Moss diversity in the state of Aguascalientes, Mexico: Revision and update

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Abstract

Background: Seven moss species were known from the state of Aguascalientes before a study by Delgadillo *et al*. (2015) listed 38 new records for its moss flora.
Hypothesis: Despite its comparatively dry climate, Aguascalientes could harbor a more diverse moss flora. Geographically, this would be an extension of the moss flora of Jalisco and Zacatecas.
Study site and dates: Moss collections in Aguascalientes were made in August 2014 and September 2015, with emphasis on northwestern and southwestern localities.
Methods: About 165 moss samples were collected in old fields, streambeds, and areas covered with chaparral vegetation. These and 140 herbarium specimens from the herbarium of Universidad Autónoma de Aguascalientes (HUAA) were studied to prepare the species list.
Results: The Aguascalientes moss flora comprises at least 95 moss species and varieties, including 50 new state records. The families Pottiaceae (34 species), Bryaceae (11) and Grimmiaceae (7) are the most important. It is a flora characteristic of the drylands, but with some highland representatives. Keys for the identification of the known moss species are included.
Conclusions: A larger species number should be expected once less-accessible areas are explored. The known Aguascalientes moss flora is characteristic of dry land areas extending to Jalisco and Zacatecas, but with some high elevation species. It comprises cleistocarpic taxa and other with peculiar adaptations. Some species form associations that require other forms of analysis.
Key words: Bryophyte, mosses, species richness, Mexico.

Diversidad de musgos en el estado de Aguascalientes, México: Revisión y actualización.

Resumen

Antecedentes: Se conocían siete especies de musgos para Aguascalientes hasta que Delgadillo *et al*. (2015) registraron 38 especies y variedades nuevas para la flora de ese estado.
Hipótesis: Aunque ocupa áreas geográficas comparativamente secas, Aguascalientes debe tener una flora más diversa. Ésta podría ser una extensión de la flora de musgos de Jalisco y Zacatecas.
Sitio de estudio y fechas: En Agosto de 2014 y Septiembre de 2015 se visitó el estado de Aguascalientes, con énfasis en localidades del noroeste y suroeste.
Métodos: Se colectaron 165 muestras de musgos en campos abandonados, lechos de arroyo y matorrales. Además, se estudiaron 140 ejemplares del herbario de la Universidad Autónoma de Aguascalientes (HUAA) para preparar el listado de especies.
Resultados: La flora contiene 95 especies de musgos, 50 de las cuales son registros nuevos para Aguascalientes. Los miembros de las familias Pottiaceae, con 34 especies, Bryaceae (11) y Grimmiaceae (7) son las más importantes. Se incluyen claves para la determinación de las especies conocidas.
Conclusiones: Se debe esperar un número mayor de especies con la exploración de áreas de difícil acceso. La flora de musgos de Aguascalientes es característica de las zonas secas que incluyen a Jalisco y Zacatecas, pero con representantes de zonas altas. Contiene taxa cleistocárpicos y otros con adaptaciones peculiares. Algunas especies forman asociaciones que requieren otras formas de análisis.
Palabras clave: Bryophyta, musgos, riqueza de especies, México.

Contributions by each author
Claudio Delgadillo-Moya designed the study, collected and identified specimens, prepared the manuscript. Ana Paola Peña-Retes collected and identified specimens, revised and contributed portions of the text, including the map.

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A preliminary contribution (Delgadillo *et al*. 2015) noted that several states in central Mexico were poorly explored and their moss floras were not well known. Guanajuato, Querétaro, and Zacatecas received some recent attention, but Aguascalientes remained unexplored until 2013. Collections reported by Delgadillo *et al*. (2015) listed the names of 45 moss species and varieties, including seven previously known for the flora of Aguascalientes; collecting effort and niche modelling analysis suggested a potential richness of 91 species for the state when a broader exploration were conducted. The earlier report also proposed that this moss flora was an extension of the dry land flora of Jalisco and Zacatecas, but no further comment was offered because of the limited floristic information available. With no other publications on the subject, additional field work was conducted to gain insight on the size and diversity of the state moss flora. This contribution updates the previous list, re-examines the distribution of the species, and provides a key for the identification of known species in Aguascalientes.

