PlantArchives Volume 20 No. 2, 2020 pp. 4639-4647 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

CONTRIBUTION TO THE BRYOFLORA INVENTORY OF JBEL TAZEKKA (MIDDLE EASTERN ATLAS, MOROCCO) : NEW DATA ON THE PRESENCE OF NEW, RARE OR ABUNDANT SPECIES

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Abstract

Tazekka National Park, located in the Eastern Middle Atlas, is known by a "Jbel Tazekka" mountain where a remarkable forest ecosystem, the cedar grove, is located. Analysis of the bryological flora of this mountain revealed the existence of 66 species including 59 mosses and 7 livers. From a morphological point of view, the listed taxa are divided into 41 acrocarps, 18 pleurocarps, 6 thalle livers and 1 leaf liver. From a systematic point of view, they are represented by 24 families and 39 genre encountered on different types of substrates. Three new taxa (two species and one variety) were inventoried (*Anomodon attenuatus*, *Didymodon nicholsonii* et *Stegonia latifolia* var. *latifolia*). In general, the distribution of bryophytic species in the study area depends primarily on the microclimate of the station. The humidity and especially the freshness of the environment are ensured by the forest formations here, especially the cedar grove. Three species, all livers, *Lunularia cruciata*, *Targonia hypophylla* and *Remboulia hemisphaerica* are the most distributed bryophytes in the site with an IES ranging from 106 to 121. We can then say that this study has enriched the bryophytic flora of Morocco.

Key words: Bryophytes; Catalogue; New species; Jbel Tazekka; Cedar; Middle Eastern Atlas; Morocco.

Introduction

Jbel Tazekka's cedar grove can be considered a biodiversity hot spot. It is a living environment for a considerable fauna and flora. Its location in the northern part of the Eastern Middle Atlas, south of the city of Taza in Morocco Fig. 1 gives it a bioclimate with high humidity levels that particularly favour the installation of bryophytes, objects of this study. This group of organisms is for the first time inventoried in the Tazzeka cedar grove. This inventory is carried out with the aim of completing the list of Moroccan bryophytes that was drawn up by Ahayoun *et al.*, 2013. So far, 619 species have been identified from the herbarium (1913-2011) of the Rabat Scientific Institute and exploration work on the cork oak forests of North West, Central Plateau and Middle Atlas. Within our laboratory, a team is in the process of completing and updating the catalogue of the bryological flora of Morocco (Fadel *et al.*, 2017; El Harech *et al.*, 2020; Fadel *et al.*, 2020; Laouzazni *et al.*, 2020; Zaza *et al.*, 2020).

Thus, in addition to the main objective of the present study, which is to establish a catalogue of the species of bryophytes of the cedar forest of the Tazekka National Park in the Middle Atlas, the other objectives aim to highlight the ecological conditions that control this flora and to highlight the species newly encountered in Morocco. It is the first inventory of the bryophytic flora of the cedar forest of Jbel Tazekka in the Moroccan Middle Atlas.

Materials and Methods

Study area

Jbel Tazekka is a mountain known by one of the kingdom's most remarkable forest ecosystems, the Atlas cedar (*Cedrus atlantica*), which extends from 1400 to 1980 m on a non-limestone primary shale substrate (Fougrach *et al.*, 2007). At the top of the mountain, there

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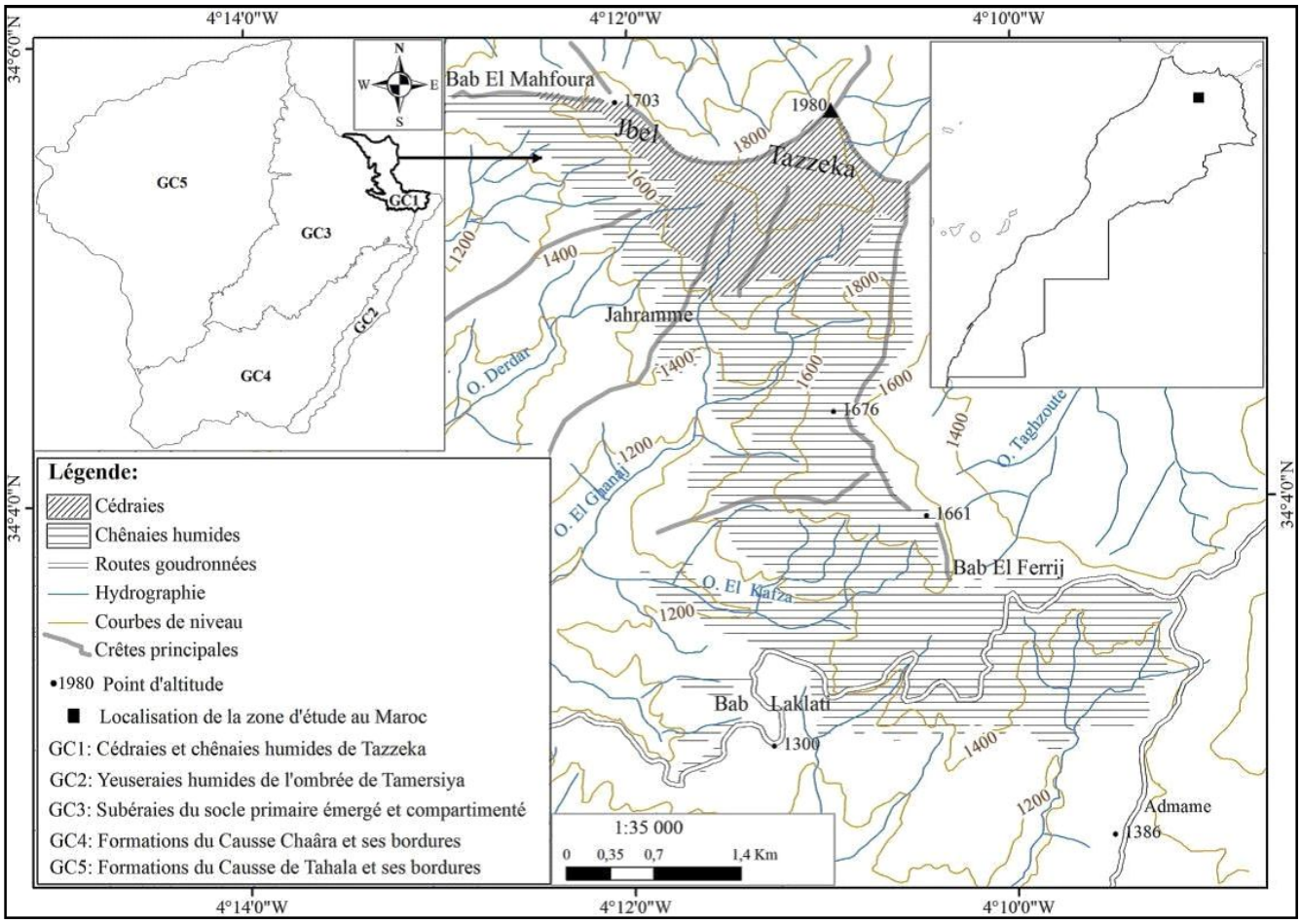

