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Bryophyte flora of Hunan Province, China. 4. Diplophyllaceae and Scapaniaceae (Hepaticae)

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Two species of *Diplophyllum*, *D. serrulatum* (Müll. Frib.) Steph. and *D. taxifolium* (Wahlenb.) Dumort., and three species of *Scapania*, *S. ciliata* Sande Lac., *S. koponenii* Potemkin, and *S. ligulata* Steph. are recorded and described for Hunan. A previous report of *S. griffithii* Schiffn. from Hunan is considered doubtful and its distribution and differentiation are discussed. *Diplophyllum taxifolium* is recorded for the first time for Hunan and it is very rare there. *Diplophyllum serrulatum* and *Scapania koponenii* are rare, and *Scapania ciliata* is moderately common. *Scapania ligulata* has two subspecies, subsp. *ligulata* and subsp. *stephanii* (Müll. Frib.) Potemkin, Piippo & T.J. Kop., *comb. nova*. Subspecies *ligulata* is rather rare and subsp. *stephanii* fairly common. Subsp. *ligulata* is more frequent in disturbed (more open and free of competition) than in primeval habitats, which might explain its larger size. *Diplophyllum serrulatum* and *Scapania koponenii* occur mostly in the warm-temperate zone. *Scapania ciliata* is mainly warm-temperate, but has some localities in the orotemperate zone. The general distribution, habitat ecology, reproduction and distinction of the taxa are discussed. *Scapania ciliata* is recorded as new for Vietnam.

Key words: *Diplophyllum*, hepatics, Hunan, *Scapania*, phytogeography, taxonomy

Introduction

This paper belongs to a series dealing with the bryophyte flora of Hunan Province. Essential background information of collecting localities and phytogeographical areas used in this study are given in parts 1 and 3 (Koponen *et al*. 2000, 2004). The method for counting frequencies, the primevity index, and the basis for dividing the taxa into flora elements are explained in Koponen *et al*. (2004). The second paper in the series is Potemkin (2000).

All the relevant types were not yet studied, but will be studied later in connection with the world monograph of these taxa by the first author.

Family Diplophyllaceae

The family Diplophyllaceae was segregated from

Scapaniaceae on the basis of different morphology, distribution pattern and ecological behaviour (Potemkin 1999). It includes two genera, *Diplophyllum s. stricto* and *Douinia*. In the Hunan Province only the genus *Diplophyllum* is represented. *Douinia* is distributed in the Atlantic Europe (Düll 1983), S Greenland (Schuster 1988) and the central Pacific coast of North America (Frye & Clark 1946). Records of *Douinia* from Japan have not been confirmed (Amakawa & Hattori 1953: p. 56, Furuki & Mizutani 1994).

Key to *Diplophyllum* in Hunan

1. Ventral lobes of non-gemmiparous leaves broadly rounded at apex, occasionally with a mucro; dorsal lobes ± ligulate and obtuse, somewhat falcate; leaves usually denticulate to serrulate distally and basally, but entire to irregularly denticulate at the middle of the postical margin of ventral lobe; dioicous, often without perianths ..... *D. taxifolium*
1. Ventral lobes of non-gemmiparous leaves ± gradually narrowed into a sharp spinose apiculus; dorsal lobes elliptic to ligulate, narrowed from a broad base into a sharply spinose apiculus, mostly not falcate; leaves slightly to strongly serrulate throughout except on the inner margin of ventral lobe; autoicous, often with perianths ..... *D. serrulatum*

Diplophyllum serrulatum (Müll. Frib.) Steph. (Figs. 1D–M, 4)

Spec. Hepat. 4: 112. 1910. — *Diplophylleia serrulata* Müll. Frib., Bull. Herb. Boiss. 3: 34. 1903.

Diplophyllum sendaicum Steph., Spec. Hepat. 6: 500. 1924.

Plants (0.5–)1.1–1.85 mm wide and 4–15 mm long, green to yellowish brown, branches lateral intercalary. Cortex ill-defined, 1–2-stratose of slightly to moderately thick-walled, usually unpigmented cells with a finely papillose outer surface; outer cortical cells only slightly smaller than internal cells, varying from not- to distinctly-flattened tangentially; usually with mycorrhiza dispersed mostly in outer and inner cortical cells. Leaves hardly to strongly serrulate except often on the inner margin of ventral lobe. Dorsal lobe 0.2–0.35(–0.4) of the ventral lobe, moderately divergent to subparallel with it, divergent with stem at an angle of ca. 30–45°, elliptic to ligulate, subacute to mostly ± abruptly spinosely pointed, 0.4–0.5 times as wide as long. Ventral lobe divergent with stem at an angle of ca. (45–)60–80(–90)°, ligulate to almost ellipsoid, somewhat falcate, 2.2–2.75 times as long as wide, chiefly gradually to sporadically rather triangulary narrowed in mostly ± abruptly spinose apex with 1(–2)-celled uniseriate end terminated by a sharply spinose cell; proximal sector of ventral lobe margin with a distinct area of hyaline and empty cells. Keel 0.24–0.37 of the ventral lobe length, straight to moderately arched. Marginal teeth usually only cell wall projections or at most 1-celled, more strongly developed to leaf base. Marginal cells distally ca. 8–12 × 9–16 μm, slightly to rather strongly and evenly thick-walled in 1–3 rows in distal and median sectors of ventral lobe margin; median cells of ventral lobe 11–17 × 17–35 μm, ± evenly thin-walled; basal cells of ventral lobe with a short to rather long (to 3/5 ventral lobe) vittate area of elongated cells, 11–16 × 35–60 μm, evenly thick- to thin-walled; oil bodies smooth, 2–6 in each median not elongated cells, subspheric, ca. 2–3.5 μm in diameter; cuticle weakly to moderately and occasionally rather coarsely papillose, with flat papillae. Gemmae common, 1–2-celled, green, thin- to somewhat thick-walled, polygonal to stellate, with strongly projected and thickened angles, ca. 14–21 μm in diameter. Intensive gemma production results in considerable reduction of leaves and in the formation of *Anastrophyllum*-like flagellae (Fig. 1G). Autoicous or, according to Amakawa and Hattori (1955), in Japan sporadically paroicous. Male inflorescence mostly on long branches of 2–6 pairs of mutually similar leaves, which are strongly inflated basally or of considerably smaller than sterile leaves 1-androus bracts. Perianths terminal on main shoot, often with small-leaved innovations, or on short lateral branches. Perianth not or little compressed; apical half conical to obovate, usually with 4 deep plicae; mouth 0.2–0.4 the width of perianth, irregularly lobed; lobes dentate laciniate with teeth 1–3(–4) cells long; cells of teeth elongated, the terminal cell spinose, strongly thick-walled to rather gradually rounded at the end and thin-walled, 9(–11) × 25–57 mm, 2.8–6.3 times as long as wide (when mouth ciliate terminal cells thin-walled).

