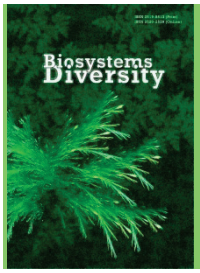

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Contribution to the knowledge of the mosses of Megriss Mountain (Algeria)

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Due to the limited knowledge on bryophytes in Algeria, this study aimed to update the Algerian bryophyte flora. Megriss Mountain (also called Jbel or Djebel Megriss), which is a part of the High Plains of Setif, was chosen as a study area for its interesting biological and landscape diversity. The inventory was carried out in different habitats (rocks, trees, soils and streams). Samples were collected from minimum survey areas of 100 cm^2 (from soil and rocks), but the sample area was sometimes increased depending on the availability of species; the trees were mostly sampled between heights of 1 and 2 meters. As a result, a preliminary list of 55 moss species were identified, including 44 acrocarpous and 11 pleurocarpous, belonging to 13 families and 29 genera. The most species-rich families were Pottiaceae, Orthotrichaceae, Brachytheciaceae, and Bryaceae, while the most diverse genera were *Lewinskya* and *Syntrichia*. Epilithic mosses were dominant, followed by terricolous mosses and finally epiphytic mosses. The most frequent species in the study area were *Orthotrichum diaphanum*, *Lewinskya acuminate*, *Didymodon insulanus*, *Grimmia pulvinata*, and *Tortella squarrosa*. The study also highlights the presence of a new species that had never been recorded in Algeria -*Orthotrichum scanicum*. A comprehensive description, microphotographs of the species are provided and its ecology is also discussed. This discovery will contribute to the enrichment of the Algerian bryophyte flora in general and of the Orthotrichaceae in particular,within the genus *Orthotrichum*, which now has a total of 11 species recorded in the country.

Keywords: biodiversity; Mediterranean bryophytes; *Orthotrichum scanicum*; Setifian High Plains.

Introduction

The bryophyte flora of Algeria has been the subject of a relatively extensive number of studies that started in the XIX century, but which has become more limited since the second half of the XX century; during the sessions of the Botanical Society of France, occasional collections of mosses from some Algerian provinces were presented by Pinoy, Klincksieck, Trabut, and Maire. As a result, Camus (1906) and Trabut (1914, 1927) identified a few species of bryophytes. Furthermore, the French bryologists Feódor Jelenc did much fieldwork in Algeria and published the first compilation of reports dealing with bryophytes from northern Africa (Jelenc, 1955, 1967). Moreover, Ros et al. (1999) synthesized all accessible references to create an annotated list of bryophytes in northern Africa, in which Algeria had the most significant number of taxa (648 taxa). This checklist was later updated in the Mediterranean checklists of liverworts and mosses (Ros et al., 2007, 2013). Also, Bischler (2004) included much data about Algerian hepatics without precise localities. Recently an inventory of the mosses of the Tonga watershed (Northeastern Algeria) was carried out by Boukhatem et al. (2017).

To contribute to the knowledge of Algerian bryophyte flora, particularly that of the northern part of the Setifian High Plains, Megriss Mountain was chosen to be explored, which is considered one of the most interesting and important ecosystems in terms of biological and landscape diversity (Boulaacheb, 2013). Despite this interest, its bryoflora has not been deeply studied. Therefore, the present work aims to provide a preliminary list of the mosses of Megriss Mountain and to provide knowledge on the geographical distribution and ecology of an epiphyte moss reported for the first time in Algeria.

Material and methods

Study area. Megriss Mountain is a part of the Setifian High Plains, which are situated in northeastern Algeria at latitude 36°19'54" N and longitude 5°21'14" (Fig. 1), and culminates at 1737 m elevation. It is characterized by a sub-humid bioclimatic stage with a cold winter variant. The warmest month is August, with a maximum of 26.4 °C, while January is the coldest one, with a minimum of –0.6 °C. The average annual precipitation is 500 mm, of which an important quantity falls as snow (Boulaacheb, 2013).

