

A synopsis of *Macromitrium* (Orthotrichaceae) in China

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Abstract – Three species of *Macromitrium* (Bryopsida, Orthotrichaceae), namely *M. blumei* Nees ex Schwägr., *M. cuspidatum* Hampe, and *M. turgidum* Dixon are reported for the first time from China (Hainan and Tibet). Studies of their types and morphological similar species suggest that *M. turgidum* Dixon var. *laeve* Dixon is conspecific with *M. turgidum* Dixon. A key to 27 Chinese species of *Macromitrium* with their distribution range is presented. For Chinese *Macromitrium*, east Asiatic element, element endemic to China, and tropical Asian element account for 37.04%, 33.33% and 22.22%, respectively. 62.96% species of Chinese *Macromitrium* have a tropical distribution pattern. China has a close relationship with Japan and tropical Asia in the flora of *Macromitrium*.

Bryopsida / distribution pattern / *Macromitrium blumei* / *M. cuspidatum* / *M. turgidum* / *M. turgidum* var. *laeve* / Synonym

INTRODUCTION

Macromitrium is the largest genus of the family Orthotrichaceae, comprising about 368 species (Crosby *et al.*, 1999) with the highest diversity around the Pacific Ocean. *Macromitrium* has been revised for New Zealand and Australia (Vitt & Ramsay, 1983, 1985a, 1985b, 1986), Papua New Guinea (Vitt *et al.*, 1995), Mexico (Vitt, 1994), Central America (Allen, 2002), South Africa (Rooy & Wijk, 1992), and Japan (Noguchi, 1967). In China, 58 species of *Macromitrium* have been reported, of which 24 are currently recognized (Redfearn *et al.*, 1996; Xiong, 2000; Guo *et al.*, 2006; Guo *et al.*, 2007a-c; Guo & He, 2008a, b; Jia *et al.*, 2011a,b).

During our taxonomic revision of the Chinese *Macromitrium*, we found that some specimens collected from Hainan and Xizang, China, matched the descriptions of *M. blumei* Nees ex Schwägr., *M. cuspidatum* Hampe and *M. turgidum* Dixon, which were not known from China. Based on our examination of the types of these three species and comparisons with similar taxa, we confirm that the specimens belong to *M. blumei*, *M. cuspidatum* and *M. turgidum*, which are thereby recorded for the first time from China. Furthermore, *M. turgidum* Dixon var. *laeve* Dix cannot be distinguished from the type variety, and the two varietal names are considered synonyms. A key to the species of *Macromitrium* with their distribution range in China is given, and the floristic and phytogeographical characteristics of Chinese *Macromitrium* are also analyzed.

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DESCRIPTION

Macromitrium cuspidatum Hampe, *Icon. Musc.* 20. 1844

Figs 1-15

Type: “Indonesia, In insula Iava legi diligentissimus Dr. Junguhu; ab amicissimo Dr. Gottsche Communicatum” (Lectotype designated by Vitt (1995): BM!)

Plants robust, large, brown-yellowish, somewhat glossy. Stems prostrate, with blackish rhizoids. Stem leaves small, inconspicuous, lanceolate-acuminate. Branches about 3.0 cm long. Branch leaves 3.0-4.8 mm long, loosely erect, with spreading curved to sometimes deflexed apices when dry, wide spreading-recurved when moist, ovate-lanceolate to elliptic lanceolate, apical area mostly asymmetric, sharply contracted to a long cuspidate or a long aristate point (up to 1.5 mm long), sometimes undulate above; margins subentire near apex, plane above, reflexed to recurved and plicate below; costae long excurrent; all laminal cells longer than wide; upper laminal cells elliptic-rounded to long oval, 20.0-30.0 μm long, 5.0-7.0 μm wide, smooth; median laminal cells short to long rectangular, 18.0-35.0 μm long, 5.0-7.0 μm wide, with straight to somewhat curved lumens; lumens 3.0-4.0 μm wide, smooth; basal laminal cells 25.0-60.0 μm long, 8.0-12.0 μm wide, long rectangular, thick-walled, lumens curved to sigmoid, 2.0-3.0 μm wide, smooth, hyaline, yellow at insertion. Perichaetial leaves erect, not much differentiated from branch leaves, lanceolate to acuminate, all laminal cells longer than wide, smooth. Calyptra campanulate, hairy, covering the whole capsule, the hair smooth and erect. Setae 4.0-5.0 mm long, twisted to left. Capsules erect, ovoid, about 1.5 mm long, with somewhat small mouth; peristome single; exostome of 16, well developed, pale, blunt teeth, coarsely papillose. Spores anisomorphic, coarsely papillose, 15.0-30.0 μm in diameter.

Macromitrium cuspidatum is characterized by: 1) robust plants, 2) ovate-lanceolate to elliptic lanceolate branch leaves with an asymmetric apex sharply contracted to a long cuspidate or a long aristate point, 3) smooth, uniformly rectangular laminal cells, and 4) ovoid capsule with hairy calyptra covering the whole capsule.

Macromitrium cuspidatum was recorded from Indonesia (Ternate, Java, Sumatra), Philippine (Luzon, Palawan, Ponay, Mindoro), Papua New Guinea (Frieda River, Aitape Subdistrict, Normanby Island, Mt. Pabinama) (Vitt *et al.*, 1995), and Malaysia (Eddy, 1996). This species is a typical epiphyte. The specimen collected from Hainan Island, China (MO 3974405) agrees well with the lectotype of *M. cuspidatum*.

Specimens examined: **China:** Hainan, Linshui Co., *P. L. Redfearn, Jr.* 36210 (MO 3974405). **Indonesia:** Java, Salak, *S. Kurz* 845 (HB2620014). **Philippines:** Palawan Island, *H. M. Cussaw* 3886 (HB262002). **Papua New Guinea:** Frieda River, *T. Koponen* 36080 (H).