Materials and methods

In August 2014 and September 2015, the authors collected about 165 moss specimens, mainly in north- and southwestern localities in Aguascalientes (Table 1, Figure 1). Abandoned fields

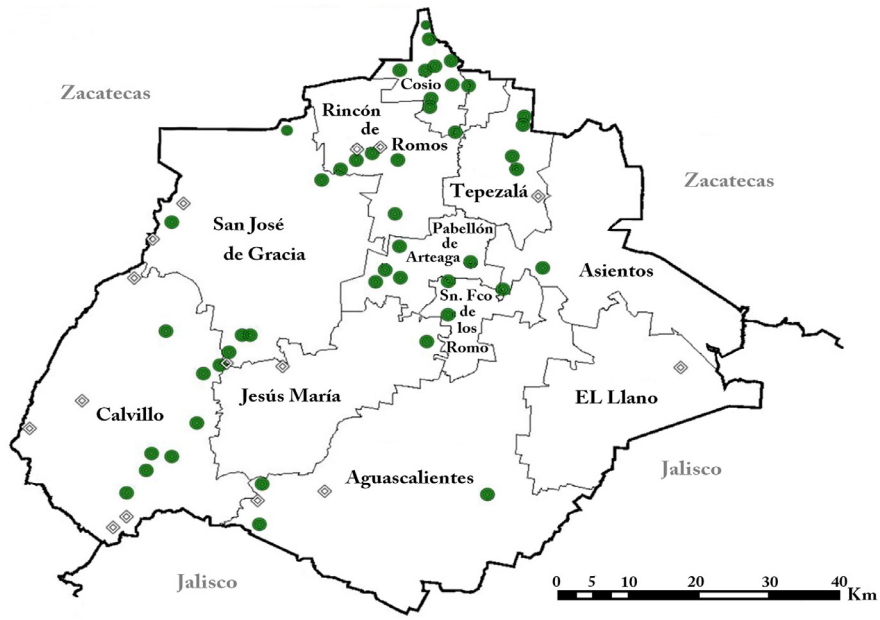

Figure 1. Collecting localities in Aguascalientes. Localities reported by Delgadillo *et al*. (2015) are indicated by diamonds. Solid circles represent recent collections by the authors and by HUAA personnel.

Table 1. Moss collecting sites in Aguascalientes in 2014, 2015. Specimen numbers preceded by PP were collected by Paola Peña. Four-digit numbers belong to collections by C. Delgadillo.

Specimen Number	Localities	Coordinates (N – W)	Elev. (m)
PP 297-305; 7704-7720	Cerro El Salteador	21° 44' 37" - 102° 31' 34"	1950-2000
7675-7677	San Antonio Montoya	21° 56' 32" - 102° 04' 00"	2040
7678-7683	Cerca de Ojo de Agua	22° 01' 29" - 101° 56' 35"	2000
7684	Cerca de Charco Azul	22° 02' 56"- 102° 01'36"	1950
PP 321-323; 7744-7747	17 km W La Congoja	22° 09' 8" - 102° 39'32"	2520
PP 306-320; 7734-7743	10 km S La Congoja	22° 11' 31" - 102° 38'15"	2580
PP 324-327; 7748-7754	10 km NW San José de Gracia	22° 09' 36" - 102° 22'16"	2290
7694-7695	San Gil	22° 11' 51" - 102° 01' 16"	2030
PP 328-336; 7755-7769	Boca del Túnel de Potrerillo	22° 13' 48" - 102° 26'49"	2020
PP 288; 7693	Tepezala	22° 13' 22" - 102° 11' 08"	1980
PP 289-291; 7696	Cerca de La Boquilla	22° 15' 32" - 102° 22' 48"	1960
PP 292-293; 7697	Cerca de La Boquilla.	22° 14' 59" - 102° 23' 49"	2010
PP 294-295; 7698-7703	Cerca de La Boquilla	22° 15' 01' - 102° 24' 16"	2080
PP 284-287; 7685-7692	Las Pilas	22° 15' 15" - 102° 10' 40"	2000

(San Antonio Montoya), riparian vegetation or stream beads (Ojo de Agua, Charco Azul), and scrubland vegetation elsewhere were the source of our collections. In addition, 140 miscellaneous specimens from the herbarium of Universidad Autónoma de Aguascalientes (HUAA), served to update the floristic list for that state. All specimens were identified and deposited in the Bryophyte Collection of the National Herbarium (MEXU), with duplicates for HUAA and other herbaria.

Results

The list of taxa in Table 2 contains 50 new records for the moss flora of Aguascalientes. These are unmarked under "A" to distinguish them from previously reported records (Delgadillo *et al*. 2015), and bring the total number to 95 taxa, *i.e*., four species above the previously estimated number. Most of the species are also known from Jalisco or Zacatecas so that the Aguascalientes moss flora may indeed represent an extension of the flora from those states (Delgadillo *et al*. 2015).