Megriss Mountain contains diverse ecosystems which consist of grasslands, lowlands, streams, temporary pools, reforestation of *Cedrus atlantica* (Endl.) Manetti ex Carrière, also *Quercus ilex* L. woods (Boulaacheb, 2013). Additionally, there are a few species of trees such as *Fraxinus angustifolia* Vahl, *Populus alba* L., and *Salix alba* Kern. (Boulaacheb, 2008). The soils of Megriss Mountain are classified into two types: vertisols and leached soils (Lahmar et al., 1993).

Sampling methods. In 2012, the initial fieldwork was conducted. Years later, further fieldwork was carried out in April 2021, June 2021, and October 2022. In the course of this fieldwork, samples were collected at only ten stations (Table 1).

Wherever mosses were available on rocks and soils, a minimum survey area of 100 cm^2 (10 × 10 cm) was selected. However, this area could be increased depending on the availability of species. The trees were mostly sampled between heights of 1 and 2 meters.

The specimens collected were as complete as possible because fertile samples are easier to determine. Each sample was collected in a paper envelope indicating substrate type. When an epiphyte was being collected, it was important to mention whether it had been taken from the upper, the middle or the lower part of the tree trunk. All mosses collected were preserved and used in Boulaacheb's private herbarium collection as well as further identification.

Identification of the mosses. Moss samples were macroscopically and microscopically examined in the laboratory of the Urban Project, City and Territory (PUViT) which is affiliated with the Department of Architecture, team of Urban-Periurban Ecology and Biodiversity, using a Zeïss stemi 2000-c stereomicroscope and Optika microscope. Photomicrographs of the studied samples were captured using Optika proview 4,8,15529 software. Their identification was performed by determining the morphological character of each specimen with identification keys to bryophytes such as the Moss Flora of Britain and Ireland (Smith, 2004), the Handbook of

mosses of the Iberian Peninsula, the Balearic Islands (Casas et al., 2006), all volumes of the series Flora Briofítica Ibérica (Guerra et al., 2006, 2010, 2014, 2018; Brugués et al., 2007; Brugués & Guerra, 2015) as well as website resources like Bryologia Gallica & Ultramarina (http://bryologia.gallica.free.fr/les-bryophytes-defrance.php) and the British Bryological Society (www.britishbryologicalsociety.org.uk) (Hodgetts et al., 2020) was followed for the mosses' nomenclature.