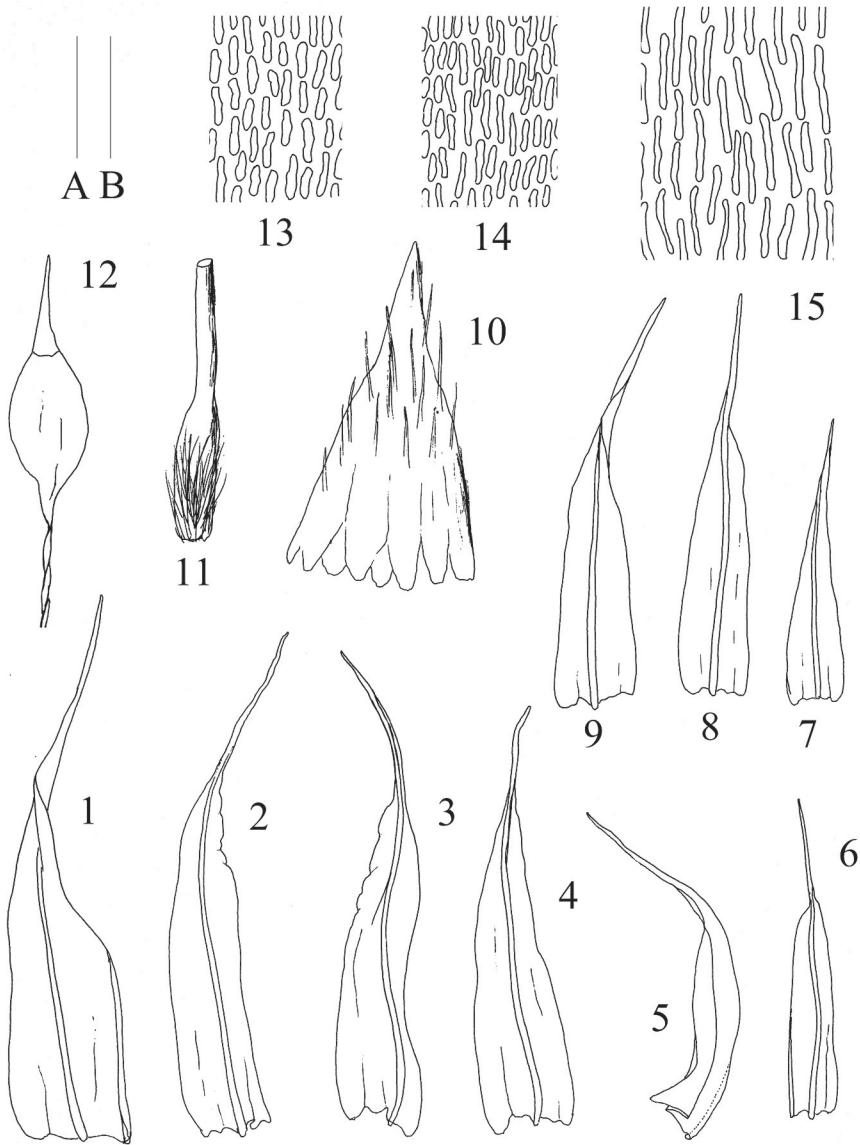
Habitat: on trunks and branches in moist sclerophyll forest with Lauraceae, *Quercus*, *Castanopsis*, and *Rhododendron dactyloides*, alt. 600-800 m.

Total range: China (Hainan), Indonesia (Java, Sumatra, Ternate), Kam-puchea (Tan & Iwatsuki, 1993), Philippines (Luzon, Mindoro, Palawan, Ponay), New Guinea, and Papua New Guinea (Tan & Iwatsuki, 1991; Vitt *et al.*, 1995).

Macromitrium turgidum Dixon, *J. Siam Soc., Nat. Hist. Suppl.* 9: 22. 1932

Figs 16-55

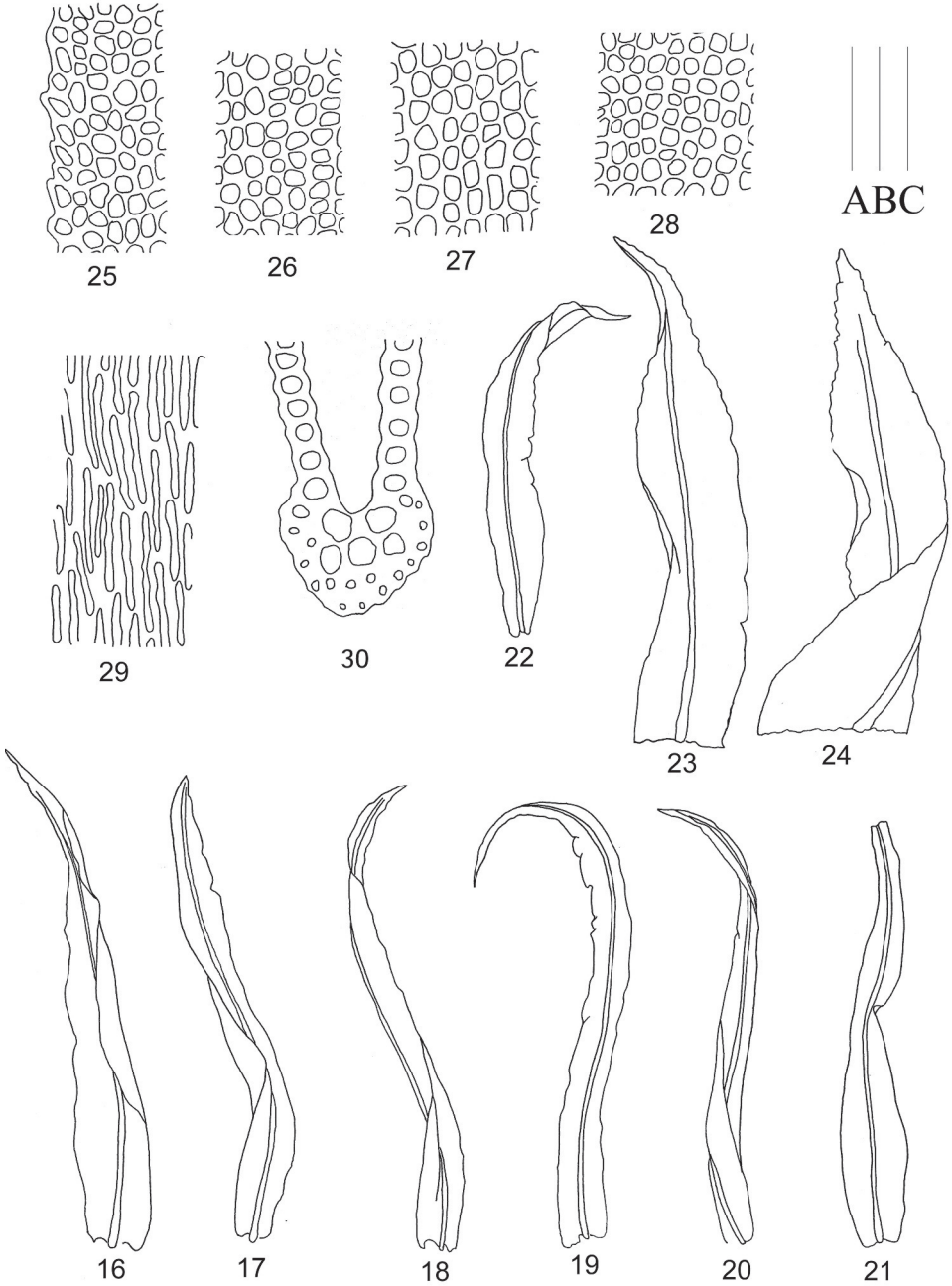
Type: “Thailand, Chantaburi. Krat, Kao Kuap, on tree in evergreen forest, alt. c. 700 m., *A. F. G. Kerr* no. 438, 27 Dec. 1929” (holotype: BM000825435!).