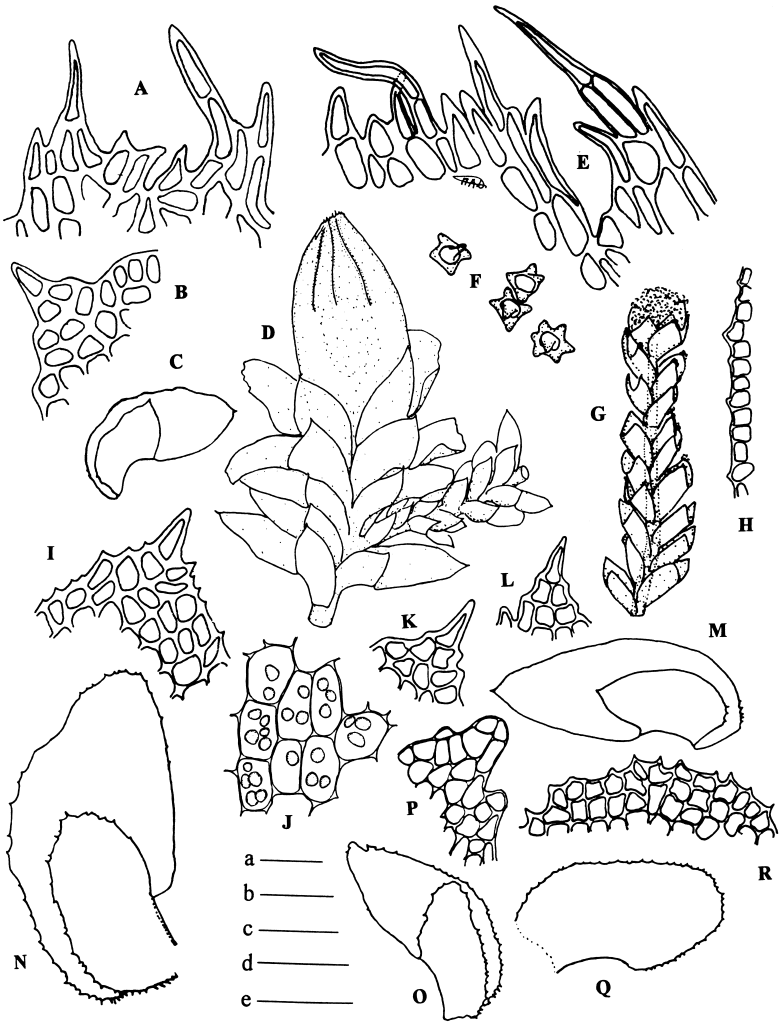

Fig. 1. *Diplophyllum apiculatum* (**A**–**C**), *D. serrulatum* (**D**–**M**) and *D. taxifolium* (**N**–**R**). — **A** and **E**: Sectors of perianth mouths. — **B**, **I**, **K**: Apical portions of ventral lobes. — **C**, **N**, **O**: Leaves. **O**: Leaf modified by gemma formation. — **D**: Sector of shoot with perianth and male branch. — **F**: Gemmae. — **G**: Small-leaved sector of abundantly gemmiparous shoot. — **H**: Median sector of postical margin of ventral lobe with strongly suppressed serrulations. — **J**: Median cells of ventral lobe with oil bodies. — **L**: Apical portion of dorsal lobe. — **M**: Female bract. — **P**: Apical sector of ventral lobe (of leaf **O**) modified from gemma formation. — **Q**: Ventral lobe of small leaf. — **R**: Apical sector of ventral lobe from **Q**. — **A**–**C** drawn from *Schuster 450'* (LE); **D** from *Koponen et al. 57950* (H); **E**, **F**, **G**, **I**, **M** from *Koponen et al. 50749* (LE); **H**, **J**, **K**, **L** from *Koponen et al. 57953* (H); **N**–**R** from *Koponen et al. 55516* (H). Scale bars: a: 0.4 mm (**C**, **D**, **G**). b: 20 µm (**J**). c: 40 µm (**A**, **B**, **E**, **F**, **H**, **I**, **K**, **L**, **P**, **R**). d: 0.2 mm (**N**, **O**, **Q**). e: 0.4 mm (**M**).

Spores 11.5–14 μm, yellowish brown, distinctly papillose. Elaters 6–9 μm in diameter.

Illustrations: Amakawa & Hattori 1955 (figs. XVII: 27–33; XVIII).

Study of extensive collections of *Diplophyllum serrulatum* from the area showed that its distinctions from the related *D. apiculatum* (A. Evans) Steph. need to be studied from fresh material. Variability of the perianth mouth of *D. serrulatum* completely overlaps with that of *D. apiculatum* (Fig. 1A, E). Serration of the leaf margin in *D. serrulatum* tends to be almost suppressed in robust forms, but very distinct in weak plants. On the other hand Hunanese plants

of *D. serrulatum* develop small-leaved *Anastrophyllum*-like flagellae associated with intensive gemma production. Such flagellae are unknown in *D. apiculatum*. Oil bodies observed in plants of *D. serrulatum* about half a year after collecting were smooth (Fig. 1J) whereas Schuster (1974) described oil bodies of *D. apiculatum* as composed of distinct and slightly protuberant globules. Oil bodies of *D. serrulatum* appeared to be granulate at the beginning of their disintegration only. The other distinctive characters of *D. serrulatum* and *D. apiculatum* are the shapes of distal portions of perianth, which are conical with ± straight sides (*vs.* obovate with ± convex sides and more strongly narrowed to the mouth (mouth width usually 0.2–0.4 *vs.* 0.35–0.5 maximal perianth width). Additional distinctions include: ventral lobes mostly gradually narrowed from about the middle to the apex (*vs.* more abruptly narrowed in distal portion); both lobes with ± abrupt 1(–2)-celled uniseriate ends with strongly elongated sharply spinose terminal cells (*vs.* 1–2-celled uniseriate ends with moderately elongated, not or slightly spinose terminal cells) (Fig. 1B, C).

In Hunan *Diplophyllum serrulatum* frequently has gemmae and perianths. It is a rare species, and was collected in 11 localities mostly in the warm-temperate zone (Fig. 4). It occurs in river valleys in primeval mid-subtropical evergreen forests and primeval evergreen broad-leaved forests and in cultivated bamboo forest (*Phyllostachus pubescens*). Once it was taken on rocky mountain top with *Fokienia hodginsii, Pinus kwantungensis,* and *Tsuga longibracteata*. It was collected from dry to moist, open to shaded cliffs (26 collections), boulders (3), sand (3), and trunk (1), often with *Scapania ciliata*, at 640–1350 m. In China it was previously known only from Taiwan (Piippo 1990). Primevity index 7/4/0. Frequency in Hunan: rare.

