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Lichenized fungi of the arid zones of central Mexico: new records for the country and the state of Aguascalientes

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The lichen biota of several regions of Mexico is scarcely known, including the central part of the country, where the state of Aguascalientes is located. Before this study, lichen records of Aguascalientes were almost nonexistent. The aim of this work was to catalogue the lichen biota from arid environments of Aguascalientes, a widespread habitat in this part of Mexico. A total of 253 samples were collected and 20 families, 44 genera, and 56 lichen species were detected. The families with the highest species richness are Physciaceae (13) and Verrucariaceae (nine); the genus with the highest number of species is *Physcia* (Physciaceae; five). The lichenized fungi identified up to species level were found growing mainly on rock (33) and bark (14). The most common growth forms were crustose (55 %) and foliose (43 %). All species (56) are new records for Aguascalientes; *Phaeophyscia hirtella* (Physciaceae) and *Scytinium subaridum* (Collemataceae) are, in addition, new records for the country, and seven species represent the second collection documented for Mexico. This is the first work on the lichens of Aguascalientes. The results contribute to the biodiversity knowledge of Mexico and remark the need to increase efforts to improve the Mexican lichen biota inventory.

Keywords: arid environments, diversity, illustrated checklist, lichen collection, North America.

Lichenized fungi (lichens) (Hawksworth 2015) are complex organisms formed by the association of green algae and/or cyanobacteria (photobiont) with fungi (mycobiont); these symbiotic organisms display a huge range of form, size, and color diversity (Brodo et al. 2001). Until 2016, more than 19000 species were recognized in the world (Lücking et al. 2017). The neotropics, which include a substantial part of the Mexican territory, are home to lichen genera with elevated speciation rates, often related to high levels of endemism (Galloway 2008). Lücking et al. (2009) estimated that ca. 3600 lichen species may occur in the tropical regions of Mexico. Herrera-Campos et al. (2014), based on literature, data bases, and herbarium specimen examination, showed that there are 2722 species registered for Mexico; however, and due to the high ecosystem diversity found in the country, they suggested that the actual number of lichen species may be close to 5000. In Mexico, the study of lichens has a slow progress and has focused on a few regions. For instance, the Sonoran Desert caught special attention, where more than 1900 lichen species were extensively documented (Nash III et al. 2002, 2004, 2007). No other Mexican region has been thoroughly studied as the Sonoran Desert, although there were efforts to document specific groups, such as family Parmeliaceae (Herrera-Campos et al. 2016) and genus *Cora* (Hygrophoraceae; Moncada et al. 2019). Herrera-Campos et al. (2014), mainly based on literature, data gathered from the herbarium MEXU (which holds the largest Mexican lichen collection), and the Consortium of North American Lichen Herbaria (CNALH) database, showed that the central-northern region of Mexico is the part of the country with fewer lichen species records. The area includes the states of Aguascalientes, Guanajuato, Querétaro, San Luís Potosí, and Zacatecas, and there is scarce literature that accounts for the lichen diversity of the region (e.g., Miranda 2008; Puy-Alquiza et al. 2018). There are no publica-

tions focused on the lichens of Aguascalientes, although there are a few sources that suggest the presence of 2–8 species in the state (CONABIO et al. 2010; Herrera-Campos et al. 2014); nevertheless, there are no clear references to herbarium specimens to support that information. A considerable portion of Aguascalientes is covered by arid and semiarid ecosystems, such as semiarid scrubs and desert grasslands (Siqueiros-Delgado et al. 2017). Those habitats are generally perceived as poor in terms of lichen species richness; however, studies performed in other arid and semiarid regions have shown that lichen diversity in these environments can be higher than previously thought (Nash III et al. 2002, 2004, 2007; Rosentreter et al. 2007). This may be related to the lichen role as an important element in biological soil crusts, which are a fundamental component of arid and semiarid habitats (Bowker et al. 2010). Because of the lack of information on lichen species richness in the Mexican state of Aguascalientes, the aim of this study was to inventory the lichen species found in its territory, focusing collecting efforts in arid environments.

Materials and methods

Area of study

The state of Aguascalientes is located in the central part of Mexico, between meridians 101° 53' and 102° 52' West and parallels 22° 27' and 21° 28' North; it has an extension of 5680.33 km^2 and is surrounded by the states of Jalisco and Zacatecas (CONABIO et al. 2010) (Fig. 1). Aguascalientes is located within the geographic region known as the Mexican Plateau (INEGI 1981) and there are three geologic provinces found in its territory: the Sierra Madre Occidental (West), the Mesa Central (East), and the Eje Neovolcánico (South) (Siqueiros et al. 2017). Most of the state has a semi-dry climate, with an average annual temperature of 17.4 °C, and an average rainfall of 526 mm (INEGI 1981). Elevation in Aguascalientes ranges from 1540 m (valley of the Calvillo river) to 3050 m (Sierra Fría) (CONABIO et al. 2010). From a floristic point of view, most of the state is part of the Mexican xerophytic region, which includes areas with grasslands and xerophilous scrubs; however, there are other regions of Aguascalientes

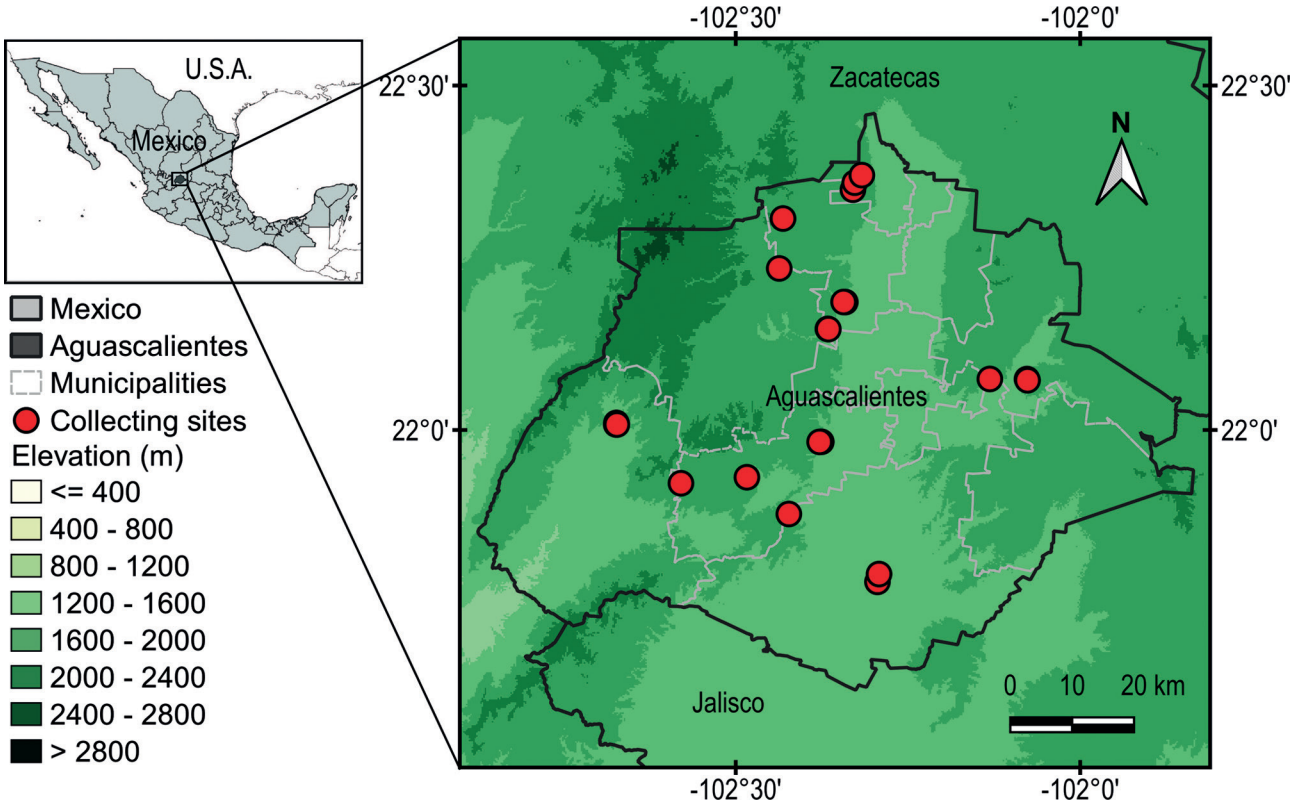

Fig. 1. Map of Aguascalientes, showing municipality borders, elevation ranges, and collecting sites.