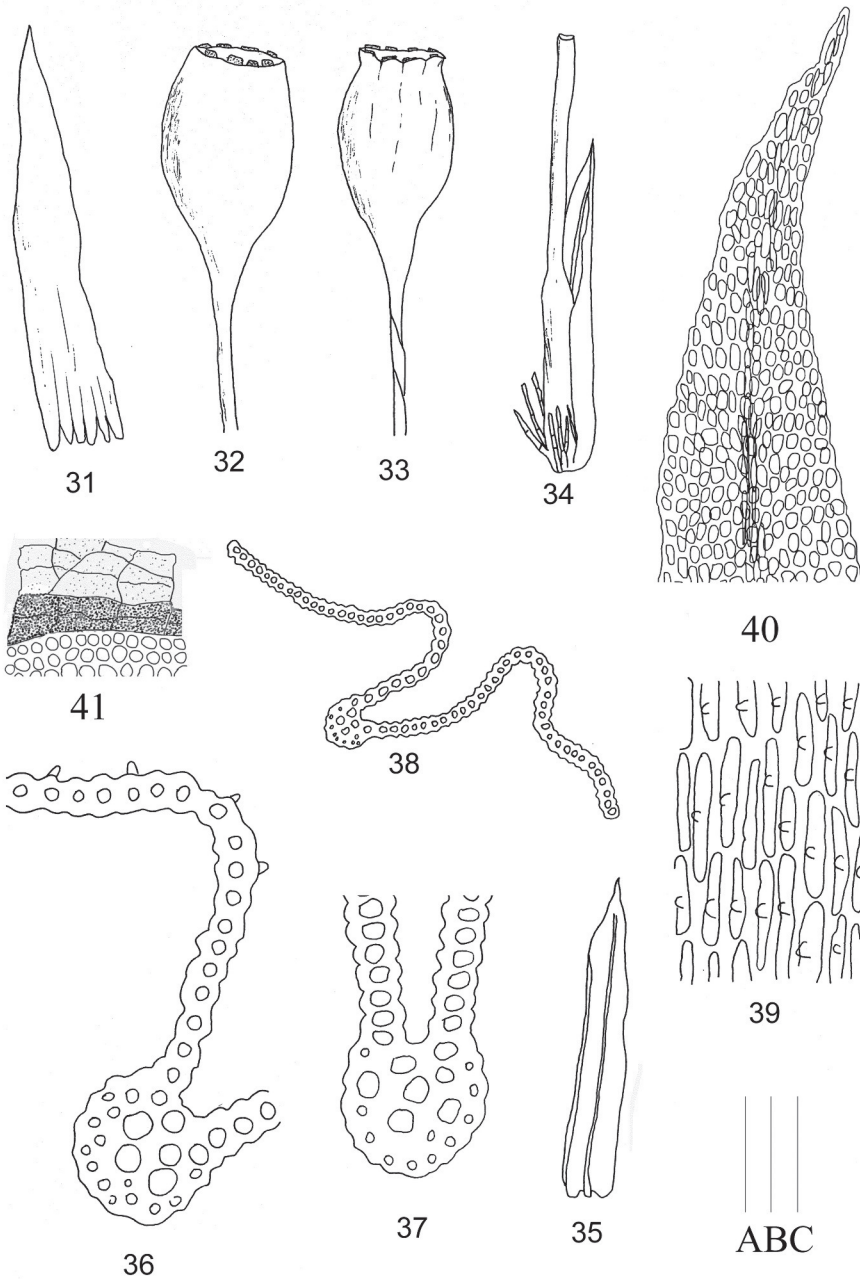
Figs 1-15. *Macromitrium cuspidatum* Hampe. **1-6.** Branch leaves. **7-9.** Perichaetial leaves. **10.** Calyptra. **11.** Seta with foot and a few paraphyses. **12.** Capsule when dry. **13.** Upper cells of branch leaf. **14.** Medium cells of branch leaf. **15.** Lower cells of branch leaf (from *P. L. Redfearn Jr.* 36210, with W. D. Reese *et al.*, MO). Line scales: A = 1 mm (1-12); B = 65 μ m (13-15).

Macromitrium turgidum Dixon var. *laeve* Dixon, *J. Bombay Nat. Hist. Soc.* 39: 778. 1937. **syn. nov.** Type: "(India) Tako Senyak, Assam, 4000', *N. L. Bor no.* 113, 19 Mar. 1934" (lectotype designated here: BM000825438!).

