Taxonomic studies on *Cryphaea* (Cryphaeaceae, Bryopsida). 2. Revision of Asian species

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Seven species in the moss genus *Cryphaea* Mohr (Cryphaeaceae) are recognized for Asia. *Cryphaea clandestina* Enroth, *C. lanceolata* P. Rao & Enroth, *C. obovatocarpa* Okam., and *C. songpanensis* Enroth & T. J. Kop. are restricted to southeast Asia, *C. omeiensis* Rao *sp. nova* is described from Sichuan Province of China, *C. amurensis* Ignatov occurs in the far east of Russia, and *C. heteromalla* Mohr, a largely European species, is in Israel and Turkey. A key to the species and a distribution map of all species except *C. heteromalla* are given. *Cryphaea sinensis* Bartr. is transferred to the genus *Sphaerotheciella* Fleisch. as *S. sinensis* (Bartr.) P. Rao *comb. nova*.

Key words: Asia, Bryopsida, *Cryphaea*, distribution, nomenclature, *Sphaerotheciella*, taxonomy

This paper is a revision of all species of *Cryphaea* Mohr reported from Asia. Wijk *et al.* (1959) listed five species for Asia: *C. borneensis* Bartr. (Bartram 1936), *C. henryi* Thér. (Henry 1928), *C. leveillei* Thér. (Thériot 1907), *C. obovatocarpa* Okam. (Okamura 1911), and *C. sinensis* Bartr. (Bartram 1935). *Cryphaea borneensis* was transferred to *Cyptodontopsis* Dix. by Iwatsuki (1969), and the same was done with *Cryphaea leveillei* by Rao and Enroth (1999), who treated *C. henryi* as the latter's taxonomic synonym. The mainly European *C. heteromalla* Mohr was recorded from Istanbul, Turkey by Robinson and Godfrey (1960), and later from Israel by Herrnstadt *et al.* (1982). Enroth (1990) described *C. clandestina* Enroth

from New Guinea, and *C. amurensis* Ignatov was described by Ignatov and Czerdantseva (1995) from far east of Russia. *Cryphaea songpanensis* Enroth & T. J. Kop. was described by Enroth and Koponen (1997a, 1997b) from China. Recently, Rao and Enroth (1999) described yet another species from China, *C. lanceolata* P. Rao & Enroth. In the present paper, a new species *C. omeiensis* P. Rao is described and illustrated from China.

The species are treated in alphabetical order. For convenience, all species are fully described. However, only *Cryphaea amurensis*, *C. clandestina*, and *C. omeiensis* are illustrated, because *Cryphaea lanceolata*, *C. obovatocarpa*, *C. songpanensis*, and *C. sinensis* were already illustrated by Rao and Enroth (1999), and *Cryphaea heteromalla* will be treated in detail in a forthcoming paper by me, because it is mainly distributed in Europe. To make comparison and identification of the seven species easier, their stem leaves, branch leaves, inner perichaetial leaves, and capsule shapes are compared in Fig. 1. Their geographic distributions (for *C. heteromalla*, only Asian localities) are presented in Fig. 2.

Key to the Asian species of Cryphaea

1. Leaf apices contracted into an arista (costa excurrent) C. clandestina Leaf apices not contracted into an arista.....2 1 2. Plants less than 1.5 cm tall; stem leaves 0.8-0.9 mm long C. songpanensis 2. Plants larger; stem leaves longer than 1.2 mm 3 3. Linear laminal cells extending from leaf base to above 2/3 the leaf length, distinctly prorate; costa relatively weak, reaching only 0.25–0.6 the leaf length C. amurensis 3. Linear laminal cells restricted to the leaf base, cells smooth or indistinctly prorate; costa stout, reaching 4. Leaf apices narrowly acuminate; costa of stem leaves percurrent, costa in branch leaves relatively much shorter than in stem leaves 5 4. Leaf apices acute; costa of stem leaves not reaching the apex, costa of equal relative length in branch and stem 5. Leaves abruptly acuminate from an ovate base; linear basal laminal cells prorate; costa of inner perichaetial leaves tapering downwards C. omeiensis 5. Leaves gradually acuminate; linear basal laminal cells smooth or indistinctly prorate; costa of inner perichaetial leaves tapering upwards C. lanceolata 6. Leaves ovate (oblong)-acute, leaf margins plain; laminal cells distinctly prorate; costa of perichaetial leaves disappearing below apex C. obovatocarpa Leaves elliptic-acute, concave, leaf margins recurved; 6. laminal cells not distinctly prorate; costa of perichaetial leaves excurrent as a short arista C. heteromalla

Cryphaea amurensis Ignatov (Figs. 1–3)

Arctoa 4: 69. *fig. 1.* 1995 — Holotype: Russia. Khabarovsk Territory, Dusse-Alin Range, Bureya Reserve, Levaya Bureya River Valley 2 km upstream the mouth of Chapkhoz Creek, mossy spruce forest, on bark of *Abies*, 590 m alt., 51°40'N, 134°22'E, 16.VIII.1989 *O. V. Grigorjeva 89-M*-88 (MHA!)

