyphellae in the circle (mm)	0.1–0.6	0.5–1.0	0.6–2.2	0.3–1.3	0.1–0.4

of *Parmelia.*

In *P. shinanoana* and *P. pseudoshinanoana*, pseudocyphellae may originate exclusively along the lobe margins, just back from the tips. In these species, they form a continuous rather distinct white line, a rim along the margins of lobes (Fig. 1A, B). It is noted here that laminal pseudocyphellae are not found in *P. shinanoana* and *P. pseudoshinanoana*. Similar continuous or subcontinuous marginal pseudocyphellae, though they are less distinct, are formed in most other species of *Parmelia.* In these species, laminal angular or linear pseudocyphellae may also originate near the tips and reach their maximum size in 2–3 years or on the surface 3–5 mm back from the tips as mentioned above. The size and density of laminal mature pseudocyphellae seem to be species specific as in *Cetrelia.* For instance, they are sparse and angular or very short (mostly less than 0.7 mm long) even in mature stages and are situated on the same level as the surface in *P. fertilis* (Fig. 2A). Laminal pseudocyphellae are usually faintly white-rimmed and are longer (sometimes more than 2.0 mm long) and often fuse into a subreticulate network in *P. adaugescens* and *P. praesquarrosa* (Fig. 2B), though they are sometimes sparse and short in *P. adaugescens.* In *P. marmarize* and *P. marmorophylla* (Fig. 2C), they are more or less white-rimmed, quite minute (0.1–0.5 mm long), and crowded. Minute pseudocyphellae are also characteristic of *P. angustifolia*, in which they are more distinctly white-rimmed and elevated especially on older lobes. Although laminal pseudocyphellae are not conspicuously elevated on lobes of *P. marmorophylla*, pseudocyphellae on the amphithecium are formed on distinctly elevated ridges as in *P. niitakana*, a Taiwanese species. Very conspicuously white-rimmed and more or less elevated laminal pseudocyphellae are characteristic of *P. angustifolia, P. omphalodes* and *P. subdivaricata* (Fig. 2D).

The other type of pseudocyphella is characteristic of three Asian species, *P. isidioclada* (Fig. 3A), *P. laevior* (Fig. 3B), and *P. pseudolaevior.* These

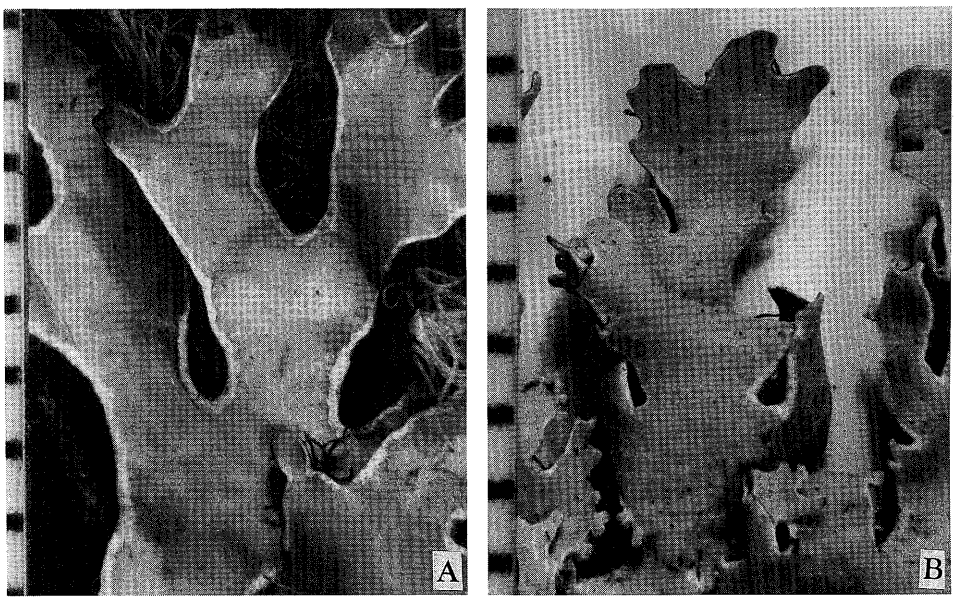

Fig. 1. Marginal pseudocyphellae found in *Parmelia.* Scales indicate mm. A: *P. shinanoana* (S. Kurokawa, Lich. Rar. Crit. Exs., no. 130). B: *P. pseudoshinanoana* (S. Kurokawa 59207).

