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Zennoske Iwatsuki and Timo Koponen: On the taxonomy and distribution of *Rhodobryum roseum* and its related species (Bryophyta)

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ACTA BOTANICA FENNICA

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SOCIETAS PRO FAUNA ET FLORA FENNICA

ON THE TAXONOMY AND DISTRIBUTION OF RHODOBRYUM ROSEUM AND ITS RELATED SPECIES (BRYOPHYTA)

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Abstract

IWATSUKI, ZENNOSKE (Hattori Bot. Lab., Nichinan, Japan) & KOPONEN, TIMO (Dept. Bot., Univ. Helsinki, Finland): On the taxonomy and distribution of *Rhodobryum roseum* and its related species (Bryophyta). — Acta Bot. Fennica 96: 1—22. 1972.

R. ontariense (Kindb.) Kindb. is a distinct species, and is clearly separated from *R. roseum* (Hedw.) Limpr. The taxonomy and distribution of these two species are studied. The typification of *R. ontariense* is suggested, and a new combination, *R. laxe-limbatum* (Ochi) Iwats. et Kop. is introduced. The generic concept of *Rhodobryum* is briefly discussed in reference to characters of some other species of the genus.

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Contents

I. Introduction

The genus *Rhodobryum* (Schimp.) Limpr.

SCHIMPER (1860) separated *Rhodobryum* as a subgenus from *Bryum*, and later, LIMPRICHT (1895) gave it generic rank. Since then, the genus *Rhodobryum* has been accepted by most bryologists (e.g., DIXON 1924, BROTHERUS 1924, ANDREWS 1940, NYHOLM 1958), while others (e.g., BRAITHWAITE 1888—1895, C. MÜLLER 1901, OCHI 1954) considered it as a section or subgenus of *Bryum*. The subterraneous stolons, the structure of costa similar to that in *Mniaceae* with only a small bundle of stereids or none, the presence of polysety, and the terminal rosettes of leaves on stems have been used as generic characters by LIMPRICHT (1895) and BROTHERUS (1924). The character mentioned last has been critisized (e.g., FLEISCHER 1902 —04) because there are many *Bryum* species with similar rosettes. However, if we include only those species which share all the characters mentioned above, *Rhodobryum* forms a rather small but natural genus. The species of *Rhodobryum* have several common characters, in addition, such as leaf border mainly uni-stratose, presence of micronemata, and a stem epidermis of the *Bryum* type (KOPONEN 1968: 137). If this concept is followed, many of the species treated as *Rhodobryum* by PARIS (1905) and BROTHERUS (1924) must be removed to the genus *Bryum* or to other genera of *Bryaceae* (cf. also FLEISCHER 1902—04).

In addition to its type species, *R. roseum*, *Rhodobryum*, will include at least *R. giganteum*, *R. laxe-limbatum* (cf. p. 14) and *R. ontariense*. Also, more species from subtropical and tropical regions may belong here. It may be added that the resulting genus, *Rhodobryum* s.str., shows some relation with the genus *Plagiomnium* Kop. (KOPONEN 1968: 137) and, in fact *Rhodobryum* was included in the *Mniaceae* by PODPERA (1954).

Rhodobryum roseum and *R. ontariense*.

R. roseum has been commonly thought to be a species widely distributed in the temperate and boreal zones of the Northern Hemisphere. Most of the handbooks include Europe, North America, and certain areas in Asia, such as the Himalayas and Japan, in its range. KINDBERG (1889) evidently was the first who found some taxonomic discontinuity in *R. roseum* when he separated the North American population at the specific level and named it as

Bryum ontariense. RENAULD & CARDOT (1896, cf. BRITTON 1900) critisized KINDBERG's concept, stating that the characters listed by KINDBERG were also present in the European material of *R. roseum*, and they held the opinion that *R. ontariense* was merely a variety of *R. roseum*. The name *Rhodobryum* (or *Bryum*) *ontariense* was later used by some American bryologists, in recording the local moss floras, e.g., DEMETRIO (1907), JENNINGS (1913), WOLFE (1924), BROWN (1929), KNOBLOCH & BLEEKMAN (1937), and DUVALL (1938). However, ANDREWS (1935) reduced *R. ontariense* to a synonym of *R. roseum*. The recent list of the mosses of North America (CRUM, STEERE & ANDERSON 1965) does not mention *R. ontariense*. However, some European bryologists have been aware of the taxonomic difference between the European and the American plants; for instance, AHTI & FAGERSTÉN (1967) noted Tuomikoski's opinion who considered *R. ontariense* as a distinct species. MÜLLER (1896, 1897) described several species of *Bryum* (*Rhodobryum*) from China, some of which were reduced in the synonymy of *R. roseum* by BROTHERUS (1924).

The present study is based mainly on the collections in the University of Helsinki (H), The Hattori Botanical Laboratory (NICH), and the New York Botanical Garden (NY), in addition to the field research in Japan and North America (by the senior author) and in Europe and Japan (by the junior author).

II. Taxonomy of *Rhodobryum roseum* and *R. ontariense*

The European *R. roseum* has been well illustrated by many authors, e.g., BRUCH, SCHIMPER & GÜMBEL (1839 as *Bryum*), BRAITHWAITE (1888—95 as *Bryum proliferum*), LIMPRICHT (1895), ROTH (1905), DIXON (1924), WATSON (1955) and NYHOLM (1958). It is easily noticed that these illustrations are different from the figures based on American material (JENNINGS 1951) and Japanese materials (NOGUCHI 1965; SEKINE 1969), although all of them are shown as »*R. roseum*». The most useful diagnostic characters separating *R. roseum* and *R. ontariense* are found in the gametophytes, as mentioned below.

Growth habit. Both *R. roseum* and *R. ontariense* are large species compared with taxa of *Bryum*, with stems under optimal conditions reaching a height of 5 cm or more. However, on a basis of the material studied, *R. roseum*, on an average, seems to be larger than *R. ontariense*. One of the most striking differences visible to the naked eye is the number of leaves of the terminal rosette (Table 1). In *R. roseum*, usually 16—21 leaves spread horizontally in wet condition, while the rosette of *R. ontariense* gives a more rounded shape due to the numerous (18—52) leaves. In dry condition, the leaves of *R. roseum* tend to remain spread out while the leaves of *R. ontariense* are strongly twisted and often turn upwards (Fig. 1). Both of the species have subterranean stolons.

