Anales del Instituto de Biología Universidad Nacional Autónoma de México,
Serie Botánica 71(2): 63-72. 2000

Urban mosses in Mexico City

Claudio Delgadillo M.*
Ángeles Cárdenas S.*

Resumen. Se reconocen 87 especies y variedades de musgos del área urbana de la ciudad de México, incluyendo 23 que sólo se conocen por registros de principios de los años 1900. Algunas de las que crecen sobre el suelo podrían ser redescubiertas, pero varias epífitas parecen haber sido eliminadas permanentemente. Los cambios en la diversidad, incluyendo la extinción de especies o de comunidades de musgos, son debidas principalmente a la desaparición de hábitats naturales en el ambiente urbano y a la contaminación atmosférica.

Palabras clave: musgos urbanos, ciudad de México, flora.

Abstract. Eighty-seven species and varieties of mosses are known from present urban localities in Mexico City. This number includes 23 taxa collected only in the early 1900's. Although some of the soil inhabitants may yet be re-discovered, the expansion of the urban area in Mexico City may have eliminated several epiphytic species permanently. The changes in moss diversity, including the extinction of species or moss communities, are mainly dne to disappearance of natural habitats in the urban environment and to atmospheric pollution.

Key words: urban mosses, Mexico City, flora.

Introduction

Mosses are an important part of urban landscapes. In Mexico there is no published reference to the number of species for any urban area, although preliminary evaluations have been made on moss responses to such urban pressures as atmospheric pollution (Durán, 1993). In Mexico City, as in other metropolitan

*Departamento de Botánica, Instituto de Biología, UNAM, Apartado Postal 70-233, Del. Coyoacán, 04510 México, D.F. Mexico

areas, mosses appear to reduce their numbers and biomass with increasing pollution or heat accumulation (cf. Meininger *et al.* 1985). Sulfur dioxide (SO_2) is a major contaminant that breaks down chlorophyll molecules and effectively destroys many urban mosses, but desiccation also inhibits growth and sexual reproduction. Thus, Mexico City would be expected to be a "moss desert" due to high levels of pollutants and the size of the urban area. However, without past records little may be said about the changes in floristic composition that have occurred with increasing population and industrial growth within the city limits. Although moss inventories would seem impractical in the ever-shifting landscape of Mexico City, they could answer many practical questions, including what species are potentially resistant to desiccation or pollution. Also, such inventories could serve to monitor changes in air quality.

This contribution is the first overview of the diversity of mosses in the metropolitan area of Mexico City. Because of its floristic approach, it does not intend to answer questions related to the ecology of mosses, but to serve as a record of the species known from this urban area. The use of herbarium specimens and literature records can give a historical perspective and substantiate floristic changes that have occurred over the years.

Method

Specimens collected by the authors and others in the herbarium of the National University of Mexico (MEXU) served to determine the species from urban areas in Mexico City (Table 1). Although strictly supported by herbarium material, the species list in Table 1 was supplemented with information from the literature to obtain the period of time for which a given taxon has been known from the area. The specimens represent current urban localities, but some of them may have been collected in areas with remnants of the original vegetation. In all cases we excluded the specimens from such well-known sites as Ajusco, Desierto de los Leones, and Contreras because, although part of the city, they are essentially undeveloped forested areas. A representative specimen is cited by collector and collection number in the last column of Table 1.

The species listed in Table 2 are all records from the literature for which there are no further collecting reports. Most specimens may have been obtained from localities that were not urban or suburban at the time of collecting. As such, these provide important historical background. The specimens have not been studied, but the species cited in Table 2 include the approximate year when they were first observed in the area. The collector name is given after the bibliographic citation for further reference.