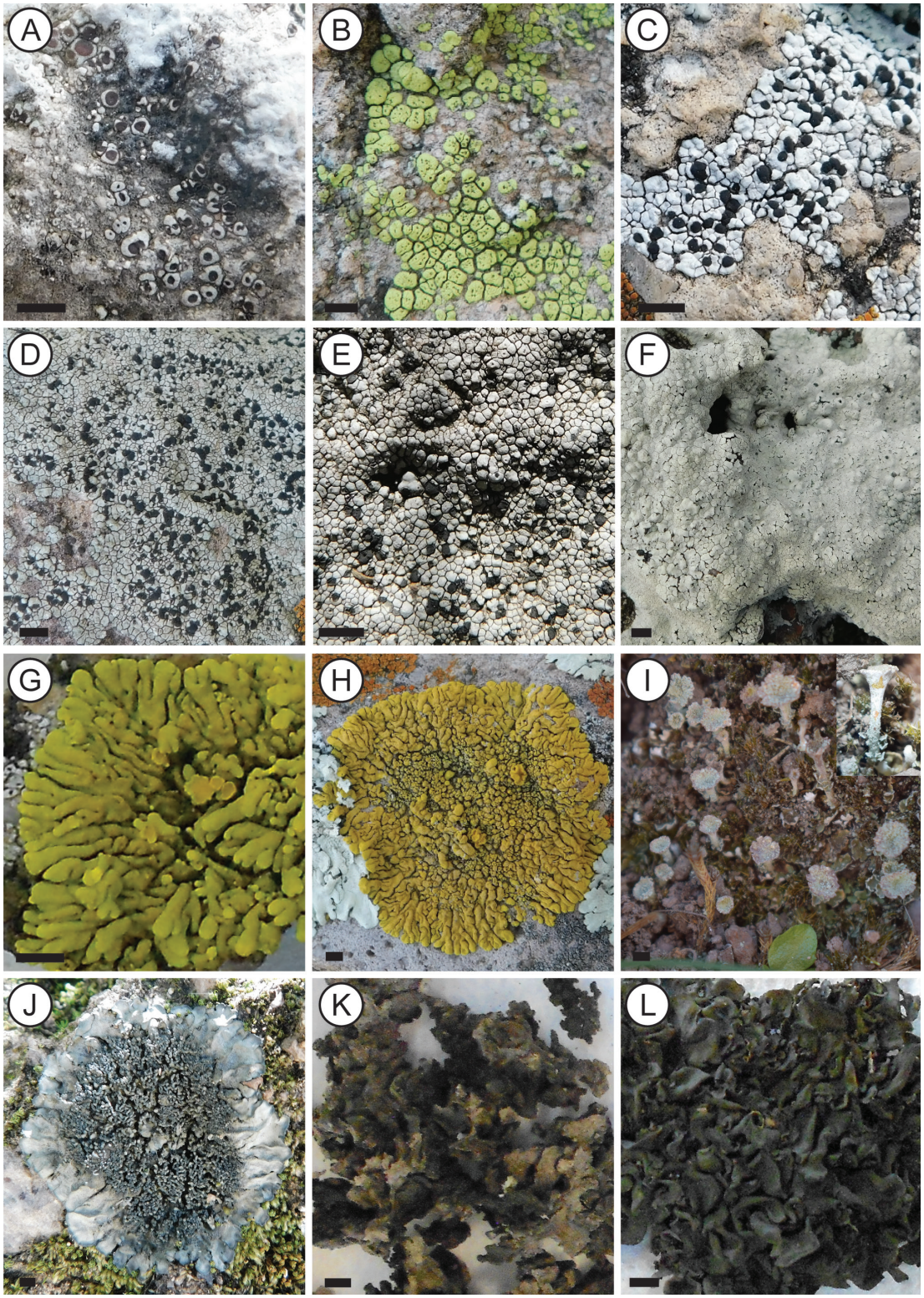

Fig. 2. Lichenized fungi from the arid zones of Aguascalientes. **A, B.** Acarosporaceae. **A.** *Acarospora veronensis*; **B.** *Pleopsidium oxytonum*. **C-F.** Caliciaceae. **C.** *Buellia dispersa*; **D.** *Buellia nashii*; **E.** *Buellia stellulata*; **F.** *Dimelaena oreina*. **G, H.** Candelariaceae. **G.** *Candelina mexicana*; **H.** *Candelina submexicana*. **I.** Cladoniaceae. **I.** *Cladonia chlorophaea*. **J.** Coccocarpiaceae. **J.** *Coccocarpia palmicola*. **K, L.** Collemataceae. **K.** *Lathagrium cristatum*; **L.** *Leptogium denticulatum*. Bars 2 mm.