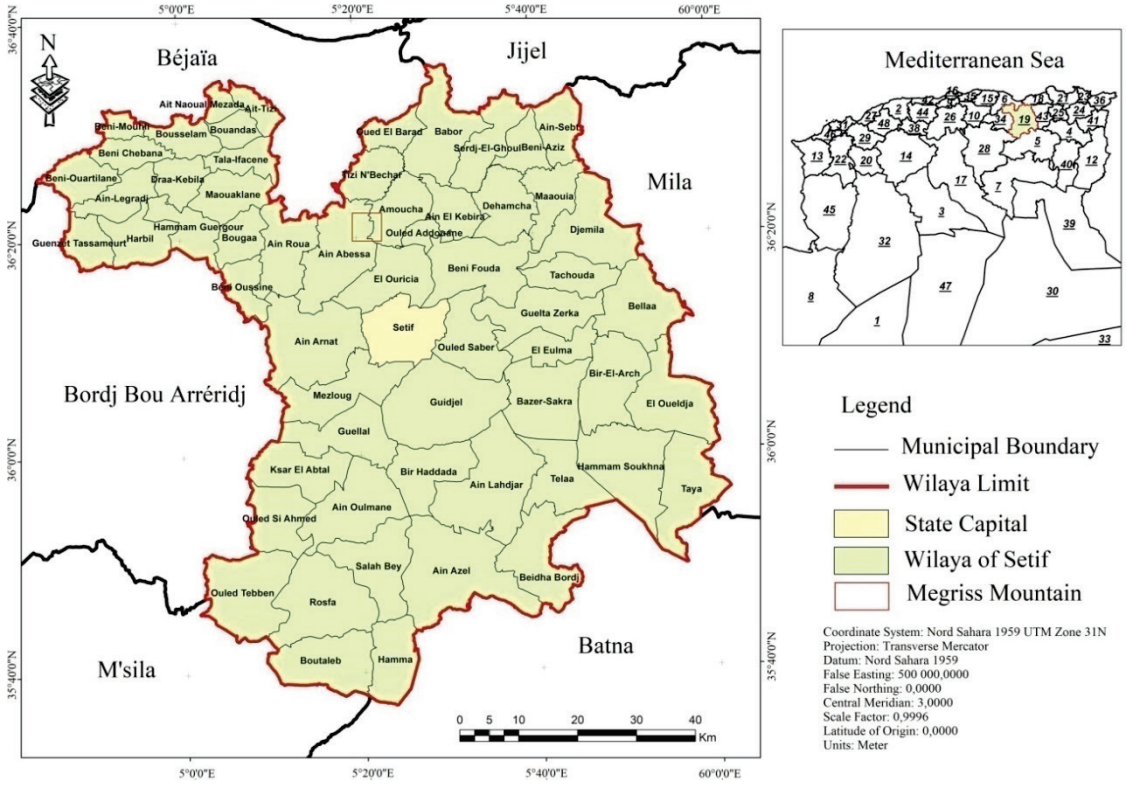

Fig. 1. Study area location in Northern Algeria: Megriss Mountain belongs to the Wilaya of Setif (number 19 in the upper right map), situated northwards of the city of Setif (the base map is from GeoJamal website with the permission of the author)

Table 1
Geographic coordinates of the sampled stations

Station	Latitude	Longitude	Altitude, m
1	36°21'15.4" N	5°22'39.6" E	1036
2	36°21'40.0" N	5°20'19.8" E	1108
3	36°20'05.5" N	5°20'34.8" E	1364
4	36°20'09.4" N	5°20'52.5" E	1525
5	36°20'01.9" N	5°20'14.4" E	1553
6	36°20'05.8" N	5°20'31.5" E	1554
7	36°20'00.7" N	5°20'14.1" E	1555
8	36°20'09.0" N	5°22'50.2" E	1565
9	36°19'52.9" N	5°20'42.9" E	1614
10	36°19'50.1" N	5°21'02.5" E	1686

Results

As a result of the current study, a total of 55 moss species were identified to their specific/generic level, including 11 pleurocarpous (20%) and 44 acrocarpous mosses(80%). These species are distributed in over 29 genera belonging to 13 families, among which four families reveal a remarkable specific richness; the Pottiaceae, represented by 17 species (i.e., 30.9%), the Orthotrichaceae with 10 species (18.2%), and then the Brachytheciaceae and the Bryaceae, which are each represented by six species (10.9%). The Grimmiaceae are represented by four species (7.3%) and the Hypnaceae by three species (5.5%). The Bartramiaceae and the Ditrichiaceae both are represented by two species (3.6%). The remaining five families are each represented by only one species (1.8%, Fig. 2).

At the generic level, *Lewinskya* F. Lara, Garilleti & Goffinet and *Syntrichia* Brid. are the most diverse, with five species each (Fig. 2).

Mosses of the study area were found inhabiting different types of habitats (Table 2); 20 species (36.4%) were epilithic, 13 species (23.6%) were terricolous, 9 species (16.4%) were epiphytic, of which 8 of them belong to the Orthotrichaceae family, and 2 (3.63%) were aquatic, of which *Drepanocladus aduncus* Hedw. was semi aquatic while *Fontinalis antipyretica* Hedw. was aquatic. Eight species (14.4%) were found growing on both soils and rocks, namely; *Homalothecium aureum* (Spruce) H. Rob., *Hypnum cupressiforme* Hedw. var. *lacunosum* Brid., *H. jutlandicum* Holmen & E. Warncke, *Scleropodium touretii* (Brid.) L. F. Koch., *Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr var. *ruralis*, *Tortella squarrosa* (Brid.) Limpr., *Tortula inermis* (Brid.) Mont, and *T. subulata* Hedw. The remaining three species were growing on rocks and trees, namely: *Grimmia pulvinata* (Hedw.) Sm., *Orthotrichum cupulatum* Brid. and *O. diaphanum* Brid. although in our study area, *O. diaphanum* was found growing more on trees.