Plants bright green to brownish. Stolons creep-

ing along tree trunk. Stems erect or sometimes curved at the tip, ca. 1.5-2.4(-3.2) cm long, rarely branched. Branches short, ca. 0.5-1.0(-1.5) cm long. Stem leaves oblong-acuminate, concave at base, ca. $1.5-1.7 \times 0.6-0.7$ mm. Leaf margins crenate in the upper 1/3-1/2 of the leaves, entire below, recurved in the lower 2/3. Costa weak, sometimes furcate, ending at 0.25-0.6 of the leaf length. Leaf cells incrassate, basal and median laminal cells linear, extending to above 2/3 the leaf length, ca. $20-30 \times 4-8 \mu$ m, distinctly prorate; alar cells rounded or subquadrate, ca. $8-14 \mu$ m across. Pseudoparaphyllia filamentous, $100-150 \mu$ m long.

Autoicous. Perigonia solidary, bud-like, perigonial leaves ovate, ecostate. Perichaetia lateral, usually 3-5, in clusters. Outer perichaetial leaves with acuminate apex, ecostate to partly costate; laminal cells prorate, upper laminal cells oblong. Inner perichaetial leaves with long arista (ca. 1/3 the leaf length); cells prorate. Capsules oblongovoid, ca. 0.9 mm long, mostly 3-5, usually growing in two rows on one side of the stems or branches. Seta ca. 0.12-0.2 mm long. Peristome double, hyaline, exostome teeth ca. 170-180 µm long, papillose above, almost smooth below; endostome slightly papillose above, smooth below. Columella persistent, ca. 3/5 the capsule length. Operculum conic. Calyptra mitrate, coarsely papillose above. Spores ca. 26 (22-29) µm, papillose.

The leaf shape of this species is similar to that of *Cryphaea obovatocarpa*. However, *C. amurensis* is smaller (stems 1.5–1.7 mm long), and the linear laminal cells extend from the leaf base to the upper part of the lamina. The leaf cells are distinctly prorate, and the apical cells are linear rather than rounded to rhombic as in *C. obovatocarpa*. The costa is weaker and shorter, reaching to ca. 1/2 of the lamina, and the leaf margin is recurved in *C. amurensis*, but plain in *C. obovatocarpa*. The arista of inner perichaetial leaves is longer, ca. 1/3 the leaf length. Additionally, the spore diameter in *C. amurensis* is only ca. 22– 29 µm, while that of *C. obovatocarpa* is 45– 50 µm.

Illustrations: Ignatov & Czerdantseva 1995: 68 (fig.1).

HABITAT. On tree bark or trunk

DISTRIBUTION. Endemic to Russia (Khabarovsk).



Fig. 1. Comparison of stem leaves (A), branch leaves (B), capsule (C), and inner perichaetial leaves (D) of Asian *Cryphaea* species. Use the longer scale for leaves and inner perichaetial leaves, and the shorter scale for capsules. — a: *C. amurensis* Ignatov. — b: *C. clandestina* Enroth — c: *C. heteromalla* Mohr. — d: *C. lanceolata* P. Rao & Enroth. — e: *C. obovatocarpa* Okam. — f: *C. omeiensis*. P. Rao. — g: *C. songpanensis* Enroth & T.J. Kop.

Additional specimens examined: **Russia**. Khabarovsk Territory. Verkhnebureinskij Distr. Tastakh Creek mouth, right bank of Bureya River, 430 m on *Abies*, 1997 *M. Ignatov* 97-261 (MHA); Verkhnebureinskij Distr., Bureinskij State Reserve, Levaya Bureya River near Vankish Creek mouth, 700 m, on trunk of *Alnus*, 1997 *M. Ignatov* 97-263 (MHA);



Fig. 2. Distribution of *Cryphaea amurensis* Ignatov (\blacklozenge), *C. clandestina* Enroth (\Box), *C. heteromalla* Mohr (\blacktriangle ; only Asian localities shown), *C. lanceolata* P. Rao & Enroth (\circ), *C. obo*vatocarpa (\bullet), *C. omeien*sis P. Rao (\blacksquare), and *Cryphaea songpanensis* Enroth & T.J. Kop.(\bigstar)

Verkhnebureinskij Distr., Bureinskij State Reserve, right bank of Pravaya Bureya River near Umalta-Makit Creek mouth (station of reserve), 550 m, on *Populus* trunk in forest in flood-valley, 1997 *M. Ignatov* 97-267 (H); Verkhnebureinskij Distr., Bureinskij State Reserve, right bank of Pravaya Bureya River, 4 km upstream from the junction with Levaya Bureya River, 570 m, on trunk of *Populus* in conifer forest, 1997 *M. Ignatov* 97-269 (H).