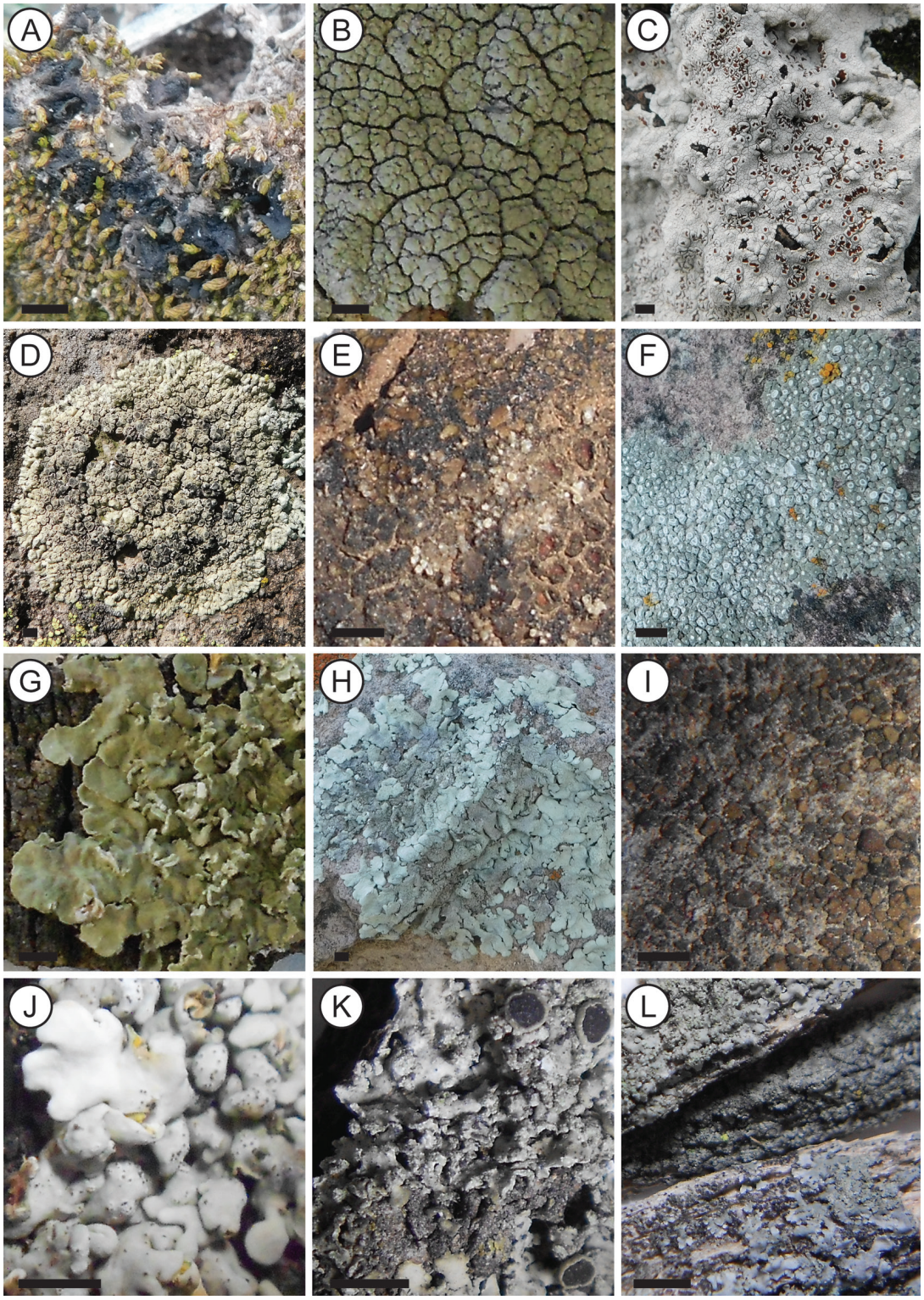

Fig. 3. Lichenized fungi from the arid zones of Aguascalientes. **A.** Collemataceae. **A.** *Scytinium subaridum*. **B.** Graphidaceae. **B.** *Diploschistes gypsaceus*. **C.** Haematommataceae. **C.** *Haematomma fenzlianum*. **D.** Lecanoraceae. **D.** *Protoparmeliopsis muralis*. **E.** Lichinaceae. **E.** *Lempholemma chalazanum*. **F.** Megasporaceae. **F.** *Circinaria contorta*. **G, H.** Parmeliaceae. **G.** *Parmotrema austrosinense*; **H.** *Xanthoparmelia lavicola*. **I.** Peltulaceae. **I.** *Peltula hassei*. **J-L.** Physciaceae. **J.** *Heterodermia rugulosa*; **K.** *Hyperphyscia adglutinata*; **L.** *Hyperphyscia minor*. Bars 2 mm.

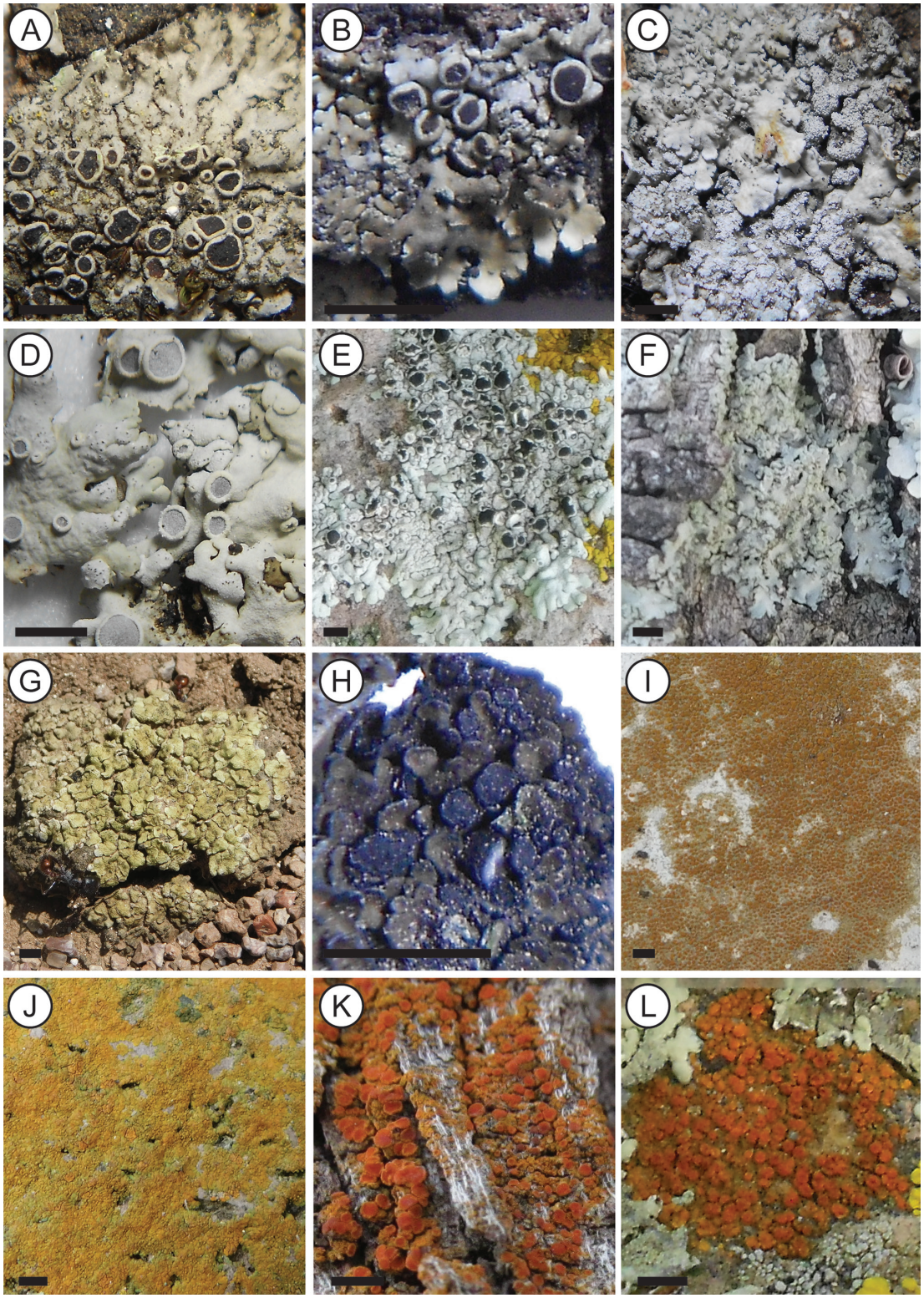

Fig. 4. Lichenized fungi from the arid zones of Aguascalientes. **A-F.** Physciaceae. **A.** *Phaeophyscia hirsuta*; **B.** *Phaeophyscia hirtella*; **C.** *Physcia atrostriata*; **D.** *Physcia biziana*; **E.** *Physcia phaea*; **F.** *Physciella chloantha*. **G, H.** Psoraceae. **G.** *Psora icterica*; **H.** *Psorula rufonigra*. **I-L.** Teloschistaceae. I. *Athallia vitellinula*; **J.** *Caloplaca brouardii*; **K.** *Caloplaca microphyllina*; **L.** *Caloplaca saxicola*. Bars 2 mm.