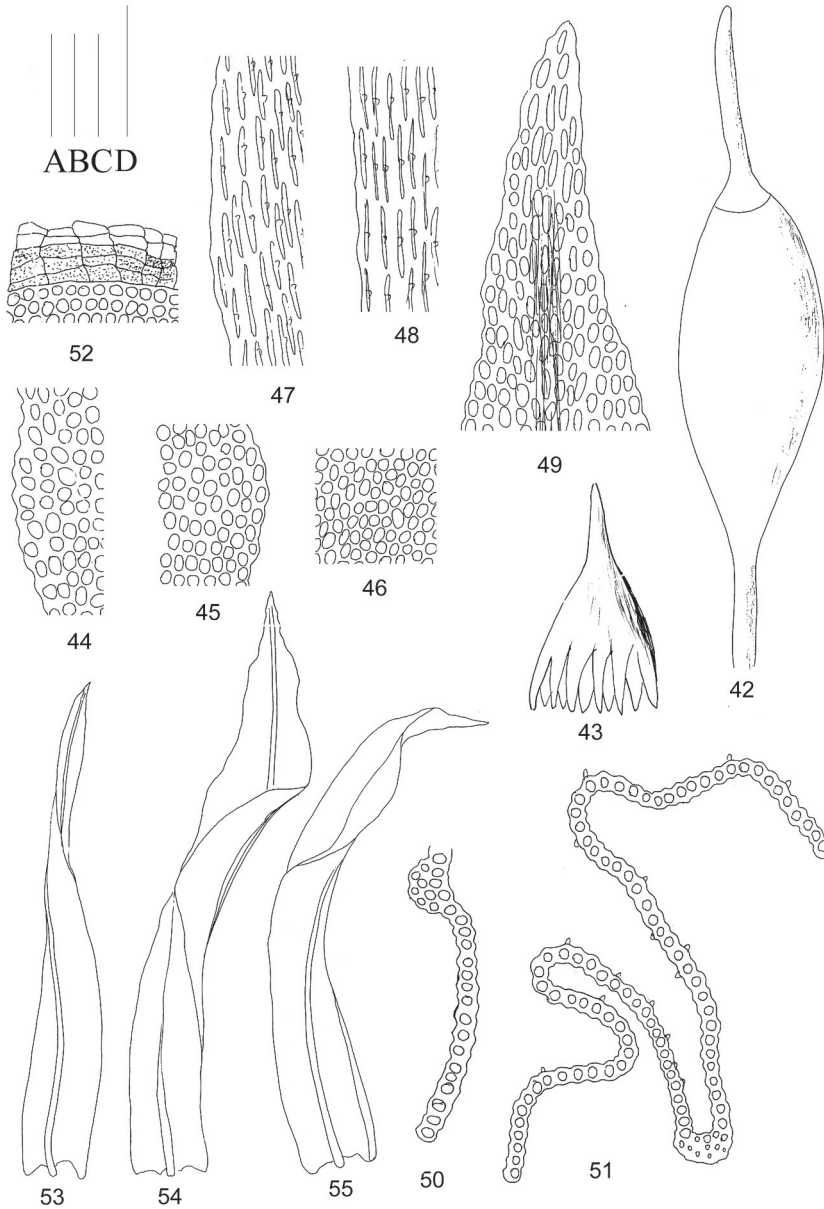
Plants robust, brown-yellowish or green-yellowish above, dark brown below. Stems creeping, densely covered with brown-reddish rhizoids, densely



Figs 16-30. *Macromitrium turgidum* Dixon. **16-22.** Branch leaves. **23-24.** Upper parts of branch leaves enlarged. **25.** Upper marginal cells of branch leaf. **26-27.** Upper cells of branch leaves. **28.** Medium cells of branch leaf. **29.** Lower cells of branch leaf. **30.** Transverse section of the medium part of branch leaf (from *P. Z. Zheng 29713, IBSC*). Line scales: A = 1 mm (16-22); B = 200 μ m (23-24); C = 40 μ m (25-30).



Figs 31-41. *Macromitrium turgidum* Dixon. **31.** Immature calyptra. **32.** Capsule when moist. **33.** Capsule when dry. **34.** Seta with inner perichaetial leaf. **35.** Inner perichaetial leaf. **36.** Transverse section of the lower part of inner perichaetial leaf. **37-38.** Transverse section of the medium part of inner branch leaf. **39.** Lower cells of perichaetial leaf. **40.** Apex of branch leaf. **41.** Peristome. (from P. Z. Zheng 29713, IBSC). Line scales: A = 1 mm (31-35); B = 100 μ m (38, 40-41); C = 40 μ m (36-37, 39).



Figs 42-55. *Macromitrium turgidum* Dixon. **42.** Capsule when moist. **43.** Calyptra. **44-45.** Upper cells of branch leaf. **46.** Medium cells of branch leaf. **47-48.** Lower cells of branch leaf. **49.** Apex of branch leaf. **50.** Transverse section of the medium part of branch leaf. **51.** Transverse section of the lower part of branch leaf. **52.** Peristome teeth reduced and fused to a low membrane. **53-55.** Branch leaves. (42-47, 49, 53-55 from A. F. G. Kerr 438, BM000825435; 48, 50-52 from lectotype of *M. turgidum* var. *leave*, N. L. Bor 113, BM000825438). Line scales: A = 0.44 mm (1, 12-14); B = 44 μ m (3-10); C = 70 μ m (11); D = 2 mm (2).

branching. Branches up to 2.5 cm long. Stem leaves inconspicuous, with rhizoids at base. Branch leaves loosely erect, with spreading curved to somewhat deflexed and contorted apices when dry, not evenly spreading when moist, 4.5-6.5 mm long, from lanceolate or ovate base gradually tapered to long narrowly acuminate apices, narrowly recurved at places, some undulate at upper margins; upper and median laminal cells rounded quadrate to elliptic, 4.0-7.0 × 4.0-7.0 μm, thick-walled, clear and smooth; lower laminal cells long-rectangular, 15-30 × 5.0-7.0 μm, thick-walled, lumens straight, hyaline and distinctly tuberculate, 2.0-3.0 μm wide, 12.0-16.0 μm long; costa strong and excurrent. Perichaetial leaves ligulate-lanceolate or ovate-oblong, erect, acute or short-acuminate, with an excurrent costa; all laminal cells longer than wide, smooth; upper and median laminal cells rectangular, 21.0-42.0 μm long, 7.0-9.0 μm wide, with lumens 2.0-3.0 μm wide, thick-walled, those near costa at base rather large, 30.0-70.0 × 12.0-15.0 μm, straight and thin-walled, pellucid. Calyptra large, mitrate, covering the whole capsule, naked and smooth, lobed at base. Setae 4.0-7.0 mm, smooth, strongly twisted to left. Capsules erect, ovate, contracted under the mouth, moderately plicate; peristome double, often disintegrated, reduced to a low membrane; exostome yellowish papillose, endostome pellucid. Opercula conic-rostrate, 0.7-0.8 mm long. Spores monomorphic, 20-28 μm in diameter, smooth and somewhat pellucid.