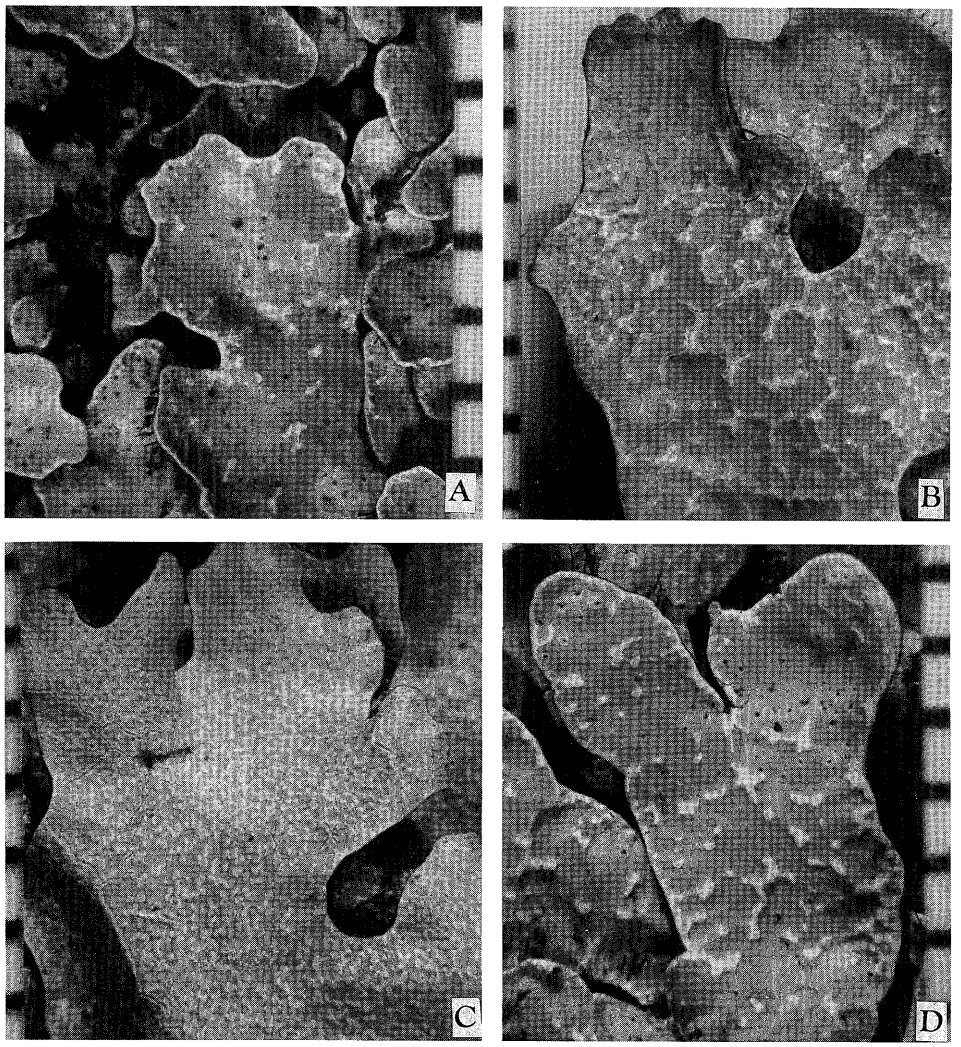

Fig. 2. Laminal pseudocyphellae found in *Parmelia*. Scale indicate mm. A; *P. fertilis* (S. Kurokawa 64320). B: *P. praesquarrosa* (holotype). C: *P. marmorophylla* (holotype). D: *P. subdivaricata* (S. Kurokawa 60050).

pseudocyphellae are exclusively formed along the lobe edge as round, widely spaced, and rather inconspicuous white spots. They are not covered with the persistent epicortex roof and do not fuse each other to make angular or linear aggregates. They are apparently identical with the punctiform pseudocyphellae of *Punctelia* and *Flavopunctelia*. Even though these species have been appropriately classified under *Parmelia* because of the production of salazinic acid, a commonest medullary substance in *Parmelia* (Hale 1987), they show a close affinity especially to *Punctelia* and form a distinct group which seems to have differentiated in eastern Asia. In the present paper, therefore, new subgenus, subgenus Nipponoparmelia, is proposed to accommodate these three species.