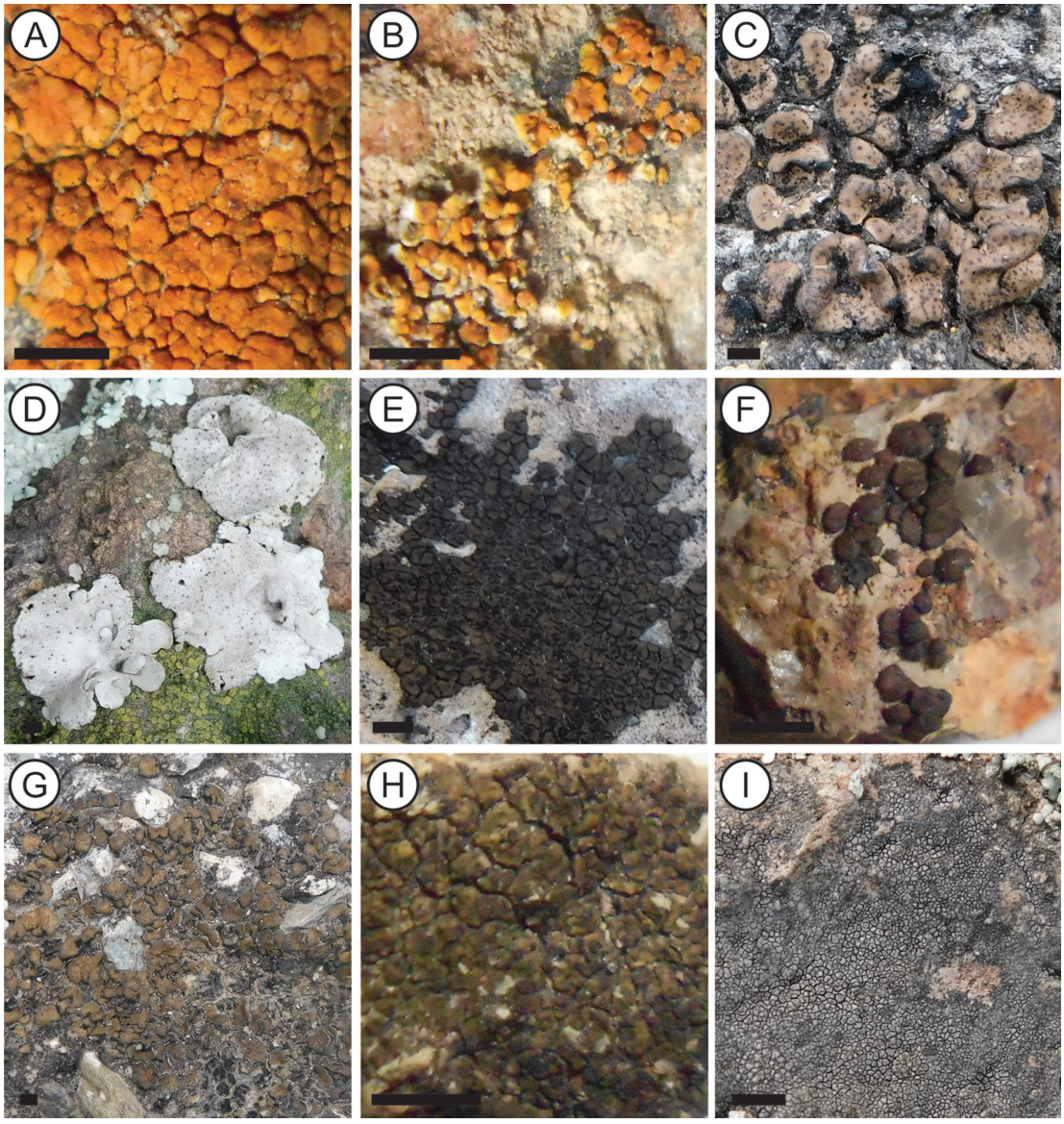

Fig. 5. Lichenized fungi from the arid zones of Aguascalientes. **A, B.** Teloschistaceae. **A.** *Squamulea squamosa*; **B.** *Squamulea subsoluta*. **C-I.** Verrucariaceae. **C.** *Clavascidium lacinulatum*; **D.** *Dermatocarpon miniatum*; **E.** *Heteroplacidium compactum*; **F.** *Placidium acarosporoides*; **G.** *Placidium squamulosum*; **H.** *Staurothele monicae*; **I.** *Verrucaria inficiens*. Bars 2 mm.

considered as part of the Mesoamerican mountain region that have conifer and oak forests (Rzedowski 2006).

Fieldwork and taxonomic identification

Lichenized fungi were collected from March 2018 to March 2020; the localities (Fig. 1) were selected considering sites with grasslands and xerophilous scrubs. Specimens found on rock, bark, and soil were collected; basic data such as locality, substrate type, orientation, specimen color, and digital photographs were taken in the field. Collected material was processed at the herbarium of the Universidad Autónoma de Aguascalientes (HUAA), and lichen identification was accomplished using specialized literature (Sheard 1974; Wetmore & Kärnefelt 1998; Brodo et al. 2001; Wetmore 2001, 2004a, 2004b; Nash III et al. 2002, 2016; Bungartz et al. 2004; Lücking et al. 2007; Knudsen et al. 2008; Breuss 2010; Westberg et al. 2011; Brodo 2016; Egan et al. 2016; Pérez-Pérez & Nash III 2016), and employing standard techniques of light microscopy, conventional chemical spot tests, and exposure to

UV light when required. The specimens were integrated to the recently created lichen collection of the herbarium HUAA.

Data base review

Species distribution information was based on the specimen records available in the online data bases of the Consortium of North American Lichen Herbaria (CNALH; https://lichenportal.org/cnalh/collections/index.php) and herbarium MEXU (Universidad Nacional Autónoma de México, Portal de Datos Abiertos; https://datosabiertos.unam.mx/biodiversidad/).

Results

A total of 253 lichen specimens were collected and were found to be distributed in 44 genera and 20 families (Tab. 1). There are currently 56 lichen species confirmed (Tab. 2, Figs. 2–5), although it was not possible to identify all samples to the species level (28 specimens were determined up to genus). Physciaceae (Figs. 3J–L and 4A–F) and Verrucariaceae (Fig. 5C–I) are the families with the highest number of genera (five and six, respectively) and species (13 and nine, respectively). The most diverse genera are *Physcia* (Physciaceae; five spp.), *Buellia* (Caliciaceae), *Caloplaca* (Teloschistaceae), *Dermatocarpon* (Verrucariaceae), and *Heterodermia* (Physciaceae); the last four genera have three spp. each. Considering only the confirmed species, most of the taxa grow on rock (33), although there are other species that grow on bark (14), soil (6), rock/soil (2), and bark/rock (1). The most frequent growth forms were the crustose (55 %) and foliose (43 %). According to the consulted databases, only *Squamulea subsoluta* (Nyl.) Arup, Søchting & Frödén (Teloschistaceae) was previously recorded for Aguascalientes; however, there is no literature that confirms *S. subsoluta* as member of the lichen biota of the state. Therefore, all species in this study are new records for Aguascalientes. In addition, two of those species were not previously registered for Mexico, i.e. *Phaeophyscia hirtella* Essl. (Physciaceae; Fig. 4B) and *Scytinium subaridum* (P.M. Jørg. & Goward) Otálora, P.M. Jørg. & Wedin (Collemataceae; Fig. 3A), so they represent two new country records. Finally, seven species collected in this study represent the second record that document the presence of those taxa in Mexico (Tab. 2).