Fig. 1: Geographical location of the study site (Jbel Tazekka) in the Middle Atlas of Morocco. (Makrane *et al.*, 2016).

is the presence of limestone rocks. This natural forest formation has been located in a protected area since 1950 (Benabid, 2000) and located in the middle of Tazekka National Park. The area of pure and mixed cedar (with *Quercus canariensis* and *Quercus rotundifolia*) is about 202 ha (Makrane *et al.*, 2016); it corresponds to beautiful forests that adorn the Tazekka massif. The bioclimate in this mountain is moist to per-humid in cold or very cold winter, characterized by medium rainfall exceeding 1060 mm per year; it is frequently cloudy (Benabid, 2000). Hydrological input is important in this area, accentuated by snowfall, dew and fog. The humid atmosphere of the summit of Jbel Tazekka thus favours the development of the majestic cedar that is surrounded by green oak and zeen oak in the east and southeast exposures from 1500 to 1800 m above sea level. The medium appears to be suitable for the installation of bryophytes on different types of substrate that are dominated by browned silica soils and clay marls.

Collecting plant material

The sampling of bryophytes in Jbel Tazekka was carried out in 2013, 2014 and 2015 during the favourable harvest period that, in Morocco, corresponds to that of spring. The collection of plant material was carried out according to an altitudinal gradient at the level of 34 stations table 1; in each of these stations, bryophytes are collected at a random route, *i.e.* where they are present. The sampling covered the different forest formations encountered (holm oak, zeen oak and pure or mixed cedar forest) and the different substrates where bryophytic species are observed (soil, rock, trunk, tree bases, water, etc.). The samples were photographed in-situ and then brought back to the laboratory for identification after a macroscopic and microscopic description. Species determination is based on the following keys: Augier (1966), Paton (1999), Smith (2004), Casas *et al.*, (2006) and Casas *et al.*, (2009). The nomenclature adopted is that of the North African bryophyte vegetation developed by Ros *et al.*, (1999).

Data analysis

The relative frequency of species was estimated using the index of ecological importance (IES) (Lara and Mazimpaka, 1998; Albertos *et al.*, 2001) whose formula is as follows: IES = F (1+C).

Where F (relative frequency) = 100 x/n and C (average recovery) = $\Sigma c_i / x$, with x corresponds to the number of stations containing the species, n is the total number of stations and c_i is an estimation corresponding to the class of recovery assigned to species in each station.

Recovery classes are defined according to the following scale from the recovery percentage: : 0,5 (<1%); 1 (1% à 5%); 2 (6% à 25%); 3 (26% à 50%); 4 (51% à 75%); 5 (> 75%). In the index, coverage and frequency, which are the two parameters of abundance, are combined to best reflect any change in species abundance (Albertos *et al.*, 2001); the values of these parameters are reported in table 2. Then, the values of IES obtained were combined in frequency classes as follows: very scarce (<25), scarce (26-50), moderately abundant (51-100), abundant (101-200) and dominant (> 200). This analysis was done using Microsoft Excel, 2013 version.

Table 1: Description of the sampled stations of Jbel Tazekka.