The moss flora of Aguascalientes contains numerous taxa from dry land areas. Among them, the Pottiaceae are rather frequent, with 34 species and varieties for a 36 % of the total state moss flora. The Bryaceae, with 11 species, only make a 12 %. The Grimmiaceae, with seven species (*ca*. 7 % of the total), are also noteworthy because they are rock inhabitants and more diverse than fifteen other families that are represented by five or less in the state moss flora. At the generic level mosses are represented by 43 genera, or nearly 13 % of the Mexican moss flora.

The list contains such taxa as *Anomobryum conicum* that seem rare or may be infrequently collected while others such as *Aloina hamulus* and *Didymodon* spp., are rather frequent in the region. The flora also includes a significant number of high elevation taxa that are known to occur in Jalisco or in the alpine regions of central Mexico; *Aongstroemia orientalis* and species of *Grimmia* are in this group. Most species live on soil or rocks. The number of epiphytes is comparatively small (14 species, Table 2) because, in addition to low rainfall, tree cover is sparse and may offer scarce protection against desiccation. Species of *Fabronia*, *Leskea*, *Lindbergia*, and *Orthotrichum* usually occupy these habitats.

Hennediella stanfordensis, only known from the state of Guerrero, is represented by two poorly preserved specimens from San Francisco de los Romo area, but the identification is facilitated by a differentiated papillose leaf margin with thick-walled elongated cells, and a mucro standing against an entire leaf apex. *Jaffueliobryum arsenei* and *Ptychomitrium chimborazense* have narrow ranges; the former is known from Zacatecas to Querétaro, but in Aguascalientes it seems more frequent although it is officially recognized as rare (Delgadillo 1996). The distribution of the latter in Mexico extends from Zacatecas to Puebla, but collections have been occasional, only. *Archidium donnellii*, *Pleuridium mexicanum*, and *Tortula acaulon* are the only cleistocarpic mosses known for this state. *Anomobryum plicatum* and *Entosthodon obtusatus* are tentatively included in the list because specimen identification was uncertain due to immature or sterile material available. There are no species restricted to Aguascalientes, but its flora includes *Grimmia involucrata*, *G. pulla*, *Hennediella heteroloma*, *Jaffueliobryum arsenei*, and *Trichostomum subangustifolium*, endemic to Mexico.

Although most species are cited in Sharp *et al*. (1994), the keys introduced in this contribution reflect recent taxonomic and nomenclatural arrangements. They should facilitate the identification of mosses from Aguascalientes. For this purpose, observations in the following paragraph are to be considered.

Moss keys usually distinguish the erect from the prostrate habit. Such growth forms may be labeled as "acrocarpous" and "pleurocarpous", as defined in standard floras and glossaries, but they have been omitted in the keys to avoid confusion. Broadly speaking, such terms describe the position of the perichaetium in a branching system. In the acrocarpous mosses, a single perichaetium is formed at the end of a primary module of a branch system; in the pleurocarpous mosses one or more perichaetia are produced per primary or secondary module, at the end of lateral innovations that lack branch primordia or developed branches. A third moss growth type that is seldom mentioned is termed "cladocarpous" where the primary modules end in vegetative growth and the perichaetia are produced at the end of lateral branches of secondary or tertiary branches (La Farge-England 1996). Withey (1996) suggests that the cladocarpous condition is

Table 2. Mosses from the state of Aguascalientes. A, species previously recorded by Delgadillo *et al*. (2015); those without a mark are new state records. The records for Jal (Jalisco) and Zac (Zacatecas) were cited by Sharp *et al*. (1994) or come from specimens at MEXU (H). Sb = substrate: R, rock; S, soil; Sr, soil-covered rocks; T, trunk; r, root