Based on the Checklist of the Mediterranean mosses (Ros et al., 2013), this study revealed one new species record for Algeria belonging to the Orthotrichaceae family, which is *Orthotrichum scanicum* Grönvall. A description of the species is provided below based on our observations and the literature.

Specimen examined. Algeria. Setif: Megriss Mountain, Ain Guelou, 36°21'40.0" N 5°20'19.8" E, ca 1108 m a.s.l., on the medium part of the bark of *Fraxinus angustifolia*, 25.10.2022, leg. A. Mazari 13, Boulaacheb private herbarium n° 92.

Morphological characteristics. The sample of *Orthotrichum scanicum* collected was easily identifiable based on the presence of the diagnostic characteristics stated by Lara et al (2009) and Guerra et al. (2014): leaves linear-lanceolate to ovate-lanceolate with a costa ending below the apex, an acute and irregularly toothed apex, recurved and unistratose margins, unistratose laminal cells and, often with broad oval base. Leaves are also characterized by rounded upper cells, rectangular-elliptical median cells and rectangular basal cells (Fig. 3).

Orthotrichum scanicum collected in our area was also characterized by capsules broadly emergent and which contain eight ribs, immersed stomata located in the lower ½ of the urn, exostome with eight pairs of teeth and endostome with 16 segments (eight long segments interspersed with eight short ones), often appendiculate. Spores 18–19 µm in diameter (Fig. 4).

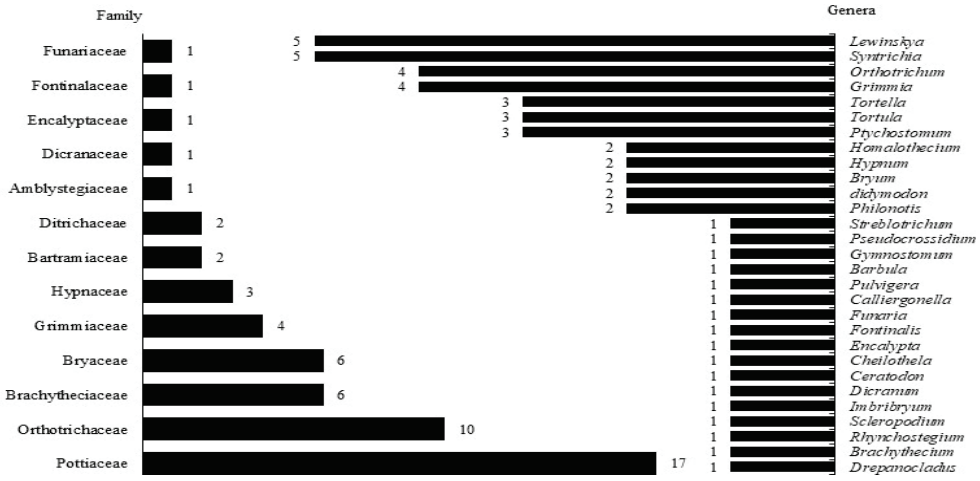

Fig. 2. Number of species recorded for each family and genus at the Megriss Mountain

