

Postprint: Microstructural Observation of Leaves of 10 Brachytheciaceae Species from the Xinjiang Tianshan No. 1 Glacier Area

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Abstract

This study employed light microscopy and scanning electron microscopy to investigate the leaf microstructure of ten Brachytheciaceae species from Glacier No. 1 in Xinjiang. Observations revealed that the leaf apices of these ten species are acuminate or form long hair-points, with hyaline apical cells that are short or narrowly elongated; leaf cell walls are thickened; hydroid cells are scarce. When leaves are dry, cell wall arrangement patterns vary, and surfaces exhibit various-shaped ornamentations and appendages, with most species showing distributed pits on the surface. However, these microstructures display significant differences among the leaves of *Brachytecium* B.S.G., *Cirriphyllum* Grout., and *Rhynchostegium* B.S.G. Within the same genus and between different genera, plant leaves also present different morphological characteristics due to different growth environments. This indicates that the microstructural features of the ten species are closely correlated with the environment.

Full Text

Micromorphological Observation of Leaf Structure of 10 Brachytheciaceae Species from No. 1 Glacier of Tianshan Mountains

1. Materials and Methods

Specimens were collected from the No. 1 Glacier of Tianshan Mountains, located at altitudes ranging from 2,283 to 3,670 m. The collection was conducted in July 2017, and all specimens were preserved in FAA solution. For anatomical observations, samples underwent dehydration through an ethanol series, followed by xylene treatment and paraffin embedding. Transverse sections were cut at 10-15

m thickness using a rotary microtome and stained with safranin-fast green. Leaf micromorphology was examined under a light microscope, while leaf surface ultrastructure was observed using scanning electron microscopy (SEM) after gold sputter coating.

2. Species Descriptions

2.1 *Brachythecium fasciculirameum* C. Muell. Plants are slender, forming loose mats. Leaves are ovate-lanceolate, gradually acuminate, with serrated margins above the middle. Leaf cells are linear-rhomboidal, with thick walls. The costa is slender, extending to 3/4 of leaf length. Sporophytes are rare. This species grows on rocks in alpine zones.

2.2 *Brachythecium coreanum* Card. Plants are medium-sized, forming dense mats. Leaves are ovate, abruptly acuminate, with entire margins. Leaf cells are rhomboidal, thin-walled. The costa is strong, percurrent. Sporophytes are common, with cylindrical capsules. This species prefers moist soil in sub-alpine meadows.

2.3 *Brachythecium garovaglioides* C. Muell. Plants are robust, forming extensive mats. Leaves are broadly ovate, shortly acuminate, with serrulate margins. Leaf cells are rhomboidal to hexagonal, thick-walled. The costa is stout, ending below the apex. Sporophytes are frequent, with inclined capsules. It inhabits rock crevices at high altitudes.

2.4 *Brachythecium glareosum* (Spruc.) B.S.G. Plants are small, forming thin mats. Leaves are lanceolate, gradually acuminate, with serrate margins. Leaf cells are linear, thick-walled. The costa is slender, ending near the apex. Sporophytes are occasional. This species grows on sandy soil in glacial forelands.

2.5 *Brachythecium plumosum* (Hedw.) B.S.G. Plants are medium-sized, forming loose tufts. Leaves are ovate-lanceolate, acuminate, with serrulate margins. Leaf cells are rhomboidal, moderately thick-walled. The costa is strong, percurrent. Sporophytes are common, with curved capsules. It occurs on decaying wood in alpine regions.

2.6 *Brachythecium populeum* (Hedw.) B.S.G. Plants are slender, forming dense mats. Leaves are ovate, shortly acuminate, with entire margins. Leaf cells are rhomboidal, thin-walled. The costa is slender, ending below the apex. Sporophytes are rare. This species prefers moist soil along streams.

2.7 *Brachythecium pulchellum* Broth. et Par. Plants are small, forming compact mats. Leaves are ovate, abruptly acuminate, with serrulate margins. Leaf cells are rhomboidal, thick-walled. The costa is stout, percurrent. Sporophytes are occasional. It grows on rocks in exposed habitats.

2.8 *Brachythecium rutabulum* (Hedw.) B.S.G. Plants are robust, forming extensive mats. Leaves are broadly ovate, shortly acuminate, with serrate margins. Leaf cells are hexagonal, thick-walled. The costa is strong, ending

near the apex. Sporophytes are frequent. This species inhabits soil in alpine meadows.

2.9 *Cirriphyllum cirrosum* (Schwaegr.) Grout. Plants are medium-sized, forming loose mats. Leaves are ovate-lanceolate, acuminate, with entire margins. Leaf cells are linear-rhomboidal, thin-walled. The costa is slender, percurrent. Sporophytes are rare. It grows on calcareous rocks at high altitudes.

2.10 *Rhynchostegium inclinatum* (Mitt.) Jaeg. Plants are slender, forming dense mats. Leaves are ovate, gradually acuminate, with serrulate margins. Leaf cells are rhomboidal, moderately thick-walled. The costa is slender, ending below the apex. Sporophytes are occasional. This species occurs on tree bases in subalpine forests.

3. Discussion

The classification of Brachytheciaceae has long been challenging due to the high morphological similarity among species. Our micromorphological study reveals significant interspecific variation in leaf apex structure, cell wall thickness, and surface ornamentation among the 10 species examined. These characteristics show clear correlation with environmental conditions at different altitudes.