Range in Hunan (specimens cited in Koponen *et al*. 2000 are not repeated): Mangshan. *4b*. 51495a. *7a*. *7b*. 50727a. *7c*. Taoyuandong. *20a*. 57942, 57943a, 57945a, 57947 (with *Scapania ciliata*), 57950, 57952, 57953, 57954a, 57957, 57964a, 57965. *21a*. 48504, 48543b. *21c*. 56050b, 56053b, 56054. *25a*. 56195a. *31*. 57419a (with *S. ciliata*), 57421b, 57424, 57425a, 57431, 57432b, 57433. *36*. 57132. *37*. 56680, 56681, 56699a, 56704b.

Total range: Asia 2: Chi Ja Ko Tai (Piippo 1990, Engel & Smith Merrill 1998).

Diplophyllum taxifolium (Wahlenb.) Dumort. (Figs. 1N–Q, 4)

Rec. d'Observ.: 16. 1835. — *Jungermannia taxifolia* Wahlenb., Fl. Lappon. 389. 1812.

Diplophyllum taxifolium differs from *D. serrulatum* in (1) ventral lobes of non-gemmiparous leaves ± broadly rounded to blunt at apex; (2) dorsal lobes ± ligulate falcate and (3) obtuse, and (4) dioicous sexual condition and rarity of perianth-bearing plants (unknown from Hunan). The leaves in *D. serrulatum* are mostly ± serrulate along postical margin of ventral lobe (*vs.* mostly subentire at least in median sector of proximal margin in *D. taxifolium*), but the degree of leaf serration overlaps strongly in Hunanese plants of both species and is not a very useful character in identification. Despite the strong variability of perianth mouth structure (Schuster 1974: p. 205), *D. taxifolium* can be recognized by its less elongated cells of perianth mouth, which varies from dentate-ciliate, with cells 2–3 times as long as wide, to subentire, with subisodiametric cells (Inoue 1976: p. 8, fig. 1). The spectrum of variability of perianth mouth in Chinese plants remains unknown.

Problems in identification of *Diplophyllum taxifolium* and *D. serrulatum* were dealt with by Inoue (1976: p. 178). Mature plants with leaves not modified by gemma production should be studied. Gemma production in *D. serrulatum* usually results in obtuse ventral lobe tips resembling those of *D. taxifolium*, whereas juvenile leaves of *D. taxifolium* may develop a stronger serration resembling that of *D. serrulatum*.

Selected illustrations: Schuster 1974 (figs. 336: 1–9; 337; 338: 2, 4, 5–7, 11, 13); Inoue 1976 (pl. 8); Gao & Zhang 1981 (fig. 32: 9–16).

Diplophyllum taxifolium was collected on cliffs and it is rare (collected in three localities). One of the localities was by a large waterfall in partly disturbed habitat in the warm-temperate zone, and the two others were in primeval oro-temperate forest.

In China it was previously known from Heilongjiang and Jilin Provinces (Piippo 1990). Primevity index 2/1/0. Frequency in Hunan: rare.

RANGE IN HUNAN: Taoyuandong. *20a*. 57948a, around waterfall and its brook, at 670 m. Badagongshan. *45*. 55516, deciduous-evergreen forest along brook on cliff, at ca. 1450 m. *55a*. 54351, deciduous mixed forest with *Acer, Betula, Fagus, Tilia*, at ca. 1540 m (Fig. 4).

TOTAL RANGE: Am 1; Eur; As 1; As 2: Chi Ja Ko Tai; As 5 (Piippo 1990, Engel & Smith Merril 1998).

Family Scapaniaceae

Scapaniaceae is treated as a monogeneric family after Potemkin (1999). The genus *Scapania* is represented in Hunan by three species.

Key to *Scapania* in Hunan

1. Cuticle almost smooth or moderately papillose, never with dense hemispherical papillae obscuring cell lumen; leaf margin ± serrate-dentate, terminal cells of teeth chiefly not spinose, 1.15–1.65 times as long as wide .. 2
1. Cuticle coarsely papillose with dense hemispherical papillae obscuring cell lumen; leaf margin spinose dentate to ciliate, terminal cells of teeth mostly 1.6–7.0 times as long as wide 3
2. Leaf lobes broader and often obtuse .... 3a. *S. ligulata* subsp. *ligulata*
2. Leaf lobes rather narrow and triangularly pointed .... 3b. *S. ligulata* subsp. *stephanii*
3. Leaf margin ± ciliate to rarely rather longly spinose-dentate, terminal cells of teeth mostly (2.5–)3–7(–9.5) times as long as wide, constantly bleached ..... 1. *S. ciliata*
3. Leaf margin rather shortly spinose-dentate with terminal cells of teeth ± (1.45–)1.6–2.0(–3.1) times as long as wide, sporadically bleached ..... 2. *S. koponenii*

Scapania ciliata Sande Lac. (Fig. 4)

in Miquel, Ann. Mus. Bot. Lugd.-Bat. 3: 209. 1867.

Scapania spinosa Steph., Bull. Herb. Boiss. 5: 107. 1897.

Scapania levieri Müll. Frib., Beih. Bot. Centralbl. 11: 542. 1902.

Scapania hawaica Müll. Frib., Nova Acta Acad. Caes. Leop.-Carol. German Nat. Cur. 83: 160. 1905.

Plants (1.2–)3–4(–4.5) mm wide and 10–40 mm long, usually green to rarely yellowish, fuscous or purple, simple or with solitary ventral intercalary branches in upper shoot sectors and often with branched lower shoot sector adjacent to substrate. Cortex (2–)3–4(–5)-stratose and with strongly thickened cells usually with a deeper pigmented middle lamella; cortex often interrupted ventrally by several tiers of rather thin-walled cells; outer cortical cells with somewhat stronger thickenings than those of the internal cortical cells, not- to ± strongly-flattened tangentially; mycorrhizae regularly present in area close to cortex ventral interruption. Leaves ciliate throughout, with usually shorter and more sparse teeth near lobe bases. Dorsal lobe 0.35–0.5 of the ventral lobe, moderately divergent from it, divergent from stem at an angle of ca. 20–60°, oblique cordate, oblong to reniform, plane to slightly convex or concave, broadly rounded to obtuse and rarely triangularly pointed, slightly to strongly extending beyond the further edge of stem, (0.8–)1.0–1.25 times as wide as long, arcuately inserted, not decurrent. Ventral lobe divergent from stem at an angle of ca. 50–85°, ± oval, plane to ± convex with recurved postical margin, ± broadly rounded at apex, 0.6–0.8 times as wide as long, decurrent below keel insertion, not differentiated near postical margin base. Keel acute and 3–5-stratose from leaf base to sinus, 0.2–0.3 of the ventral lobe, straight to indistinctly arched, wing absent or locally narrow, entire. Marginal teeth or cilia 1(–2), more rarely 3 cells at base, 1–2(–3) cells long, with 1–2-celled uniseriate tips, with terminal cells mostly (2.5–)3–7(–9.5) times as long as wide, constantly bleached. Marginal cells (8–)10–17(–23) × (9–)11–23(–28) μm, thick- to thin-walled, sporadically ± bleached; median cells of ventral lobe (11–)14–23(–25) × (14–)17–28 μm, thin-walled with vestigial to small, acute, rarely medium-sized slightly bulging trigones; basal cells of ventral lobe form ± definite area of lax tissue in small-celled leaves and not in large-celled leaves, 16–24 × 35–48 μm, thin-walled, with rather large extensive acute to strongly bulging, often subconfluent trigones; oil bodies nonpersistent, (2–)3–5 per cell, rounded, (2–)3–4(–5) μm in diam. (seen in less papillose cells of perianth); cuticle regularly coarsely papillose. Gemmae sporadically present, (1–)2-celled, colorless, thin- to slightly thick-walled, broadly to narrowly ovoid and subspheric, occasionaly rounded trigonal, ca. 10–14(–17) × 17–25(–30) μm, (1.1–)1.2–2.0(–2.5) times as long as wide; gemmiparous leaves tend to develop branched