Cryphaea clandestina Enroth (Figs. 1, 2 and 4)

Ann. Bot. Fennici 27: 183. *fig. 3a–i.* 1990. — Holotype: Papua New Guinea. Morobe Prov., 3 km W of Lake Wamba (5 km S of Tep-tep Airstrip), in very wet rainforest along major stream W of first ridge from Lake Wamba, 2 400 m, 146°31′E, 6°00.5′S, moist, rather sunny twigs overhanging river, 25. VII.1981 *D. H. Norris 64675* (H!). Paratypes: Same locality and date, on moist, diffusely lit twigs, *D. H. Norris 64720* (H!). Morobe Prov., Lake Wamba 5 km S of Teptep airstrip, heavily disturbed (pigs) montane forest with large *Pandanus* trees S of lake, 2 400 m, 6°01′S, 146°33′E, on decaying bush, 23.VII.1981 *T. Koponen 33439* (H!).

Plants light yellow to yellowish green, slightly glossy, slender, 1–5 cm tall. Stolons creeping, bearing small, scale-like, ecostate leaves and reddish brown, smooth, unbranched rhizoids. Stems fairly delicate, scarcely branched. Stem leaves erect-patent when dry, spreading when wet, ca. $1.7-2.0 \times 0.5-0.7$ mm, narrowly-ovate lanceolate, decurrent at base. Leaf margins slightly recurved to about mid-leaf, serrulate in the upper half of leaves, crenate to entire below. Costa single, excurrent. Leaf apex contracted into a short arista. Leaf cells incrassate; lumen smooth but cells minutely prorate; basal central lamina cells linear to linear-rhomboidal, extending to above 1/2 of leaf length, but the cells gradually getting shorter and wider along central part up, without sharp demarcation in transitional area, ca. $20-30 \times 4-5 \ \mu m$. Pseudoparaphyllia filamentous, usually 3–4 cells long, unbranched.

Autoicous. Perigonia solitary, bud-like. Outer perigonial leaves ovate, ecostate, inner ones becoming gradually smaller, the innermost narrowly ovate with a percurrent costa. Perichaetia pseudolateral, often 2–3 in clusters; costae of outer perichaetial leaves percurrent to short-aristate, upper lamina cells linear; inner perichaetial leaves sheathing, hyaline in alar areas, yellowish elsewhere, ca. 1.7-2.5 mm long, the aristae gradually getting longer in inner leaves, in the innermost ones even longer than lamina, laminal cells linear, minutely prorate, lumen smooth. Capsule elongate ovoid, 0.8–1.1 mm long; stomata absent; exothecial cells thin-walled, irregular. Seta very short, ca. 0.05 mm. Peristome double, brownish; exostome teeth ca. 240 µm long, lanceolate; en-



dostome segments distinctly papillose. Columella persistent, ca. 2/3 the length of capsule. Operculum ca. 0.3 mm high, broad conical-rostellate. Calyptra mitrate, ca. 0.4 mm high. Spores 22– 25 μ m in diameter, finely papillose.

This is a peculiar species with the leaf apex contracted into an arista, a character readily distinguishing it from all other Asian *Cryphaea* species. The leaf margins are serrulate in the upper half of leaves, entire below. The central and upper laminal cells are linear-rhomboidal. ILLUSTRATIONS: Enroth 1990: 183 (fig. 3).

HABITAT. In rain forest, on twigs overhanging river and on decaying bush, at 2 400 m.

DISTRIBUTION. Endemic to Papua New Guinea (Morobe Prov.).

Cryphaea heteromalla (Hedw.) Mohr (Figs. 1 and 2)

in Web. Tab. Synop. Musc. 1814. — Neckera heteromalla Hedw., Spec. Musc. 202. 1801. — Daltonia heteromalla



Fig. 4. Cryphaea clandestina Enroth (from holotype, H). — a: Stem leaves. b: Branch leaves. - c: Leaf apex. - d: Basal central lamina cells. — e: Alar cells. - f: Marginal cells at midleaf. - g: Upper lamina cells. - h: Inner perichaetial leaf. - i: Capsule. — j: Operculum. — Use the upper 1 mm scale for a and b, the left lower 1 mm scale for i, the right lower 1 mm scale for h, and the 50 µm scale for c-g.

Hook. & Tayl., Musc. Brit. 81. 1818. — *Pilotrichum heteromallum* (Hedw.) Fürnr., Flora 10 (Beibl.1): 82.1827.

Pilotrichum arboreum P. Beauv., Prodr. 37. 1805. — *Cryphaea arborea* (P. Beauv.) Lindb., Öfv. Finska Vet. Akad. Förh. 20: 392. 1863.