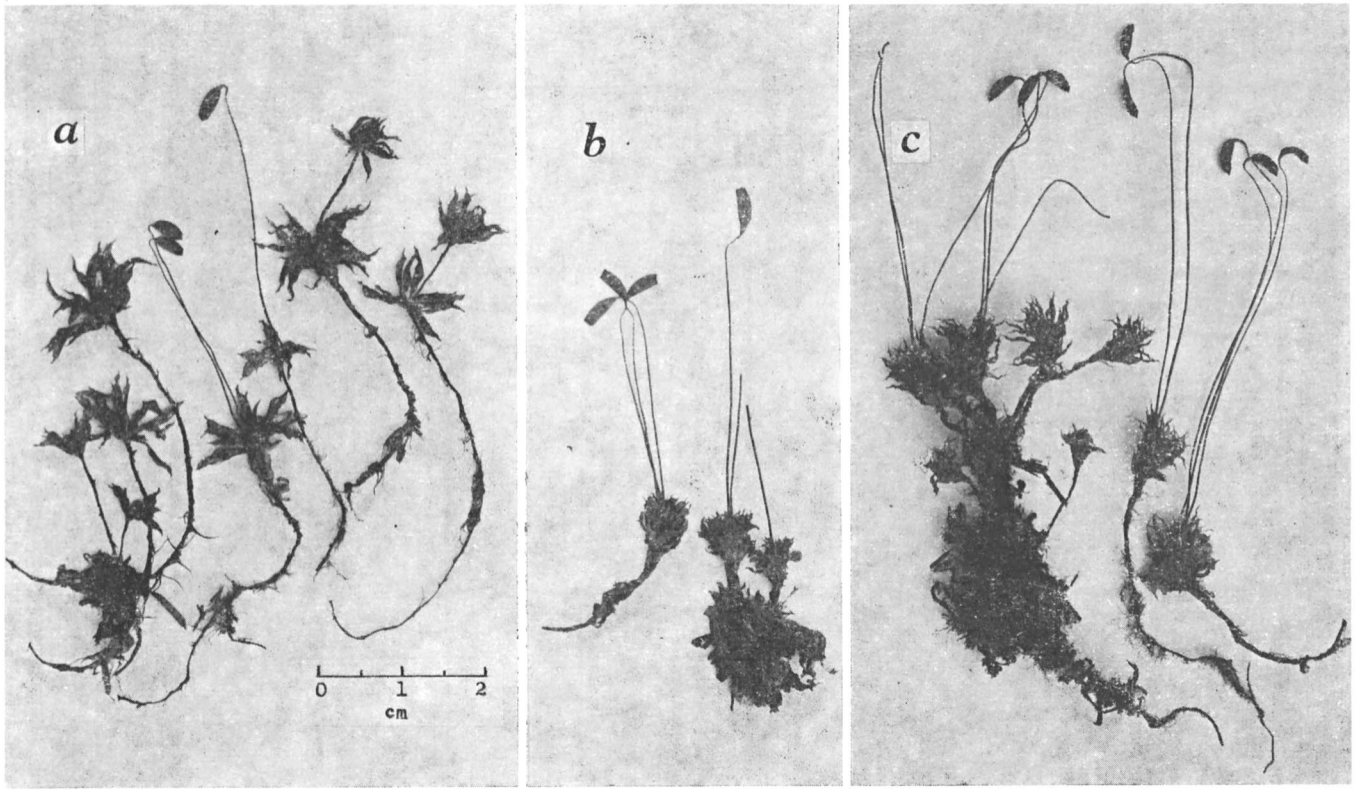


FIG. 1. Dry specimens of *Rhodobryum roseum* (a) and *R. ontariense* (b & c). *R. roseum* has fewer, less shrunken leaves than those of *R. ontariense*. Subapical innovation is common in *R. roseum*. — a. Norway, Kaalaas 598 (H). — b. Canada, Ontario (lectotype of *Bryum ontariense;* S-PA). — c. Japan, Nagano Pref., Okamura (NICH 37346).

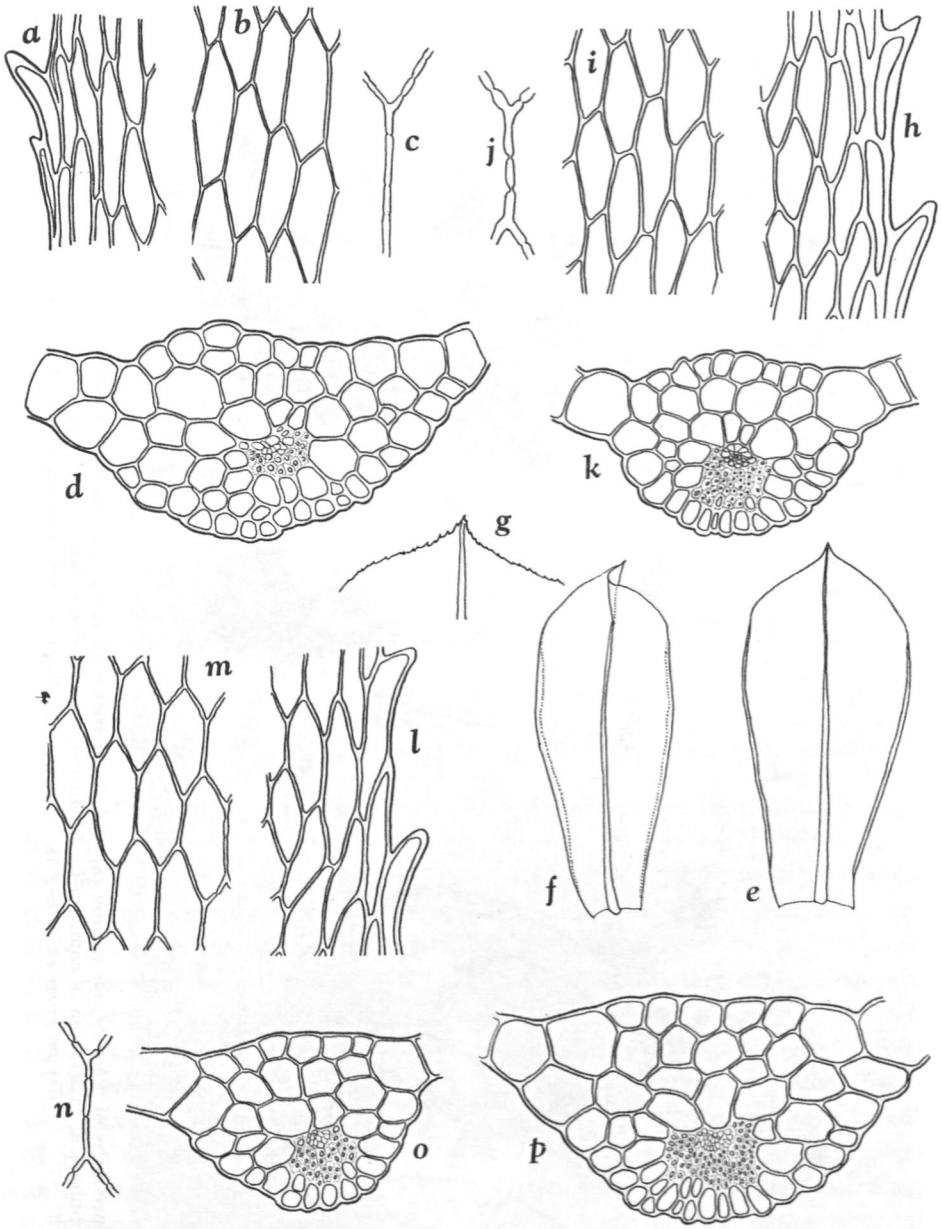


FIG. 2. *Rhodobryum roseum* (Hedw.) Limpr. (a-d) and *R. ontariense* (Kindb.) Kindb. (e-p). — a, h, l. Cells at leaf-margin, × 190. — b, i, m. Median leaf-cells, × 190. — c, j, n. Walls of median leaf-cells, × 375. — d, k, o, p. Cross-sections of costae, × 190. — e, f. Leaves, × 6. — g. Leaf-apex, × 19. — Figs. a-d were drawn from specim. from Sweden, coll. Een et al., NICH 290635; figs. e-k from the lectotype of *Bryum ontariense* Kindb. in S-PA; figs. l-o from the isotype of *Rhodobryum leptorhodon* C.M. (C.M. 863) in H; fig. p from Musci Japon. Exs. 864 in NICH.