Table 2
Mosses of Megriss Mountain: their families and substrate types

Species	Aquatic	Terrestrial	Epilithic	Epiphytic
Drepanocladus aduncus Hedw.	+	–	–	–
Philonotis calcarea (Bruch & Schimp.) Schimp.	–	+	–	–
Ph. tomentella Molendo	–	+	–	–
Brachythecium rutabulum (Hedw.) Schimp.	–	+	–	–
B. sp.	–	+	–	–
Homalothecium aureum (Spruce) H. Rob.	–	+	+	–
H. sericeum (Hedw.) Schimp.	–	+	–	–
Rhynchostegium megapolitanum (Blandow ex F. Weber & D. Mohr) Schimp.	–	–	+	–
Scleropodium touretii (Brid.) L. F. Koch.	–	+	+	–
Bryum argenteum Hedw.	–	+	–	–
B. radiculosum Brid.	–	–	+	–
Imbribryum mildeanum (Jur.) J. R. Spence	–	–	+	–
Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen	–	–	+	–
P. pseudotriquetrum (Hedw.) J. R. Spence & H. P. Ramsay ex Holyoak & N. Pedersen	–	+	–	–
P. torquescens (Bruch & Schimp.) Ros & Mazimpaka	–	–	+	–
Dicranum scoparium Hedw.	–	+	–	–
Ceratodon purpureus subsp. *stenocarpus* (Brauch & Schimp. ex Müll. Hal.) Dixon	–	–	+	–
Cheilothela chloropus (Brid.) Broth.	–	+	–	–
Encalypta vulgaris Hedw.	–	–	+	–
Fontinalis antipyretica Hedw.	+	–	–	–
Funaria hygrometrica Hedw.	–	–	+	–
Grimmia funalis (Schwägr.) Bruch & Schimp.	–	–	+	–
G. orbicularis Bruch ex Wilson	–	–	+	–
G. ovalis (Hedw.) Lindb.	–	–	+	–
G. pulvinata (Hedw.) Sm.	–	–	+	+
Calliergonella cuspidata (Hedw.) Loeske	–	+	–	–
Hypnum cupressiforme Hedw. var. *lacunosum* Brid.	–	+	+	–
H. jutlandicum Holmen & E. Warncke	–	+	+	–
Lewinskya acuminate (H. Philib.) F. Lara, Garilleti & Goffinet	–	–	–	+
L. affinis (Schrad. ex Brid.) F. Lara, Garilleti & Goffinet	–	–	–	+
L. breviseta (F. Lara, Garilleti & Mazimpaka) F. Lara, Garilleti & Goffinet	–	–	–	+
L. rupestris (Schleich. ex Schwägr.) F.Lara, Garilleti & Goffinet	–	–	+	–
L. striata (Hedw.) F. Lara, Garilleti & Goffinet	–	–	–	+
Orthotrichum cupulatum Brid.	–	–	+	+
O. diaphanum Brid.	–	–	+	+
O. pumilum Sw. ex anon.	–	–	–	+
O. scanicum Grönvall	–	–	–	+
Pulvigera lyellii (Hook. & Taylor) Plášek, Sawicki & Ochyra	–	–	–	+
Barbula unguiculata Hedw.	–	–	+	–
Didymodon insularus (De Not.) M. O. Hill	–	–	+	–
D. vinealis (Brid.) R H. Zander	–	–	+	–
Gymnostomum calcareum Nees & Hornsch.	–	–	+	–
Pseudocrossidium hornschuchianum (Schultz) R. H. Zander	–	+	–	–
Streblotrichum convolutum (Hedw.) P. Beauv. var. *convolutum*	–	–	+	–
Syntrichia laevipila Brid.	–	–	–	+
S. montana Nees var. *calva* (Durieu & Sagot ex Bruch & Schimp.) J. J. Amann	–	–	+	–
S. ruraliformis (Besch.) Mans.	–	+	–	–
S. ruralis (Hedw.) F. Weber & D. Mohr var. *ruralis*	–	+	+	–
S. virescens (De Not.) Ochyra	–	–	–	+
Tortella flavovirens (Bruch) Broth. var. *flavovirens*	–	+	–	–
T. nitida (Lindb.) Broth.	–	–	+	–
T. squarrosa (Brid.) Limpr.	–	+	+	–
Tortula inermis (Brid.) Mont	–	+	+	–
T. muralis Hedw.	–	–	+	–
T. subulata Hedw.	–	+	+	–

Discussion

The results of the current study indicate a higher number of acrocarpous mosses compared to the pleurocarpous mosses. Based in our observations during fieldwork and according to (Govindapyari et al., 2012), this may be due to the ability of acrocarpous mosses to colonize areas with more or less moisture and sunlight, while pleurocarpous mosses may be more common in areas with more moisture and shadow.

Our inventory shows a clear dominance of the Pottiaceae, the Orthotrichaceae, the Brachytheciaceae, and the Bryaceae. This dominance has been observed in many areas with Mediterranean climate, such as in several studies carried out in Morocco (Cano et al., 2002; Ahayoun et al., 2016; Laouzazni et al., 2018; El Harech et al., 2020; Fadel et al., 2020, 2021; Zaza et al., 2020, 2021), France (Hugonnot & Celle, 2013), and Spain (Ros & Guerra, 1987; Rams et al., 2014).