Plants yellowish green, stout. Stolons creeping along tree trunk or branches. Stems erect, ca. 1.0– 2.5 cm long, scarcely branched. Stem leaves oblong-acuminate, concave, ca. $1.5-1.8 \times 0.5-0.9$ mm. Leaf margins entire, or slightly crenate on apex, recurved in lower 1/2. Costa stout, ca. 50 µm wide at base, 25 μ m wide at the end, reaching at 0.6– 0.75 the leaf length. Leaf cells incrassate, basal central laminal cells rectangular, ca. 16–50 × 6– 10 μ m, restricted to the lower 1/15; cells in other parts round to elliptic, ca. 6–10 × 7–14 μ m, not or faintly prorate. Branch leaves similar to stem leaves, but cells distinctly prorate. Pseudoparaphyllia filamentous, 100–140 μ m.

Autoicous. Perigonia solidary, bud-like, perigonial leaves ovate, ecostate, laminal cells prorate. Perichaetia lateral, usually 8–12, growing on one side of stems or branches (in two rows). Outer perichaetial leaves with acuminate apex, costa strong, tapering upwards, disappearing below apex; laminal cells rectangular in the lower portion, gradually becoming ellipical in the upper portion, minutely prorate (almost undiscernably) in the apex area, smooth elsewhere. Inner perichaetial leaves aristate (ca. 1/6 the leaf length), cells prorate. Capsules oblong-ovoid, ca. 1.1-1.6 mm long. Seta short, ca. 0.15-0.18 mm. Peristome double, yellowish, exostome teeth ca. 360 µm long, 60 µm wide at base, densely papillose; endostome ca. 360 µm long, densely papillose. Annulus formed of a tier of thin-walled cells. Columella persistent, ca. 2/3-3/4 the capsule length. Operculum conic. Calyptra mitrate, ca. 0.65 mm high. Spores ca. 15 (10–18) μ m, finely papillose.

ILLUSTRATIONS: Wilson 1855: tab. XXII; Berkeley 1863: pl. 3, fig. 3; Braithwaite 1905: t. CXXIVc, as *Cryphaea arborea*; Smith 1978: fig. 242. 5–7.

HABITAT. Trunk of tree.

DISTRIBUTION. Africa (Wijk *et al.* 1959), Asia (Israel, Turkey), Europe.

SELECTED SPECIMENS EXAMINED: **Turkey**. Istanbul Prov. Trunk of oak tree, deciduous forest at Istanbul Univ., School of Forestry. N of Istanbul, near the Black Sea coast. 24.X.1952 *R. K. Godfrey* GH-1160C (DUKE). **Italy**. Peninsula Istria, ad arborum campestrium (*Acer, Ulmus*) truncos prope lacum "Cepic-See" (Lago d'Arsa), ca. 30 m s. m., sociis *Tortula laevipilaeformi, Orthotricho tenello, Leucodonte sciuroide, Anomodonte viticuloso, Leskea polycarpa et aliis*, m. Apr. fr., *J. Baumgartner* (H). **Austria**. Küstenland, Isonzo- und Wippach-Tal, an alten Pappeln und Weiden, Strazig bei Görz, März 1903, Ranziano a. d. Wippach, Mai 1903 *K. Loitlesberger* (H).

Cryphaea lanceolata P. Rao & Enroth (Figs. 1 and 2)

Bryobrothera 5: 179. *fig.* 2. 1999. — Holotype: China. NW Sichuan, Minshan Range, Nanping Co., Bia-He River valley 70 km SW of Nanping City and 3 km NE from Jiu-Dao-Guai Bridge, orotemperate *Betula utilis-Fraxinus-Prunus-Tilia* forest, alt. 2 480–2 510 m, 33°14′N, 103°46′E, on branch of fallen trunk of recently cut deciduous tree, 19.IX.1991 *T. Koponen 46842* (H!).

Plants light green to dark brown. Stems erect, up to 5 cm high, reddish to dark brown. Branches pinnate, ca. 1.5–2 cm long. Stem leaves ca. 1.8– 2.0×0.36 –0.4 mm, lanceolate, concave, decurrent, imbricate when dry, erect-patent when wet; leaf apex acuminate. Leaf margins serrulate to slightly crenate in the upper 1/3 of leaves, entire elsewhere, recurved in the lower ca. 2/3. Costa strong, reaching 0.7-0.9 the leaf length, ca. 60-70 µm wide at base, tapering upwards. Leaf cells relatively uniform but the apical cells longer (ca. $12-24 \times 7-8 \mu m$) than subjacent ones, irregular, laminal cells ca. $10-16 \times 7-8 \mu m$, ovate, rectangular or rhomboidal, marginal cells slightly shorter; alar cells indistinct, similar to marginal cells, quadrate or rounded; basal laminal cells ca. 25- $50 \times 8-9 \,\mu\text{m}$, oblong to linear, minutely prorate. Branch leaves smaller than stem leaves, ca. $1.3 \times$ 0.55 mm, their shape similar to stem leaves, but cells more distinctly prorate especially in the upper portion of lamina, and costa shorter, not percurrent; secondary branches sometimes developed, up to 1 cm long. Pseudoparaphyllia filamentous, uniseriate, ca. 100 µm long.