Table 1. Mosses collected in present urban sites in Mexico City

Taxon	Yrs. observed[1]	Habitat[2]	Reference/Specimen[3]
Aloina hamulus (C.M.) Broth.	1984-1986	S	Cárdenas 3499
Anomobryum filiforme (Dicks.) Solms.	1982	S	Cárdenas 1467
Barbula convoluta Hedw.	1982	S	Zander *et al.* T188
Brachymenium mexicanum Mont.	1974-1983	R	Cárdenas 2980
B. conostomum (Tayl.) Jaeg.	1982	S,E	Cárdenas 1477
B. occidentale (Hampe) Jaeg.	(1931)-1982	S,R,E	Thériot (1931); Cárdenas 1475
B. ruderale (Brid.) Buck	(1931)-1983	S,R,E	Thériot (1931); Cárdenas 2808
Brauna secunda (Hook.) B.S.G.	1944-1968	R	Delgadillo 2085
Bryoerythrophyllum campylocarpum (C.M.) Crum	1983	S	Cárdenas 2803
B. inaequalifolium (Tayl.) Zand.	1982	S	Cárdenas 1872
Bryum argenteum Hedw.	1924-1995	S,R	Amable 258
B. billardieri Schwaegr.	(1928)-1968	R	Thériot (1928); Delgadillo 1665
B. chryseum Mitt.	1926-1944	S	Amable 1568
Campylopus pilifer Brid.	1926-1982	S,R	Sharp 314
Ceratodon sp.	1983	S	Cárdenas 2797
Chenia leptophylla (C.M.) Zand.	1975-1982	S	Hermann 26142
Cyrto-hypnum mexicanum (Mitt.) Buck & Crum	1983	S,R,E	Cárdenas 2824
Didymodon australasiae (Hook. & Grev.) Zand. var. *australasiae*	1926-1984	S	Delgadillo 1639
D. australasiae var. *umbrosus* (C.M.) Zand.	1926-1984	S	Amable 1593
D. hampei Zand.	1982-1984	S	Cárdenas 3504

[1]Years in parentheses are previous records of a taxon as reported in the literature.
[2]S = soil, R = rock, E = epiphyte.
[3]Specimens at MEXU are indicated by the collector's name and number.

Table 1 *(continues)*

Taxon	Yrs. observed	Habitat	Reference/Specimen
D. incrassatolimbatus Card.	1925	S	Amable 1348
D. revolutus (Card.) Will.	1925-1986	S	Cárdenas 3562
D. rigidulus Hedw. var. *gracilis* (Schleich.) Zand.	1908-1984	S	Cárdenas 1472
D. rigidulus var. *icmadophilus* (Schimp.) Zand.	1956	S	Sánchez & Herrera s.n., 1956
D. rigidulus var. *subulatus* (Thér. & Bartr.) Zand.	1925-1984	S	Cárdenas 3566
Entodon beyrichii (Schwaegr.) C.Müll.	1925-1989	S,R,E	Cárdenas 2827
E. serrulatus Mitt.	1982	E	Cárdenas 1476
Fabronia ciliaris (Brid.) Brid. var. *ciliaris*	1980	E	cf. Sharp (1945); Durán & Rivera 233a
F. ciliaris var. *polycarpa* (Hook.) Buck	1980-1982	E	Durán & Rivera 291
F. ciliaris var. *wrightii* (Sull.) Buck	1980-1982	E	Cárdenas 1864b
Fissidens crispus Mont.	1982-1984	S	Cárdenas 2826
Funaria hygrometrica Hedw. var. *calvescens* (Schwaegr.) Mont.	1924-1968	S	Amable 1257
F. hygrometrica var. *hygrometrica*	1924-1991	S	Delgadillo 5626
Grimmia involucrata Card.	1925-1926	R	Amable 1448
G. pulla Card.	1982	R	Cárdenas 1461
Gymnostomum aeruginosum Sm.	1986	S	Delgadillo 5021
Haplocladium angustifolium (Hampe & C.M.) Broth.	1931-1982	R,E	Amable 1806
Hedwigidium integrifolium (P. Beauv.) Dix.	1982	R	Cárdenas 1462
Hygroamblystegium fluviatile (Hedw.) Loeske	1926	R	Amable 1453
Leptodontium flexifolium (Dicks.) Hampe	1980-1984	E	Cárdenas 3501
Leskea angustata Tayl.	1925-1926	E	Amable 1603
Lindbergia mexicana (Besch.) Card.	1923-1982	E	Durán & Rivera 274
Orthotrichum diaphanum Schrad.	1924-1980	E	Durán & Rivera 66a
O. pycnophyllum Schimp.	1907	E	Pringle 15079