The diagnostic features of *Macromitrium turgidum* Dixon are: 1) robust plants, 2) long lanceolate, usually crisped branch leaves when moist, 3) smooth upper and median laminal cells; distinctly tuberculate lower cells, 4) uniformly rectangular and smooth cells of perichaetial leaves, 5) ovate capsule contracted under the mouth, 6) double, low membranous peristome with yellowish and papillose exostome and colorless endostome, and 7) large, mitrate, naked calyptrae.

The specimens from Tibet (*S. Y. Ge* 4833, MO) and Hainan (*P. Z. Zhen* 29713, IBSC) agree with the type of *M. turgidum*, even if the leaves tend to be more lanceolate than those of the type, which are oblong lanceolate.

Morphologically, *Macromitrium turgidum* is very similar to *M. sulcatum* (Hook.) Brid. recorded from Kampuchea, Thailand, Vietnam, Sri Lanka, Burma, Borneo, Philippines, and India (Gangulee, 1976; Tan & Iwatsuki, 1991). These two species develop robust plants, double peristomes, naked and smooth calyptrae, and basal laminal cells of branch leaves long-rectangular, thick-walled, strongly tuberculate. The main differences between them are from their branch leaves. The branch leaves of *M. sulcatum* are oblong-lanceolate with acute apices, and its median and upper laminal cells are smaller and arranged in diagonal rows, while those of *M. turgidum* are linear-lanceolate, lanceolate to ovate- or oblong-lanceolate, acuminate, or gradually tapered to long narrowly acuminate, and the median and upper laminal cells arranged in longitudinal rows.

Macromitrium lorifolium Paris & Broth., which has been reported from Vietnam (Tan & Iwatsuki, 1993), is also rather similar to *M. turgidum*, but the branch leaves of the former are strongly crisped even when moist, and with distinctly denticulate apices.

Dixon (1937) described the variety, *M. turgidum* var. *laeve* from Assam (India). According to the description, it differs from the typical variety by the smooth lower cells of branch leaves. However, Dixon himself was not certain whether the variety is a distinct taxon, noting that "in one or two of the gatherings, the basal cells are indiscriminately smooth or tuberculate on the same specimen". We checked the type of *M. turgidum* var. *laeve* and found that the

basal and lower cells of the branch leaves are strongly tuberculate, and the type of the variety is not distinctly different from that of the typical variety. Therefore we treat the variety as a synonym of *M. turgidum*.

Specimens examined: **China:** Xizang (Tibet), Motuo Co., Mt. Gelin Dahua, *Y. G. Su* 4833 (MO); Motuo Co., Baibong, *Y. G. Su* 4641 (MO); Hainan, Mt. Wuzhi, Shijiukun, *P. Z. Zheng* 29713 (IBSC). **Thailand** (Siam): Kao Bangto, Pang-nga, *A. F. G. Kerr* 425 (BM000825436); Rāṭchaburī, Prachuap, Kao Luang, *A. F. G. Kerr* 151 (BM000825434). **India:** Assam, Daffla Hills, *N. L. Bor* 90 (syntype of *M. turgidum* var. *laeve*, BM000825437).

Habitat: on trunks or rotten trunks in evergreen forests, alt. 1100-1200 m.

Total range: China (Hainan, Xizang), India (Assam), and Thailand (Dixon, 1932).

Macromitrium blumei Nees ex Schwägr., *Sp. Musc. Frond.*, *Suppl.* 4 316B, 1842

Figs 56-65

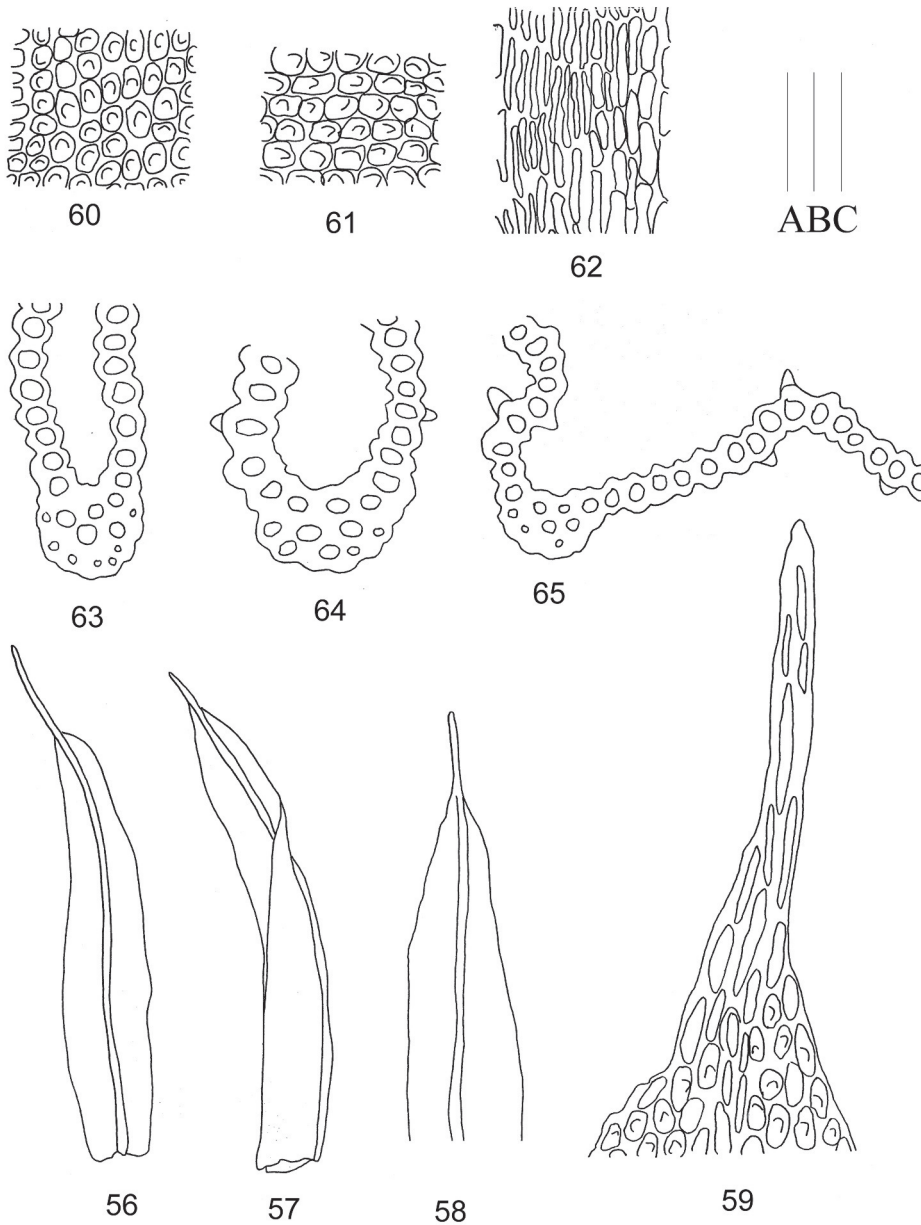
Type: “Indonesia, Java, Blume, legit, misit Al. Braun ad Muellerum, Herb. Muell., comm. Schliephacke” (isotype: H(HB2600011, H-BR!)).