Stations	Longitude /Latitude	Altitude (m)	Forest tree
1	N34.08267/ W04.17813	1765	Pure cedar
2	N34.08383/W04.17899	1770	Pure cedar
3	N34.08448/W04.18052	1751	Pure cedar
4	N34.08352/W04.18210	1762	Pure cedar
5	N34.08265/W04.18389	1740	Pure cedar
6	N34.08196/W04.18530	1730	Pure cedar
7	N34.07930/W04.18966	1723	Pure cedar
8	N34.07997/W04.18984	1681	Zeen oak + holm oak
9	N34.08193/W04.18944	1680	Zeen oak + holm oak
10	N34.08060/W04.19160	1689	Pure cedar
11	N34.08427/W04.19378	1682	Pure cedar
12	N34.08892/W04.19803	1581	Pure cedar
13	N34.08973/W04.18312	2146	Pure cedar
14	N34.08878/W04.18374	2053	Pure cedar
15	N34.08859/W04.18548	1931	Pure cedar
16	N34.08798/W04.18516	1842	Pure cedar
17	N34.08798/W04.18516	1866	Pure cedar
18	N34.08695/W04.18094	1832	Pure cedar
19	N34.08669/W04.17952	1888	Pure cedar
20	N34.08523/W04.17996	1824	Pure cedar
21	N34.07465/W04.17724	1762	Cedar + zeen oak
22	N34.06490/W04.17973	1678	Cedar + zeen oak
23	N34.08677/W04.19601	1567	Pure cedar
24	N34.09011/W04.19965	1610	Pure cedar
25	N34.09503/W04.20314	1558	Pure holm oak
26	N34.09756/W04.20391	1498	Pure holm oak
27	N34.09887/W04.20400	1466	Pure holm oak
28	N34.10008/W04.20485	1381	Pure holm oak
29	N34.10667/W04.20563	1339	Pure holm oak
30	N34.07994/W04.19122	1675	Cedar + holm oak
31	N34.08512/W04.18891	1753	Cedar + holm oak and zeen oak
32	N34.08512/W04.18891	1753	Cedar + holm oak and zeen oak
33	N34.08690/W04.18620	1814	Pure cedar
34	N34.08919/W04.18617	1923	Pure cedar

Results and Discussion

The Jbel Tazekka Bryoflore study in Tazekka National Park recorded 66 species and varieties, including 59 mosses, 7 liverworts, while no Anthocerote were observed at the site. These species are distributed over 39 genera belonging to 24 families, four of which reveal a more important specific wealth, namely: The Pottiaceae with 16 taxa followed by Orthotrichaceae (9 taxa), Brachytheciaceae (7 taxa) and Bryaceae (5 taxa) Fig. 2. The genus *Orthotrichum*, which contains the most species, is widely distributed in Jbel Tazekka, it is observed from 1581 m to 2146 m altitude, at the base and trunks of cedar, green oak and zeen oak.

The species identified in the study area are grouped into a list where they are presented by phylum and then by family in alphabetical order. For each species are noted: the type or types of substrates where the species was harvested, its vegetative state (only gametophyte (G) or sporophyte-gametophyte (S)) and the numbers of stations whose geographical coordinates (longitude, latitude and altitude) were recorded using a GPS tool (GPS Essentials on Android). All these data are carried forward in Table 1 by adding the forest formation encountered. The species preceded by an asterisk (*) correspond to species cited for the first time in Morocco.

List of Bryophytes from Jbel Tazekka

Phylum of Liverworts

Fossombroniaceae

Fossombronia angulosa (Dicks.) Raddi: leaf liverwort, terricolous, aquatic and sub-aquatic; (S),

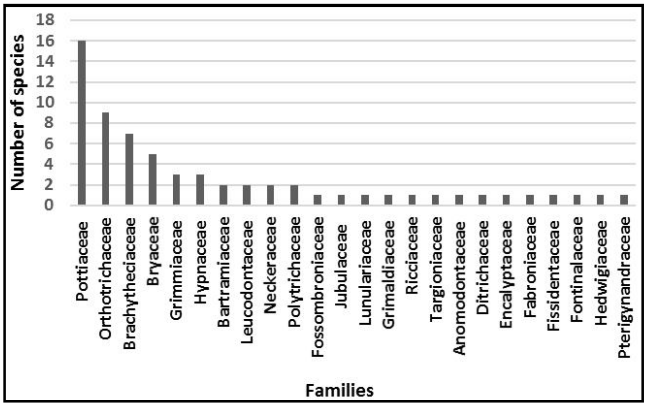

Fig. 2: Presence of species by family.

collected in running water of a river, on soil soaked in water and on siliceous soil shaded under cedar. Station (3); Alt: 1751 m.

Fossombronia foveolata Lindb.: leafy liverwort, soil, aquatic and sub-aquatic; (G), taken from the ravine of a river under the cedar and from shady siliceous soil. Stations (12, 23); Alt: 1581 m, 1567 m.

Jubulaceae

Frullania dilatata (L.) Dum.: leafy liverwort, saxicolous, corticolous; (G), taken from limestone, on the trunk and at the base of the cedar. Stations (13, 14, 15); Alt: between 1931 m to 2146 m.

Lunulariaceae

Lunularia cruciata L. Dumort. Ex Lindb.: liverwort thalloid, fairly frequent throughout the massif, soil, underwater and saxicolous; (G), taken near running water, on soil soaked in oozing water, siliceous soil, whether or not shaded, under cedar, holm oak and zeen oak. Stations (3, 5, 8, 16, 22, 23, 24, 27, 28); Alt: between 1466 m to 1842 m.