The lower surface of Japanese species of *Parmelia* is black and continuously covered with rhizines. However, whitish or pale brownish peripheral zone is usually present on the lower surface of three Asian species with punctiform pseudocyphellae, though it is

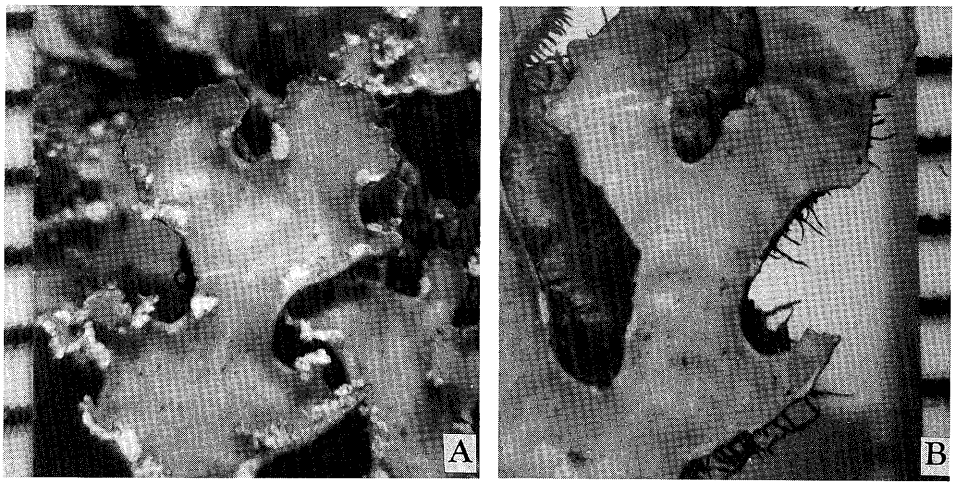

Fig. 3. Punctate pseudocyphellae found in *Parmelia*. A: *P. isidioclada*. (S. Kurokawa 68604). B: *P. laevior*. (S. Kurokawa 81021).

very narrow and inconspicuous. The peripheral zone is naked or not rhizinate and may be referable to the albo-ambitu observed in some species of *Parmotrema*. The rhizines of *Parmelia* are black and usually shiny, 0.5–2 or sometimes more than 2 mm long, and either simple to sparsely to densely furcate, simple with a few weakly squarrosely branched, or simple with numerous strongly squarrosely branched. The following Japanese species have simple to furcate rhizines: *P. adaugescens, P. angustifolia, P. fertilis, P. isidioclada, P. laevior, P. marmariza, P. marmorophylla, P. omphalodes, P. pseudolaevior, P. saxatilis*, and *P. shinanoana*. The following species have simple rhizines and at least some squarrosely branched rhizines: *P. erumpens, P. praesquarrosa, P. pseudoshinanoana, P. squarrosa, P. subdivarivata*, and *P. sulcata*. The presence or absence of squarrose rhizines, therefore, is one of the most reliable characters to distinguish species of *Parmelia*.

Asexual propagules such as soredia, isidia, pustules, and lobules are formed in a few Japanese species of *Parmelia*. Soredia are found in only one species *P. sulcata*. They appear to originate from pseudocyphellae and become aggregated into orbicular or linear soralia. Cylindrical isidia are formed in two species, *P. saxatilis* and *P. squarrosa*. In *P. isidioclada*, isidia appear granular projections formed on pseudocyphellae in initial stages. These granular projections give arise densely branched short cylindrical or coralloid isidia, which soon become crumbling and subsorediate at the tips. Lobules in *Parmelia* are dorsiventral and usually originate along lobe margins. They are very narrow, well branched, suberect or sometimes even erect, and rarely sparsely rhizinate below as main lobes. Two lobulate species are known in Japan: *P. pseudolaevior* and *P. pseudoshinanoana*. *P. erumpens* is the only species forming pustular soredia in *Parmelia*.

Reproductive structures Although apothecia are adnate to substipitate in most species of *Parmelia*, they are more or less stipitate in three Asian species, *P. isidioclada, P. laevior*, and *P. pseudolaevior*. Apothecia are rarely found in most sorediate, isidiate, or lobulate species. In contrast, they are common in species without vegetative propagules. Even though Räsänen (1949) reported asci of *P. psoromoides* to be 2-spored, the examination of the type revealed that the

asci are apparently 8-spored as in other species of the genus (Kurokawa 1993). Thus, asci are 8-spored in all species of *Parmelia* so far as we know at present. Although they are cylindrical in most species of *Parmelia*, they are clavate or subclavate only in three species, *P. isidioclada, P. laevior*, and *P. pseudolaevior*. Larger spores are found in three species, *P. adaugescens* (12–18×20–33 μm), *P. niitakana* (13–15 × 27–30 μm), and *P. psoromoides* (18–20 × 28–36 μm, Kurokawa 1993). It is noteworthy that these three species are endemic to Southeast or East Asia.