Plants small in mat, often far-creeping but not very tall, green-yellowish at shoot tips. Branches 5-10 mm long and repeatedly innovating. Branch leaves densely arranged, coiled around the stem when dry, often regularly so as to give the shoots a characteristic rope-like appearance. Branch leaves oblong to lingulate, 1.1-1.9 mm long, 0.3-0.4 mm wide, plicate below, keeled; margins entire or slightly crenulate above with bulging cells, plane or recurved below; apex broad, obtuse or rounded, often asymmetrical; costa strong, excurrent forming a conspicuous apiculus or short awn 0.14-0.53 mm in length; upper laminal cells in longitudinal rows, thick-walled, strongly convex-mammillate, lower laminal cells elongate very thick walled, with a tall tubercle or mammilla arising over the center of the lumen, cells at insertion smooth. Perichaetial leaves about as long as normal leaves but broader, convolute and closely enfolding the base of seta and vaginula. Calyptrae naked and plicate. Setae 12-18 mm long, red-brown, smooth to faintly roughened. Capsules erect, urceolate, smooth, narrowed to a shallowly cylindrical mouth. Peristome double; exostome rudimentary; endostome a white or colourless membrane, finely striate-papillose.

Macromitrium blumei has been reported from Malaysia (Eddy, 1996), Indonesia (Touw, 1992) and the Philippines (Tan & Iwatsuki, 1991). It is characterized by: 1) small, mat-forming, broadly spreading plants with short branches often bearing branchlets, 2) small branch leaves, densely coiled around the stem forming “rope-like” shoots, 3) isodiametric, bulging to mammillate upper laminal cells, 4) elongate, pellucid, thick-walled lower laminal cells with distinct papillae or tubercles, 5) 8-16 mm long setae, 6) urceolate smooth capsule narrowed to a short cylindrical mouth, with a double peristome composed of a rudimentary exostome and a colourless membranous endostome, and 7) naked calyptrae.

Guo *et al.* (2006) described *Macromitrium blumei* in detail, and compared the typical variety to var. *zollingeri* (Mitt. ex Bosch & Sande Lac.) S.L.Guo, B.C.Tan & V.Virtanen. They noted that the latter could be distinguished by its longer leaves, longer leaf awn, and ligulate leaf outline with a higher leaf length/width ratio. In appearance, the leaves of *M. blumei* var. *zollingeri* are curled loosely around the stem because of its longer branch leaves and longer leaf awn, rather than coiling tightly around the stems to give the shoots a rope-like appearance.

Specimens examined: **China:** Hainan, Diaoluoshan, Shiqing woodland, *Collection Team* 2880 (IBSC); Mt. Diaoluoshan, *P. J. Lin & L. Zhang* 978 (IBSC). **Philippines:** Luzon, Mt. Tabayo, *M. Jacobs* B641 (H3090123). **Malaysia:** Borneo, *Clemens* 3557 (H3090124). **Indonesia:** Java, *E. Nyman* 150 (H (H-BR 260006)); Sumatra, *A. Ernst* (H(H-BR 2600017)).



Figs 56-65. *Macromitrium blumei* Nees ex Schwägr. **56-57.** Branch leaves. **58.** Upper part of branch leaf. **59.** Apex of branch leaf. **60.** Upper laminal cells. **61.** Medium laminal cells. **62.** Lower laminal cells. **63.** Transverse sections of the upper part of leaf. **64-65.** Transverse section of the lower part of leaf (from *Collection Team 2880*, IBSC). Line scales: A = 0.40 mm (56-57); B = 200 μ m (58); C = 40 μ m (59-65).

Habitat: on trunks, alt. 1000-1200 m.

Total range: China (Hainan); Indonesia (Java, Lombok, Sumatra), Philippines (Luzon, Mindoro), and Malaysia (Borneo) (Eddy, 1996).