Aytoniaceae

Reboulia hemisphaerica L. Raddi: liverwort thalloid, terricolous; (S), taken from a shaded siliceous soil, under green oak and zean oak and cedar. Stations (4, 5, 8, 16, 21, 24, 27, 32); Alt: between 1498 m to 1842 m.

Ricciaceae

Riccia lamellosa Raddi: liverwort thalloid, terricolous; (S), harvested from the forest on dry, unshaded siliceous soil near running water. Stations (3, 12); Alt: 1752 m, 1581 m.

Targioniaceae

Targionia hypophylla L.: liverwort thalloid, terricolous; (S), harvested in a humid and shaded environment, on a siliceous soil sunny or shaded under the cedar, the holm oak and the zeen oak. Stations (4, 5, 8, 16, 21, 24, 27, 28); Alt: between 1466 m to 1842 m.

Phylum of Mosses

Anomodontaceae

**Anomodon attenuatus* (Hedw.) Hub.: pleurocarpous, saxicolous, terricolous; (G), New for Morocco, harvested on wet limestone rocks, on shaded moist soil and at the base of the cedar. Stations (13, 14, 17); Alt: between 1866 m to 2146 m.

Bartramiaceae

Bartramia pomiformis Hedw.: acrocarpous, saxicolous, terricolous; (S), collected on shale rocks and the base of zean oak and holm oak, on limestone rock, shaded siliceous soil. Stations (4, 20, 34); Alt: between 1762 m and 1923 m.

Bartramia stricta Hedw.: acrocarpous, saxicolous, terricolous; (S), harvested at the base of the cedar, on shady siliceous soil with little humidity near running water, on limestone rock near a river. Stations (4, 12, 15, 17, 24, 31); Alt: between 1581 m to 1931 m.

Brachytheciaceae

Brachythecium rutabulum (Hedw) Schimp: pleurocarpous, saxicolous, terricolous; (G), harvested on unshaded siliceous soil, under zeen oak, on schist. Stations (3, 8, 22); Alt: between 1678 m and 1752 m.

Brachythecium salebrosum (Hoffm. ex F. Weber & D. Mohr) Schimp.: pleurocarpous, corticolous, epiphyte, saxicolous; (G), harvested from the trunk and at the foot of the cedar, on shaded limestone rocks. Station (14); Alt: 2054 m.

Brachythecium velutinum Hedw.: pleurocarpous, corticolous, epiphyte; (S), harvested from the trunk and at the base of cedar, zeen oak and holm oak. Stations (7, 10, 14, 34); Alt: between 1689 m and 2054 m.

Brachythecium veltinium var. *venustum* Arcangeli: pleurocarpous, corticolous, epiphytic saxicole and terricolous; (S), harvested from the cedar bark, under holm oak and zeen oak, on siliceous, shaded soil, between the cracks in the limestone rocks. Stations (9, 34); Alt: 1680 m, 1923 m.

Homalothecium lutescens (Hedw.) H. Rob.: pleurocarpous, corticolous, epiphyte, terricolous, saxicolous; (G), harvested on shady siliceous soil, on the cedar trunk and on limestone rocks. Stations (4, 6, 12, 24, 34); Alt: between 1581 m and 1923 m.

Homalothecium sericeum (Hedw.) Schimp.: pleurocarp, terricolous, epiphyte; (G), harvested on shady siliceous soil, under the cedar. Stations (19, 26); Alt: 1888 m, 1558m.

Rhynchostegiella tenella (Dicks.) Limpr.: pleurocarpous, saxicolous, terricolous; (S), collected on limestone rocks, under cedar, on siliceous soil, whether or not shaded, near running water. Station (2); Alt: 1770 m.

Bryaceae

Anomobryum julaceum (Schrad. ex G. Gaertn., B. Mey. & Scherb.) Schimp.: acrocarpous, terricolous, aquatic; (G), harvested on a cool soil soaked in oozing water. Station (12); Alt: 1581 m.

Bryum alpinum Huds. ex With: acrocarpous, terricolous, aquatic; (G), in a very humid environment on

soil fresh soaked with water. Station (12); Alt: 1581 m.

Bryum capillare var. *capillare* Hedw.: acrocarpous, saxicolous, epiphyte, terricolous; (S), harvested from the trunk and at the base of holm oak, on limestone rocks near the river, on unshaded siliceous soil. Stations (29, 33, 34); Alt: between 1381 m and 1923 m.

Bryum dichotomum Hedw.: acrocarpous, terricolous; (G), harvested on siliceous soil, fresh and humid, shaded, under the cedar. Station (6); Alt: 1730 m.

Bryum donianum Grev.: acrocarpous, terricolous; (G), harvested on damp shaded siliceous soil, under cedar. Station (2); Alt: 1770 m.

Ditrichaceae

Ceratodon purpureus (Hedw.): acrocarpous, terricolous; (G), harvested on siliceous, cool and moist soil, under cedar, zeen oak and holm oak. Stations (6, 8); Alt: 1730 m, 1681 m.

Encalyptaceae

Encalypta vulgaris (Hedw.) Hoffm.: acrocarpous, saxicolous, epiphyte, terricolous; (S), harvested on the basis of zeen oak. Station (32); Alt: 1753 m.