Autoicous. Perigonia solidary, bud -like. Perigonial leaves ovate, ca. 0.35-0.70 mm, ecostate, laminal cells thick-walled. Perichaetia solidary, or 2-5 in clusters. Outer perichaetial leaves ca. 1.1-1.8 mm. long, broadly lanceolate; apex acuminate; margins incurved; costa reaching ca. 3/5 leaf length; laminal cells linear in the inner part, shorter in the marginal part, prorate. Inner perichaetial leaves ca. $2.5-2.7 \times 0.7-0.8$ mm, broadly oblong; apex abruptly narrowed to an arista, which is slightly shorter than lamina; margins hyaline on both sides; cells linear or long-rectangular, minutely prorate, basal cells incrassate, brownish, mostly with 2-3 internal papilla-like thickenings; costa strong, excurrent, the excurrent part ca. 1/3-1/2 of the leaf length. Capsule ca. 1.2×0.8 mm, ellipsoid; stomata absent; exothecial cells thinwalled, irregular. Seta ca. 0.15 mm. Peristome double, very fragile and easily broken; exostome teeth ca. 250–270 µm long, lanceolate, smooth below, papillose above; endostome segments shorter, narrow lanceolate to linear, densely papillose. Annulus consisting of a tier of thin-walled cells. Columella persistent, very long, connecting with operculum, with a swollen tip. Operculum conic, smooth. Calyptra not seen. Spores 25-35 µm, papillose.

ILLUSTRATIONS: Rao & Enroth 1999: 180 (fig. 2).

HABITAT. Epiphytic, on tree branches and trunks.

DISTRIBUTION. Endemic to China (Sichuan, *Hubei, *Hunan).

Additional specimens examined: China. Hubei Province. Shennongjia Forest District, along the trail from Qiujiaping towards Laojun Mt., disturbed valley with Pinus and Fagus above 2 000 m, 1 446-2 150 m., on tree, 3.IX.1980 Sino-Amer. Exped. No. 663ga (MO); Mt. Shennongjia mountain behind Gui-Zhu-Yuan lumbering bridge in scattered grass, broad-leaf forest, 1 600-1 700 m, on bark of tree, VI-VII 1976 P. C. Wu 472a (MO); Shennongjia Forest District, between Dalongtan and Tianchi Pass, disturbed Abies-Picea-Pinus forest with rocky cliffs, 2 150-2 400 m, on lower, shaded trunks of gymnosperms (Abies or Picea), 9.IX.1980 Sino-Amer. Exped. No. 916 A-2 (NY). Hunan Province. Shi-Men Co., Hu-Ping-Shan, Pinus (seeded from airplanes), Euonymus, Rosa, Miscanthus low forest deciduous-evergreen mixed bush, mid-subtropical zone, 1 800-1 860 m, 30.IX.1998 T. Koponen, S. Huttunen, S. Piippo & P.-C. Rao 54034 (H).

Cryphaea obovatocarpa Okam. (Figs. 1 and 2)

Bot. Mag. Tokyo 25:135. *fig. 4.* 1911. — Syntypes: Japan. Prov. Tango, Maruda in Maruyae-mura, Kasa-gun, 28.V.1910 and 10.I.1911 *Kishida* (not seen); Tango, Maruda in Maruyae-mura, 10.I.1911 *S. Okamura* (PC-Cardot!).

Plants relatively robust, ca. 4 cm tall. Stolons creeping along tree trunk or branches. Stems erect, with four to eight branches in the upper part. Stem leaves imbricate when dry, spreading when wet, ovate or oblong below, acuminate above, decurrent, concave, $2.2-2.4 \times 1.0-1.3$ mm. Leaf margins crenulate above, entire elsewhere. Costa single, extending to ca. 0.67 the leaf length. Leaf cells relatively uniform, incrassate, often with papilla-like internal thickenings and occasionally (especially juxtacostal cells) prorate, ca. 8-10 µm and rounded or hexagonal near margins, inner laminal cells ca. 10-12 µm, becoming linear towards base, where ca. $45 \times 10 \ \mu\text{m}$; basal cells brownish usually in one row; alar cells weakly differentiated. Branch leaves similar to stem leaves, but distinctly prorate (especially in the upper portion of lamina). Pseudoparaphyllia filamentous, ca. 200-250 µm long.