The Pottiaceae family is already known as the largest family within Bryopsida in terms of genera count (Zander, 1993). Moreover, a majority of Pottiaceae mosses show strong adaptation to harsh environments, specifically arid conditions like those found in open montane areas (Zander, 1993; Gradstein et al., 2001), confirming that significant arid areas of Northern Africa may provide a suitable habitat for the Pottiaceae (Ben Osman et al., 2021).

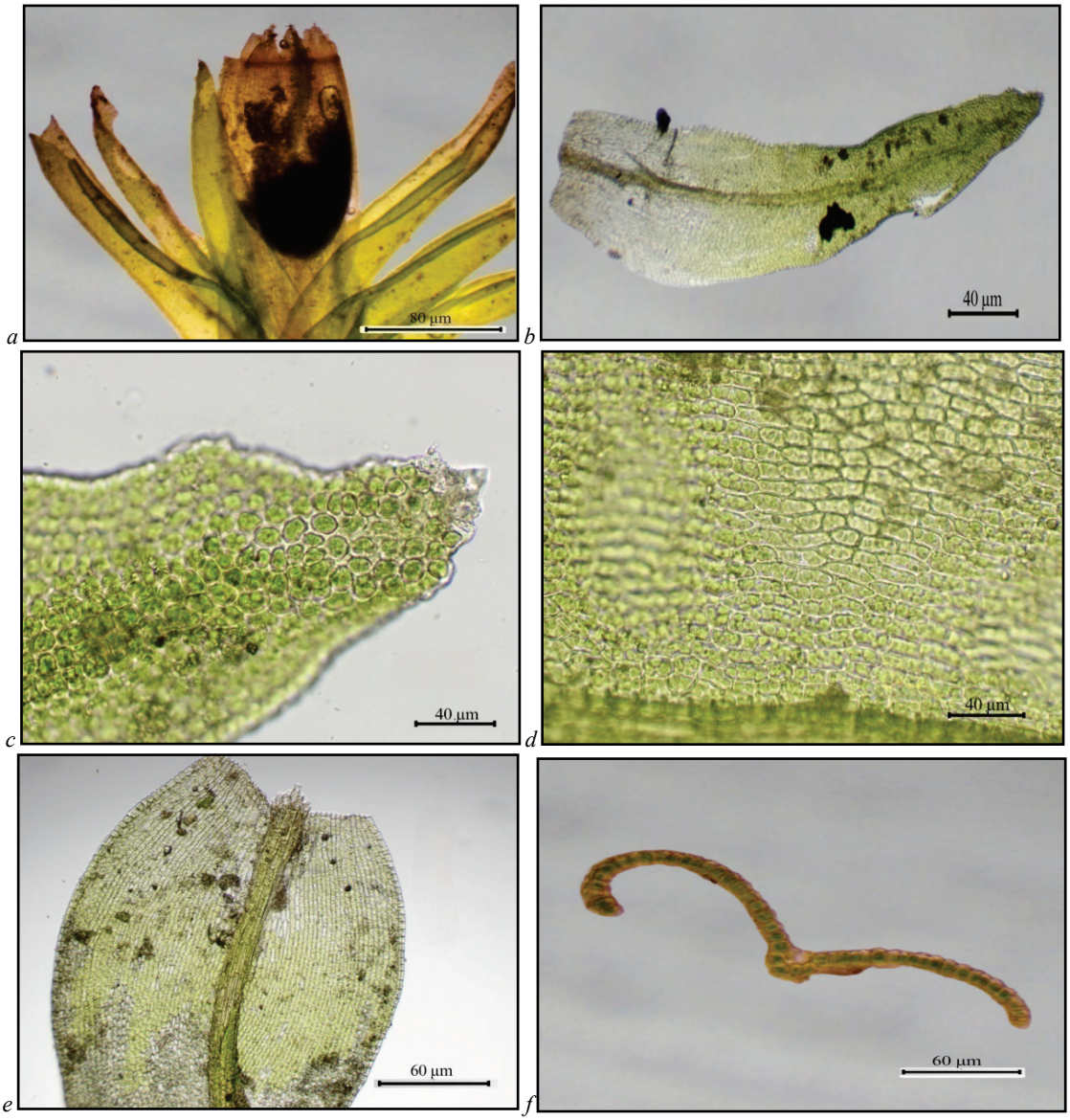

Fig. 3. Microphotographs of the gametophyte part of *Orthotrichum scanicum* from Jbel Megriss (Boulaacheb private herbarium nº 92): *a* – habitus of the plant; *b* – leaf; *c* – apex of leaf showing apical cells; *d* – median cells; *e* – base of leaf; *f* – leaf cross-section at base of leaf

Furthermore, the Orthotrichaceae family is the second most species-rich family. All species inventoried within this family in our study area were previously attributed to a single genus, *Orthotrichum* Hedw. This genus is considered to be one of the richest genera in the Orthotrichaceae (Lara et al., 2016), with 163 species in the world (Medina et al., 2013) and 40 species in the Mediterranean region (Ros et al., 2013). Most of these species are epiphytic (Lara et al., 1994; Lara & Mazimpaka, 2001; Lara et al., 2016). Our study found that nine out of ten species of Orthotrichaceae were growing on trees, which is similar to the results observed by (Draper et al., 2003; Draper et al., 2005; Draper et al., 2006), where they found that the Orthotrichaceae family and *Orthotrichum* genus were dominant in the epiphytic bryoflora of three areas in Morocco, confirming their ecological significance in the Mediterranean region (Lara et al., 1994; Lara & Mazimpaka, 2001). However, in recent years, there has been a significant taxonomical revision of the genus *Orthotrichum* Hedw. (Draper et al., 2021). The European and Mediterranean species were divided into three different genera. The genus *Pulvigera* Plášek, Sawicki & Ochyra which includes *P. lyellii* (Hook. & Taylor) Plášek, Sawicki & Ochyra (*Orthotrichum lyellii* Hook. & Taylor) (Plášek et al., 2015), *Lewinskya* F. Lara, Garilleti & Goffinet for the phaneroporous and monoicous taxa of *Orthotrichum* and *Orthotrichum* s.s. for the rest of species (Lara et al., 2016).