Discussion

Despite several efforts, knowledge about lichen species richness in Mexico is still scarce. This study serves as a clear case to show that more fieldwork and taxonomic studies are required to improve the lichen inventory of Mexico. Herrera-Campos et al. (2014) made a synthesis of the lichen species found in Mexico and showed that Aguascalientes was the second state with the lowest number of known taxa (only two). It is noteworthy that Herrera-Campos et al. (2014) consulted the CNALH data base, which has 19 records for 13 species found in Aguascalientes, some of them collected more than a century ago; however, that study only recorded two species for the state, but provided no scientific names. Other study on the biological diversity of Aguascalientes (CONABIO et al. 2010) mentioned the presence of eight species and eight genera in the state; unfortunately, this study also fails to provide species names and the location of the herbarium specimens. Therefore, in the case of Aguascalientes, the low number of lichen species for the state recorded in the literature may be due to a lack of scientific collection efforts. This situation certainly suggests that all species found in this study are new records for the state.

Arid regions could be perceived as places where biodiversity seems to be low when compared to other ecosystems (e.g., temperate or tropical forests), although some studies focused on lichens from arid regions have shown that their lichen biotas are richer than expected and have interesting cases (Rosentreter & Belnap 2001; Nash III et al. 2002, 2004, 2007; Rosentreter et al. 2007; Concostrina-Zubiri et al. 2014). An example of the latter can be found in the two species that are new records for Mexico. One of them is *Scytinium subaridum* (Collemataceae), which has a disjunct distribution in the world, occurring both in the Mediterranean region and NW North America (Aragón et al. 2004); in addition, Arizona was known to be the meridional limit of the species distribution in North America, but our study shows that the distribution of *S. subaridum* can go even further south to central Mexico. *Phaeophyscia hirtella* (Physciaceae), the second new record for the country found in this study, is a taxon that was thought to occur only in Canada and USA (Esslinger 1978), where New Mexico and Texas were southernmost areas of its known distribution range.

Considering the 56 species documented for this study, Aguascalientes leaves the next to the last position in terms of known species richness for the Mexican states (see Herrera-Campos et al. 2014). This result places Aguascalientes with a very similar species richness as its neighbor state Zacatecas (57 spp.), but far from Jalisco (338 spp.), another

Tab. 1. Collection data of the lichenized fungi specimens from the arid zones of Aguascalientes. Collector: AMD, A. Martínez-Durón; DFS, D.F. Simijaca; GO, G. Ocampo; MIMV, M.I. Miguel-Vázquez.

Family / Species	Municipality	Georeference		Elevation (m)	Date	Collector & collector no.
		Latitude N	Longitude W			
Acarosporaceae						
Acarospora veronensis A. Massal.	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 232
Acarospora sp.	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 246
		21.98259°	–102.37817°	2035	20 Aug 18	MIMV 846
	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 856
		22.14668°	–102.36617°	2051	23 Aug 18	MIMV 873
Pleopsidium oxytonum (Ach.) Rabenh.	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 795
	Calvillo	22.00791°	–102.67355°	1858	16 Aug 18	MIMV 819
	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 127
		21.922557°	–102.57949°	2250	2 Aug 18	AMD 237
		21.98259°	–102.37817°	2035	20 Aug 18	MIMV 845
	Rincón de Romos	22.30687°	–102.43127°	2279	6 Sep 18	MIMV 885
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 893
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 909
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 915
Caliciaceae						
Buellia dispersa A. Massal.	Cosío	22.348696°	–102.329826°	2150	13 Feb 20	DFS 2079
	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 227
	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 912
B. nashii Bungartz	Jesús María	21.98259°	–102.37817°	2035	20 Aug 18	MIMV 842
		21.98259°	–102.37817°	2035	20 Aug 18	MIMV 850
B. stellulata (Taylor) Mudd	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 879
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 895
Dimelaena oreina (Ach.) Norman	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 129
	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 874
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 884
Candelariaceae						
Candelaria concolor (Dickson) Stein	Aguascalientes	21.7794518°	–102.294174°	1850	28 Mar 18	GO 2393a
	Calvillo	22.00784°	–102.67245°	1881	16 Aug 18	MIMV 825
Candelariella sp.	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 135
Candelina mexicana (B. de Lesd.) Poelt	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 905
C. submexicana (de Lesdain) Poelt	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 794
		22.07208°	–102.07623°	2000	9 Aug 18	MIMV 796
	Cosío	22.348696°	–102.329826°	2150	13 Feb 20	DFS 2083
	Jesús María	21.98259°	–102.37817°	2035	20 Aug 18	MIMV 841
	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 853
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 888
Candelina sp.	Cosío	22.348696°	–102.329826°	2150	27 Mar 18	GO 2384
	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 224
		21.922557°	–102.57949°	2250	2 Aug 18	AMD 236
		21.93129°	–102.48373°	2005	2 Aug 18	AMD 238
		21.93129°	–102.48373°	2005	2 Aug 18	AMD 240

Family / Species	Municipality	Georeference		Elevation (m)	Date	Collector & collector no.
		Latitude N	Longitude W			
Cladoniaceae						
Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2091
Cladonia sp.		22.30687°	–102.43127°	2279	13 Feb 20	DFS 2090
Coccocarpiaceae						
Coccocarpia palmicola (Sprengel) Arv. & D. J. Galloway	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2093
		22.14668°	–102.36617°	2051	23 Aug 18	MIMV 871
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 891
Collemataceae						
Lathagrium cristatum (L.) Otálora, P.M. Jørg. & Wedin	Calvillo	22.00784°	–102.67245°	1881	16 Aug 18	MIMV 829
Leptogium denticulatum Tuck.	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2095
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 907
Leptogium sp.	Calvillo	22.01019°	–102.67324°	1833	16 Aug 18	MIMV 814
Scytinium subaridum (P.M. Jørg. & Goward) Otálora, P.M. Jørg. & Wedin	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 225
Graphidaceae						
Diploschistes gypsaceus (Ach.) Zahlbr.	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2089
Haematommataceae						
Haematomma fenzlianum A. Massal.	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 134
	Rincón de Romos	22.30687°	–102.43127°	2279	6 Sep 18	MIMV 887
Lecanoraceae						
Lecanora sp.	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 132
Lecidella stigmatea (Ach.) Hertel & Leuckert	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 911
Protoparmeliopsis muralis (Schreb.) M. Choisy	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 851
		22.1857°	–102.34336°	2003	23 Aug 18	MIMV 868
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 908
Lichinaceae						
Heppia lutosa (Ach.) Nyl.	Asientos	22.07396°	–102.13102°	2005	9 Aug 18	MIMV 802b
Lempholemma chalazanum (Ach.) B. de Lesd.	Asientos	22.07208°	–102.07623°	2000	9 Aug 18	MIMV 798
Lempholemma sp.	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 869
		22.14668°	–102.36617°	2051	23 Aug 18	MIMV 870
Megasporaceae						
Aspicilia sp.	Cosío	22.348696°	–102.329826°	2150	27 Mar 18	GO 2383
Circinaria contorta (Hoffm.) A. Nordin, Savić & Tibell	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 791
	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 239
		21.93129°	–102.48373°	2005	2 Aug 18	AMD 247
		21.98274°	–102.37571°	1975	20 Aug 18	MIMV 836
	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 861
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 910
Circinaria sp.	Calvillo	22.00791°	–102.67355°	1858	16 Aug 18	MIMV 820