cilia and/or partly subentire margins. Dioicous or paroicous. Androecia hardly defined from sterile shoot sectors, formed of several pairs (1–2 on paroicous and up to 10 pairs on male shoots) of 1–4-androus bracts with dorsal lobes larger and more strongly convex than on sterile leaves and often purple near keel. Female bracts larger than leaves, with larger dorsal lobes and longer keels. Perianth strongly compressed and eplicate distally, hardly compressed, occasionally pluriplicate and multistratose proximally up to the middle third, mouth densely shallowly lobulate-ciliate to ciliate when lobules suppressed, with cilia 1–5(–7) cells long, 1–3-celled at base.

SELECTED ILLUSTRATIONS: Müller 1905 (taf. 10b as *Scapania hawaica*; taf. 14b as *S. levieri*; taf. 27a as *S. spinosa),* Amakawa & Hattori 1954 (fig. VII: 14–16 as *S. spinosa),* Amakawa 1964 (fig. 4: a–f as *S. levieri)*; Inoue 1974: pl. 37.

Scapania ciliata is the most easily recognized species among the regional *Scapania* due to (1) ciliate to spinose-dentate leaf margins with (2) distinctively bleached and glistening cilia or teeth; (3) very densely coarsely papillose cuticle with hemispherical papillae usually obscuring cell lumen; (4) ventral lobes broadly rounded at apex, and (5) mostly rounded dorsal lobes. It is closest to *S. bhutanensis* Amak., known from Eastern Himalayas and Yunnan (Potemkin 2002). The latter is distinct from *S. ciliata* in (1) dorsal lobe mostly ovate to cordate, moderately convex, often subparallel to stem; (2) keel very short, 0.09–0.2 of the ventral lobe, often arched; (3) marginal cilia near dorsal lobe base long and sporadically branched; (4) gemmae brown and broader, ca. 14–19 × 16–30 μm, × 1.0–1.6 as long as wide, and (5) cilia of perianth mouth branched.

Scapania ciliata is moderately common in Hunan (28 localities). It has a rather aggressive reproductive strategy, freely disseminating by gemmae and spores. The species occurs along streams and near waterfalls in primary and secondary warm-temperate evergreen mixed forests, along river beds in primeval warm-temperate forests, and mixed broad-leaved evergreen and deciduous forest with dense bamboo undergrowth, second-growth evergreen forest with planted *Cunninghamia lanceolata, Cryptomeria* or *Metasequoia glyptostroboides,* and *Pinus massoniana*, in second-growth forest, as well as in *Liriodendron, Alniphyllum, Metasequoia,* and *Phellodendron* plantations, and in cultivated bamboo (*Phyllostachus pubescens*) forests. Eleven of the collecting localities were primeval and 17 disturbed, three of them heavily so, such as road and path sides or even man-made habitats like stonewalls. Based on this data, *Scapania ciliata* can survive in disturbed habitats, if a suitable substrate is available. It was collected on cliffs (52 collections), boulders and stones (11), humus (2), sand (2), fallen trees (2), trunk (1), stump (1), and gravel (1) at 273–1750 m (Fig. 4). In China *Scapania ciliata* was previously known from seven central Chinese and Himalayan provinces (Piippo 1990). Primevity index 11/14/3. Frequency in Hunan: moderately common.

RANGE IN HUNAN (specimens cited in Koponen *et al.* 2000 are not repeated): Mangshan. *3b*. 51566a. *4b*. 51477. *5*. *7a*. 50981. *12b*. *14a*. Wulingyuan. *16c*. *17c*. 58463a. *19d*. Taoyuandong. 20a. 57947 (with *Diplophyllum serrulatum*), 57948b, 57949a, 57950 (with *D. serrulatum*), 57954c, 57957 (with *D. serrulatum*). *21a*. 48500, 48503a, 48504 (with *D. serrulatum*), 48543a, 54856a, 56005a. *21c*. 55149a, 55154, 55157, 55177a, 56039, 56050a, 56053a, 56054 (with *D. serrulatum*), 56055b, 56058a, 56064a, 56073c. *21d*. 55926, 55945a. *23b*. 55874. *25a*. 56195b. *25c*. 56637. *27*. 55211a. *31*. 56314, 56317a, 56318, 57419a (with *D. serrulatum*), 57421a, 57424 (with *D. serrulatum*), 57425b, 57426a, 57428, 57429a, 57431 (with *D. serrulatum*), 57432a, 57433 (with *D. serrulatum*), 57714a. *32*. 57193a. *34*. 56990a. *35*. 56408. *37*. 56679a, 56680 (with *D. serrulatum*), 56686, 56699b, 56703, 56704a, 56705a, 56730a. Badagongshan. *43*. 48414, 48457a. *44b*. 50189a. *55c*. 58779. Yankou. *74b*. 60961A, 60965A. *79a*. 60626A. *79b*. 59539, 59585A, 60662, 60669A, 60679, 60704.

The species was reported by Nicholson (1930) as *Scapania levieri* from SW Hunan: Yün-shan bei Wukang, 900–1180 m, 7.8.1917–30.6.1918 *Handel-Mazzetti 11130*. The collections of Handel-Mazzetti were unavailable for study.

TOTAL RANGE: As 2: Chi Ja Ko Tai; As 3: Bhu Ne Si In (NE) (Amakawa 1971, Long & Grolle 1990, Piippo 1990) Vi (Prov. Kontum, *Averjanov* (LE), new for Vietnam).

Scapania koponenii Potemkin (Fig. 4)

Ann. Bot. Fennici 37: 41. 2000.