KEY TO CHINESE SPECIES OF *MACROMITRIUM* WITH THEIR DISTRIBUTION

So far, a total of 61 species and varieties of *Macromitrium* have been recorded from China. In “Flora Bryophytorum Sinicorum (Vol. 5)” (Jia *et al.*, 2011a) and “Moss flora of China (English version, vol. 5) (Jia *et al.*, 2011b), only nine species and 18 species (including one variety) were confirmed, respectively. In the present study, 27 species of *Macromitrium* have been taxonomical recognized in China. The key to the species of *Macromitrium* with their range in the world is as follows:

1. Branch leaves lingulate or ingulate-lanceolate, leaf apices distinct mucronate, or subacute, obtuse, or acute with a pointed end. 2
1. Branch leaves linear, linear-lanceolate, or lanceolate to oblong lanceolate, gradually narrowed to slender acute or short acuminate apices, or apices obtuse acute, acute or acuminate, not distinct mucronate 9
2. Leaf apices strongly or moderately incurved when moist, basal laminal cells smooth; China; Japan, Korea, and Soviet Far East (Noguchi,1989); Thailand and Vietnam (Tan & Iwatsuki, 1993); Sri Lankan (Bruhl, 1931)
. *M. japonicum* Dozy et Molk.
2. Leaf apices not incurved when moist, basal laminal cells tuberculate or unipapillose 3
3. Branch leaves densely arranged in spiral ranks when dry, giving the shoots a rope-like appearance 4
3. Branch not arranged in spiral ranks when dry, not giving the shoots a rope-like appearance 7
4. Median and upper cells isodiametric, obscure, pluri-papillose, with peculiar proliferation of 1-3 pluri-papillose cells on both surfaces, rendering upper cells obscure forming a crust on surface; China (Zhang, 1999); India (Robinson, 1968; Gangulee, 1976). *M. incrustatifolium* Robins.
4. Median and upper laminal cells densely pluri-papillose, rather obscure, or medium and upper laminal cells strong bluging or conic-mammillate, lower laminal cells inflate, unipapillose or tuberculate. 5
5. Calyptrae naked; China; Indonesia, Philippines, and Malaysia (Eddy, 1996)
. *M. blumei* Nees ex Schwägr.
5. Calyptrae hairy. 6
6. Median and upper laminal cells strong bulging or conic-unipapillose; China
. *M. fortunatii* Cardot et Thér.
6. Median and upper laminal cells densely pluripapillose; China; Kampucher, Thailand, Vietnam, Laos, and Myanmar (Tan & Iwatsuki, 1993); East Nepal, Sikkim, and India (Gangulee, 1976); Sri Lankan (Tixier, 1975)
. *M. nepalense* (Hook. et Grev.) Schwägr.
7. Upper and median laminal cells unipapillose, or bulging to highly unipapillose, basal laminal cells strongly tuberculate; costa reaching the apex and excurrent to form a hair point; China. *M. taiwanense* Nog.

7. Upper and median laminal cells flat, rather obscure, distinctly pluri-papillose, basal laminal cells unipapillose, or smooth; costa reaching the apex but not excurrent to form a hair point. 8
8. Lower and basal laminal cells often with a single large papilla, apices not incurved when moist; China; Japan (Noguchi, 1989). *M. tosae* Besch.
8. Lower and basal laminal cell often smooth, apices often slightly incurved when moist; China; East Nepal, Sikkim, India, and Burma (Gangulee, 1976)
. *M. moorcroftii* (Hook. et Grev.) Schwägr
9. Calyptrae naked 10
9. Calyptrae hairy 14
10. Peristome absent; China; Japan, Korea (Noguchi, 1989); Vietnam (Tan & Iwatsuki, 1993) *M. gymnostomum* Sull. et Lesq.
10. Peristome present 11
11. All laminal cells smooth, flat and clear; China; Guatemala, Costa Rica, Cuba, Jamaica, the Dominican Republic, Mexico, Hawaii, Australia, New Zealand, Papua New Guinea, New Guinea, Malaysia, Indonesia, throughout the South Pacific Islands, Japan, and Philippines (Cao *et al.*, 2008); Kampucher (as *M. reinwardtii*, Tan & Iwatsuki, 1993) Sri Lankan (Abeywickrama & Jansen, 1978) *M. microstomum* (Hook. et Grev.) Schwägr.
11. Basal cells thick walled, tuberculate, or unipapillose 12
12. Branch leaves tendency to be fragile, median and upper laminal cells bulging to conic-papillose; China *M. uraiense* Nog.
12. Branch leaves not easy broken off , median and upper laminal cells clear and smooth, or strongly bulging or unipapillose 13
13. Plants yellow-greenish, not reddish, leaves not easy spreading, usually crisped, plicate distinctly when moist, median and upper laminal cells clear and smooth; China; India and Thailand (Dixon, 1932). *M. turgidum* Dixon
13. Plant lustrous, reddish to chestnut-brown, leaves spreading when moist, median and upper laminal cells strongly bulging or conic-unipapillose; China, Papuan New Guinea, Indonesia, Philippines (Vitt *et al.*, 1995)
. *M. macrosporum* Broth.
14. Branch leaves linear-lanceolate, the leaf apices easily broken off; China and South Korea (Guo *et al.*, 2007a) *M. clastophyllum* Cardot
14. Branch leaves lanceolate, ovate-lanceolate to broadly oblong-lanceolate, the leaf apices not easily broken off 15
15. Peristome absent 16
15. Peristome present 20
16. Basal laminal cells strong curved sigmoid and smooth, setae shorter than 0.5 mm; sporophytes not emergent from perichaetial leaves; capsules ovoid, smooth, without plicate under the mouth; China (Guo & He, 2008b)
. *M. hainanese* S.L.Guo et S.He
16. Basal laminal cells straight, setae longer than 3 mm; sporophytes emergent from perichaetial leaves; capsules oblong-cylindric or oblong, often constricted or slightly constricted below the mouth 4-angled or 4-furrowed 17
17. All laminal cells of branch leaves smooth and flat; China
. *M. ousiense* Broth. et Paris
17. Upper and median laminal cells of branch leaves mammilate or pluri-papillose 18
18. Upper and median laminal cells of branch leaves mammilate; China, Japan (Noguchi, 1989). *M. holomitrioides* Nog.
18. Upper and median laminal cells of branch leaves pluri-papillose or unipapillose 19