Fabroniaceae

Fabronia pussila Raddi: pleurocarpous, small saxicolous plant, or arboreal, terricolous; (S), with a very slender stalk, harvested at the base and on the trunk of cedar and holm oak. Stations (1, 10, 18, 25); Alt: between 1689 m and 1832 m.

Fissidentaceae

Fissidens viridulus (Sw.) Wahlemb: acrocarpous, terricolous; (S), harvested in shaded and humid areas on shady silica soil with low humidity, at the edge of running water. Stations (12, 23); Alt: 1567 m, 1581 m.

Fontinalaceae

Fontinalis antipyretica Hedw.: pleurocarpous, sub-aquatic, terricolous; (S), moderately robust, rather rigid, very long, harvested on shaded siliceous soil in the cedar forest and in a stream. Stations (12, 23); Alt: 1567 m, 1581 m.

Grimmiaceae

Grimmia decipiens (Hedw): acrocarpous, saxicolous, terricolous; (G), harvested from shale and dry siliceous soil with or without shade. Station (22); Alt: 1678m.

Grimmia trichophylla Grev.: Acrocarpous, saxicolous, epiphytic, terricolous; (S), harvested in a shaded and unshaded environment, on dry siliceous soil, shaded or unshaded, near a river, on schist. Stations (22, 27); Alt: 1498 m, 1678 m.

Schistidium crassipilum H. H. Blom: acrocarpous, saxicolous, epiphytic, terricolous; (S), harvested in a shady area, on the limestone rocks near the river, on the cedar trunk, on siliceous soil. Stations (31, 34); Alt: 1675 m, 1923m.

Hedwigiaceae

Hedwigia ciliata var. *leucophaea* (Hedw) : acrocarpous, saxicolous, terricolous; (G), harvested on shaded siliceous soil. Station (16); Alt: 1842 m.

Hypnaceae

Hypnum cupressiforme Hedw.: pleurocarpous, saxicolous, epiphytic, terricolous; (G), harvested on shaded or unshaded siliceous soil near a stream. Stations (4, 12); Alt: 1581 m, 1762 m.

Hypnum lacunosum var. lacunosum (Brid.) = *H. cupressiforme* var. *lacunosum* Brid. = *H. cupressiforme* var. *elatum* Schimp.: pleurocarpous, saxicolous, epiphytic, terricolous; (G), harvested from the base of the cedar, on shaded siliceous soil with low humidity. Station (6); Alt: 1729 m.

Hypnum lacunosum var. *tectorum* (Brid.) = *H. cupressiforme* var. *tectorum* Brid.: pleurocarpe, terricole; (G), recoltee sur sol siliceux ombrage humide sous le cedre. Stations (6, 19); Alt: 1729 m, 1888 m.

Leucodontaceae

Antitrichia californica Sull.: pleurocarpous, epiphytic, corticolous; (S), harvested from the trunks of cedar and zeen oak. Stations (11, 32); Alt: 1682 m, 1753 m.

Leucodon sciuroides (Hedw) Schwaeger. var *morensis*: pleurocarpous, corticolous; (S), taken from the holm oak trunk. Station (26); Alt: 1558 m.

Neckeraceae

Leptodon smithii (Dicks) Mohr: pleurocarpous, epiphytic, corticolous; (G), harvested from cedar trunks, zeen oak bark. Stations (33, 34); Alt: 1814 m, 1923 m.

Pterogonium gracile (Hedw.): pleurocarpous, saxicolous, terricolous, corticolous; (G), on the trunk and base of holm oak and cedar, on siliceous soil. Stations (2, 13, 20, 26); Alt: from 1558 m to 2146 m.

Orthotrichaceae

Orthotrichum affine Schrad. ex Brid.: acrocarpous, corticolous; (S), on the base and trunk of cedar and holm oak. Stations (1, 25); Alt: 1581 m, 1765 m.

Orthotrichum anomalum Hedw. Brh.: acrocarpous, corticolous; (S), harvested from the trunk and base of

the cedar. Stations (2 ,15); Alt: 1770 m, 1931 m.

Orthotrichum cupulatum Hoffm.: acrocarpous, corticolous; (S), harvested on the basis of cedar, trunk and base of holm oak. Station (25); Alt: 1581 m.

Orthotrichum pumilum Sw., Monthly: acrocarpous, corticolous; (S), harvested from cedar trunks. Stations (14, 17); Alt: 1866 m, 2053 m.

Orthotrichum lyelli Hook. & Taylor.: acrocarpous, corticolous, saxicolous; (S), harvested from the base and trunks of cedar, zeen oak and holm oak. Stations (1, 10); Alt: 1689 m, 1765m.

Orthotrichum rupestre Schleich.: acrocarpous, corticolous; (S), harvested from the base and trunk of cedar. Stations (1, 2, 10, 25, 30); Alt: from 1339 m to 1770 m.

Orthotrichum striatum Hedw: acrocarpous, corticolous, saxicolous; (S), harvested from the trunk of the cedar and zeen oak, on the basis of cedar, limestone rocks. Stations (6, 7, 14, 17); Alt: from 1723 m to 2053 m.

Orthotrichum tenelllum Bruch ex Brid.: acrocarpous, corticolous; (S), harvested from the base and trunks of cedar, zeen oak and holm oak. Stations (1, 10, 30); Alt: from 1339 m to 1765 m.