Table 1 *(end)*

Taxon	Yrs. observed	Habitat	Reference/Specimen
Platygyriella densa (Hook.) Buck	1982-1983	S,E	Cárdenas 1474
P. pringlei (Card.) Buck	1983-1989	S,R,E	Cárdenas 2818
Pogonatum oligodus (C.M.) Mitt.	1982	S	Cárdenas 1456
Pseudocrossidium replicatum (Tayl.) Zand.	1907-1986	S	Delgadillo 1647
Pterobryopsis mexicana (Ren. & Card.) Fleisch.	1944	R	Sharp 331
Pylaisiella falcata (B.S.G.) Ando	1907-1982	E	Pringle 10416
Racopilum tomentosum (Hedw.) Brid.	1944-1983	S	Delgadillo 1657a
Ranuella lagoensis (Hampe) Buck	1968	R	Delgadillo 1644
Rhynchostegium pringlei Card.	1925	S	Amable 1347
Sagenotortula quitoensis (Tayl. in Hook.) Zand.	1984	S	Cárdenas 3546
Sematophyllum subpinnatum (Brid.) Britt.	1983	E	Cárdenas 2816
Syntrichia amphidiacea (C.M.) Zand.	(1945)-1983	E	Sharp (1945); Cárdenas 2823
S. fragilis (Tayl.) Ochyra	(1931)-1982	E	Thériot (1931); Durán & Rivera 674b
S. obtusissima (C.M.) Zand.	1924-1982	S,R	Delgadillo 1638
S. pagorum (Milde) Amann	(1945)-1984	E	Sharp (1945); Durán & Rivera 345
S. papillosa (Wils. ex Spruce) Jur.	1980	E	Durán & Rivera 90a
Timmiella anomala (B.S.G.) Limpr.	1927-1968	S	Delgadillo 1655
Tortella humilis (Hedw.) Jenn.	1968	S	Delgadillo 2094
Trichostomum brachydontium Bruch	(1931)-1984	S	Thériot (1931); Zander T170
Weissia sp.		S	Cárdenas 3551

Results

Table 1 includes 64 species and varieties of mosses from the present urban area of Mexico City. Most of these taxa grow on soil, walls, or other man-made substrates where disturbance is moderate. The rock inhabitants are usually found in protected habitats that are part of the original landscape such as, for instance, on the grounds of the National University which, surrounded by urban development, maintains an ecological reserve for organisms inhabiting the lava flow from the extinct Xitle volcano. The epiphytic species are widely distributed in Mexico, but in general they are comparatively infrequent in this urban area.

Besides substrate preference, two distinct groups may be observed among known urban mosses, namely, those that are comparatively rare in Mexico City and those that are widely distributed there. Among those in the rare species group, *Didymodon incrassatolimbatus, Orthotrichum pycnophyllum,* and *Rhynchostegium pringlei* have not been collected since the early 1900's. The first grows on soil and may still appear in the collecting record, but the last two are epiphytic and may have become extinct in the urban area. The same is also true of *Grimmia involucrata, Hygroamblystegium fluviatile,* and *Pterobryopsis mexicana*. These grew on rock and apparently have disappeared locally, although the last species is fairly common elsewhere in Mexico. *Aloina hamulus*, on the other hand, is usually found on compacted calcareous soil in its natural habitat, but in Mexico City the species has been found on old adobe walls.

The species that are widely represented in the city are usually considered weedy mosses. *Bryum argenteum* and *Funaria hygrometrica* are good examples. Several species have been collected repeatedly or have persisted in the collecting record over long intervals. *Campylopus pilifer* grows on exposed soil and rocks and is common on the lava flow of the University grounds. *Didymodon australasiae* grows on soil; *Lindbergia mexicana, Orthotrichum diaphanum, Syntrichia amphidiacea,* and *S. fragilis* are frequent epiphytes along waterways of native or introduced arboreal species.

Table 2 lists 23 additional taxa bringing the total to 87 species known from the present urban area of Mexico City. This last group of species, however, was apparently collected only in the early 1900's. Some of the species are usually associated with forest habitats. Thus, for instance, *Anacolia laevisphaera, Barbula orizabensis, Cryphaea patens, Epipterygium mexicanum, Hypnum amabile,* and *Taxiphyllum taxirameum* may have been collected from suburban habitats no longer present in Mexico City.

Discussion

The mosses of the urban flora of Mexico City are only partly known. The species listed in Table 1 are perhaps a small portion of those that may be discovered when a detailed study is undertaken. To be sure, despite continuous disturbance, the

Table 2. Mosses collected in the present urban area of Mexico City in the early 1900's