TABLE 1. Number of leaves in rosettes of *R. roseum* and *R. ontariense*. The lowest scale-like leaves and the innermost small perichaetial leaves were excluded. One female stem was used from each studied specimen

	Number of leaves in rosettes												
	16—18	19—21	22—24	25—27	28—30	31—33	34—36	37—39	40—42	43—45	46—48	49—51	52—54
R. roseum													
Europe	6	2											
Caucasus		1											
Altai						1							
Alaska		1											
Total number of rosettes	6	4				1							
R. ontariense													
Caucasus				2	1						1		1
Altai	1	1	1										
Himalayas			1		1			1					
Japan				1	1	2	2	1	2	1			
N. America				2		1	1	2	3		1		
Total number of rosettes	1	1	2	5	3	3	3	4	5	1	2		1

TABLE 2. Apex angle of leaves in *R. roseum* and *R. ontariense*. Three well developed leaves from each female stems of 11 collections (9 from Europe, 1 from Kazakhstan, and 1 from Alaska) of *R. roseum*, and 10 collections (5 from eastern N. America and 5 from Japan) of *R. ontariense* were used. Angle was measured under a microscope using a protractor and an Abb's drawing camera

Angle (degree)	65°	70°	75°	80°	85°	90°	95°	100°	105°	110°	115°	120°	Total
R. roseum	3	1	7	5	4	3	5	4				1	33
R. ontariense				1		6	2	8	6	4	1	2	30

In addition, subapical branching often takes place in *R. roseum* especially in small stems, thus a verticillate structure of plants are often observed (cf. Fig. 365 in BRUCH, SCHIMPER & GÜMBEL 1839 and Fig. 142 in NYHOLM 1958), whereas subapical branching is rare in *R. ontariense*.

Leaf characters. When the characters of the leaves of *Rhodobryum* are studied, the serial variation of them should be considered. The lower stem leaves are small and scaly, and the comal leaves are much bigger and in different shape. However, variations are found in the size and shape within the comal leaves, e.g., the leaves are usually small and wide on the lower portion, much bigger on the middle portion, and smaller and narrower toward the center of rosette (cf. Fig. 3). To compare the characters of leaves of the different species, the leaves from corresponding position on each plant should be considered.

TABLE 3. Spore size of *Rhodobryum roseum* and *R. ontariense*. The longest dimension of 30 spores from each capsule from different localities were measured.

Spore size, μm	—16.2	16.3—17.5	17.6—18.8	18.9—20.1	20.2—21.4	21.5—22.7	22.8—24.0	24.1—	Total
R. roseum									
Specim. from Latvia (Malta 161)	1	3	10	10	4	2			30
Specim. from La Chaux, Switzerland (Ch. Meylan)		2	4	10	10	2	2		30
Total number of spores	1	5	14	20	14	4	2		60
R. ontariense									
Specim. from Ontario (Garton 2468)				1	11	9	9		30
Specim. from North Carolina (Anderson 12656)	2	8	12	6	1	1			30
Specim. from Japan (NICH 37346)		1	1	3	10	10	4	1	30
Specim. from Himalayas (Bahadru 5730)		2	7	9	10	2			30
Total number of spores	2	11	20	19	32	22	13	1	120

TABLE 4. Useful diagnostic characters of *R. roseum* and *R. ontariense*

	R. roseum	*R. ontariense*
Subapical branching	Often present	Rare
Number of comal leaves	Mostly 16—21	18—52
Shape of median comal leaves	Spathulate to obovate having weakly revolute margin	Obovate to elliptical having strongly revolute margin
Apex of median comal leaves	Acute (usually 65°—100°)	Widely acute (usually 90°—120°)
Costa of median comal leaves	Usually does not reach to apex	Percurrent to shortly excurrent
Cross-section of costa at lower portion	With small stereid band separated by 1 layer of cells from epiderm at dorsal side	With larger stereid band extending to epiderm
Costa of perichaetial leaves	Percurrent to shortly excurrent with weak serration	Long excurrent with large and sharp teeth

Many characters of the comal leaves can be used in separating *R. roseum* and *R. ontariense* (Tables 1, 2, 4; Figs. 2, 3). The leaves of *R. ontariense* are more narrowly spathulate or obovate in outline than those of *R. roseum*. This may be due partly to the fact that the margin is more strongly recurved in *R. ontariense*. The apex of the leaves of *R. roseum* is more acute (mostly

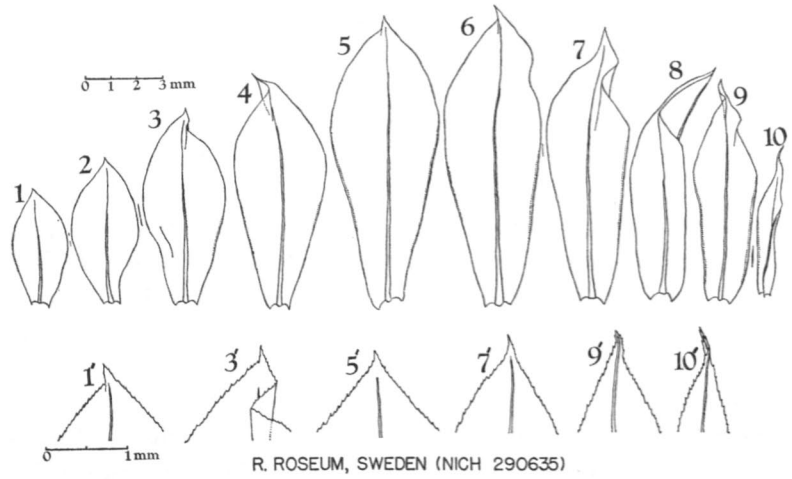
65°—100°), while it is wider (mostly 90°—120°) in *R. ontariense* (Table 2). The border is present in both of the species at the recurved part of the leaves, but it is weak near the apex. The marginal teeth are usually longer and sharper in *R. ontariense*. The costa is usually percurrent to shortly excurrent in the median comal leaves of *R. ontariense*, while it usually does not reach the apex in *R. roseum*, a difference more easily seen in the inner perichaetial leaves (Fig. 3). In addition, the internal structure of costa is also remarkably different. In *R. roseum*, the dorsal stereid band is much less developed than in *R. ontariense* (Fig. 2). The stereids, in addition, are centrally situated in *R. roseum*, usually being separated by one layer of ordinary cells from the epidermal layer, while in *R. ontariense*, the stereid band is more dorsally situated and stereids extend to the epidermis.

Sporophyte. Diagnostic differences in the shape of capsules or other characters of the sporophyte were not found. Both of the species are polysetose, having 1—5 setae per stem. The spore size in *R. ontariense* may be slightly larger (Table 3), but the number of available specimens with spores was too small to state it more precisely. The sporophytes of *R. ontariense* are not very rare in material from eastern North America and the Himalayas. In Japan, five specimens out of 67 examined were fertile.

Variation of the characters. Some statistical overlapping in the specific characters of *R. roseum* and *R. ontariense* were found (Tables 1—4). The number of leaves to some extent depends on the vitality of the plant and it was observed that the male plants have fewer leaves than female plants. In exposed habitats both of the species remain small, and *R. ontariense* also has fewer leaves with more acute apices than it does under optimal conditions. In a number of small specimens of *R. roseum* the costa was found to be more or less percurrent, although its inner structure was similar with only small group of stereids to that in normal material. In spite of these discrepancies, the specimens seen could be easily determined when the combination of characters was evaluated, except some quite depauperate forms.

In spite of careful examinations and comparisons of the specimens of *R. ontariense* from different regions, such as eastern North America, China, the Himalayas, Caucasus and Europe, the authors were unable to find any reliable characters to separate these populations at the specific or infraspecific levels (cf. Figs. 2, 3). *R. roseum* is rather unvariable species.