A	TAXA	Jal	Zac	H	Sb
X	*Aloina hamulus* (Müll. Hal.) Broth.	X	X	*	S S, Sr
	Anacolia laevisphaera (Taylor) Flowers	X	X	*	S
	Anoectangium aestivum (Hedw.) Mitt.	X	X	*	S
	Anomobryum conicum (Hornsch.) Broth.				R
X	*Anomobryum julaceum* (Gaertn., Meyer & Schreb.) Schimp.	X	X	*	S
	Anomobryum plicatum Cardot	X		*	S
	Aongstroemia orientalis Mitt.	X			S
	Archidium donnellii Austin		X	*	S
X	*Barbula orizabensis* Müll. Hal.	X			S
X	*Brachymenium mexicanum* Mont.	X	X	*	R, S, Sr
X	*Brachymenium systylium* (Müll. Hal.) A. Jaeger	X			T
	Brachythecium frigidum (Müll. Hal.) Besch.				Sr
	Brachythecium ruderale (Bird.) W. R. Buck	X			Sr
X	*Braunia andrieuxii* Lorentz	X	X	*	R, S, Sr
	Braunia plicata (Mitt.) A. Jaeger				T
X	*Braunia secunda* (Hook.) Bruch & Schimp.	X	X	*	R
	Bryoerythrophyllum inaequalifolium (Taylor) R. H. Zander	X	X	*	S
	Bryoerythrophyllum recurvirostrum (Hedw.) Chen var. *recurvirostrum*	X		*	S
	Bryoerythrophyllum recurvirostrum var. *aeneum* (Müll. Hal.) R. H. Zander		X		S
X	*Bryum argenteum* Hedw.	X	X	*	S
X	*Bryum billarderi* Schwägr.	X	X	*	S
X	*Bryum chryseum* Mitt.	X	X	*	S, Sr
	Bryum coronatum Schwägr.				S
X	*Campyliadelphus chrysophyllus* (Brid.) Kanda				S
	Campylopus albidovirens Herz.	X			S
	Campylopus flexuosus (Hedw.) Brid.	X			S
X	*Campylopus pilifer* Brid.	X	X	*	R, Sr
X	*Ceratodon purpureus* (Hedw.) Brid. subsp. *stenocarpus* (Bruch & Schimp.) Dixon	X			S
X	*Crossidium crassinervia* (De Not.) Jur.		X	*	Sr
X	*Didymodon australasiae* (Hook. & Grev.) R.H. Zander	X	X	*	R, S
X	*Didymodon revolutus* (Cardot) R.S. Williams	X	X		S
X	*Didymodon rigidulus* var. *gracilis* (Schleich. Ex Hook. & Grev.) R.H. Zander	X	X	*	S
X	*Didymodon rigidulus* var. *icmadophilus* (Schimp. ex Müll. Hal.) R.H. Zander	X	X	*	S
X	*Didymodon rigidulus* var. *rigidulus*	X	X	*	S, Sr
	Entodon beyrichii (Schwägr.) Müll. Hal.	X	X	*	R
X	*Entosthodon apiculatopilosus* (Cardot) Fife		X	*	S
	Entosthodon jamesonii (Taylor) Mitt.				S
	Entosthodon obtusatus (Schimp.) Fife				S
	Entosthodon obtusifolius Hook. f.	X		*	S
	Epipterygium immarginatum Mitt.	X		*	S
X	*Erythrodontium longisetum* (Hook.) Paris	X			T
X	*Erythrodontium squarrosum* (Hampe) Paris	X		*	R
	Fabronia ciliaris var. *ciliaris*	X	X	*	T
X	*Fabronia ciliaris* var. *polycarpa* (Hook.) W.R. Buck	X			T
	Fabronia ciliaris var. *wrightii* (Sull.) W.R. Buck	X	X	*	T
X	*Fabronia macroblepharis* Schwägr.		X	*	T
X	*Fissidens bryoides* Hedw.	X	X	*	Sr
X	*Fissidens crispus* Mont.	X	X		S, Sr
	Fissidens elegans Brid.				Sr

Table 2. Continuation.