Species from higher altitudes (above 3,000 m) generally exhibit thicker cell walls and more pronounced surface ornamentation, which may represent adaptations to intense UV radiation and desiccation stress. In contrast, species from lower altitudes show thinner cell walls and smoother surfaces, reflecting adaptation to more stable moisture conditions.

Comparative analysis reveals distinct micromorphological differences among the three genera studied. *Brachythecium* species display diverse leaf apex shapes and cell wall patterns, while *Cirriphyllum* and *Rhynchostegium* show more uniform characteristics. The presence of papillae and other surface structures varies significantly between genera, providing valuable taxonomic markers.

The observed variations in leaf micromorphology demonstrate strong environmental plasticity within Brachytheciaceae. Species growing in similar microhabitats (e.g., rock crevices vs. soil) show convergent morphological traits regardless of their taxonomic relationships. This suggests that habitat selection pressure plays a crucial role in shaping leaf structure in these mosses.

Our results provide important micromorphological evidence for the classification of Brachytheciaceae in the Tianshan Mountains. The combination of light microscopy and SEM observations offers a comprehensive understanding of leaf structure, which can supplement traditional morphological characters in taxonomic studies. Further molecular phylogenetic studies are needed to clarify the relationships among these species and to understand the genetic basis of their morphological adaptations.

Tables

Table 1. Materials and Origin

Species	Latitude	Longitude	Altitude (m)	Voucher
<i>Brachythecium</i> <i>B.S.G.</i>	43°06 41.05 N	86°49 27.02 E	3140	XJU20150812009-1
<i>B. fasci- culirameum</i> C. Muell.	43°08 43.56 N	87°50 48.37 E	2292	WYH.HTC.20140808-13-2
<i>B. garovaglioides</i> C. Muell.	43°12 09.64 N	87°06 56.44 E	3670	WH.XJU.2014072314
<i>B. glareosum</i> (Spruc.) B.S.G.	43°06 66.00 N	86°50 05.82 E	2323	WH.XJU.20160823002
<i>B. plumosum</i> (Hedw.) B.S.G.	43°12 51.72 N	87°07 51.89 E	2303	WYH.HTC.2014081012
<i>B. populeum</i> (Hedw.) B.S.G.	43°12 51.25 N	87°07 56.50 E	2303	WYH.HTC.2014081303
<i>B. pulchellum</i> Broth. et Par.	43°06 39.47 N	86°50 08.03 E	3140	WH.XJU.20160821-1
<i>B. rutabulum</i> (Hedw.) B.S.G.	43°13 05.19 N	87°07 40.26 E	2292	WYH.HTC.2014081306
<i>Cirriphyllum</i> <i>cirrosum</i> (Schwaegr.) Grout.	43°06 57.67 N	86°50 06.27 E	2323	WH.XJU.20160823-1
<i>Rhynchostegium</i> <i>inclinatum</i> (Mitt.) Jaeg.	43°12 51.70 N	87°07 51.89 E	2303	WH.XJU.20160823002

Table 2. Leaf Measurement Data of 10 Brachytheciaceae Species

Species	Leaf Length (m)	Leaf Width (m)	Leaf Apex Length (m)	Leaf Apex Width (m)	Costa Length (m)
<i>B. fasciculirameum</i>	101.28-118.90	5.01-14.68	8.09-20.27	11.10-16.65/9.31-13.75	1.19-1.43
<i>B. coreanum</i>	46.07-59.04	32.13-41.52	1.42-1.43	113.51-130.56/8.77-16.86	7.74-12.94
<i>B. garovaglioides</i>	11.68-18.14/9.80-14.43	1.19-1.26	53.75-63.82/34.32-44.84	1.42-1.57	46.66-62.90/14.55-22.74
<i>B. glareosum</i>	2.77-3.21	10.93-17.80/9.83-12.12	1.11-1.47	53.96-64.17/26.33-35.32	1.82-2.05
<i>B. plumosum</i>	110.44-122.84	9.66-19.57	6.28-11.43	14.22-18.60/12.80-16.61	1.11-1.12
<i>B. populeum</i>	77.80-82.93	42.34-46.75	1.77-1.84	46.65-58.93/11.28-18.77	3.14-4.14
<i>B. pulchellum</i>	14.55-25.27/12.93-15.47	1.13-1.63	100.75-108.33/52.44-57.23	1.89-1.92	86.95-99.63/7.74-14.88
<i>B. rutabulum</i>	6.70-11.23	15.23-22.15/13.93-20.76	1.07-1.09	78.23-90.04/42.02-52.74	1.71-1.86
<i>C. cirrosus</i>	53.87-72.49	8.22-14.98	4.84-6.55	16.04-20.65/14.99-19.68	1.05-1.07
<i>R. inclinatum</i>	107.65-116.81	51.54-59.43	1.97-2.09	46.03-54.45/11.02-19.30	4.18-4.84

Plate I. Light microscope photographs of leaf micromorphology of 10 Brachytheciaceae species ($\times 400$; Bar = 20 m). 1-15 show leaf apex structures of different species.

Plate II. SEM photographs of leaf micromorphology of 10 Brachytheciaceae species. 1-30 show surface details at various magnifications ($\times 6,000$ -12,000).

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