Chromosome numbers. YANO (1957) reported the chromosome number of *R. roseum* as n=11 based on gametophytic material. The voucher specimen from the summit of Mt. Myoko (Yano no. 1044) proved to be *R. roseum* s.str., but the other specimen from Mt. Togakushi (Yano no. 867) is *R. ontariense*. Thus, both *R. roseum* and *R. ontariense* have the same chromosome number n=11, at least in Japanese materials. CHOPRA (1957) reported the chromosome



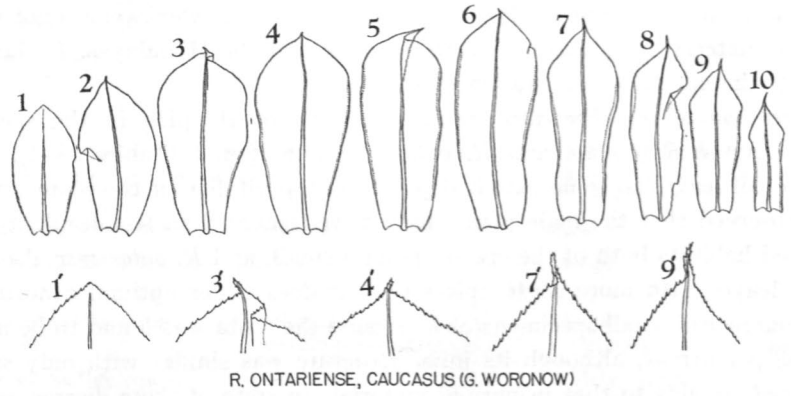
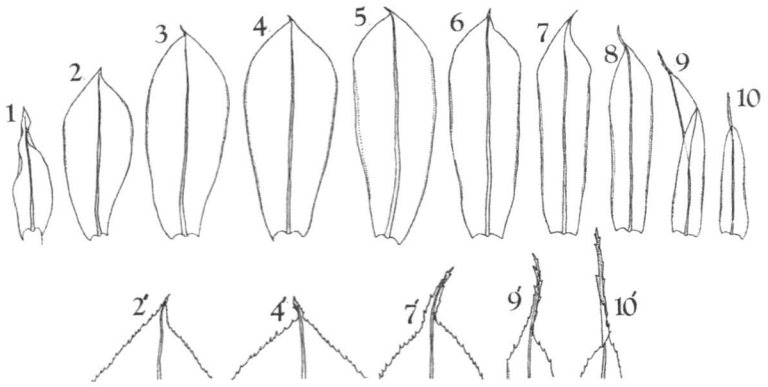


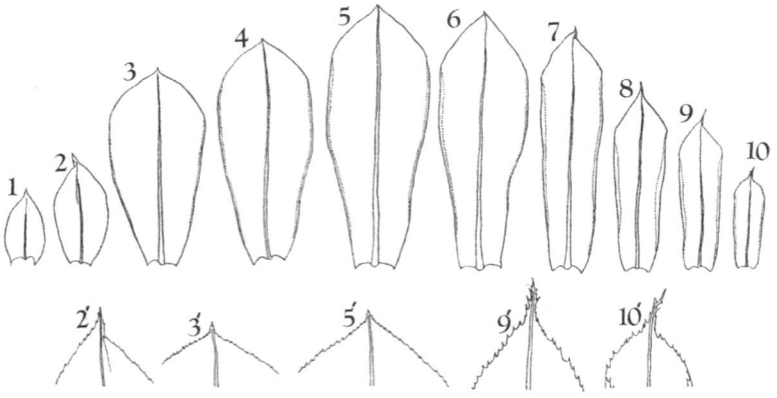
FIG. 3. Leaf spectra of *Rhodobryum roseum* and *R. ontariense*. One well-developed female stem was taken from each specimen, and 10 leaves were taken from base to the center of rosette. Apices of some leaves are shown below each spectrum.

number of Indian material of *R. roseum* as n=10. However, the present authors could not confirm the identity of Chopra's material.

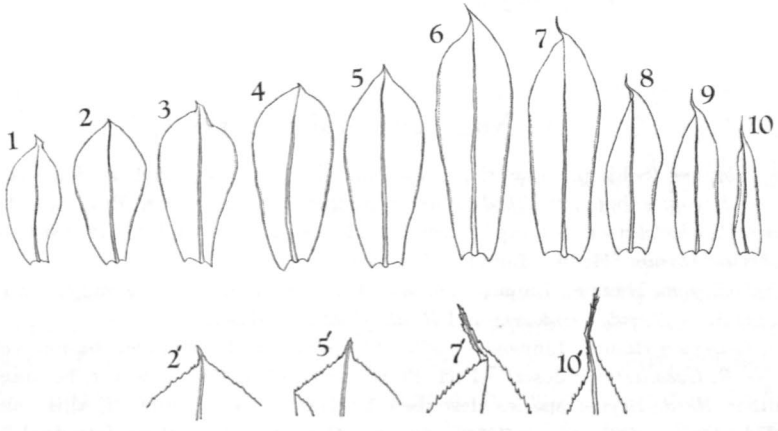
YANO (1957) confirmed the chromosome number of *R. giganteum* as n=11 which was previously reported by SHIMOTOMAI & KOYAMA (1932). He pointed out that *R. roseum* and *R. giganteum* have a similar karyotype, and their chromosomes are strikingly large in size compared with other genera of *Bryaceae* (*Pohlia, Brachymenium, Plagiobryum, Bryum* and *Anomobryum*) studied by him.



R. ONTARIENSE, JAPAN (MUSCI JAPON. 445)



R. ONTARIENSE, U.S.A., TENNESSEE (IWATS. 598)



R. ONTARIENSE, HIMALAYA, SIMLA (LEVIER 5578)

III. Some other members of the genus *Rhodobryum*

Two other species of *Rhodobryum* from Asia, *R. giganteum* and *R. laxe-limbatum* (cf. p. 14) can be separated from *R. roseum* and *R. ontariense* through the absence of stereids in the costa, which could be used as a sectional character (cf., also BROTHERUS 1924). As specific characters, the biserrate marginal teeth of leaves and the large size of the plant in *R. giganteum*, and the broadly spathulate leaf and the well developed leaf border in *R. laxe-limbatum* (Fig. 4) can be mentioned. *R. laxe-limbatum* also has subterranean stolons and a terminal rosette similar to *R. roseum*, and should be considered a member of *Rhodobryum*, although it was originally described as *Bryum* (OCHI 1968).

As illustrated by BROTHERUS (1924) the costae of *R. olivacea* Hampe (Australia) and *R. beyrichianum* (Hornsch.) Par. (Central and South America) are different from that of *R. roseum*. The costae of these species have very high dorsal ridge, and no stereids. Thus, in cross-section, they have a very different shape from that of *R. roseum*. As pointed out by DIXON & POTIER DE LA VARDE (1930), a similar type of costa is also found in the type specimens of *R. curranii* Broth. from the Philippines and *R. madurense* Dix. et de la Varde from India (cf. Fig. 4). The shape, border and apex of leaves of these species are rather similar to *R. roseum*.

Bryum truncorum (Brid.) Brid. was often confused with the species of *Rhodobryum*. However, it can be easily separated from all the other species of *Rhodobryum* by a costa of the *Bryum*-type which has strongly developed stereids (cf. Fig. 4), in addition to the small size of plants and the absense of subterranean stolons.

R. nanorosula (C. Müll.) Par. may be the same as *R. ontariense*, but we could not see the type.

OCHI (1967) reduced *Bryum globicoma* C. Müll. (= *Rhodobryum globicoma* (C. Müll.) Paris) to a synonym of *B. truncorum* (Brid.) Brid.

IV. Nomenclatural remarks

Rhodobryum (Schimp.) Limpricht, Laubm. Deutschl. Oesterreichs Schweiz 2: 444. 1892. — *Bryum* subgen. 3. *Rhodobryum* Schimper, Synops. Musc. Eur. 381. 1860. — *Bryum* sect. *Rhodobryum* (Schimp.) Husnot, Fl. Mouss. N. Ouest Ed. 2, 112. 1882. — Type: *Rhodobryum roseum* (Hedw.) Limpr. (cf. ANDREWS 1940).

Rhodo-Bryum Hampe, Linnaea 36: 517. 1870 (nom. inval. sine indic. basion. vel descr. gen.). — *R. subtomentosum* and *R. albo-limbatum* described.

Rhodo-Bryum Hampe, Linnaea 38: 663. 1874 (nom. inval. sine indec. basion. vel descr. gen.). — *R. leucocanthum* described (cf. FLORSCHÜTZ 1964: 190); however, because of the two other *Rhodo-Bryum* species described by HAMPE (1870) himself, this cannot be regarded as a *descriptio generico-specifica*, since the genus was not monotypic.