Autoicous. Perigonia usually single, borne in the branch axils; perigonial leaves ovate, with a short apiculate apex, ecostate, laminal cells prorate. Perichaetia usually 3-6, in clusters on one side of stems and branches. Outer perichaetial leaves ovate (-oblong) acuminate, costa ca. 0.1–1 the leaf length, cells distinctly prorate. Inner perichaetial leaves oblong, acuminate at apex, ca. 2–3.2 mm long, concave; the margins incurved, crenulate above, entire elsewhere; costa percurrent, tapering upwards, disappearing below apex; laminal cells linear, prorate; basal cells brownish, with 0-3 internal papilla-like thickenings per cell. Capsule narrowly ellipsoid, ca. 0.8–1.0×0.5– 0. 6 mm; stomata not seen; exothecial cells rectangular, irregular form or fused, densely papillose. Seta ca. 0.08 mm long. Peristome double; exostome teeth linear, ca. 250 µm long, papillose; endostome segments linear, as long as the exostome teeth, papillose. Annulus formed of a tier of thin-walled cells. Columella persistent, reaching ca. 1/2 the capsule length. Operculum conic, obtuse, smooth. Calyptra mitrate, almost smooth, ca. 0.55 mm high. Spores ca. $45-50 \mu$ m, papillose.

ILLUSTRATIONS: Okamura 1911:136 (fig. 4); Noguchi 1989: 623 (fig. 277B); Chiang 1996: 90 (fig. 1); Rao & Enroth 1999: 182 (fig. 3).

HABITAT. Epiphytic on tree trunks.

DISTRIBUTION. China (Taiwan; fide Chiang 1996, specimen not seen), Japan

Additional specimens examined: Japan. Honshu, 11.XI.1951 N. Takaki (H). Aichi Prefecture, Adera, trunks of trees, 25.I.1949 N. Takaki 5587 (MICH, S); Aichi, Kitashidara, Ôno, on bark of trees, 25.I.1949 N. Takaki 69 (F). Gifu Prefecture. North of Gifu, on Morus alba in mulberry field, ca. 200 m. s. m., Inui, 25 km. 27.III.1958 N. Takaki (Musci Japonici Ser. 14, 1959, ed. A. Noguchi 674) (B, CANM, F, G, L, NY, S, US, W). Hyogo Prefecture. On Morus alba, ca. 400 m. above sea, Tomisu, 5.V.1954 Y. Tatebe (Musci Japonici Ser. 9, 1955, ed. A. Noguchi & S. Hattori 413) (B, CANM, COLO, F, G, GRO, H, L, NY, S, US, W). Kyoto Prefecture. On tree-trunks, 100 m alt., Yakuno-cho, 6.X.1967 M.Mizutani (Musci Japonici ser. 23, 1968, ed. A. Noguchi 1113) (B, BM, CANM, COLO, EGR, F, G, H, JE, L, MICH, MO, NY, S, US, W); Musashi, Dorf Asakawa, selten. 1.IV.1910, collector's name unreadable (S); 14. VIII. 1930 H. Sasaoka 5702 (US). Saitama Prefecture. Chichibu-gun, Arakawa-mura, Hino, the foot of Mt. Kumakura, alt. 400 m, on bark of Morus bombycis, 18.V.1980 H. Kiguchi 8988 (NICH). Honshu. Arakawa-mura, Chichibugun, 31.VII.1983 H. Deguchi 27002 (HIRO). Shiga Prefecture. Sakata-gun, Samegai-mura, alt. 300 m, 13.V.1962 N. Takaki 27876 (US). Tokyo. An Bäumen, 1.III.1910 K. Sakurai (H-BR 1067002).



Fig. 5. Cryphaea omeiensis P. Rao (from holotype, H). — a: Stem leaves. b: Branch leaves. - c: Leaf apex. - d: Basal central lamina cells. — e: Alar cells. - f: Marginal cells at midleaf. - g: Capsule. h: Operculum. - i: Calyptra. — j: Outer perichaetial leaves. - k: Inner perichaetial leaves. - I: Lamina cells of inner perichaetial leaves. - Use the upper 1 mm scale for a and b, the middle 1 mm scale g-i, the lower 1 mm scale for j and k, and the 50 µm scales for c-f and l.

Cryphaea omeiensis P. Rao, *sp. nova* (Figs. 1, 2 and 5)

Haec species differt a C. lanceolata foliis brevioribus et latioribus; costa bractearum perichaetiorum deorsum attenuatis.

HOLOTYPE: China. Prov. Sichuan, Mount Omei Shan SW OF Chendu, alt. 1 000–1 200 m, epiphytic in forest, on tree trunk. 24.X.1980 *A. Touw* 23924 (L).

Plants yellowish green to dark brown. Stolons creeping along substrate; rhizoids hyaline to brownish, unbranched, 0.5–1 mm long. Stems erect, ca. 3 cm long, reddish to dark brown, rarely branched, in cross section with 2–3 rows of thick-

walled brownish cortical cells sharply demarcated from the hyaline, larger, thin-walled medullary cells. Stem leaves erect when dry, patent when wet, ovate, concave below, more or less abruptly contracted into a lanceolate tip, ca. $1.2-1.4 \times 0.55-$ 0.7 mm. Leaf margins slightly recurved, irregularly serrulate above (mostly in apex), entire below. Costa strong, almost percurrent. Leaf cells incrassate, basal central cells rectangular to linear, forming a small group, sometimes extending to the middle part of lamina within the narrow juxtacostal area, $25-40 \times 5-8 \mu m$, prorate; cells in the other parts of leaves smaller, elliptic to round or subquadrate, mostly 9–12 μm across, not prorate. Branch leaves similar, but costa weaker, not percurrent. Pseudoparaphyllia filamentous, ca. 50 μm long.