Chemistry When Krog (1951) systematically first studied the chemical ingredients of *Parmelia* with the microchemical methods, she concluded that species of *Parmelia* sens. str. contained salazinic acid and atranorin in common and also found accessory lobaric acid in *P. omphalodes* and usnic and protolichesterinic acids in *P. fraudans*. Atranorin and salazinic acid are produced by all Japanese species of *Parmelia*.

Consalazinic acid is often accompanied with salazinic acid and seems to be of no taxonomic value. Although usnic acid has been found in none of Japanese species of the genus, fatty acids were demonstrated as accessory compounds in *P. adaugescens, P. marmariza, P. omphalodes*, and *P. squarrosa*. Although lobaric acid has been demonstrated in all Japanese specimens of *P. saxatilis*, it seems to be an accessory compound in *P. omphalodes* and European and American *P. saxatilis*.

Gyrophoric acid as a chemical constituent in the cortex was first reported in *P. shinanoana* and *P. martinicana* [= *Canoparmelia martinicana* (Nyl.) Elix et Hale] by Kurokawa and Takahashi (1970). Through the present study, it is also found as a constant component in *P. isidioclada*, even though the location of it in the thallus has not been examined yet. A trace of protocetraric acid has been often demonstrated in *P. fertilis, P. isidioclada, P. praesquarrosa,* and *P. subdivaricata*.

Distribution *Parmelia saxatilis*, the type species of *Parmelia*, is the most widespread species of the genus, occurring in both hemispheres and known to all lichenologists. *Parmelia sulcata* is another well known species, which also occurs in both hemispheres. Distribution ranges of these two species might give the impression that species of the genus should be widely distributed or even weedy in the world. However, a number of species treated in this paper are in fact distributed in rather restricted area, though some of them are locally common and weedy. As to distribution patterns of Japanese species of the genus, the following five groups may be recognized.

1) Temperate and boreal weedy group. Although *P. saxatilis* and *P. sulcata* are widely distributed and common in both hemispheres as mentioned above, they are quite rare in Japan: *P. saxatilis* is known only from a few localities in Honshu (see under *P. saxatilis*) and the rarity of *P. sulcata* in Japan was already remarked by Kurokawa (1968).

2) Circumpolar boreal and arctic group. *P. omphalodes* is a well-known lichen which has been reported from Europe and North America and is not known from the Southern Hemisphere. Even though it has long been confused with *P. fertilis* or *P. cochleata* in Japan, *P. omphalodes* can be considered to be one of the commonest circumpolar boreal and arctic species of the genus, since the range now includes also Japan, Aleutian and Kurile Islands, and Korea.

3) Group distributed disjunctively in eastern Asia and eastern North America. *P. squarrosa* principally shows disjunctive distribution in eastern Asia and eastern North America. The distribution pattern is quite similar to those of *Anaptychia hypoleuca* (Ach.) Mass., *A. palmulata* (Mich.) Ach., and *Myelochroa galbina* (Ach.) Elix et Hale (Kurokawa 1972). However, Hyvönen (1985) reported the range extention of

P. squarrosa to Europe.

4) Australian group. *P. erumpens* apparently belongs to the Australian group, since it is so common and even weedy in Australia with range extention to New Zealand, Papua New Guinea, Sabah, Indonesia, Taiwan, India, Nepal, South Africa, and Japan (Sharma and Kurokawa 1990).

5) East Asian species. Other 12 species belong to the East Asian group. Six of 12 species, viz., *P. angustifolia, P. marmariza, P. marmorophylla, P. praesquarrosa, P. pseudolaevior,* and *P. pseudoshinanoana*, are endemic to Japan so far as we know at present. Six other species are also distributed mainly in Japan, but they show range extentions to Korea, Taiwan, Saghalien, Siberia, China, or the Himalayan Region. It is noteworthy that three species with punctate pseudocyphellae belong to this group and are mainly distributed in Japan with range extention to Siberia, Korea, or Taiwan.

Key to the subgenera and Japanese species of *Parmelia*

1. Pseudocyphellae round and punctiform, formed on lobe margins (Fig. 3); apothecia more or less stipitate; asci clavate to subclavate ..... Subgenus Nipponoparmelia Kurok.
2. Thallus with coralloid-isidioid outgrowths apically crumbling and subsorediate; gyrophoric acid present ..... *P. isidioclada* Vainio
2. Thallus lacking subisidiate soredia; gyrophoric acid lacking.
3. Thallus with dense suberect, marginal (or in part laminal) lobules .. *P. pseudolaevior* Asah.
3. Thallus without lobules ..... *P. laevior* Nyl.