Orthotrichum speciosum Nees.: acrocarpous, corticolous; (S), harvested from the trunk of the cedar. Station (2); Alt: 1770 m.

Polytrichaceae

Pogonatum aloides (Hedw.) P.Beauv.: acrocarpous, saxicolous, epiphytic, terricolous; (S), harvested from shaded siliceous soil and cedar base. Stations (4, 17); Alt: 1762 m, 1866 m.

Polytrichum juniperinum Hedw.: acrocarpous, very long, saxicolous, terricolous; (G), harvested on shaded siliceous soil with little moisture, near running water. Stations (4, 6, 12); Alt: from 1581 m to 1762 m.

Pottiaceae

Barbula unguiculata Hedw.: acrocarpous, saxicolous, epiphytic, terricolous; (G), harvested between cracks in limestone rocks and on shaded siliceous soil. Stations (4, 27); Alt: 1498 m, 1762 m.

Cinclidotus riparius (Brid.) Arnott: acrocarpous, aquatic, terricolous; (G), harvested from shaded or unshaded siliceous soil in running water. Stations (12, 23); Alt: 1567 m, 1581m.

Didymodon insulanus (De Not.) M.O.Hill: acrocarpous, saxicolous, epiphytic, terricolous; (G), harvested from sunny bare siliceous soil, limestone and schist. Station (6); Alt: 1729 m.

***Didymodon nicholsonii* Culm.: acrocarpous, saxicolous, epiphytic, terricolous; (S), New to Morocco, harvested from cracks in schist rocks. Station (21); Alt: 1762 m.

Dydimodon tophaceus (Brid) Lisa.: acrocarpous, saxicolous, terricolous; (G), harvested from shaded and unshaded siliceous soil. Station (31); Alt: 1753 m.

***Stegonia latifolia* (Schwägr.) Venturi ex Broth.,: acrocarpous, terricolous; (S), New to Morocco, harvested from moist siliceous soil under cedar. Station (20); Alt: 1824 m.

Syntrichia ruralis (Hedw.) F. Weber & D. Mohr: acrocarpous, saxicolous, epiphytic, terricolous; (S), harvested from the trunk and base of the cedar on siliceous soil. Stations (2, 17, 30); Alt: from 1339 m to 1866 m.

Syntrichia laevipila Brid.: acrocarpous, saxicolous, epiphytic; (S), harvested from holm oak trunks and limestone rocks. Station (6); Alt: 1729 m.

Syntrichia norvegica F. Weber: acrocarpous, corticolous; (S), harvested from the trunk and base of the cedar. Station (2); Alt: 1770 m.

Timmiella barbuloides (Brid.) Mönk.: acrocarpous, saxicolous, epiphytic, terricolous, corticolous; (S), at the base of the cedar, on shaded, slightly moist siliceous soil. Station (6); Alt: 1729 m.

Tortella ceapitosa (Schw.) Limb: acrocarpous, terricolous; (G), harvested from moist siliceous soil under cedar. Station (2); Alt: 1770 m.

Tortula subulata Besch.: acrocarpous, epiphytic, corticolous, terricolous; (S), harvested from the trunk and base of the cedar on siliceous soil. Stations (2, 6, 17); Alt: from 1729 m to 1866 m.

Tortula subulata (Hedw.) var. *subulata*: acrocarpous, terricolous; (S), harvested on shaded siliceous soil with little moisture under the cedar. Station (11); Alt: 1682 m.

Tortula vahliana (Schultz) Mont.: acrocarpous, corticolous; (S), harvested from the base of the cedar. Station (2, 15); Alt: 1770 m, 1931 m.

Trichostomum brachydontium Bruch.: acrocarpous, terricolous; (G), harvested on freshly moist shaded siliceous soil under cedar. Station (4); Alt: 1768 m.

Weissia controversa var. *crispata* Hedw.: acrocarpous, saxicolous, terricolous; (S), harvested on shaded siliceous soil under cedar. Station (2); Alt: 1770 m.

Pterigynandraceae

Pterigynandrum filiforme Hedw. var. *majus* (De Not.) De Not.: pleurocarpous, saxicolous, epiphytic, terricolous; (S), harvested at the base and on the trunk of the cedar and on calcareous rocks. Stations (2, 13, 20, 33); Alt: from 1770 m to 2146 m.

During sampling, 41 species were found to be fertile versus 25 sterile. Among the mosses, 41 species are acrocarpous and 18 pleurocarpous; while among the liverworts, thallus species are more abundant (six taxa) than leaf species (one taxa). Bryophytes are found on different types of substrates. Terricolous species (40%) dominate in the study site, precisely on siliceous soils, followed by saxicolous species (21%), then epiphytes and corticolous species representing together 34%. There are also sub-aquatic bryophytes (4%) and aquatic bryophytes (1%), respectively *Fissidens viridulus*, *Fossombronia angulosa*, *Bryum alpinum* and *Bryum julaceum* fixed on a water-soaked floor and then *Fossombronia angulosa*, *Fontinalis antipyretica* and *Cinclidotus riparius* totally immersed. These last two species are sensitive to pollution, so their presence indicates that the waters do not have a pollution load (Werner, 2001).