19. Upper and median laminal cells of branch leaves moderately pluri-papillose, basal laminal cells strongly thick-walled and sinuous, often strongly tuberculate; China *M. tuberculatum* Dixon
19. Upper and median laminal cells of branch leaves densely pluri-papillose, basal laminal cell smooth; China *M. formosae* Cardot
20. Sporophytes slightly exserted or emergent from perichaetial leaves, setae short, usually shorter than 2 mm; China; Japan (Noguchi, 1989) *M. prolongatum* Mitt.
20. Sporophytes exserted or emergent from perichaetial leaves, setae longer than 2 mm 21
21. Basal laminal cells curved sigmoid, or curved to sometimes shallow-sigmoid, smooth 22
21. Basal laminal cell straight, not curved sigmoid 23
22. Branch leaves wide spreading recurved to squarrosely-recurved and funiculate when moist, narrowly lanceolate to lanceolate from an oblong lower portion, gradually narrowed to a slender, acute apex, older leaves sometimes broken off, apices often extended to a long ligulate fragile portion; China; Indonesia, Japan, Papua New Guinea; Philippines, and Solomon islands (Noguchi, 1989; Vitt *et al.*, 1995) *M. angustifolium* Dozy *et* Molk.
22. Branch leaves wide spreading recurved when moist, ovate lanceolate to elliptic lanceolate, apical area asymmetric to symmetric, most leaves sharply contracted to a long-cuspidate to aristate point, rugose-undulate above, margins subentire; China; Indonesia, and Kampuchea (Tan & Iwatsuki, 1993), Philippines, New Guinea, Papua New Guinea (Vitt *et al.*, 1995) *M. cuspidatum* Hampe
23. Upper and median laminal cells of branch leaves smooth and clear; China *M. taiheizanense* Nog.
23. Upper and median laminal cells of branch leaves strongly bulging, smooth or with 3-4 low poorly formed papillae to distinct pluri-papillose, or with a single, large horn like, or forked papilla. 24
24. Upper and median laminal cells of branch leaves pellucid, hexagonal, strongly inflated, smooth or with 3-4 small papillae, or with a single, large horn-like or forked papilla; China (Guo *et al.*, 2007a); Japan (Noguchi, 1989). *M. comatum* Mitt.
24. Upper and median laminal cells of branch leaves strongly bulging, smooth or with 3-4 low poorly formed papillae to distinct pluri-papillae 25
25. Upper and median laminal cells hexagonal rounded to rounded quadrate, strongly bulging, clear, smooth or poorly-developed pluri-papillose, basal cells confined to small area, rectangular hexagonal, smooth or some cells with single conical papillae; China; Australia (Vitt & Ramsay, 1985) *M. involutifolium* (Hook. *et* Grev.) Schwägr.
25. Upper and median laminal cells pluri-papillose, basal cells smooth and clear or distinctly unipapillose 26
26. Branch leaves to 3.2 mm long, narrowly acuminate to acuminate, occasionally broadly acuminate, median and upper laminal cells of branch leaves pellucid, collenchymatous, bulging, with 3-5 small papillae or sometimes smooth; inner perichaetial leaves to 2.5 mm long, abruptly constricted from an oblong base to a long acuminate or aristate apex; China (Guo & He, 2008a); Vietnam (as *M. syntrichophyllum*, Tan & Iwatsuki, 1993). . . . *M. cavaleriei* Cardot *et* Thér.

26. Branch leaves to 2.0 mm long, broadly acuminate to narrowly acute, median and upper laminal cells of branch leaves rather obscure, strongly pluripapillose; inner perichaetial leaves to 1.5 mm long, ovate- or triangular-lanceolate, gradually narrowed to a shortly acuminate apex; China (Guo & He, 2008a); Japan and Korea (Noguchi, 1989) *M. ferriei* Cardot *et* Thér.

FLORISTIC ELEMENTS AND PHYTOGEOGRAPHY OF CHINESE *MACROMITRIUM*

Twenty seven species of Chinese *Macromitrium* could be divided into different floristic elements based on their ranges in the world. The names given to each of the floristic elements are different when enumerated and used by different authors. In the present study, we adopt the categorical names based on the distribution of seed plants of China as documented by Wu (1991).

The flora of Chinese *Macromitrium* consists of five geographical elements, which are listed in Table 1. Floristic analysis on Chinese *Macromitrium*

Table 1. The geographical elements of Chinese *Macromitrium*

| <i>Distribution types</i> | <i>Species number</i> | <i>Percentage</i> | <i>Species</i> |
|--|-----------------------|-------------------|--|
| 1. Pantropical element | 1 | 3.70 | <i>M. microstomum</i> |
| 2. Tropical Asian and Oceanian element | 1 | 3.70 | <i>M. involutifolium</i> |
| 3. Tropical Asian element | 6 | 22.22 | <i>M. macrosporum</i> <i>M. nepalense</i> <i>M. angustifolium</i> <i>M. cuspidatum</i> <i>M. turgidum</i> <i>M. Blumei</i> |
| 4. East Asia element | | | |
| 4.1. Sino-Himalayan element | 2 | 7.41 | <i>M. incrustatifolium</i> <i>M. moorcroftii</i> |
| 4.2. Sino-Japanese element | 8 | 29.63 | <i>M. clastophyllum</i> <i>M. comatum</i> <i>M. ferriei</i> <i>M. gymnostomum</i> <i>M. holomitrioides</i> <i>M. japonicum</i> <i>M. prolongatum</i> <i>M. tosae</i> |
| 5. Element endemic to China | 9 | 33.33 | <i>M. cavaleriei</i> <i>M. fortunatii</i> <i>M. hainanese</i> <i>M. formosae</i> <i>M. ousiense</i> <i>M. taiheizanense</i> <i>M. taiwanense</i> <i>M. tuberculatum</i> <i>M. uraiense</i> |
| Total | 27 | 100.00 | |

showed that East Asiatic element, Element endemic to China and tropical Asian element account for 37.04%, 33.33% and 22.22%, respectively. All the nine species endemic to China are distributed in southern China, southwestern China with tropical distribution pattern. Therefore, Among the 27 species of Chinese *Macromitrium*, 17 belong to tropical elements, accounting for 62.96% of the total species. The three newly-recorded species in the present study all belong to tropical Asian element. Among the 10 species of East-Asiatic element, eight belong to Sino-Japanese element, showing close relationship between China and Japan in the flora of *Macromitrium*.

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