Autoicous. Perigonia solitary, bud-like, perigonial leaves ecostate, with an acute apex, cells rhombic or irregular, hyaline, smooth, thin-walled. Perichaetia usually 4–14, in 2 rows on one side of stems; outer perichaetial leaves concave, ecostate, acute above, cells linear, rectangular, or irregular in central part, but short rectangular in the margins, elliptic in apex, prorate; inner perichaetial leaves 1.6-2.0 mm, lamina oblong, margins hyaline on both sides, arista strong, ca. 2/5 the leaf length, costa strong, especially in apex, tapering downwards, usually disappearing near leaf base in the innermost leaves, occasionally reaching the base. Laminal cells rectangular, linear-rhomboidal, or irregular, $50-80 \times 8-12 \,\mu\text{m}$, prorate; marginal cells short-rectangular. Capsule ellipsoid, ca. 1.0×0.5 mm; stomata absent; exothecial cells thin-walled, irregular. Seta ca. 0.03–0.05 mm long. Peristome double, hyaline to yellowish; exostome teeth lanceolate, ca. 180-210 µm long, ca. 35-40 µm wide at base, finely papillose above, almost smooth below, endostome segments shorter, almost smooth, 12–15 µm wide. Annulus present, formed by a circle of thin-walled cells. Columella persistent, ca. 3/4 the length of capsule. Operculum about 0.3 mm high, broad conic. Calyptra brownish, about 0.4 mm, mitrate, not distinctly papillose. Spores 24–30 µm in diameter, finely papillose.

Cryphaea omeiensis resembles *C. lanceolata* in that the costa of stem leaves is nearly percurrent. However, the species is different from *C. lanceolata* in leaf shape (ovate-acuminate rather than lanceolate), shorter and wider leaves $(1.2-1.4 \times 0.55-0.7 \text{ mm vs}. 1.8-2.0 \times 0.36-0.4 \text{ mm in } C. lanceolata)$, shorter columella (just 3/4 the length of capsule, not as long as capsule), and by the costa of perichaetial leaves (strong at apex, tapering downwards rather than vice versa).

Cryphaea omeiensis also resembles *Sphaerotheciella sinensis* (Bartr.) P. Rao (*see* below) in the leaf shape. However, the former can be distinguished from the latter by the leaf areolation (central linear cells restricted to basal area, not extending to the upper part of leaves), capsule shape (ellipsoid, not subglobose), peristome structure (endostome well-developed, not membranous), and by an exosporic rather than endosporic spore germination.

HABITAT. On tree trunk.

DISTRIBUTION. Endemic to China (Sichuan).

Cryphaea songpanensis Enroth & T. J. Kop. (Figs. 1 and 2)

Ann. Bot. Fennici 34: 205. 1997. — *C. leptopteris* Enroth & T. J. Kop., Harvard Pap. Bot. 10: 1. 1997, *hom. illeg.* (*non C. leptopteris* Müll. Hal. 1901). — Holotype: China. NW Sichuan, Minshan Range, Songpan Co. Valley of R. Fujiang 3 km E of Huanglong hotel, lower oroboreal *Picea-Abies-Lonicera-Salix-Juniperus-Rosa* forest, 2 900–2 930 m, 32°45′N, 103°52′E, on the trunk of *Abies* at the height of 1 m, 9.IX.1991 *T. Koponen 45197* (H!).

Plants small, gregarious, dull green, usually densely branched, irregular. Stolons creeping. Stems up to ca. 1.5 cm long, erect, densely branched. Branches approximately 0.5 cm long. Stem leaves imbricate when dry, patent when wet, ovate-lanceolate to ovate-acuminate, decurrent, ca. 0.8-0.9 $\times 0.35-0.4$ mm; apices abruptly acuminate. Leaf margins crenulate above, entire below, recurved from the base to about 2/3 of the leaf length. Costa single, occasionally forked, relatively strong, extending to 0.5-0.67 the leaf length, ca. 20 μ m wide at base, tapering upwards. Leaf cells incrassate, upper laminal cells ca. $5-7 \times 7-10 \,\mu\text{m}$, gradually longer below, to ca. 12-20 µm long at base, minutely prorate. Branch leaves smaller than, but their shape similar to, stem leaves, appressed when dry, erect-patent when wet, ovate-lanceolate, apices narrowly acuminate, very minutely prorate, leaf apices long-acuminate, more or less twisted, tips uniseriate. Costa reaching to about 0.15–0.2 the leaf length, mostly forked. Pseudoparaphyllia mostly uni- or biseriate, often basally branched, to ca. $100(-150) \,\mu m \log$.