Family / Species	Municipality	Georeference		Elevation (m)	Date	Collector & collector no.
		Latitude N	Longitude W			
Parmeliaceae						
Canoparmelia texana (Tuck.) Elix & Hale	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 130
Parmotrema austrosinense (Zahlbr.) Hale	Aguascalientes	21.7794518°	–102.294174°	1850	28 Mar 18	GO 2394
	Cosío	22.358896°	–102.327110°	2070	27 Mar 18	GO 2385
Parmotrema sp.	Calvillo	22.01019°	–102.67324°	1833	16 Aug 18	MIMV 807
	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 872
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 886
Xanthoparmelia lavicola (Gyelnik) Hale	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 793
Xanthoparmelia sp.	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 852
Peltulaceae						
Peltula hassei (Zahlbr.) Büdel, Kauff & Bachran	Cosío	22.348696°	–102.329826°	2150	13 Feb 20	DFS 2078
	Jesús María	21.98274°	–102.37571°	1975	20 Aug 18	MIMV 838
Peltula sp.	Rincón de Romos	22.30687°	–102.43127°	2279	6 Sep 18	MIMV 889
Physciaceae						
Heterodermia albicans (Pers.) Swinscow & Krog	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2087
H. diademata (Taylor) D. D. Awasthi	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 244b
H. rugulosa (Kurok.) Wetmore	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 219b
		21.93129°	–102.48373°	2005	2 Aug 18	AMD 244a
Hyperphyscia adglutinata (Flörke) H. Mayrh. & Poelt	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 243
		21.98274°	–102.37571°	1975	20 Aug 18	MIMV 833
H. minor (Fée) D. D. Awasthi	Jesús María	21.98259°	–102.37817°	2035	20 Aug 18	MIMV 849
Phaeophyscia hirsuta (Mereschk.) Essl.	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 787
		22.0738°	–102.07706°	1975	9 Aug 18	MIMV 789
	Cosío	22.358896°	–102.327110°	2070	27 Mar 18	GO 2388
	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 245
	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2088
		22.30687°	–102.43127°	2279	13 Feb 20	DFS 2092
P. hirtella Essl.	Rincón de Romos	22.1857°	–102.34336°	2003	23 Aug 18	MIMV 865
Physcia aipolia (Ehrh. ex Humb.) Furnr.	Aguascalientes	21.7794518°	–102.294174°	1850	28 Mar 18	GO 2392a
P. atrostriata Moberg	Aguascalientes	21.7794518°	–102.294174°	1850	28 Mar 18	GO 2392b
P. biziana (A. Massal.) Zahlbr.	Aguascalientes	21.7794518°	–102.294174°	1850	28 Mar 18	GO 2393b
	Calvillo	22.00791°	–102.67355°	1858	16 Aug 18	MIMV 823
	Cosío	22.358896°	–102.327110°	2070	27 Mar 18	GO 2386
	Jesús María	21.98274°	–102.37571°	1975	20 Aug 18	MIMV 840a
P. crispa Nyl.	Cosío	22.348696°	–102.329826°	2150	13 Feb 20	DFS 2080
P. phaea (Tuck.) J.W. Thomson	Calvillo	22.01019°	–102.67324°	1833	16 Aug 18	MIMV 811b
		22.01019°	–102.67324°	1833	16 Aug 18	MIMV 813
	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 913
		22.30687°	–102.43127°	2279	13 Feb 20	DFS 2086
Physcia sp.	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 785
Physciella chloantha (Ach.) Essl.	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 219a

Family / Species	Municipality	Georeference		Elevation (m)	Date	Collector & collector no.
		Latitude N	Longitude W			
Psoraceae						
Psora icterica (Mont.) Müll. Arg.	Asientos	22.07208°	–102.07623°	2000	9 Aug 18	MIMV 800
Psorula rufonigra (Tuck.) Gotth. Schneider	Rincón de Romos	22.30687°	–102.43127°	2279	13 Feb 20	DFS 2085
Stereocaulaceae						
Lepraria sp.	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 241
	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 904
Teloschistaceae						
Athallia pyracea (Ach.) Arup, Frödén & Søchting	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	MIMV 782
A. vitellinula (Nyl.) Arup, Frödén & Søchting	Asientos	22.07396°	–102.13102°	2005	9 Aug 18	MIMV 801
Caloplaca brouardii (B. de Lesd.) Zahlbr.	Calvillo	22.01019°	–102.67324°	1833	16 Aug 18	MIMV 811a
C. microphyllina (Tuck.) Hasse	Aguascalientes	21.790749°	–102.291878°	1860	28 Mar 18	GO 2395
	Cosío	22.358896°	–102.327110°	2070	27 Mar 18	GO 2387
	Jesús María	21.93129°	–102.48373°	2005	2 Aug 18	AMD 248
C. saxicola (Hoffm.) Nordin	Asientos	22.0738°	–102.07706°	1975	9 Aug 18	MIMV 790
		22.0738°	–102.07706°	1975	9 Aug 18	MIMV 792
	Jesús María	21.98274°	–102.37571°	1975	20 Aug 18	MIMV 835
	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 855
		22.14632°	–102.36545°	2055	23 Aug 18	MIMV 883
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 898
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 914
Squamulea squamosa (B. de Lesd.) Arup, Søchting & Frödén	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 125
		21.922557°	–102.57949°	2250	2 Aug 18	AMD 230
S. subsoluta (Nyl.) Arup, Søchting & Frödén	Cosío	22.348696°	–102.329826°	2150	27 Mar 18	GO 2382
	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 221
		21.922557°	–102.57949°	2250	2 Aug 18	AMD 235
Trapeliaceae						
Trapelia sp.	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 877
Umbilicariaceae						
Umbilicaria sp.	Calvillo	22.00784°	–102.67245°	1881	16 Aug 18	MIMV 828a
Verrucariaceae						
Clavascidium lacinulatum (Ach.) M. Prieto	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 906
Dermatocarpon miniatum (L.) W. Mann	Calvillo	22.01019°	–102.67324°	1833	16 Aug 18	MIMV 809
	Rincón de Romos	22.14668°	–102.36617°	2051	23 Aug 18	MIMV 878
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 892
		22.2344°	–102.43683°	2119	6 Sep 18	MIMV 903a
D. moulinsii (Mont.) Zahlbr.	Calvillo	22.00784°	–102.67245°	1881	16 Aug 18	MIMV 828b
D. reticulatum H. Magn.	Calvillo	22.00784°	–102.67245°	1881	16 Aug 18	MIMV 830
Dermatocarpon sp.	Rincón de Romos	22.2344°	–102.43683°	2119	6 Sep 18	MIMV 903b
Heteroplacidium compactum (A. Massal.) Gueidan & Cl. Roux	Asientos	22.07396°	–102.13102°	2005	9 Aug 18	MIMV 802a
	Jesús María	21.877962°	–102.422866°	2330	14 Mar 18	AMD 128
		21.98259°	–102.37817°	2035	20 Aug 18	MIMV 844
	Rincón de Romos	22.14632°	–102.36545°	2055	23 Aug 18	MIMV 880
		22.14632°	–102.36545°	2055	23 Aug 18	MIMV 881
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 894b