Taxon	Yrs. observed	Habitat	Reference: Specimen
Amblystegium serpens (Hedw.) B.S.G.	(1914)	E	Thériot (1931): Arsène 9493
Anacolia laevisphaera (Tayl.) Flow.	(1900)	S,R	Flowers (1952): Orcutt 6740
Barbula orizabensis C.M.	(1914)	S	Thériot (1931): Arsène 9464
Brachymenium acuminatum Harv.	(1914)	S,R	Thériot (1928): Arsène 9151
B. fabronioides (C.M.) Par.	(1906)	S,R	Ochi (1980): Ross 27
B. saint-pierrei Thér.	(1933)	S	Thériot (1933): Woronow 616
B. systylium (C.M.) Jaeg.	(1909)	E,R	Ochi (1978): Pringle 10846
B.m ferruginascens (Stirt.) Giac.	(1933)	S	Thériot (1933): Antipovitch s.n.
B.m recurvirostrum (Hedw.) Chen var. *aeneum* (C.M.) Zand.	(1900)	S	Zander (1978): Orcutt 3817a
Cryphaea patens Hornsch.	(1909)	E	Crum (1951): Pringle 10612
Didymodon vinealis (Brid.) Zand.	(1933)	S	Thériot (1933): Woronow 607
Entosthodon muhlenbergii (Turn.) Fife	(1914)	S	Crum (1951): Arsène 9472
Epipterygium mexicanum (Besch.) Broth.	(1933)	S	Thériot (1933): Antipovitch 61
Funaria sartorii C.M.	(1914)	S	Thériot (1928): Arsène 9472?
Hygroamblystegum varium (Hedw.) Moenk.	(1926)	S	Thériot (1931): Amable 1453
Hypnum amabile (Mitt.) Hampe	(1914)	S,R,E	Thériot (1931): Arsène 2270
Leptobryum pyriforme (Hedw.) Wils.	(1926)	S	Thériot (1931): Amable 1264 p.p.
Molendoa sendtneriana (B.S.G.) Limpr.	(1914)	S,R	Crum (1951), Thériot (1928), Zander (1977): Arsène 9432, 9462
Pohlia wahlenbergii (Web. & Mohr) Andr.	(1914)	S	Thériot (1928): Arsène 9500
Rhynchostegium riparioides (Hedw.) Card.	(1914)	S,R	Thériot (1931): Amable 1450
R. serrulatum (Hedw.) Jaeg.	(1926)	S,E	Thériot (1931): Amable s.n.
Taxiphyllum taxirameum (Mitt.) Fleisch.	(1914)	S,R	Thériot (1931): Arsène 10999
Weissia subangustifolia (Thér.) Zand.	(1926)	S	Thériot (1931): Amable 1613 p.p.

rooftops and walls of ancient buildings and houses, and parks and gardens offer a broad range of potential substrates already represented in our herbarium records. Species of *Brachythecium, Bryum*, and *Didymodon* (Table 1) may have been present for much of the city's history. Some of them have persisted in suburban areas, but others have remained uncollected because of their small size or inconspicuous nature. Most visiting bryologists have collected in undisturbed areas and rarely have contributed to urban collections. On the other hand, the moss flora of the city certainly includes incidental species (e.g., *Gymnostomum aeruginosum* and *Trichostomum brachydontium*) that establish themselves for short periods of time. These disappear with new sidewalks, when the soil in gardens is removed, or with the beginning of succession in certain protected habitats. Such epiphytes as *Cyrto-hypnum mexicanum* and *Entodon serrulatus* are particularly vulnerable in the city environment. They cannot readily become established on such trees as *Eucalyptus*, *Casuarina*, and *Ligustrum* that are ubiquitous throughout the city. Besides air pollution, the continual removal of trees by the city administration prevents a more diverse bryophyte flora.

In addition to air pollution (Durán, 1993), the disappearance of natural habitats is most certainly the primary cause of extinction of species or moss communities in the urban environment. A conspicuous example among those already cited is that of *Orthotrichum pycnophyllum*, an epiphytic moss that is fairly common on trees and shrubs in the forested areas around Mexico City, but no longer seen in the urban area. The area of Peña Pobre, just south of the National University main campus, yielded important specimens when A.J. Sharp visited there in 1944. He obtained a specimen of *Pterobropsis mexicana* from rock, but this is usually an epiphyte elsewhere. The Peña Pobre area is currently the site of a shopping mall. In the last 30 years, according to unpublished data from the City administration, human settlements that occupied 1200 ha in 1970 increased to about 10 154 ha in 1999 (Gobierno del Distrito Federal, Programa de Ordenamiento Territorial de los Asentamientos Humanos en el Suelo de Conservación del Distrito Federal). The shift in land use practices have altered moss habitats and the change from suburban to urban conditions is responsible for the loss of moss diversity. Although various terrestrial species reported in the early 1900's may reappear elsewhere in the metropolitan area, others such as *Cryphaea patens*, *Epipterygium mexicanum*, and *Hypnum amabile* that grow in moist, shaded microhabitats, may not be expected anywhere in the urban area. The change in construction materials may also lead to the gradual disappearance of species, as is the case of *Aloina hamulus* that has been collected on adobe walls. Adobe blocks are no longer used in modern urban construction, but are still present in older parts of the city (e.g., in Coyoacán).