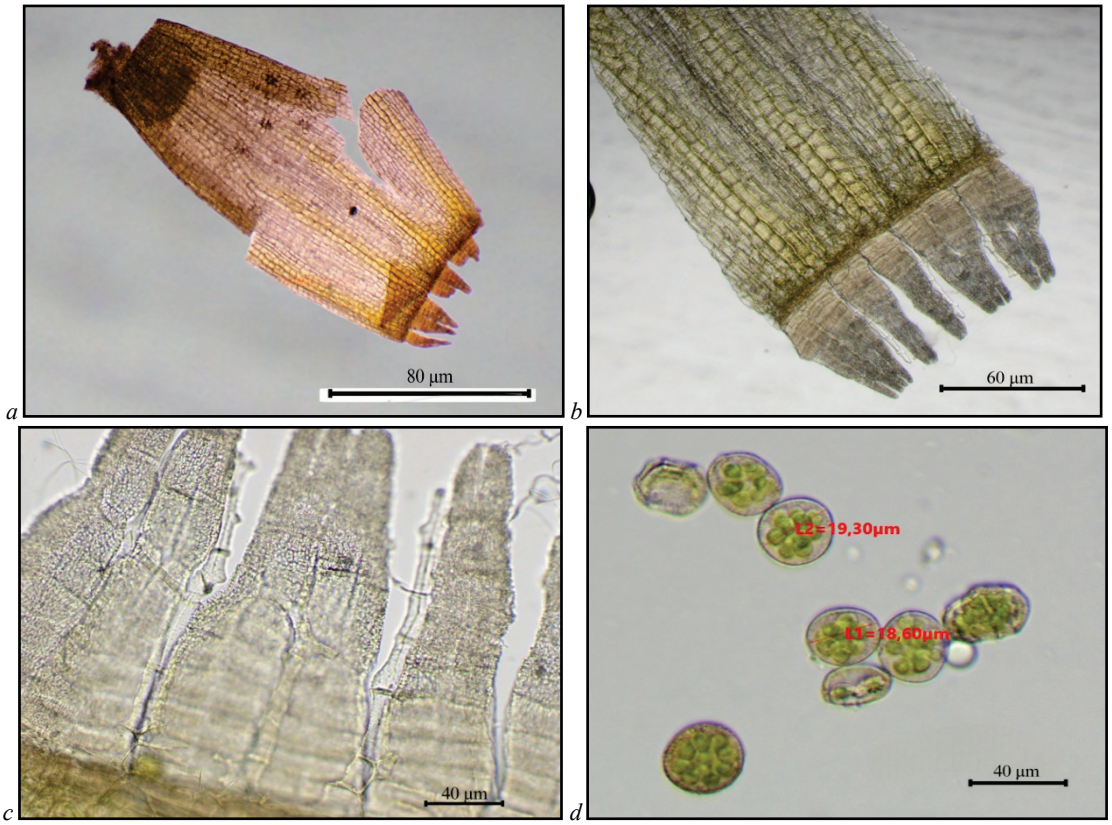

Fig. 4. Microphotographs of the sporophyte part of *Orthotrichum scanicum* from Jbel Megriss (Boulaacheb private herbarium nº 92); *a*, *b* – capsule wall showing ribs, immersed stomata and exostome teeth; *c* – endostome segments and exostome teeth; *d* – spores

Among the 55 species recorded in Megriss Mountain, two species were widely distributed in the *Cedrus atlantica* forest; *O. diaphanum* and *Lewinskya acuminate* (H. Philib.) F. Lara, Garilleti & Goffinet; both species are common epiphytic mosses in the Mediterranean area and their prevalence is likely an indication of the mainly temperate conditions of the forests with a well-developed epiphytic stratum (Draper et al., 2006). Other species were found to be widespread: *Didymodon insulanus* (De Not.) M. O. Hill, *Grimmia pulvinata* (Hedw.) Sm. and *Tortella squarrosa* (Brid.) Limpr. This common distribution has also been observed in some Moroccan mountain regions (Draper et al., 2006; Laouzazni et al., 2021). This might due the similarity of climatic and edaphic conditions of both Algeria and Morocco.

In terms of habitats, epilithic mosses were the most dominant. Twenty moss species were found exclusively in saxicolous habitats. This dominance may be explained by the presence of specific environmental conditions such as the profusion of stones and boulders and other rocky substrates. That was also observed by Zaza et al. (2021) in Morocco.

Orthotrichum scanicum: the new moss record, was previously believed to be a rare and threatened species in Europe and was placed on the world red list of bryophytes. However, recent studies have shown that it is actually widespread and locally common in countries around the Mediterranean Sea, such as Morocco (Blockeel, 2012), where it was found growing between altitudes of 1050 and 1950 m. This species can be found in various types of forests, growing on the bases, branches, and trunks of different phorophytes (Draper, 2003).

According to the checklist of Ros et al. (2013), a total of 16 species and one variety of the genus *Orthotrichum* s.l. were reported from Algeria, which at present correspond to *Pulvigera lyellii* (Hook. & Taylor) Plášek, Sawicki & Ochyra, five species of *Lewinskya*, and ten species and one variety of *Orthotrichum* s.s. The discovery of a new species: *O. scanicum*, has increased the number of *Orthotrichum* species in Algeria to 11, and this number may continue to increase with further surveys.

Conclusion

The Algerian climate and landscapes are highly variable, which can give rise to the richness and diversity of bryophytes. The discovery of a new moss species highlights the urgent need for further surveys to collect and identify more species on Megriss Mountain, to update the bryoflora of the country, and to contribute to a better understanding of the ecology and distribution of the Orthotrichaceae in general and the species *Orthotrichum scanicum* in particular. Further studies should be conducted to characterize species and verify their geographical distribution and status.

We would like to express our deepest gratitude to Francisco Lara for his valuable contribution in confirming the species *Orthotrichum scnanicum*. Additionally, we extend our thanks to Mr. Chaaouan Djamel for granting us permission to use the base map for our study location.

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