Family / Species	Municipality	Georeference		Elevation (m)	Date	Collector & collector no.
		Latitude N	Longitude W			
Placidium acarosporoides (Zahlbr.) Breuss	Rincón de Romos	22.18562°	–102.34086°	1959	23 Aug 18	MIMV 859
		22.30687°	–102.43127°	2279	6 Sep 18	MIMV 894a
P. squamulosum (Ach.) Breuss	Asientos	22.07208°	–102.07623°	2000	9 Aug 18	MIMV 799
	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 233
Staurothele monicae (Zahlbr.) Wetmore	Jesús María	21.922557°	–102.57949°	2250	2 Aug 18	AMD 222
Verrucaria inficiens Breuss	Calvillo	22.00791°	–102.67355°	1858	16 Aug 18	MIMV 821
	Rincón de Romos	22.1857°	–102.34336°	2003	23 Aug 18	MIMV 867

Tab. 2. Annotated lichenized fungi species list of arid zones of Aguascalientes. Information about growth form, substrate, voucher, and distribution in Mexico is provided.

Species	Growth form[a]	Substrate[b]	Voucher[c]	Distribution in Mexico[d]	Figure
Acarosporaceae					
Acarospora veronensis	C	R	AMD 232	BC, BCS, COAH, DGO, SON	2A
Acarospora sp.	C	R	AMD 246; MIMV 846, 856, 873	NA	—
Pleopsidium oxytonum	C	R	AMD 127, 237; MIMV 795, 819, 845, 885, 893, 909, 915	BC, BCS, MEX, NAY, SON	2B
Caliciaceae					
Buellia dispersa	C	R	AMD 227; DFS 2079; MIMV 912	BC, BCS, CHIH, DGO, SON, VER, ZAC	2C
B. nashii	C	R	MIMV 842, 850	BC, BCS, CHIH, COAH	2D
B. stellulata	C	R	MIMV 879, 895	BC, BCS, CDMX, MICH, SON	2E
Dimelaena oreina	C	R	AMD 129; MIMV 874, 884	BC, BCS, CHIH, DGO, GTO, HGO, JAL, MICH, SON, ZAC	2F
Candelariaceae					
Candelaria concolor	Fo	B	GO 2393a; MIMV 825	BC, BCS, CHIH, CDMX, GTO, MEX, MOR, NL, PUE, SIN, SON, TAMS, VER, ZAC	–
Candelariella sp.	C	R	AMD 135	NA	–
Candelina mexicana	C	R	MIMV 905	BCS, CHIH, COAH, DGO, GTO, MEX, MICH, MOR, OAX, PUE, SON, VER, ZAC	2G
C. submexicana	C	R	DFS 2083; MIMV 794, 796, 841, 853, 888	BC, BCS, CHIH, COAH, DGO, GTO, HGO, JAL, MOR, QRO, SIN, SON, ZAC	2H
Candelina sp.	C	R	AMD 224, 236, 238, 240; GO 2384	NA	–
Cladoniaceae					
Cladonia chlorophaea	Fr	S	DFS 2091	BC, CDMX, CHIS, CHIH, COAH, DGO, GTO, MEX, MOR, NL, OAX, PUE, SLP, VER	2I
Cladonia sp.	Fr	S	DFS 2090	NA	–
Coccocarpiaceae					
Coccocarpia palmicola	Fo	R, S	DFS 2093; MIMV 871, 891	BCS, CHIH, CHIS, COAH, COL, DGO, GTO, GRO, HGO, JAL, MICH, MOR, NAY, OAX, PUE, SIN, SON, TAMS, VER	2J

Species	Growth form[a]	Substrate[b]	Voucher[c]	Distribution in Mexico[d]	Figure
Collemataceae					
Lathagrium cristatum	Fo	R	MIMV 829	BC, BCS, CHIH, COAH, NL, OAX, SON	2K
Leptogium denticulatum	Fo	R	DFS 2095; MIMV 907	BCS, CHIH, DGO, HGO, JAL, MICH, OAX, SIN, SON, VER	2L
Leptogium sp.	Fo	R	MIMV 814	NA	–
**Scytinium subaridum*	Fo	S	AMD 225	No records	3A
Graphidaceae					
Diploschistes gypsaceus	C	R	DFS 2089	BC, PUE	3B
Haematommataceae					
Haematomma fenzlianum	C	R	AMD 134; MIMV 887	BCS, CHIH, COAH, DGO, GTO, HGO, JAL, MICH, OAX, SLP, SON, ZAC	3C
Lecanoraceae					
Lecanora sp.	C	R	AMD 132	NA	–
Lecidella stigmatea	C	R	MIMV 911	BC, BCS, CHIH, COAH	–
Protoparmeliopsis muralis	C	R	MIMV 851, 868, 908	BC, BCS, CHIH, DGO, NL, OAX, PUE, SON, VER	3D
Lichinaceae					
Heppia lutosa	C	R	MIMV 802b	BC, BCS, CHIH, COAH, DGO, JAL, SON	–
Lempholemma chalazanum	C	S	MIMV 798	BC	3E
Lempholemma sp.	C	S	MIMV 869, 870	NA	–
Megasporaceae					
Aspicilia sp.	C	R	GO 2383	NA	–
Circinaria contorta	C	R	AMD 239, 247; MIMV 791, 836, 861, 910	BCS	3F
Circinaria sp.	C	R	MIMV 820	NA	–
Parmeliaceae					
Canoparmelia texana	Fo	B	AMD 130	BCS, CHIS, CHIH, DGO, GTO, GRO, HGO, JAL, MEX, MICH, MOR, NAY, NL, OAX, PUE, SIN, SON, TAMS, VER, ZAC	–
Parmotrema austrosinense	Fo	B	GO 2385, 2394	BC, CHIS, COAH, GTO, GRO, HGO, JAL, MICH, MOR, NL, OAX, PUE, SLP, SIN, SON, TAMS, VER	3G
Parmotrema sp.	Fo	R	MIMV 807, 872, 886	NA	–
Xanthoparmelia lavicola	Fo	R	MIMV 793	BCS, CHIH, COAH, GTO, JAL, MOR, OAX, PUE, SIN, SON, ZAC	3H
Xanthoparmelia sp.	Fo	R	MIMV 852	NA	–
Peltulaceae					
Peltula hassei	C	R, S	DFS 2078; MIMV 838	BC, BCS, CHIH, COAH, SON	3I
Peltula sp.	C	S	MIMV 889	NA	–
Physciaceae					
Heterodermia albicans	Fo	R	DFS 2087	BCS, CAMP, CHIH, COAH, DGO, GRO, GTO, JAL, MEX, MICH, MOR, NL, QR, SLP, SON, YUC, VER, ZAC	–