Scapania cf. *aspera* M. & H. Bernet *sensu* Potemkin *in* Koponen *et al.,* Ann Bot. Fennici 37: 24. 2000.

Scapania koponenii was recently described by Potemkin (2000). It is rare (nine localities) in Hunan and occurs both in primeval and disturbed habitats in the warm-temperate zone.

Disturbed habitats were bamboo forest (*Phyllostachys pubescens*), *Cunninghamia* plantation, and second-growth evergreen mixed forest, and road, path and brook-side cliffs. The primeval habitats were *Cyclobalanopsis, Lithocarpus, Pinus kwantungensis, Pseudotaxus, Rhododendron,* and *Schima* forests, and a rocky mountain top with *Fokienia hodginsii, Pinus kwantungensis,* and *Tsuga longibracteata*. It was collected on moist to rather dry, open to completely shaded cliffs at 500–1180 m (Fig. 4). *Scapania koponenii* usually occurs with gemmae and often has perianths. Mature capsules are known only from a spring collection from Fujian Province. In China known from Fujian, Guangdong, Hunan, Jiangxi, and Zhejiang Provinces (Potemkin 2000). Primevity index 4/5/0. Frequency in Hunan: rare.

RANGE IN HUNAN (specimens cited in Potemkin 2000 are not repeated): Mangshan. *3a*. *6*. *7a*. *7b*. *7c*. *7e*. Wulingyuan. *18a*. *52954b*. *19d*. Taoyuandong. *21c*. *56055a*.

TOTAL RANGE: As 2: Endemic to China (Potemkin 2000).

Scapania ligulata Steph. subsp. ***ligulata*** (Figs. 2C, F, J, N, 4)

Hedwigia 44: 14. 1904. — Holotype: Japan. Yakushima, 1900 *Faurie 882* (G-025969!).

Plants 1.5–4.2 mm wide and 5–40 mm long, deep green to yellowish, fuscous and purplish brown, with sporadic ventral intercalary branches and subfloral innovation. Cortex 2–5-stratose of strongly thick-walled cells with mostly indefinite middle lamellae, usually interrupted ventrally by several tiers of ± thin-walled cells; outer cortical cells with smaller, similar or larger cavities than in intracortical cells, tangentially flattened or not; mycorrhizal infection occasionally present postically in lower shoot sector. Leaves dentate to serrate distally and medially mainly (in strongly dentate forms teeth spread to lobe bases), rarely subentire. Dorsal lobe (0.25–)0.3–0.6(–0.85) of the ventral lobe, subparallel to moderately divergent with it, divergent with stem at angle ca. 20–60°, obliquely reniform, oblong and ovate, mostly ± convex, exceptionally ± concave with incurved antical margin, rounded and short apiculate, a little extending beyond the further edge of stem, 0.77–1.18 times as wide as long, subtransversely to mostly arcuately inserted, largely not decurrent. Ventral lobe divergent with stem at angle ca. 35–85°, oblong-ligulate to broadly lanceolate and ovate, blunt and rounded, 0.6–0.9 times as wide as long, arcuately inserted and decurrent below the keel insertion, not hyaline and similarly pigmented near base margin. Keel acute, 2–4–7-stratose and 2–3 cells wide from leaf base to sinus, 0.15–0.42(–0.5) of the ventral lobe length, straight to indistinctly arched; wing absent or narrow, entire. Marginal teeth 1–2–4(–6–8) cells at base, 1–4(–5) cells long, with 1–2(–4)-celled uniseriate ends, with terminal cells (1.0–)1.2–1.5(–1.7) times as long as wide. Marginal cells distally (9–)10–14(–17) × 10–17(–20) μm, hardly to strongly thick-walled in several rows (Fig. 2D–F); median cells of ventral lobe (10–)11–18(–20) × (14–)17–25(–30) μm, thin- to slightly thick-walled with vestigial to moderate, acute and sporadically slightly bulging trigones; basal cells of ventral lobe form mostly small to exceptionally extensive area of lax tissue, (11–)14–28 × 21–42, thin- to thick-walled, with moderate acute to bulging and often confluent trigones; oil bodies nonpersistent, finely granulate (1–)2–5(–7) per median cell of ventral lobes, ± rounded, 3.5–5.5 μm in diam., to ovoid, 2–2.5 × 3.5–4 μm, exceptionally (*Koponen et al*. *58412*) 4.5–7(–9) × 4–7 μm; cuticle smooth to finely and moderately papillose. Gemmae mostly present, predominantly 1- or occasionally 2-celled, colorless to brownish when developed on nonpigmented leaves and exceptionally purplish or brownish when developed on similarly pigmented leaves, thin- to occasionally ± thick-walled, mainly broadly ovoid, often with admixture of elliptical, ovate, lemon-shaped, subsphaeric, rarely narrowly ovoid, (10–)11–14(–15) × (11–)17–23(–25) μm, (1–)1.4–1.8(–2.17) times as long as wide; gemma production leads to reduction and/or modification of lobe shapes from oblong to ovate, reduction of marginal teeth and formation of area of elongated cells along leaf margins. Dioicous. Androecia ± compact to rather lax, of 3–5–10 pairs of 2–4-androus bracts, which are smaller than sterile leaves, dentate and subequally bilobed. Female bracts similar to leaves, but larger. Perianth strongly to moderately com-