A	TAXA	Jal	Zac	H	Sb
X	*Fissidens guianensis* Mont.	X			S
X	*Fissidens sublimbatus* Grout				S
	Funaria hygrometrica var. *calvescens* (Schwägr.) Mont.	X	X	*	S
	Funaria hygrometrica var. *hygrometrica*	X	X	*	S
	Globulinella globifera (Hampe) Steere	X			S
X	*Grimmia elongata* Kaulf.	X			R
	Grimmia involucrata Cardot		X	*	R
X	*Grimmia laevigata* (Brid.) Brid.		X		R
X	*Grimmia longirostris* Hook.	X	X	*	R, Sr
X	*Grimmia ovalis* (Hedw.) Lindb.		X	*	R
X	*Grimmia pulla* Cardot	X			R, Sr
	Gymnostomum aeruginosum Sm.	X		*	Sr
	Haplocladium microphyllum (Hedw.) Broth.	X		*	R
X	*Hennediella heteroloma* (Cardot) R.H. Zander	X	X	*	r
	Hennediella stanfordensis (Steere) Blockeel				R
	Hyophila involuta (Hook.) A. Jaeger	X	X	*	R
X	*Jaffueliobryum arsenei* (Thér.) Thér.		X	*	R
X	*Leptodontium flexifolium* (Dicks..) Hampe	X	X	*	S
X	*Leskea angustata* Taylor	X	X	*	T
	Lindbergia mexicana (Besch.) Cardot		X	*	T
	Orthotrichum bartramii R.S. Williams				T
	Orthotrichum diaphanum Schrad. ex Brid.		X	*	T
	Orthotrichum pycnophyllum Schimp.	X	X	*	T
	Plaubelia sprengelii var. *stomatodonta* (Cardot) R.H. Zander	X	X	*	S
X	*Pleuridium mexicanum* Cardot		X	*	S
X	*Pogonatum campylocarpon* (Müll. Hal.) Mitt.	X	X	*	S, Sr
X	*Pogonatum oligodus* (Kunze ex Müll. Hal) Mitt.		X	*	S, Sr
	Pohlia nutans (Hedw.) Lindb.				S
	Pohlia oerstediana (Müll. Hal.) A.J. Shaw	X		*	S
	Pseudocrossidium crinitum (Schultz) R.H. Zander		X	*	S
X	*Pseudocrossidium replicatum* (Taylor) R.H. Zander	X	X	*	S, Sr
	Ptychomitrium chimborazense (Spruce ex Mitt.) A. Jaeger		X	*	R
	Syntrichia bartramii (Steere) R.H. Zander				S
X	*Syntrichia chisosa* (Magill, Delgad. & L. R. Stark) R.H. Zander		X	*	R, S
X	*Syntrichia fragilis* (Taylor) Ochyra	X	X	*	R, S, Sr, T
	Syntrichia obtusissima (Müll. Hal) R.H. Zander		X	*	Sr
	Syntrichia pagorum (Milde) J.J. Amann		X	*	S, T
	Timmiella anomala (Bruch & Schimp.) Limpr.	X	X	*	S
X	*Tortula acaulon* (With.) R.H. Zander		X	*	S
X	*Tortula atrovirens* (Sm.) Lindb.		X	*	S
	Tortula brevipes (Lesq.) Broth.				R
	Trichostomum brachydontium Bruch	X	X	*	S
	Trichostomum crispulum Bruch		X	*	S
	Trichostomum subangustifolium (Thér.) R.H. Zander				S
	Weissia controversa Hedw.	X	X	*	S
	Weissia ligulaefolia (E.B. Bartram) Grout				S

a special form of pleurocarpy. In Aguascalientes, the species of *Braunia* may be considered as acrocarpous while *Anoectangium aestivum* is cladocarpous. However, because of their prostrate or erect condition, they have been termed pleurocarpous and acrocarpous, respectively, in standard taxonomic or floristic manuals.

Discussion

The Aguascalientes floristic list might contain a larger number of species for various reasons. There are many field sites that require exploration, but are privately owned and are not readily

accessible. On the other hand, farmland, cattle ranches, and industrial facilities are common and represent heavily disturbed areas whose value in moss diversity studies is virtually nil. Frequent disturbance favors the arrival of tolerant species such as *Bryum argenteum*, *B. chryseum* or *Funaria hygrometrica* while many other species are displaced from their original substrates. Despite the need for additional exploration, because the predicted number of species is essentially the same as the number of taxa recovered in our sampling, we conclude that species richness for the state has been conveniently evaluated.

With a land surface area of about 5,471 km^2 (García de Miranda & Falcón de Gyves 1984), Aguascalientes is one of the smallest states in Mexico. In spite its small size, its moss flora holds species or groups of species with peculiar features. There is a group of species that occupies disturbed areas whose frequency varies in response to human activities, as mentioned above. In this regard, the eastern and central portions of the state harbor cities, industry, highways, farm and cattle ranges that reduce or modify species dynamics depending on soil management practices. Group composition may vary with the geography, climate, and vegetation of the state; the northern areas are dominated by the dry land species while the western elevations incorporate highland taxa. Detailed mapping and phytosociological evaluations are required in this and neighboring states to detect associations. One such association may be represented by mosses growing on limestone or soils derived from calcareous rocks. *Aloina hamulus*, *Didymodon revolutus*, *Globulinella globifera*, and *Pseudocrossidium replicatum* are frequently found together in the same areas so that by finding one species the presence of others may be predicted. The frequency of sites where these species occur perhaps reflect the extent of human interference in natural moss communities.