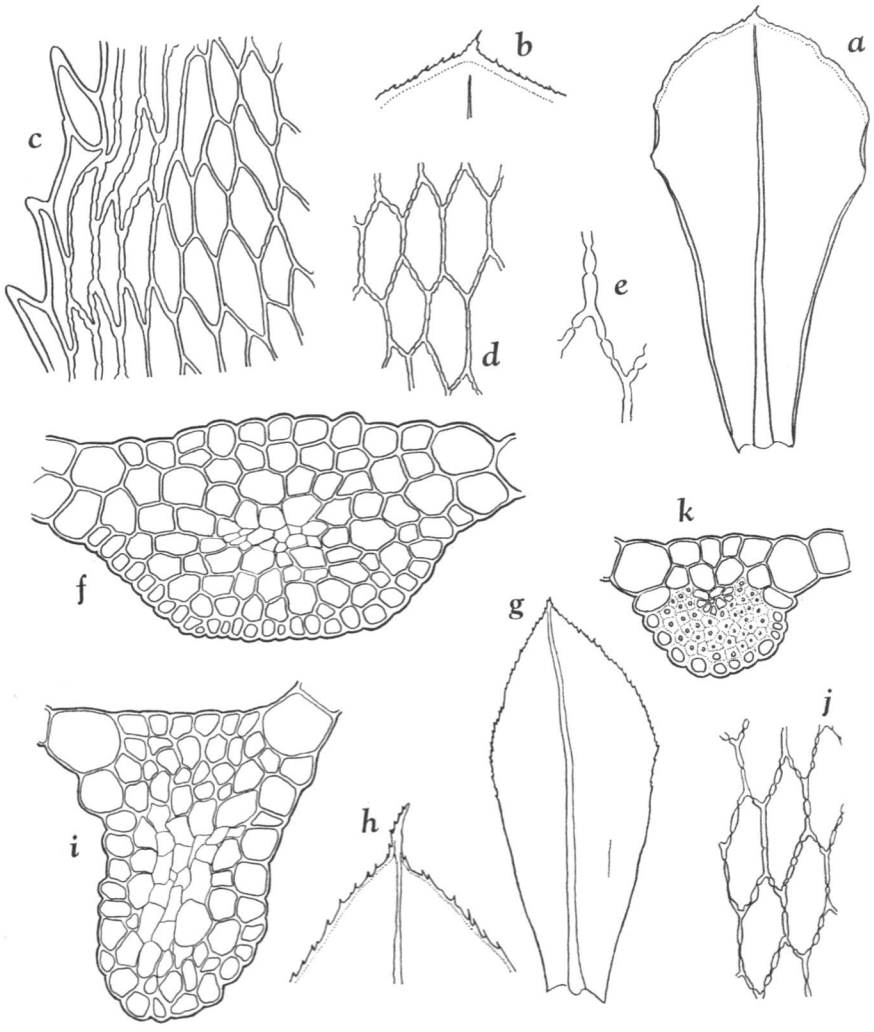


FIG. 4. *Rhodobryum laxe-limbatum* (Ochi) Iwats. et Kop. (a-f), *R. madurense* Dix. et de la Varde (g-j), and *Bryum truncorum* (Brid.) Brid. (k). — a, g. Leaves, × 6. — b. Leaf-apex, × 16. — c. Leaf-cells at margin, × 190. — d, j. Median leaf-cells, × 190. — e. Cell-wall of median leaf-cells, × 375. — f, i, k. Cross-section of costae, × 190. — h. Leaf-apex, × 19. — Figs. a-f were drawn from specim. from east Nepal, NICH 236094; figs. g-j from the isotype of *R. madurense;* fig. k from Sikkim, NICH 200735.

Bryum ontariense Kindb. was described in 1889 in two journals: March issue of Ottawa Naturalist and April issue of Bulletin of the Torrey Botanical Club. Both of the descriptions are exactly the same. KINDBERG did not cite any exact materials but wrote »quite common throughout Ontario». In 1892, he cited two of Macoun's specimens and one Dearness' specimen from Ontario

for this species. Kindberg's collections are preserved in Swedish Museum of Natural History (S-PA) and there the following specimen is kept as »Typus»: »184 *Bryum ontariense* Kindb. (ms) — *Br. roseum* Schreb. James & Lesq. Mosses N. Amer. 241, in part. Very common in Ontario on roots of trees, old logs, and rocks, fruiting at Ottawa. 1889. Ex herbario Lindberg.» In the National Herbarium of Canada (CAN), among Macoun's collections are two specimens of *R. roseum* collected in Ontario by Macoun before 1889: »Canadian Musci 184, on old logs in rich woods throughout Ontario (CAN 145198 ex herb. Geo. Lawson 1827—1895)» and »Belleville, Hastings Co., on rotten logs in wood, Sept. 17, 1868 (CAN 145191)». Also inscribed on the packet of no. 184 of Canadian Musci is the note: »184. *B. ontariense* Kindb. n. sp., fide Kindberg in lit. Jan. 14, 1889». Thus, Kindberg apparently examined no. 184 of Canadian Musci when he described the species, and there is no indication that Kindberg used the Belleville collection. By the reason mentioned above, we suggest the selection of no. 184 located in S-PA as the lectotype of *B. ontariense*. This is a good specimen with sporophytes, and the main stock was distributed by Macoun as Canadian Musci. Index Muscorum (Wijk, et al. 1967) gives the citation: »*R. ontariense* (Kindb.) Par. in Kindb., Eur. N. Am. Bryin. 2: 346, 1897» for this species. However, on that page, Kindberg did not write anything about Paris. Therefore, this species should be called as *R. ontariense* (Kindb.) Kindb. Later Paris (1898) made the same combination.

The nomenclature and the synonyms checked until now of *R. ontariense* are as follows:

Rhodobryum ontariense (Kindb.) Kindb., Spec. Europ. Northamer. Bryin. II: 346. 1897. — *Bryum* (*Rhodobryum*) *ontariense* Kindb., Ottawa Naturalist 2: 155. 1889 (March) and Bull. Torrey Bot. Club 16: 96. 1889 (April). — Lectotype (selected here): 'Very common in Ontario on roots of trees, old logs, and rocks, fruiting at Ottawa', 1889 Macoun (?) 184 (S-PA, isolectotype in CAN).

Bryum (*Platyphyllum*) *leptorhodon* C. Müll., Nuov. Giorn. Bot. Ital. n. ser., 3: 95. 1896. — *Rhodobryum leptorhodon* (C. Müll.) Par., Ind. Bryol. 1117. 1898. — Isotype: In monte Si-ku-tzui-san, prope Lao-iu-huo, China, 1894 Giraldi (C. Müller sub no. 863 in H-BR).

Bryum ptychothecioides C. Müll., Nuov. Giorn. Bot. Ital. n. ser., 4: 247. 1897. — *Rhodobryum ptychothecioides* (C. Müll.) Par., Ind. Bryol. Suppl. 300. 1900. — Isotype: China interior, prov. Schen-si septentr., prope Fu-kio, 1895 Giraldi (C. Müller sub no. 1422 in H-BR).

The following new combination is necessary (cf. p. 12):

Rhodobryum laxe-limbatum (Ochi) Iwats. et Kop., comb. nov.

Basionym:

Bryum laxe-limbatum Hampe ex Ochi, Journ. Jap. Bot. 43: 112. 1968.