In spite of the high humidity which varies between (60% and 80%), no anthocerotes were observed, the number of liverworts is significantly lower than that of mosses, but their distribution in the study site is wider. This is probably due to the high temperatures experienced in the region in late spring and summer and, at the same time, to the frequency of microclimates ensured by the vegetation cover present, which favours the abundance of liverworts. Anthocerotes require real moisture for reproduction; they grow on moist clay soils, and produce small quantities of large spores, making their dispersal less easy (Ah-Peng *et al.*, 2007). Because of their ability to revive, mosses are able to acclimatize to environmental conditions and settle on different substrates.

The most abundant species in this site belong to the liverworts: *Lunularia cruciata*, *Targonia hypophylla* and *Reboulia hemispherica* with an IES of 106, 107 and 121 table 2. These species were harvested on shaded and well moist soils and have a very wide ground coverage within their station. *Lunularia cruciata* is a species that indicates that the environment is quite rich in nutrients (Werner, 2001), hence the proliferation of many plants on the site. Then 11 other species, only one of which is hepatic, are moderately abundant according to an IES ranging from 53 to 77: *Anomodon attenuatus*, *Bartramia stricta*, *Fabronia pussila*, *Grimmia trichophylla*, *Homalothecium lutecens*, *Orthotrichum striatum*, *Orthotrichum rupestre*, *Pterogonium gracile*, *Pterigynandrum filiforme* and *Syntrichia ruralis* table 2. Many species are very rare with IES values below 12: 41 taxa including 3 liverworts (*Fossombronia angulosa*, *Fossombronia foveolata* and *Riccia lamellosa*) and 38 mosses (such as the genera *Bryum*, *Dydimodon*, *Hypnum* and other species) table 2.

On the other hand, in comparison with the lists of mediterranean bryophytes (Ros *et al.*, 2007; Ros *et al.*, 2013) and that of North Africa (Ros *et al.*, 1999), the exploration of the bryophytes of Jbel Tazekka allowed the identification of three taxa newly observed in Morocco: *Anomodon attenuatus*, *Didymodon nicholsonii* and *Stegonia latifolia* var. *latifolia*. The latter variety is found on dry soil in the cedar forest at an altitude of 1824 m (Saadi *et al.*, 2018). *Didymodon nicholsonii* is harvested from the cracks in the schist rocks at an altitude of 1762 m. *Anomodon attenuatus* is observed on moist calcareous rocks, on shaded moist soil and at the base of cedar trunks at the summit of the mountain in an altitudinal zone ranging from 1866 m to 2146 m and is moderately abundant at the site with an SEI of 53. The other two taxa are very rare table 2.

The transect on which the sampling was carried out is between 1250 and 2150 m. For a good representation of the variation in the specific richness of bryophytes as a function of altitude, it was necessary to break down this altitude range into small intervals of 100 m. In each of these intervals or altitudinal zone, the number of bryophyte taxa is estimated Fig. 3. Thus, altitudinal species diversity follows a bell-shaped curve with the maximum recorded in an altitudinal zone varying from 1750 m to 1850 m Fig. 3. These altitude intervals correspond to cedar groves that are either pure or mixed with zeen oak and/or holm oak and are located on north to northwest facing slopes. This exposure ensures a cool microclimate throughout most of the year, which is very

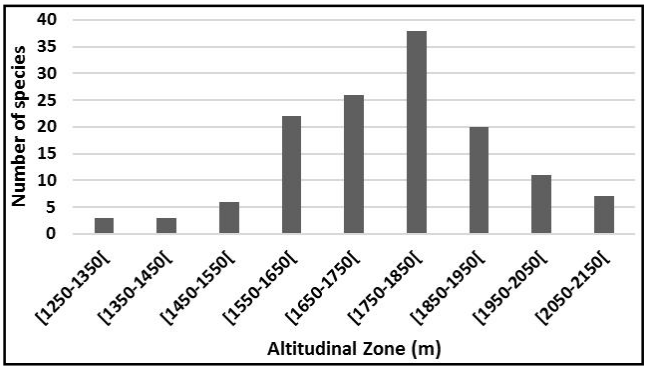

Fig. 3: Number of species in relation to the altitudinal zone of Jbel Tazekka in the Tazekka National Park (Middle Atlas).

Table 2: Valeurs de l'IES des differentes especes inventoriees dans Jbel Tazekka.