The cleistocarpic species, represented by *Archidium donnellii*, *Pleuridium mexicanum* y *Tortula acaulon*, illustrate the structural and functional diversity of mosses in Aguascalientes. These species may be more frequent in disturbed sites because, in the absence of a dehiscent system, capsules may open by mechanical disturbance by cattle or agricultural equipment. The presence of such species as *Jaffueliobryum arsenei* marks the existence of other peculiar features in the area. For instance, the monoicous condition termed "cryptoicous" observed in *J. arsenei* is characterized by the position of both sex organs on the same stem. The perichaetial leaves enclose a small male branch growing from the vaginula, at the base of the sporophyte. The same condition has been described in *Ptychomitrium* (Deguchi 1977, Deguchi & Takeda 1986) and *Jaffueliobryum* (Churchill 1987); both genera are part of the Aguascalientes moss flora.

From the geographical point of view, diversity studies may benefit from the use of environmental indicators. The introductory contribution (Delgadillo *et al*. 2015) indicated that the potential number of species in the flora would be about 91moss taxa. Because of the information in this contribution, this may be regarded as a well-known flora. Nevertheless, further exploration elsewhere may confirm or expand knowledge of the distribution of individual taxa and assist in the evaluation of the conservation status of rare or endangered species.

Key to the known moss species in Aguascalientes

Mosses with prostrate or lateral sporophytes

1. Costa short, double or absent ……..…….. 2
2. Leaves ecostate ……..……..……..……..……..……... 3
3. Leaf apex with a hyaline hair ……..…..……..……. *Braunia plicata*
3'. Leaf apex not hyaline ……..……..……..……. 4
4. Leaf margin revolute in the basal 1/3 ……..……..…..……..… *Braunia andrieuxii*
4'. Leaf margin revolute in the basal ? ….……..……..…..…..…… *Braunia secunda*
2'. Costa double, short, usually not extending beyond mid-leaf ….……..……..…..…… 5
5. Leaves not decurrent. Alar cells short, quadrate ….……..…..…. *Entodon beyrichii*
5'. Leaves with broad decurrencies. Alar cells mainly oblate ……..…..……..…….. 6
6. Leaves oblong-ovate. Seta yellow to orange, exostome smooth ……..……..
……..……..……..……..……..……..…. *Erythrodontium longisetum*
6.' Leaves suborbicular to shortly oblong-ovate. Seta red, exostome striate ……..……
……..……..……..……..……..…… *Erythrodontium squarrosum*

1'. Costa simple, slender or strong, reaching mid-leaf or beyond 7
7. Alar cells quadrate, in a small group. Costa ending in an inconspicuous abaxial spine ... 8
8. Leaves with broad decurrencies 9
9. Leaves strongly plicate, alar cells inflated; seta papillose ..... *Brachythecium frigidum*
9'. Leaves weakly plicate or only so at base, alar cells quadrate to rectangular; seta smooth ..... *Brachythecium ruderale*
8'. Leaves base rounded, without decurrencies ..... *Campyliadelphus chrysophyllus*
7'. Alar cells undifferentiated to oblate in a broad proximal region. Costa smooth or rugose... 10
10. Stem and branch leaves differentiated in size and form Paraphyllia smooth ..... *Haplocladium microphyllum*
10'. Stem and branch leaves similar, except in size. Paraphyllia papillose 11
11. Leaf cells inconspicuously papillose 12
12. Papillae borne on distal ends of leaf cells. Endostome segments as long as the teeth.. ..... *Leskea angustata*
12'. Papillae borne on cell luminae. Endostome as a fine papillose membrane ..... *Lindbergia mexicana*
11'. Leaf cells smooth 13
13. Leaves ovate 14
14. Leaves abruptly acuminate, margins entire to long-dentate..... *Fabronia ciliaris* var. *ciliaris*
14'. Leaves gradually acuminate, margins entire to irregularly dentate ..... *Fabronia ciliaris* var. *polycarpa*
13'. Leaves lanceolate to ovate or triangular 15
15. Leaves lanceolate to oblong-ovate ..... *Fabronia ciliaris* var. *wrightii*
15'. Leaves oblong-lanceolate to narrowly triangular ..... *Fabronia macroblepharis*