1. Pseudocyphellae angular or linear, marginal and/or laminal; apothecia adnate to substipitate; asci cylindrical ..... Subgenus Parmelia
4. Thallus isidiate, pustulate, or sorediate.
5. Thallus isidiate.
6. Squarrosely branched rhizines present; lobaric acid lacking ..... *P. squarrosa* Hale
6. Rhizines simple and/or furcate; lobaric acid present (TLC) in all Japanese specimens ..... *P. saxatilis* (L.) Ach.
5. Thallus sorediate or pustulate.
7. Thallus sorediate; from northern Japan ..... *P. sulcate* Tayl.
7. Thallus pustulate or pustulate-sorediate; from southwestern Japan ..... *P. erumpens* Kurok.
4. Thallus lacking isidia, soredia, and pustules.
8. Pseudocyphellae marginal (Fig. 1).
9. Thallus corticolous, lobes with numerous marginal (and in part laminal), suberect dorsiventral lobules; squarrose rhizines present; gyrophoric acid lacking ..... *P. pseudoshinanoana* Asah.
9. Thallus saxicolous, lobes lacking minute lobules; rhizines simple and furcate; gyrophoric acid present ..... *P. shinanoana* Zahlbr.
8. Pseudocyphellae marginal and laminal (Fig. 2).
10. Squarrosely branched rhizines present.
11. Lobes subirregular to sublinear, more or less serrate at the margin; pseudocyphellae more or less white-rimmed but not elevated ..... *P. praesquarrosa* Kurok.
11. Lobes sublinear elongate, subentire at margin; pseudocyphellae conspicuously white-rimmed and elevated ..... *P. subdivaricata* Asah.
10. Rhizines simple or furcate, squarrosely branched rhizines lacking.
12. Spores large, more than 20 μm long ..... *P. adaugescens* Nyl.
12. Spores small, less than 18 μm long.
13. Laminal pseudocyphellae linear elongate, usually more than 1 mm long, often forming a subreticulate network, usually white-rimmed and more or less elevated

..... *P. omphalodes* (L.) Ach.

13. Laminal pseudocyphellae minute or short, less than 0.7 mm long, rarely forming a network.
14. Laminal pseudocyphellae short and rather sparse.
15. Lobes rather shiny on the surface, with helmet-shaped lobules; laminal pseudocyphellae faintly white-rimmed, not elevated (Fig. 2A) ..... *P. fertilis* Müll. Arg.

15. Lobes rather dull on the surface, without helmet-shaped lobules; laminal pseudocyphellae conspicuously white-rimmed and elevated ..... *P. angustifolia* (Asah.) Kurok.

14. Laminal pseudocyphellae minute and crowded (Fig. 2C).
16. Lobes 1.5–3 mm wide, obtuse or subtruncate at apices; laminal pseudocyphellae sometimes fusing into a subreticulate network; amphithecium rather smooth; thallus containing fatty acids ..... *P. marmariza* Nyl.

16. Lobes 2–9 mm wide, with rotund apices; laminal pseudocyphellae hardly forming a network; amphithecium conspicuously rugose with white-rimmed and elevated pseudocyphellae; thallus lacking fatty acids ···· *P. marmorophylla* Kurok.

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黒川 遒：**ウメノキゴケ科カラクサゴケ属の日本産の種（1）**

広義のウメノキゴケ属は現在では30以上の属に分けられている．そのなかの一つのカラクサゴケ属には全世界で38種，日本産として12種が認められている（Hale 1987）．この20年近く日本を中心とする地域の野外調査で標本を蒐集し，研究した結果，日本産として17種を認めることができたので順次報告することにした．第一報ではカラクサゴケ属の分類には擬盃点の形状，大きさ，密度が重要な要素を占めることを報告した．とくに，白点状の擬盃点をもつ ***P. isidioclada, P. laevior, P. pseudolaevior*** は裂片裏側の葉縁沿いに類白色ないし淡褐色の仮根のない裸出部があり，子器はやや有柄，胞子嚢はややこん棒状である点も含めて，線状の擬盃点をもつ他の種と明らかにちがったグループをつくるので，亜属として区別できることを示した．また，日本産のカラクサゴケ属地衣の分布型に5つのタイプが認められることを報告した．