Taxa	**FR**	**CR**	**IES**	**IES classe**
Fossombronia angulosa	2,94	3	12	very sca
Fossombronia foveolata	5,88	1	12	very sca
Frunallia dilaltata	8,82	5	53	mod abund
Lunularia cruciata	23,53	3,5	106	abund
Reboulia hemispherica	26,47	3,56	121	abund
Riccia lamellosa	5,88	2	18	very sca
Targionia hypophylla	23,53	3,5	106	abund
Anomobryum julaceum	2,94	1	6	very sca
**Anomodon attenuatus*	8,82	5	53	mod abund
Antrichia californica	5,88	3	24	very sca
Barbula unguilata	2,94	2	9	very sca
Bartramia pomoformis	5,88	4	29	sca
Bartramia stricta	17,65	3,17	74	mod abund
Brachythecium rutabulum	8,82	0,5	13	very sca
Brachythecium saleborum	5,88	1	12	very sca
Brachythecium veltinium	5,88	4	29	sca
Brachythecium ventisum	2,94	1	6	very sca
Bryum alpinum	2,94	3	12	very sca
Bryum capillaire var. *capillaire*	5,88	1,5	15	very sca
Bryum dichotomum	2,94	0,5	4	very sca
Bryum donianum	2,94	2	9	very sca
Ceratodon purpureus	5,88	1,5	15	very sca
Cinclidotus nigricans	5,88	3	24	very sca
Didymodon insulanus	2,94	3	12	very sca
**Didymodon nicholsonii*	2,94	2	9	very sca
Dydimodon tophaceus	2,94	2	9	very sca
Encalypta vulgaris	2,94	3	12	very sca
Fabronia pussila	11,76	4	59	mod abund
Fissidens viriludis	5,88	2	18	very sca
Fontinalis antipyretica	5,88	3,5	26	sca
Grimmia trichophylla	11,76	4	59	mod abund
Grimmia decipiens	5,88	2	18	very sca
Hedwigia ciliata	2,94	3	12	very sca
Homalothecium lutecens	11,76	3,5	53	mod abund
Homalothecium sericeum	8,82	4	44	sca
Hypnum cupressiforme	2,94	4	15	very sca
Hypnum cupressiforme var. *lacunosum*	2,94	4	15	very sca
Hypnum lacunosum var. *tectorum*	2,94	2	9	very sca
Leptodon smiti	5,88	3	24	very sca
Leucodon sciuroides var. *morensis*	2,94	2	9	very sca
Orthotrichum affine	5,88	4	29	sca
Orthotrichum anomalum	5,88	3	24	very sca
Orthotrichum cupulatum	5,88	2,5	21	very sca
Orthotrichum lyeilli	5,88	4	29	sca
Orthotrichum pumulim	5,88	3	24	very sca
Orthotrichum rupestre	14,71	4,2	76	mod abund
Orthotrichum speciosum	2,94	1	6	very sca
Orthotrichum striatum	11,76	3,5	53	mod abund
Orthotrichum tenellum	8,82	4	44	sca
Pogonatum aloidis	2,94	5	18	very sca
Polytrichum juniperinum	5,88	5	35	sca
Pterogonium gracile	11,76	5	71	mod abund
Pterigynandrum filiforme var. *majus*	11,76	4,5	65	mod abund
Rhynchostegiella tenella	2,94	3	12	very sca
Schistidium apocarpum	5,88	4	29	sca
**Stegonia latifolia* var. *latifolia*	2,94	2	9	very sca
Syntrichia laevipila	2,94	2	9	very sca
Syntrichia norvegica	2,94	0,5	4	very sca
Syntrichia ruralis	8,82	5	53	mod abund
Timmiella barbuloides	2,94	2	9	very sca
Tortella ceaspitosa	2,94	0,5	4	very sca
Tortula subulata	8,82	4	44	sca
Tortula subulata var. *subulata*	2,94	0,5	4	very sca
Tortula vahliana	5,88	4	29	sca
Trichostomum brachydontium	2,94	2	9	very sca
Weissia controversa var. *crispata*	2,94	2	9	very sca

Where, Species in bold: Liverworts; *: species new to Morocco; FR: relative frequency; CR: relative recovery; IES: 'Ecological Importance Index'; abund: abundant; mod abund: moderately abundant; sca: scarce; very sca: very scarce.

favourable to the installation of bryophytes on different substrates. *Lununaria cruciata*, *Targionia hypophylla* and *Reboulia hemisphaerica* are the three most widely distributed species in the study site, they are found on an altitudinal fringe ranging from 1450 m to 1880 m. They can be considered the characteristic bryophytic species of the study area. The freshness of the environment within the cedar and zeen oak forest formations that characterize Jbel Tazekka can explain this distribution. Most of the bryophytic species are harvested from diverse substrates such as siliceous or calcareous rocks, tree trunks present in the study site, such as *Orthotrichum lyelli* abundant on the trunk of the cedar tree, *Lunularia cruciata* enough frequent on siliceous and moist soils, *Anomodon attenuatus* new species harvested on limestone rocks, etc.

Conclusion

A higher number was expected to be recorded in the Tazekka National Park cedar forest. This was not the case, because despite the vegetation cover occupying

this environment, which gives it a certain amount of humidity necessary for the installation of these small plants, this region is also known for its high temperatures recorded during three to four consecutive months of the year. On the other hand, the species richness noted in this site remains high (66 taxa) with a remarkable altitudinal distribution. These species have a wide distribution, especially on the siliceous earth and on the trunk of the cedar. At high altitudes, the saxicolous species are more numerous and differ according to the nature of the geological formation. There are then silicicolous species (on schist) and calcicolous species (on limestone). The family with a high specific diversification is that of the Pottiaceae. The presence of *Lunularia cruciata* and *Cinclidotus riparius* indicates that the site is eutrophic. In general, the richness of the bryological flora of an area depends mainly on two factors: the substratum, which is linked to the geological constitution, and the humidity, which is linked to the climatological conditions; these two factors control the distribution of plants in general and of bryophytes in particular. In perspective, studies pointing to the epiphytes of the different cedar forests in Morocco would provide important information on the influence of the bioclimatic and/or geographical factor on the nature and diversity of bryophyte species in relation to the state of health of these forest formations.

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