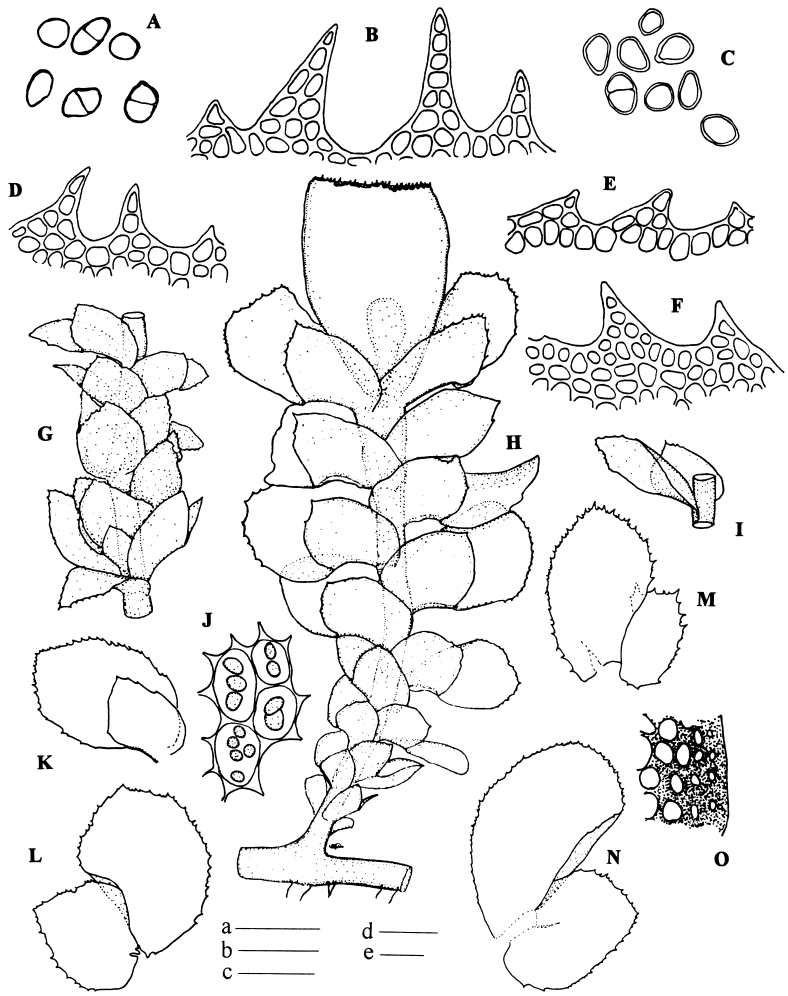

Fig. 2. *Scapania ligulata* subsp. *ligulata* (**C**, **F**, **J**, **N**) and subsp. *stephanii* (**A**, **B**, **D**, **E**, **G**–**I**, **K**–**M**, **O**). — **A** and **C**: Gemmae. — **B**: Sector of perianth mouth. — **D**, **E**, **F**: Sectors of postical margin of ventral lobes. — **G**: Sector of male shoot. — **H**: Plant with perianth. — **I**: Leaf on stem, postical aspect. — **J**: Median cells of ventral lobe with oil bodies. — **K**–**N**: Leaves. — **O**: Lateral sector of stem cross section. — Subsp. *stephanii*: **A**, **E**, **K**–**M** drawn from *Koponen et al. 58412* (H); **B**, **D**, **G**–**I**, **O** from *Koponen et al. 52954* (LE); subsp. *ligulata*: **C**, **N** from *Koponen et al. 55840* (H); **F** from *Koponen et al. 55359a* (H); **J** from *Koponen et al. 55046a* (H). Scale bars: a: 0.8 mm (**G**, **H**, **I**–**N**). b: 40 mm (**O**). c: 20 mm (**J**). d: 40 mm (**B**, **D**–**F**). e: 20 mm (**A**, **C**).

pressed, truncate, occasionally recurved, eplicate when strongly compressed, or with some plicae when somewhat inflated; mouth short to long dentate, teeth not branched, 2–6 cells at base, 3–12 cells long, with 1–4(–5)-celled uniseriate ends and terminal cells 1.3–2.0 times as long as wide.

Illustrations: Müller 1905 (taf. 49a), Amakawa & Hattori 1954 (figs. VII: 1–13*)*, Amakawa 1964 (fig. 6).

While *Scapania ligulata* subsp. *ligulata* and subsp. *stephanii* seem to be distinct taxa because of different size of plants, shape of leaf lobes and length of keel, they have virtually no reliable distinctions when extensive material from the whole range is studied. Subsp. *stephanii* appears to represent a complex of small forms with rather narrow and largely triangularly pointed lobes, whereas subsp. *ligulata* is a complex of larger forms with broader and often obtuse leaf lobes. These complexes seem to be genetically stabilized and according to published records

(Amakawa & Hattori 1954, Amakawa 1964, 1975, Inoue 1972), they have somewhat different distributions. Subsp. *stephanii* is distributed further northward than subsp. *ligulata* and does not penetrate into the Himalayas.

The maps (Fig. 4) of the subspecies *ligulata* and *stephanii* of *Scapania ligulata* show a slight difference in their altitudinal distribution. The dots of subsp. *ligulata* in the warm-temperate zone overlap completely with those of subsp. *stephanii*, which, however, has occurrences in the orotemperate zone. Subsp. *ligulata* has only two localities in primeval habitats and 15 in disturbed habitats, including four man-made habitats, while these figures for subsp. *stephanii* are 14 primeval and 26 disturbed localities, including two man-made habitats. An explanation for their different morphology might be that the larger subsp. *ligulata* is a result of growing in open habitats free of competition. Subsp. *stephanii* is better suited for growing in more shaded habitats where the light conditions and competition from other plants adapted in primeval conditions may affect its size. The difference in distribution and the different habitat ecology support our opinion that these taxa are worth recognizing at subspecific level, since their general distributions and local distributions are not similar.

Subsp. *ligulata* was collected on mesic to moist outcrops, boulders and stones (11 specimens), cliffs and outcrops (13), logs (3), humus (1), gravel (1), and bamboo base (1), in open, partially to fully shaded niches at 273–1280 m (Fig. 4). It grows in the warm-temperate zone, and more often in disturbed or man-made habitats than in primeval habitats. Disturbed habitats were road and trail sides and brook sides in second-growth forests and a bamboo cultivation, along trail in orchards (*Manihot*, sweet potato, *Citrus*), and in bamboo and *Cunninghamia* plantation forests. Primeval localities were in evergreen broad-leaved forests with *Acer, Albizzia, Castanopsis, Cyclobalanopsis, Fokienia, Indocalamus, Lindera, Liquidambar, Litsea, Meliosma, Michelia, Nyssa, Pinus massoniana, Schima,* and *Rhododendron*. *Scapania ligulata* subsp. *ligulata* was previously known from Anhui, Guangxi, and Yunnan Provinces (Koponen *et al*. 2000). Primevity index 2/11/4. Frequency in Hunan: rather rare.

RANGE IN HUNAN (the specimens cited in Koponen *et al*. 2000 are not repeated): Mangshan. *10a*. *10c*. *12b*. Wulingyuan. *17c*. 58449. *19a*. *80*. 58367A, 58381, 58383. *81a*. 58412A, 58415A. *83*. 58534A. Taoyuandong. *21c*. 56073a. *22*. 52605, 56206a, 56294. *23b*. 55840, 55841a, 55853a. *26*. 55359a, 55373, 55375. *29*. 56462a. *34*. 56990b, 56990c. Yankou. *74b*. 60928A, 60933A. *75b*. 60505a, 60507. *76b*. 60985, 60993A.

TOTAL RANGE: As 2: Chi Ja Tai; As 3: In (NE) Ne (Amakawa 1964, 1975, cf. Amakawa & Hattori 1954, Piippo 1990).

Scapania ligulata Steph. subsp. ***stephanii*** (Müll. Frib.) Potemkin, Piippo & T.J. Kop., *comb. nova* (Figs. 2A, B, D, E, G–I, K–M, 4)

S*capania stephanii* Müll. Frib., Nova Acta Acad. Caes. Leop.-Carol. German. Nat. Cur. 83: 273. 1905.