Species	Growth form[a]	Substrate[b]	Voucher[c]	Distribution in Mexico[d]	Figure
H. diademata	Fo	B	AMD 244b	CDMX, CHIH, CHIS, GRO, HGO, JAL, MICH, MOR, PUE, SLP, SIN, SON, TAMS, VER	–
H. rugulosa	Fo	B	AMD 219b, 244a	BCS, CHIH, COAH, GTO, JAL, NAY, PUE, SON	3J
Hyperphyscia adglutinata	Fo	B	AMD 243; MIMV 833	BC, BCS, CHIH, GTO, HGO, MEX, MOR, PUE, SON, VER	3K
H. minor	Fo	B	MIMV 849	JAL	3L
Phaeophyscia hirsuta	Fo	B, R	AMD 245; DFS 2088, 2092; GO 2388; MIMV 787, 789	BC, BCS, CHIH, COAH, GTO, JAL, NL, SON, TAMS	4A
**P. hirtella*	Fo	B	MIMV 865	No records	4B
Physcia aipolia	Fo	B	GO 2392a	BC, BCS, CDMX, CHIH, CHIS, COAH, DGO, GTO, HGO, JAL, NL, PUE, SLP, SIN, SON, TAMS, YUC	–
P. atrostriata	Fo	B	GO 2392b	NAY, NL, PUE, SLP, VER	4C
P. biziana	Fo	B	GO 2386, 2393b; MIMV 823, 840a	BC, BCS, CDMX, CHIH, COAH, GTO, HGO, JAL, MEX, MICH, NL, PUE, SLP, SIN, SON, YUC, ZAC	4D
P. crispa	Fo	R	DFS 2080	BCS, MEX, NAY, SLP, VER	–
P. phaea	Fo	R	DFS 2086; MIMV 811b, 813, 913	BC, BCS, CHIH, DGO, MICH, SIN, SON	4E
Physcia sp.	Fo	B	MIMV 785	NA	–
Physciella chloantha	Fo	B	AMD 219a	BCS, NL, SON	4F
Psoraceae					
Psora icterica	C	S	MIMV 800	BCS, CHIH, COAH, DGO, HGO, JAL, MEX, OAX, PUE, SON, TAMS, ZAC	4G
Psorula rufonigra	C	R	DFS 2085	BC, BCS, CHIH, COAH, DGO, MICH, PUE, SON	4H
Stereocaulaceae					
Lepraria sp.	C	B, R	AMD 241; MIMV 904	NA	–
Teloschistaceae					
Athallia pyracea	C	B	MIMV 782	No records	–
A. vitellinula	C	R	MIMV 801	CHIS	4I
Caloplaca brouardii	C	R	MIMV 811a	BC, BCS, CHIH, COAH, DGO, GRO, JAL, MICH, MOR, OAX, PUE, QRO, SIN, SON	4J
C. microphyllina	C	B	AMD 248; GO 2387, 2395	BC, BCS, CHIH, MOR, SLP, SON	4K
C. saxicola	C	R	MIMV 790, 792, 835, 855, 883, 898, 914	BC, BCS, DGO, OAX, PUE, SIN, SON	4L
Squamulea squamosa	C	R	AMD 125, 230	BC, BCS, CHIH, COAH, GTO, SIN, SON	5A
S. subsoluta	C	R	AMD 221, 235; GO 2382	BC, BCS, CHIH, COAH, DGO, GTO, HGO, JAL, MICH, NAY, NL, OAX, PUE, QRO, SIN, SON, ZAC	5B
Trapeliaceae					
Trapelia sp.	C	S	MIMV 877	NA	–

Species	Growth form[a]	Substrate[b]	Voucher[c]	Distribution in Mexico[d]	Figure
Umbilicariaceae					
Umbilicaria sp.	Fo	R	MIMV 828a	NA	–
Verrucariaceae					
Clavascidium lacinulatum	C	S	MIMV 906	BC, BCS, CDMX, CHIH, HGO, JAL, MEX, MICH, NL. SLP, SON, TAMS	5C
Dermatocarpon miniatum	Fo	R	MIMV 809, 878, 892, 903a	BC, CDMX, CHIH, COAH, MEX, MICH, NL, OAX, PUE, SON, TLAX, VER	5D
D. moulinsii	Fo	R	MIMV 828b	CHIH, COAH, PUE, SON	–
D. reticulatum	Fo	R	MIMV 830	OAX	–
Dermatocarpon sp.	Fo	R	MIMV 903b	NA	–
Heteroplacidium compactum	C	R	AMD 128; MIMV 802a, 844, 880, 881, 894b	BCS	5E
Placidium acarosporoides	C	R	MIMV 859, 894a	BC, BCS	5F
P. squamulosum	C	S	AMD 233; MIMV 799	BC, BCS, COAH, DGO, SON	5G
Staurothele monicae	C	R	AMD 222	SON	5H
Verrucaria inficiens	C	R	MIMV 821, 867	CHIH, DGO, SON	5I

* New records for Mexico.
[a] C crustrose; F foliose; Fr fruticose.
[b] B bark; R rock; S soil.
[c] Collectors: AMD A. Martínez-Durón; DFS D.F. Simijaca; GO G. Ocampo; MIMV M.I. Miguel-Vázquez.
[d] Information taken from CNALH (https://lichenportal.org/cnalh/collections/index.php) and MEXU (https://datosabiertos.unam.mx/biodiversidad/and) online data bases. State abbreviations: BC Baja California; BCS Baja California Sur; CAMP Campeche; CDMX Mexico City; CHIS Chiapas; CHIH Chihuahua; COAH Coahuila; COL Colima; DGO Durango; GTO Guanajuato; GRO Guerrero; HGO Hidalgo; JAL Jalisco; MEX Estado de México; MICH Michoacán; MOR Morelos; NAY Nayarit; NL Nuevo León; OAX Oaxaca; PUE Puebla; QRO Querétaro; QR Quintana Roo; SLP San Luis Potosí; SIN Sinaloa; SON Sonora; TAMS Tamaulipas; TLAX Tlaxcala; VER Veracruz; YUC Yucatán; ZAC Zacatecas. NA Not applicable.

bordering state; however, it is important to highlight that the latter two have a substantially larger territory. The number of species that are known to occur in the arid zones of Aguascalientes may be higher, because the 28 specimens determined up to genus level still require further study (molecular phylogenetic analyses and/or corroboration by specimen confrontation). Therefore, future determination results may increase the number of taxa recorded for the state.

The present study only considered the arid regions of Aguascalientes and does not include another ecosystems present in the state, such as *Quercus* and coniferous forests (work in progress), which according to Herrera-Campos et al. (2014) are the vegetation types with the highest number of lichen species in Mexico. This suggests that the lichen species richness for the state could be considerably higher; therefore, it is expected that in the near future, collecting and herbarium work performed at herbarium HUAA will bring a closer estimation of lichen species richness in this part of Mexico.

This study is the first effort to document the lichen species richness of the Mexican state of Aguascalientes; this undoubtedly will contribute not only to increase our knowledge about these organisms in central Mexico, but also to have a better and more realistic perspective of the lichen diversity at a country level. To have a wider impact, the specimen data presented in this study will be uploaded to the recently created Checklist of Lichens and Lichenicolous Fungi of Mexico site (https://lichenportal.org/chlal/checklists/checklist.php?clid=1288&pid=555), hosted in the Consorcio de Herbarios de Líquenes en América Latina webpage (CHLAL; https://lichenportal.org/chlal/), which represents a preliminary effort to gather and unify the lichen information generated for Mexico. The new records shown in this study are a clear example of the relevance that these inventories have, particularly important to improve the national inventory and to provide new data on distribution ranges. However, there are currently important difficulties to publish such works in major scientific journals, especially

when there are no DNA sequence data and phylogenetic analyses associated to them. There is no question that there is still plenty of work to do for obtaining a better perspective of the lichen species richness in central Mexico and arid environments. However, studies like this one, performed at regional or state levels, may be the key to develop in a relatively short term a more complete inventory of the lichen species found in Mexico.

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