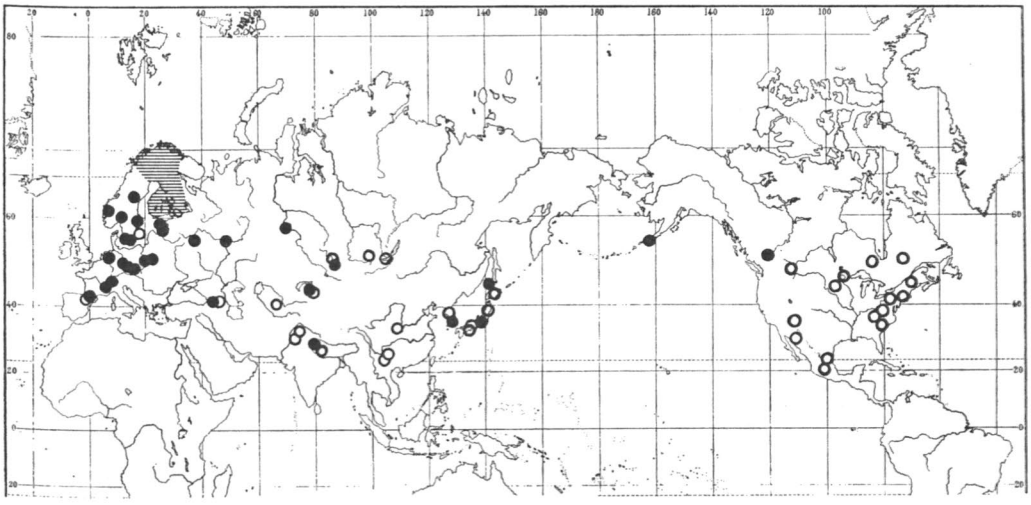


FIG. 5. World distribution of *Rhodobryum roseum* (●) and *R. ontariense* (○). Hatching indicates the area where *R. roseum* is frequent or scattered according to KOPONEN (1966). Only the specimens actually seen are shown on map.

V. Distribution and ecology of *R. roseum* and *R. ontariense*

The world distribution of the two species (Fig. 5) is summarized below, although more material should be studied in order to know their precise total range. Many of the records of »*R. roseum*» from Asia, Africa and South America should be confirmed. *R. roseum* has a continuous range in Europe from Scandinavia to the Pyrénées and occurs in scattered localities in the Caucasus, Kazakhstan, Altai, India, Siberia, Himalayas, Korea, Japan, Alaska, and British Columbia. The northernmost locality in Scandinavia is about 73° N. Lat. at northern tip of Norway, but it has not been recorded north of 62° N. Lat. in Siberia and North America. We did not see any specimens from North America east of the Rocky Mountains. Although the material from Siberia is scanty, it may suggest that *R. roseum* has a more or less continuous northern range from Europe through Asia to western North America with disjunct localities in the high mountains of Tyan Shan and the Himalayas.

On the contrary, *R. ontariense* seems to have a distinctly discontinuous southern distributional pattern. It is apparently common in eastern North America from Canada to Tennessee. This portion of its range may have a northern connection with another part along the eastern slope of the Rocky Mountains from Alberta to Mexico. We did not find any specimens of *R. ontariense* from west of the Rocky Mountains, although the identity of the

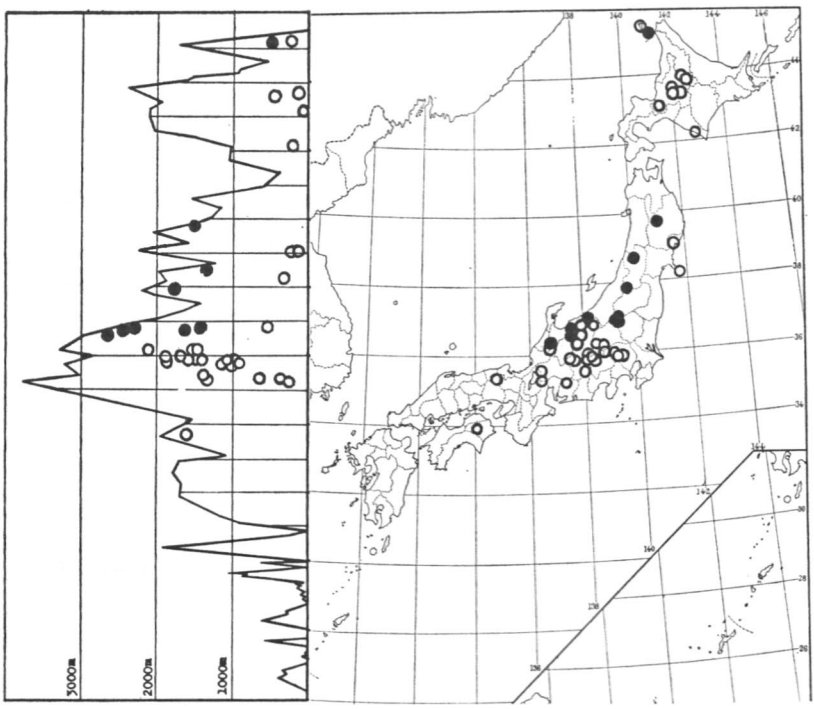


FIG. 6. Horizontal (right) and vertical (left) distribution of *Rhodobryum roseum* (●) and *R. ontariense* (○) in Japan. Vertical distribution is given where known.

records of *R. roseum* from California (BRITTON 1902) and *R. ontariense* from Oregon (DUVALL 1938) should be restudied. Its range in Japan, Korea, China, and the Himalayas is discontinuous, and it has disjunct outlying areas of occurrence in the Altai and the Caucasus. The two specimens discovered from Europe suggest that more material of »*R. roseum*» from that area should be studied and the same can be stated concerning North America. Compared with *R. roseum*, the range of *R. ontariense* extends more to the south, and does not occur north of 50° N. Lat. in both North America and Siberia. In areas where *R. roseum* and *R. ontariense* are sympatric, it is possible that there is a difference in their altitudinal occurrence; this is clearly shown in the Japanese material.

In Japan, ranges of these two species are rather clearly separated geographically as well as altitudinally (cf. Fig. 6). Both species are more frequently found in the northern half of Japan, but the range of *R. roseum* is limited to the Japan Sea side. Although, its altitudinal range is always above that of *R. ontariense*. The area facing the Japan Sea has much precipitation (snow) in winter in contrast to the Pacific side of the country which is wet in summer.

Thus, the range of *R. roseum* in Japan is limited to the deep snow areas. This illustrates a rare type of moss-distribution which also is characteristic of the range of *Claopodium crispifolium*, a moss found only in the Pacific Northwest of North America, Amur and Japan, the area sometimes referred to as »North Pacific» (cf. IWATSUKI 1971).

R. ontariense is rather widely distributed mostly in or below the deciduous, broad-leaved forest zone of central to northern Japan. Its distributional pattern is similar to those of *Aulacomnium heterostichum* and *Orthotrichum sordidum*, both of which have been found also in eastern North America and eastern Asia (cf. IWATSUKI 1958, 1971),

According to KOPONEN (1966) rich forests are the most typical habitats of *Rhodobryum roseum* in Finland where its distribution is primarily dependent upon soil conditions. The areas where it is of frequent occurrence coincide with the areas with fertile soils, and it is rare or absent in less fertile districts.

In Japan, most of collections were made on humus or soil in forest floor. Alaskan collections (Iwatsuki & Sharp nos. 1882, 1885) were made on humus, among other mosses (mostly *Brachythecium*), under *Alnus* thickets, in moist and shaded to partially shaded habitats.

R. ontariense is found on substrates different from those of *R. roseum*. They are soil (including those of bank, ground, and forest floor), humus, rocks, decaying logs, and trees. Throughout its distribution range, it is found more frequently in areas with calcareous rocks. It occurs on similar substrates in both Japan and eastern North America.

VI. List of the specimens

All the specimens of *R. roseum* outside of Europe are listed. Those of *R. ontariense* from N. America and Japan are selected as either taxonomically important or phytogeographically significant. However, all the Japanese specimens examined are mapped in Fig. 6. Abbreviations of the herbaria are according to LANJOUW & STAFLEU (1964). H-BR means the herbarium of V. F. Brotherus in H.