Leaves with dorsal lobes obliquely cordate to elliptical-lanceolate and obovate, mostly ± convex, exceptionally ± concave with incurved antical margin, apiculate to sporadically cuspidate, reaching the further edge of stem but mostly not extending beyond it, 0.63–0.85 times as wide as long, subtransversely to mostly arcuately inserted, largely not decurrent. Ventral lobe sharply triangularly pointed, (0.55–)0.6–0.75(–0.83) times as wide as long.

ILLUSTRATIONS: Müller 1905 (taf. 41, 50b), Amakawa & Hattori 1954 (VIII & IX as *S. stephanii).*

Subsp. *stephanii* was collected on cliffs and outcrops (51 specimens), stones and boulders (15), sand (3), trunks (2), bush (1), stump (1), and litter (1), at 375–1600 m. It is moderately common (42 localities) in Hunan. It was collected both in disturbed and primeval localities. Disturbed habitats were along streams and rivers in second-growth forests, second growth warm-temperate evergreen mixed forests, second-growth evergreen forests with planted *Cunninghamia lanceolata*, second-growth broad-leaved forests with mixture of *Alniphyllum, Liriodendron, Metasequoia,* and *Pinus*, in bamboo cultivations, and on road side cliffs and banks. Primeval habitats were along river shores or on slopes in primeval forests and in valleys along brooks, and evergreen broad-leaved forests in the warm-temperate zone, and in deciduous mixed forests in the orotemperate zone at 400–1600 m. In China it was known from

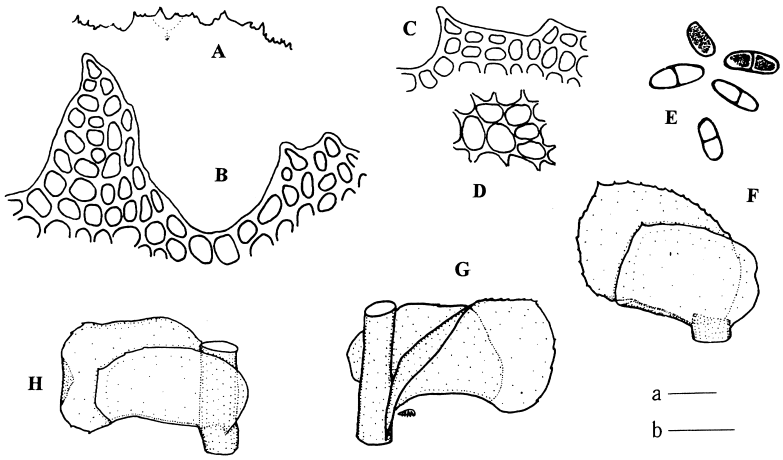

Fig. 3. *Scapania griffithii*. — **A**: Perianth mouth, mod. dentata. — **B**: Sector of perianth mouth from **A**. — **C**: Sector of postical margin of ventral lobe, medially. — **D**: Median cells of ventral lobe. — **E**: Gemmae. — **F** and **H**: Leaves on stem, antical aspect. — **G**: Leaf on stem, postical aspect. — All drawn from *M.-Z. Wang 7060* (LE). Scale bars: a: 0.4 mm (**A**, **F**–**H**). b: 40 mm (**B**–**E**).

Anhui, Fujian, Guangdong, and Jiangxi Provinces (Koponen *et al*. 2000). Primevity index 14/26/2. Frequency in Hunan: moderately common.

RANGE IN HUNAN (specimens cited in Koponen *et al*. 2000 are not repeated): Mangshan. *3b*. *5*. *7c*. *7d*. *7e*. 50634. *9a*. 49225. *10a*. 50814a. *12a*. *12b*. 50577a. Wulingyuan. *15c*. *16c*. *16d*. *17b*. 52425a. *18a*. 52954a, 58583A, 58586A. *18b*. 52600a. *18c*. 53003a. *18d*. *18e*. *19a*. *19b*. *19c*. 51800. *19d*. *84*. 58551a. Taoyuandong. *20a*. 57962, 56822. *21a*. 48543c. *21b*. 55119, 57951, 57954b. *23b*. 58898. *24*. 56282. *25a*. 56169a, 56170. 27. 55046a, 55213. *28*. 55323. *34*. 57028a. *36*. 57134. *37*. 56710. Badagongshan. *39a*. 50538a. *43*. 48423a, 54890. *45*. 55565a. *55a*. 54345. *55c*. 58770A. Yankou. *74c*. 61125. *75b*. 60506a. *79a*. 60637A. *79b*. 60601A, 60603A.

TOTAL RANGE: As 2: Chi Ja Ko Tai (Amakawa & Hattori 1954, Hong 1966, Piippo 1990).

Doubtful record

Scapania griffithii Schiffn. (Fig. 3)

Österr. Bot. Z. 49: 204. 1899. — LECTOTYPE: India. Darjeeling 1894, *rev. L. Stevens, n. 904* (G-008172).

Scapania griffithii was reported by Nicholson (1930) from SW Hunan: Yün-shan bei Wukang, 950–1200 m, 7.8.1917–25.6.1918 *Handel-Mazzetti 12215*. The specimens were unavailable for study.

Taking into account that Hunanese plants of *Scapania ligulata* frequently develop 2-celled gemmae, their confusion with *S. griffithii* seems possible. Typical *S. griffithii* apparently occurs only in the Himalayan region and adjacent territories. Its record from Taiwan (Inoue 1972) is very doubtful. Studied material from Taiwan identified by Inoue as *S. griffithii* (*Koponen 18152a,* H) much resembles his illustration of this species (Inoue 1972: fig. 3: 6–10). It may represent an abnormal form of *S. glaucoviridis* Horik., phenotype of *S. parvitexta* Steph. (mod. *leptoderma-acutiloba*) rather than *S. griffithii*. Taiwanese plants are distinct from *S. griffithii* in having small, at most 22 × 7.5 mm, gemmae and would be assigned to *S. parvitexta s. lato* (Potemkin 2002) rather than to *S. griffithii,* similar forms of which develop very diagnostic, large (ca. 30–40 × 10–14 mm), and narrow (mostly 2.6–3.0 as long as wide), chiefly bacilliform (with subparallel longitudinal walls and broadly rounded ends) gemmae, with the cell lumen homogeneous and filled with yellowish-green substances (Fig. 3E). For a detailed description of *S. griffithii, see* Srivastava and Srivastava (1994).

Discussion

Phytogeography

The bryophytes of Hunan can be divided into different flora elements based on their ranges.