From a historical point of view, the expansion of the urban area in Mexico City has brought about changes in moss diversity. In pre-colonial times the site was occupied by at least two lakes, Texcoco and Xochimilco (Wolf, 1976) where aquatic mosses must have flourished. There is no record of fossil or subfossil mosses, but in nearby Salazar Lake we have retrieved a sample of *Fissidens crispus* that is about 2420 years old (Castañeda and Delgadillo, 1998). With the establishment of

Tenochtitlán and its growth as the capital of the New Spain Viceroyship, many potential substrates for mosses must have become available. Some species listed in Tables 1 and 2 may go back to pre-colonial and colonial times as nearby sources in forested areas were available. Soil inhabitants of the genus *Didymodon*, and such epiphytes as *Lindbergia mexicana* and *Orthotrichum diaphanum* that appear to be tolerant of desiccation, would find adequate substrates in old construction and suburban parks. The literature and extant herbarium records show that these taxa occupy exposed habitats and are well represented by specimens from various urban sites. Mosses collected in Tlalpan and Mixcoac by Arsène and others in the early 1900's (Table 1, 2) are examples of the species diversity in suburban conditions. However, increase in paved surfaces, low atmospheric moisture, and high levels of pollution have apparently diminished the biomass and number of species in the metropolitan area (Durán, 1993). A requisite to learn more about the effect of urban conditions on mosses is a complete catalogue of contemporary species, with emphasis on collections from rooftops and walls, similar to that obtained by Casas and Sáiz-Jiménez (1982) from the cathedral of Seville. Because of the unpredictable fate of trees in the urban area of Mexico City, the response to heat and pollution may have to be evaluated with mosses growing on substrates other than trees; high buildings offer one such possibility.

Acknowledgements. Thanks are extended to Dr. Lawrence M. Kelly, Instituto de Biología, UNAM, for editorial suggestions to a preliminary version of the manuscript.

Literature cited

CASAS S., C. and C. SÁIZ-JIMÉNEZ. 1982. Los briófitos de la Catedral de Sevilla. *Collectanea Botanica 13*: 163-175.

CRUM, H. A. 1951. *The Appalachian-Ozarkian element in the moss flora of Mexico with a check-list of all known Mexican mosses*. Ph.D. Dissertation. University of Michigan, Ann Arbor. 504 p.

DURÁN D., A. 1993. *Evaluación briológica de los efectos de la contaminación atmosférica en la Ciudad de México*. Tesis de Maestría. Facultad de Ciencias, Universidad Nacional Autónoma de México, México, D.F. 54 p.

FLOWERS, S. 1952. Monograph of the genus *Anacolia*. *Bulletin of the Torrey Botanical Club 79*: 161-185.

MEININGER, C. A., G. W. UETZ and J. A. SNIDER. 1985. Variation in epiphytic microcommunities (Tardigrade-lichen-bryophyte assemblages) of the Cincinnati, Ohio area. *Urban Ecology 9*: 45-61.

OCHI, H. 1978. Changes in nomenclature and synonyms in the Mexican species of bryaceous mosses. *Journal of the Faculty of Education, Tottori University, Natural Science 28*: 81-86.

OCHI, H. 1980. A revision of the Neotropical Bryoideae, Musci (First Part). *Journal of the Faculty of Education, Tottori University, Natural Science 29*: 49-154.

SHARP, A. J. 1945. Bryological notes from Mexico, I. *Bryologist 48*: 37-38.

THÉRIOT, I. 1928. Mexican mosses collected by Brother Arsène Brouard-II. *Smithsonian Miscellaneous Collection 81*: 1-26.

THÉRIOT, I. 1931. Mexican mosses collected by Brother Arsène Brouard-III. *Smithsonian Miscellaneous Collection 85*: 1-44.

THÉRIOT, I. 1933. Mexican mosses. IV. *Revue Bryologique et Lichénologique* 5: 91-110.

WOLF, E. R. (ed.). 1976. *The Valley of Mexico. Studies in Pre-Hispanic ecology and society*. University of New Mexico Press, Albuquerque. 337 p.

ZANDER, R. H. 1977. The Tribe Pleuroweisieae (Pottiaceae, Musci) in Middle America. *Bryologist 80*: 233-269.

ZANDER, R. H. 1978. A synopsis of *Bryoerythrophyllum* and *Morinia* (Pottiaceae) in the New World. *Bryologist 81*: 539-560.