Mosses with erect stems and apical sporophytes

1. Stems julaceous, leaves imbricate, dry or moist 2
2. Leaves ovate-lanceolate, with an obtuse apex and excurrent costa .. *Anomobryum conicum*
2'. Leaves oblong or oblong-ovate with an obtuse to rounded apex obtuse; costa ending below the apex to subpercurrent ..... *Anomobryum julaceum*
1'. Stems not julaceous, leaves erect, sparse or crowded 3
3. Costa excurrent, ending as an awn or hyaline hair 4
4. Costa ending as an awn 5
5. Costa broad 6
6. Leaf section with hyalocysts and chlorocysts alternating in the abaxial region ..... *Campylopus albidovirens*
6'. Leaf section with groups of abaxial stereids ..... *Campylopus flexuosus*
5'. Costa narrow 7
7. Sporophytes cleistocarpous 8
8. Spores large, more than 100 μm in diam ..... *Archidium donnellii*
8'. Spores small, less than 50 μm in diam ..... *Tortula acaulon*
7'. Sporophytes stegocarpous 9
9. Leaf margin strongly revolute ..... *Pseudocrossidium crinitum*
9'. Leaf margin plane 10
10. Leaves rosulate, at the stem apex, with a strong red awn ..... *Brachymenium mexicanum*
10'. Leaves not in a rosette, with a fine yellowish awn ..... *Bryum chryseum*
4'. Costa ending in a hyaline hair 11
11. Costa broad, occupying 1/2 to 1/3 of the leaf base ..... *Campylopus pilifer*
11'. Costa narrow 12
12. Distal leaf cells hyaline ..... *Bryum argenteum*
12'. Distal leaf cells not hyaline 13

13. Photosynthetic filaments of costa 2-12 cells long ..... *Crossidium crassinervium*
13'. Costa without photosynthetic filaments 14
14. Leaf margin with one to several rows of elongated cells ..... *Brachymenium systylium*
14'. Marginal leaf cells and inner cells similar 15
15. Leaf cells in distal half rhomboidal, marginal teeth obtuse-rounded .... *Entosthodon apiculatopilosus*
15'. Leaf cells in distal half with other shapes, marginal teeth not rounded .....…….. 16
16. Leaf section with an U- or V-shaped adaxial channel 17
17. Basal marginal cells uniformly thin-walled ..... *Grimmia elongata*
17'. Transverse walls of marginal basal cells thicker than the longitudinal walls 18
18. Leaves unistratose except at margins; costa with two guide cells; seta curved .... *Grimmia pulla*
18'. Leaves distally bistratose, costa with 2-6 guide cells; seta straight .... *Grimmia longirostris*
16'. Leaf section concave, without an obvious adaxial channel 19
19. Basal leaf cells oblate toward margin ..... *Grimmia laevigata*
19'. Basal leaf cells quadrate to short-rectangular ……..... 20
20. Capsule immersed to emergent 21
21. Calyptra pilose ..... *Orthotrichum diaphanum*
21'. Calyptra smooth ..... *Grimmia involucrata*
20'. Capsule exserted 22
22. Capsule cylindrical, with a spongiose neck ..... *Bryum coronatum*
22'. Capsule ovoid-cylindrical, with a smooth neck 23
23. Leaves unistratose 24
24. Calyptra mitrate, deeply lobed..... *Jaffueliobryum arsenei*
24'. Calyptra cucullate 25
25. Leaf apex emarginate, hair point dentate ..... *Syntrichia obtusissima*
25'. Leaf apex obtuse or rounded, hair point not dentate 26
26. With foliose axillary propagulae ..... *Syntrichia pagorum*
26'. Without specialized propagulae ..... *Tortula brevipes*
23'. Leaves partly or wholly bistratose 27
27. Leaf blade with bistratose patches .....…… *Syntrichia bartramii*
27'. Leaf blade completely bistratose ..... *Grimmia ovalis*
3'. Costa ending below leaf apex or as a mucro 28
28. Mid-leaf cells thick-walled, vermicular ..... *Anomobryum plicatum*
28'. Distal mid-leaf cells thick- or thin-walled, not vermicular 29
29. Leaves distichous, equitant, with two vaginant laminae 30
30. Limbidium present, uni- to tristratose 31
31. Leaf cells strongly bulging, in distinct rows ..... *Fissidens crispus*
31'. Leaf cells slightly or not bulging, not in rows 32
32. Leaf cells pluripapillose ..... *Fissidens elegans*
32'. Leaf cells smooth 33
33. Limbidium present in all laminae, nearly extending to leaf apex …..... ..... *Fissidens bryoides*
33'. Limbidium intramarginal, usually restricted to the vaginant laminae .... *Fissidens sublimbatus*
30'. Limbidium absent ..... *Fissidens guianensis*
29'. Leaves in more than two rows, with a single lamina 34
34. Leaves rosulate ..... *Bryum billarderi*
34'. Leaves distributed along the stem 35
35. Leaves secund, margins erose-denticulate ..... *Aongstroemia orientalis*
35'. Leaves not secund, margins entire or dentate …..... 36
36. Leaf cells smooth 37
37. Leaves dimorphous, the lateral larger than the dorsal .... *Epipterygium immarginatum*