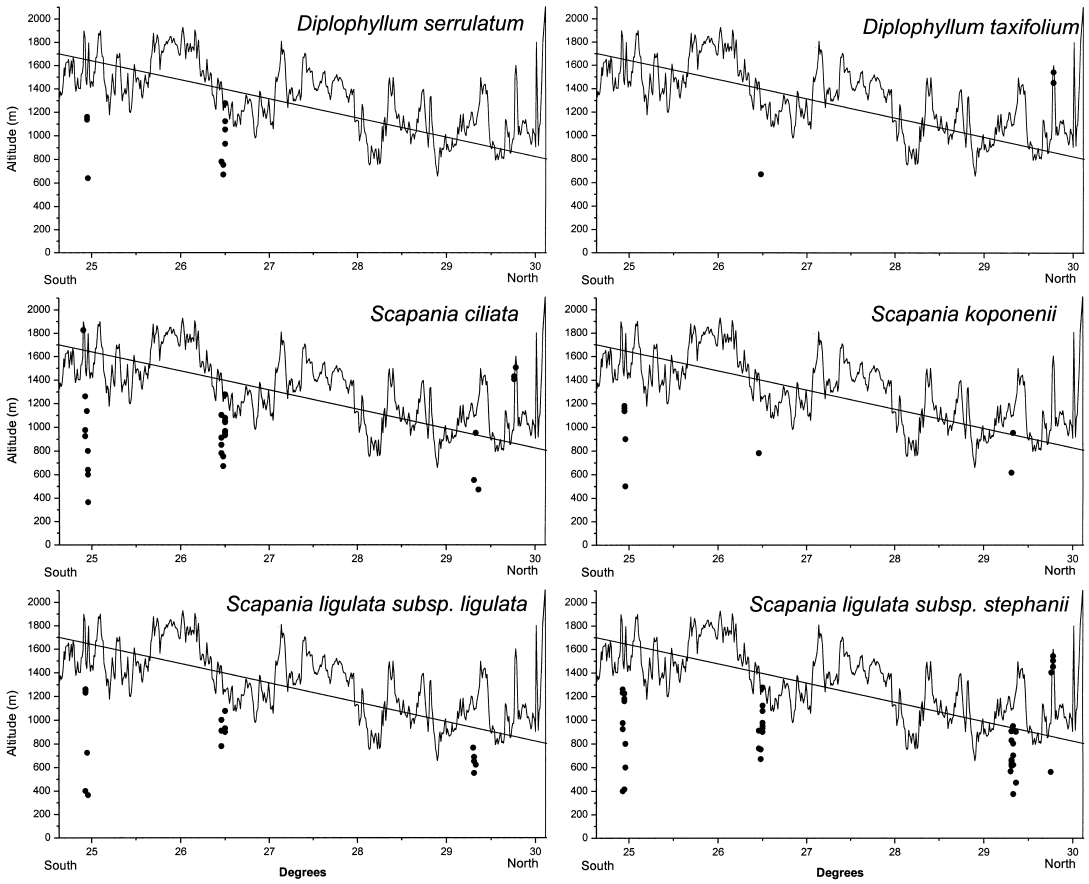

Fig. 4. Altitudinal ranges of *Diplophyllum serrulatum*, *D. taxifolium*, *Scapania ciliata*, *S. koponenii*, *S. ligulata* subsp. *ligulata* and subsp. *stephanii* in Hunan. The diagonal line indicates the upper border of the warm temperate (= meridional) zone, which is at the same time the lower border of the orotemperate zone.

Koponen *et al*. (2004) discussed the naming of such elements in detail. The present six taxa belong to three different elements (Fig. 4).

Holarctic, continuously or discontinuously circumpolar, boreal to temperate element

Diplophyllum taxifolium belongs to this flora element with widely ranging taxa. Its rarity in Hunan can be explained by the fact that it is there on the southern limit of its distribution area.

Southeast Asian temperate to warm-temperate element

Diplophyllum serrulatum
Scapania ciliata
S. ligulata subsp. *ligulata*
S. ligulata subsp. *stephanii*

The species in this element have their distribution within the temperate and warm-temperate zones in China, Japan and Korea. *Diplophyllum serrulatum* and *S. ligulata* subsp. *stephanii* have such ranges. Some bryophytes of this element extend their range to Russian Far East or to the Himalayas, and they may have disjunct localities in the mountains of the Philippines, Vietnam, or Thailand. Of the present taxa *Scapania ciliata* and *S. ligulata* subsp. *ligulata* have such ranges. In Hunan *S. ciliata* and *S. ligulata* subsp. *stephanii* occur both in the warm-temperate and orotemperate zones, while most of the localities of *Diplophyllum serrulatum* and *Scapania ligu-*

lata subsp. *ligulata* are in the warm-temperate zone. The altitudinal ranges in Hunan of all these taxa are accordant with their general ranges (*see* Koponen *et al*. 2004).

Taxon endemic to China

Scapania koponenii is until now known only from China. On the basis of its altitudinal range there it may be possible to find it in the neighbouring "second step" provinces in warm-temperate environments.

Frequency and human influence

In Table 1 the present taxa are arranged according to their general frequency in Hunan and their presence in man-made habitats (cf. Koponen *et al*. 2004).

Species of group 1 are rare in Hunan and they were not collected in man-made habitats. They are about equally frequent in primeval and in disturbed sites. *Scapania ligulata* subsp. *ligulata* of group 2 was collected less often in primeval sites than in disturbed and man-made sites. This may indicate that it can grow in more open and drier habitats than *S. ciliata* and *S. ligulata* subsp. *stephanii*. The taxa mentioned last were equally common both in primeval and in disturbed forest sites, but rarer in man-made habitats.

Koponen *et al*. (2004) concluded that the majority of Hunanese bryoflora can survive in habitats of moderate human activity rather well. The present set of species shows a similar tendency. However, half of the six taxa were not collected in sites classified as man-made habitats and two others, *S. ciliata* and *S. ligulata* subsp. *stephanii*, are rarer in such habitats than in primeval or disturbed sites. This is partly explained by their substrate ecology. The taxa are all rather strictly saxicolous. Cliffs, rocks, and stones are rather stable substrates, and these species clearly can survive a temporary opening of habitat, such as is caused by logging, but they can only rarely survive a constant and continuing lack of shading by woody plants.

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Table 1. The Hepaticae taxa arranged according to the human influence of the habitats and general frequency. 1 = ± primeval forests (45 sites). 2 = disturbed or secondary forest (65 sites). 3 = man-made habitats (36 sites). The frequency is counted for each of these habitats. 4 = total frequency in Hunan (146 sites). Frequency classes: rr = very rare, r = rare, st r = rather rare, p = moderately common, st fq = rather common. Substrate: c = cliff, stone.

	1	2	3	4	Substrate
Group 1					
Diplophyllum taxifolium	r	r	–	r	c
D. serrulatum	st r	r	–	r	c
Scapania koponenii	r	r	–	r	c
Group 2					
S. ligulata subsp. *ligulata*	r	st r	st r	st r	c
S. ligulata subsp. *stephanii*	st fq	st fq	r	p	c
S. ciliata	p	p	r	p	c

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Index of scientific names

Names accepted and formally treated in this paper are in **boldface**.