Rhodobryum roseum (Hedw.) Limpr.

U.S.S.R.

Kazakhstan. Jugum Tianschan Septentrionalis, Montes Kungej Alatau, humi in piceeto schrenkianae, 2100 m s. m, 1958 Lisowski (Musci asiae mediae exs., NICH).

Caucasus. Cathalinia. Distr. Gori, Bakuriani, 1916 Leptschenko (H-BR).

Russia

Tyamen Reg. Tobolsk, 1905 Ivanowski 53 (H-BR).

Altai, lake Teletskoje, 450 m above the sea level, Abietum, on rotten wood, 1966 Bardunov (NICH).

India

Punjab, distr. Simla, Mashobra, 8000 ft., 1906 Long 7028 & 7221 (H-BR).

Taiwan

[SASAOKA (1928) reported *R. roseum* from Formosa. There is a specimen of *R. roseum* in H-BR sent by Sasaoka (coll. 1918 by Matsuda in Mt. Daibu) and determined by Brotherus. This specimen is *R. giganteum* with sporophytes.]

Korea

Mt. Chii, 1900 m alt., on rocks, 1960 Hong 11890 (NICH).

Japan

Hokkaido, Isl. Rishiri, ca. 500 m alt., 1954 Hasegawa 15918 (NICH).

Honshu, Iwate Pref., Mt. Iwate, on rock, 1480—1800 m alt., 1959 Takaki 21399; Yamagata Pref., Mt. Gassan, 1380 m, 1955 Suzuki A60 (NICH); Fukushima Pref., Nikko, Mt. Hiuchi, 2300 m alt., on humus, 1955 Kurachi 1975 (NICH); Gunma Pref., Nikko, Ozegahara, 1400 m alt., 1968 Miyawaki 34 (HIRO); same locality, 1952 Suzuki 131 (NICH); Niigata Pref., around the top of Mt. Myoko, 2400 m alt., 1953 Yano 1044 (chromosome number, n=11); Niigata Pref., Mt. Iide, 1860 m alt., on humus, 1953 Ando 14883 (HIRO); Toyama Pref., Okukurobe, 1963 Suzuki et al. 6065 (NICH); Toyama Pref., Mt. Tateyama, 2730 m alt., on humus, 1953 Ando 15577 (HIRO); Nagano Pref., Mt. Shirouma, 1950 Takaki 9499; Gifu Pref., Mt. Hakusan, 1950 Takaki 9376.

U.S.A.

Alaska. Alaska Pen.: along road between Russell Creek and Frosty Creek, 200—300 ft alt., south of Cold Bay, on humus, 1967 Iwatsuki & Sharp 1882 & 1885 (NICH, TENN); SE of Anchorage: near Johnson Pass on Seward Highway, 900—1000 ft alt., Chugach Nat. Forest, on humus, 1967 Iwatsuki & Sharp 88 (NICH, TENN).

Canada

British Columbia. Aleza Lake Forest Exp. Station, on cliff, 1957 Boas (UBC).

R. ontariense (Kindb.) Kindb.

Unless otherwise stated, the specimens listed below have been determined or reported as *R. roseum* (or *Bryum roseum*).

Sweden

Öland: Im Eschen-Ulmenwald bei Borkholm, 1959 Hübschmann (HIRO).

Spain

Pyrénées: Valle de Aron, 1909 Casares-Gil (H).

U.S.S.R.

Caucasus. Ad saxa in sylva, expositio NE, Potzkir, 1902 Woronow (H-BR); Dagestan, Gunib, 1916 Mirhzjeva (H-BR); Dagestan, distr. Awarsk, pr. Gimri, 3500 p, 1901 Alexeenko (H-BR); Borshom, Barishevzkoje utschalije, 1916 Voronichin (H-BR); Balta ad fl. Terek, 1881 Brotherus (H-BR); Atschara pr. fl. Rion, 1877 Brotherus (H).

Turkestan. Ando Dal-Boutschor-aral p. Kodan-ssjunie, 1885 Regel (H-BR).

Kazakhstan. Jugum Tianschan Septentrionalis, Montes Kungej Alatau, humi in Piceeto schrenkianae, 2100 m s. m, 1958 Lisowski (Musci asiae mediae exs., H (cf. *R. roseum*).

Russia.

Altay Territory. Biysk Büsd, Ongudai, 1909 Keller (H-BR). Irkutsk Reg.: Baikal in west part, bay Mukhor, Salicetum, on the ground, 1967 Bardunov (NICH); Vostochnyy Sayan, river Kara-Buren in middle part, Betuleto-Salicetum herbosum, on rotten wood, 1961 Bardunov (NICH); Krasnoyarsk Territory: Minusinsk, ad lacum Kisikul, 1880 Martianoff (H-BR); Minusinsk, Kusnetski Alatau, ad fl. Ssunschul 1886 Bartascheff (H-BR).

India

India orientalis, sine loc., leg. W. Bell (NY).

Punjab. Distr. Simla, 4500—5000 f, 1904 Hein (Bryotheca E. Levier 5578, H-BR); Simla, Armandale Gardens (packing material), 1900 (Bryotheca E. Levier 3962, H-BR); Kumaon, Shimla, Naini Tal, 1900 Luayal (ex Herb. Bot. Dept. N. India, H-BR); Kumaon, 6000', leg. Thomson? 395 (NY); Kumaon, Baus Tehsil, Pithoragarh, 4200 p, 1900 Kabir Khan (Bryotheca E. Levier 1774, H-BR); Kumaon, Almora, 5000 p, 1900 Kabir Khan Bryotheca E. Levier 1775, H-BR); near Rampur, 3000', 1848 Thomson (NY); Distr. Mussoorie, in latere septentr. montis Nag Tiba, 9000', 1900 Rhada Lal (Bryotheca E. Levier 4290, H-BR); Mussoorie, below Charleville Hotel, 5000', 1899 Gollan (Bryotheca E. Levier 4529, H-BR); Mussoorie, Lal Tiba, 7500—8000 ft., on soil, 1965 Iwatsuki & Sharp 11334 (NICH); Mussoorie area, Kempty Falls, alt. 4500 ft, on soil, 1965 Iwatsuki & Sharp 11358 (NICH); the same locality, on ground, 5000 ft, 1903 Bahadru (Bryotheca

E. Levier 5730, H-BR, NY); Murree, Rawalpindi Distr., 6000 ft 1933 Stewart 13398 (NY); Murree Hills, 7—8000', 1949 Stewart 23414 (NY); Naggar, Kulu, 6000 ft, 1930 Koelz 1516 (NY, NICH); Abbottabad, N.W.F. Province, 4000—5000', 1934 Stewart 13712 (NY).

Samana Range, NW Frontier, 1898 Hare (H-BR).

Kashmir. Jhelum Valley Rd., 4000 f, Stewart 12428a (NY); below Abiabad, Poouch side, 1932 Stewart 12013 (NY).

Nepal

Sine loco, leg. Wallich (NY).

Burma

Shantounggyce, 3400', Kurz 3336 (NY)

China

Tibet, Nubra, 11,000', 1848 Thomson (NY).

Schen-si sept., prope In-Kia-po, 1895 Giraldi (Bryotheca E. Levier, 1415 H-BR, NY); prope Fu-kio, 1895 Giraldi (Bryotheca E. Levier, C. Müller sub. no. 1422-isotype of *Bryum ptychothecioides* C. Müll. in H-BR); in monte Si-ku-tzui-san prope Lao-iu-huo, 1894 Giraldi (Bryotheca E. Levier, C. Müller sub. no. 863-isotype of *Bryum leptorhodon* C. Müll. in H-BR); Lun-san-huo, inter rhizomata Polypodii, 1895 Giraldi (Bryotheca E. Levier, det. by C. Müller sub. no. 1422b as *B. leptorhodon* in H-BR); in monte Thai-pei-san, 1895 Giraldi (Bryotheca E. Levier, det. by C. Müller sub. no. 1422 ter. as *B. nanorosula* C. Müll. in H-BR).