37’. Leaves not dimorphous 38
38. Leaves with adaxial lamelae 39
39. Lamelae in section ending in a simple square apical cell ..... *Pogonatum oligodus*
39’. Lamelae ending in two flask-shaped cells (geminate) ..... *Pogonatum campylocarpum*
38’. Leaves without lamelae, sometimes with filaments or cell masses 40
40. Leaf cells plane, not bulging 41
41. Leaves unistratose 42
42. Sporophytes cleistocarpous ..... *Pleuridium mexicanum*
42’. Sporophytes stegocarpous 43
43. Plants paroicous 44
44. Leaves serrate in distal half, cells thick-walled ..... *Pohlia nutans*
44’. Leaves serrate to serrulate near apex, cells thin-walled ..... *Pohlia oerstediana*
43’. Plants gonioautoicous or cladautoicous 45
45. Stomata immersed ..... *Orthotrichum bartramii*
45’. Stomata superficial ..... *Orthotrichum pycnophyllum*
41’. Leaves bistratose 46
46. Calyptra mitrate ..... *Ptychomitrium chimborazense*
46’. Calyptra cucullate ..... *Timmiella anomala*
40’. Leaf cells mammillose or bulging 47
47. Leaves spatulate, with axillary gemmae..... *Hyophila involuta*
47’. Leaves with other shapes 48
48. Leaf apex cucullate 49
49. Leaves oblong-ovate, costa slightly spurred ..... *Globulinella globifera*
49’. Leaves lingulate, costa and lamina with photosynthetic filaments ..... *Aloina hamulus*
48’. Leaf apex open 50
50. Leaf cells short, quadrate 51
51. Leaves long-lanceolate; capsule erect, smooth ..... *Didymodon rigidulus* var. *icmadophilus*
51’. Leaves lanceolate; capsule inclined, sulcate..... *Ceratodon purpureus* var. *stenocarpus*
50’. Leaf cells irregularly shaped 52
52. Capsule inclined, asymmetric 53
53. Capsule curved, inclined to pendent; neck not flattened ..... *Funaria hygrometrica* var. *hygrometrica*
53’. Capsule nearly erect to inclined, gradually narrow, with a flat neck ..... *Funaria hygrometrica* var. *calvescens*
52’. Capsule erect and symmetric 54
54. Leaves lingulate to spatulate, apex rounded to obtuse, crenulate .....*Entosthodon obtusatus*
54’. Leaves oblong to obovate, apex entire 55
55. Leaf apex acute to acuminate ..... *Entosthodon jamesonii*
55’. Leaf apex rounded-acute ..... *Entosthodon obtusifolius*
36’. Leaf cells papillose 56
56. Papillae simple at both cell ends . *Anacolia laevisphaera*
56’. Papillae variable in number and arrangement in leaf cells 57
57. Costa with two stereid bands; the adaxial smaller or absent 58
58. Leaf margin strongly involute 59

59. Leaf cells bulging, with low papillae ..... *Weissia controversa*
59. Leaf cells strongly bulging, with columnar papillae..... *Weissia ligulaefolia*
58. Leaf margin plane, erect or revolute 60
60. Adaxial costal epidermis absent ..... *Leptodontium flexifolium*
60. Adaxial costal epidermis present 61
61. Adaxial costal epidermis smooth 62
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62. Leaf cells smooth on the adaxial surface ..... *Plaubelia sprengelii* var. *stomatodonta**
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64. Leaf margin revolute 65
65. Leaf margin revolute nearly to apex; axillary gemmae multicelluar ..... *Barbula orizabensis*
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64'. Leaf margin plane or erect 66
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66'. Cepsule with peristome 67
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63'. Leaves oblong-lanceolate to lanceolate, leaf apex acute or rounded 68
68. Leaf apex acute, ending in a sharp hyaline cell …..... *Bryoerythrophyllum recurvirostrum* var. *recurvirostrum*
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75'. Costa with 1-2 layers of adaxial over the guide cells 76
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78'. Leaves fragile, unistratose, without gemmae ..... *Syntrichia fragilis*

* With one or two stereid bands; the adaxial present or absent

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