Autoicous. Perigonia numerous and often clustered along the stems, gemmiform, perigonial leaves ovate, ecostate. Perichaetia along the stems. Outer perichaetial leaves oblong with a denticulate, somewhat twisted and acuminate apex, ca. $1.6 \times$ 0.45 mm; costa reaching ca. 1/2 the leaf length; leaf margins entire except for the apex; marginal cells rectangular and hyaline, inner laminal cells linear, minutely prorate, basal cells incrassate, brownish, sometimes with 1-3 internal papillalike thickenings. Inner perichaetial leaves hyaline but slightly coloured along costa, oblong, aristate, ca. 2.2×0.5 mm; costa strong in the upper part but diffuse below; margins denticulate above, entire below; cells more or less hexagonal, hyaline on the margin, greenish on the central part, minutely prorate in the inner portion of lamina; basal cells incrassate, brownish, mostly with 1-7 internal papilla-like thickenings. Capsule broadly cylindric, ca. $1.0-1.4 \times 0.5-0.8$ mm; apophysal stomata few, phaneropore, round-pored; exothecial cells thin-walled. Seta ca. 0.2 mm long. Peristome double; exostome teeth densely papillose above and sparsely so below, ca. 270 µm long, yellowish grey; endostome segments rudimentary or linear and ca. 200 µm long, pale greyish yellow, nearly smooth below, densely papillose above. Annulus differentiated, cells large, thinwalled. Columella persistent, reaching ca. 1/3–1/ 2 the length of the capsule. Operculum and calyptra not seen. Spores ca. 30-40 µm, papillose.

ILLUSTRATIONS: Enroth & Koponen 1997a: 3 (fig. 1, as *Cryphaea leptopteris*); Rao & Enroth 1999: 185 (fig. 5).

HABITAT. On trunk of *Abies*. DISTRIBUTION. Endemic to China (Sichuan).

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Sphaerotheciella sinensis (Bartr.) P. Rao, *comb. nova* (Fig. 6).

Cryphaea sinensis Bartr., Ann. Bryol. 8: 15. 9. 1935. — Holotype: China. Guizhou (Kweichow) Prov., on stone near stream, Nin Tao Shan, 1 000 m, *S. Y. Cheo 560a* (FH!).

A detailed description and illustrations were given by Rao and Enroth (1999, as *Cryphaea sinensis*).

ILLUSTRATIONS: Bartram 1935: 15 (fig. 9); Rao & Enroth 1999: 184 (fig. 4).

HABITAT. On stone and tree trunk, alt. 1 000–2 600 m.

DISTRIBUTION. Endemic to China (Guizhou, Gansu, *Hubei, *Hunan)

According to current generic delimitation



Fig. 6. Precociously germinated spores of *Sphaerotheciella sinensis* (Bartr.) P. Rao. (a–c from holotype of *Cryphaea sinensis* Bartr. (MO!), over-mature capsule; d–g from *T. Koponen et al. 54837* (H), immature capsule).

(Manuel 1977, 1982), Sphaerotheciella differs from Cryphaea in the globose capsules and endosporic spore germination with precocious, intracapsular protonematal development. In the protologue of Cryphaea sinensis, Bartram (1935) described the spore diameter as about 25 µm, which I could not observe because of the over-mature capsules in the type material. So, in Rao and Enroth (1999), I still recognized the species in Cryphaea, although I knew that the capsule was subglobose. New specimens from Hubei and Hunan show that the spores are clearly endosporic and protonemata intracapsular, 25-35×45-60 µm (in immature capsule). This discovery made me reexamine the type material. As a result, precociously germinated spores were found remaining in mature capsules, their size being ca. 70×140 μm (Fig. 6). Thus, it is clear that Cryphaea sinensis belongs in the genus Sphaerotheciella.

Additional specimens examined: **China**. Gansu Province, Wen Co., Tie-Lu-Zai Village, Zhong-Jia-Jiang, on the stem of broad-leaf tree, alt. 2 600 m, 3.V.1964 Z.-P. Wei 6798 (KUN). Hubei Province, Shennongjia Forest District, along the trail from Qiujiaping towards Laojun Mt., disturbed valley with *Pinus* and *Fagus* above 2 000 m, elev. 1 446–2 150 m, on dead hardwood, 3.IX.1980 *Sino-Amer. Exped. No.* 656 J (NY). Hunan Province, Sang-Zhi Co., Ba-Da-Gong-Shan, Liao-Ye-Wan, ca. 1 km NE of the administration office, along trail in second growth forest and *Liriodendron, Alniphyllum, Metasequoia* and *Phellodendron* plantations, mid-subtropical zone, alt. 1 400 m, 7.X.1998 *T. Koponen, S. Huttunen, S. Piippo & P.-C. Rao* 54837 (H).

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