Setschwan austro-occid. Prope castellum Kwapi ad septentr. oppidi Yenyüen, 27°53', in regionis calide temperatae, terra silvae, 1914 Handel-Mazzetti 2769 (H-BR).

Korea

Korean Nat. Forest, 18 miles NE of Seoul, on shaded bank of brook, 1954 Byers (NICH).

Japan

Hokkaido. Isl. Rebun, Momoiwa, 1954 Shimizu (NICH 21625); Ishikari, Antaroma, on decayed logs, 1955 Sasaki (Musci Japonici Exsic. 644, H, NICH); Kamikawa Distr., Asahikawa-shi, Kamui-cho, Kamui-kotan, along small creek in temperate deciduous (*Acer-Magnolia-Quercus*) wood, ca. 120 m alt., 1970 Koponen 12428 (H, NICH); Ishikari, Mt. Ashibetsu, Yufure valley, 400—600 m alt., on tree, 1970 Mizutani 881 (NICH).

Honshu. Iwate Pref.: Ofunato, Higoroichi, on limestone boulders in a deciduous forest, ca. 150 m alt., 1961 Mizutani (Musci Japonici Exsic. 894, H, NICH); Iioka-mura, 1911 Okamura (NICH 37348); Miyagi Pref.: Isl. Kinkazan, 1908 Uematsu 470 (H); Saitama Pref.: Mt. Buko, 1950 Takaki 13318; Nagano Pref.: Mt. Yatsu, on soil in open place, ca. 1900 m alt., 1954 Iwatsuki (Musci Japonici Exsic. 445, H, NICH); Kitasaku-gun, Fusemura, 1912 Okamura (NICH 37346); Kamiina-gun, Miwa-mura, 1000—1100 m alt., on limestone, 1952 Takaki 11650; Igire, 1950 Kubota in herb. Takaki 25619; Mt. Ontake, Ohtaki-guchi, ca. 100 m alt., on shaded humus, 1953 Noguchi 32124; Kirigamine Plateau, Kannonzawa, 1500 m alt., 1950 Takaki 8823; Aichi Pref.: Nishi-mikawa, Komayama, 1951 Takaki 10214; Shiga Pref.; Mt. Ibuki, 700 m alt., on exposed limestone, 1964 Takaki 29924; Sakata-gun, Samegaimura, Mt. Ryozen, Ashira-dani, 200 m alt., limestone area, 1964 Takaki 29823; Tottori Pref.: Yazu-gun, Wakasa-machi, Tsukuyone, Mt. Hyōnosen, ca. 600 m alt., sine dat., Ochi 929 in herb. Noguchi 66368.

Shikoku. Tokushima Pref.: Mt. Tsurugi, 1700 m alt., on limestone, 1954 Yamanaka & Inoue in herb. Noguchi 33711.

Canada

Ontario. Very common in Ontario on roots of trees, old logs, and rocks, fruiting at Ottawa, 1889, Macoun? no. 184 (lectotype of *Bryum ontariense* Kindb. in S-PA); »on old logs in rich woods throughout Ontario» (Macoun, Canadian Musci no. 184-isolectotype of *B. ontariense* in CAN 145198); Belleville, Hastings Co., on rotten logs in woods, 1868 Macoun 627 (CAN 145191). Thunder Bay Distr.: Kaministiquia River at Kakabeka Falls, Paipoonge Twp, moist rich woods on logs and rich peat, 1954 Garton (CAN, NICH); Hell Holes, along Salmon River near Roblin, Lennox and Addington Co., side of shaded limestone boulder, 1964 Crum 261 (CAN, NICH).

Alberta. Bow River Watershed, mixed with grasses, under *Salix*, east-facing slope, beside Cochrane-Nordegg Road, N8-27-7-W5, on Bar C Ranch, ¼ mile south of Forest Reserve Gate, 1964 Bird 9244 (UAC, NICH, UBC).

Quebec. Gatineau Hills, vicinity of Kingsmere and Old Chelsea, 45—31 N., 75—50 W, on thin humus over granite, 1954 Crum 2802 (CAN, NICH).

U.S.A.

Michigan. Alpena Co.: on limestone boulder on slope of 1st sink, limestone sink holes near Leer, 1957 Iwatsuki 1263 (NICH). — Vermont. Oreans Co.: Barton Landing, Swamp, 1908 Winslow (NICH). — Minnesota, Winona Co.: on a horizontal elm trunk in a moist shaded place, 1901 Grout 146 a, and over a well shaded lime boulder in the wooded north-facing bluff near Winona, 1902 Holzinger, 146b (both in Holzinger, Musci Acrocarpi Boreali-Americani no. 146 in NICH). — Iowa, Allamakee Co.: Post Township, Section 2, *Abies* grove, 1945 Conard (CAN, NICH). — Tennessee, Van Buren Co.: bottom of Fall Creek gorge, ca. 2000 ft alt., on sandstone, 1957 Iwatsuki 598 (NICH); Blount Co.: side of the little River, near Townsend, on limestone bluff, 1956 Sharp & Iwatsuki 352 (TENN, NICH). — Arizona, Pima Co.: Santa Catalina Mountains, ravine near top of Mt. Lemmon, 9000 ft, on bank, 1923 Bartram 50 (NICH); Apache Co.: Phelps Botanical Area, 9500 ft, moist soil below beaver dam, 1949 Phillips (ARIZ, UBC).

Mexico

Tamaulipas, Rancho del cielo above Gomez Farias, vertical surface of cliff, 1970 Sharp 3570 (TENN, NICH); Hidalgo, above Chapulhuacan, 3500 ft, moist crevices of dolomite?, 1944 Sharp 1544 (TENN, NICH); above Real del Monte, near Pachuca, 9600 ft, soil on ridge, 1944 Sharp 816 (TENN, NICH).

R. laxe-limbatum (Ochi) Iwats. et Kop.

India

Darjeeling Distr.: Lebong, 5000 p, 1900 Hartless (Bryotheca E. Levier, 2291, H-BR).

Nepal

East Nepal, Yamphodin-Ghatte, alt. 1600—2100 m, 1963 Kanai, Murata & Togashi (NICH 236880a & 236924); Hati Sar-Mangalbare-Lam Pokhari-Michin Dhap, alt. 2600—3000 m, 1963 Hara, et al. (NICH 236064 & 236094).

R. curranii Broth.

Philippines

Luzon, Benguet Prov., 1908 Curran 15635 (isotype in NY).

R. madurense Dix. et de la Varde

India

Madura, upper Palnis, 1929 Foreau (herb. Dixon 1189, isotype in NICH).

Summary

The species commonly known as *Rhodobryum roseum* is shown to include two distinct taxa, *R. roseum* s.str. and *R. ontariense*. They can be separated, e.g., through the number of comal leaves in one rosette, shape of leaves and the structure of costa (Table 4). The characters of the costa, the clear terminal rosette, polysety and subterranean stolons, among others, are characters common to these species and to *R. giganteum* and *R. laxe-limbatum*, and they form a distinct genus, *Rhodobryum* s.str.

R. roseum is distributed from Europe through Asia to western North America (Fig. 5). No specimens from eastern North America were seen where *R. ontariense* is common. The range of *R. ontariense* is more southern than the range of *R. roseum*, and in Japan at least there is a clear difference in their altitudinal distribution (Fig. 6).

Both of the species are mainly species of woodlands growing on soil, humus, rotten wood, etc. *R. ontariense*, however, occurs more often on calcareous substrata and has often been recorded growing on limestone cliffs.

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