



# CONTRIBUTION TO THE ELABORATION OF THE BRIKCHA SIBE BRYOFLOTA INVENTORY IN THE CENTRAL WESTERN RIF OF MOROCCO

Hifssa Laouzazni, Jamila Dahmani\*, Jamila Zaza and Nadia Belahbib

Laboratory of Botany, Biotechnology and Plant Protection, Faculty of Sciences, Ibn Tofail University, BP 133, Kénitra 14000, Morocco.

## Abstract

The Brikcha area, in the western Rif mountains, is a site of biological and ecological interest (SIBE) of the same name as a result of its plant and animal species richness, its bryoflora has however never been inventoried although it is part of its biological diversity. Thus, this study was initiated in the Brikcha SIBE and has documented the presence of 60 species: 15 taxa are of liverworts, 2 taxa are of hornworts and the remaining 43 species consist of mosses. They are spread over 47 genera belonging to 32 families. Most of these taxa comes of terricolous (45%) and epiphytic (32%) biotopes. Rare taxa in the studied area are few in number, accounting for only about 15 percent of the total of species. The frequent taxa reached 25% of the total bryoflora of the site. The Pottiaceae family on the one hand and those of Brachytheciaceae, Bryaceae, Fissidentaceae, Neckeraceae and Orthotrichaceae on the other hand, are the best represented, while the genera of *Bryum*, *Fissidens* and *Orthotrichum*, are the most species rich in the study area. The biological interest of the Brikcha SIBE is marked by the wide distribution of terricolous or epiphytic species and associations with some forest trees forming the plant cover.

**Key words:** Bryophytic flora, Inventory, Brikcha mountains, Morocco.

## Introduction

The bryophytes of the Moroccan Rif have been studied only briefly (Jimenez *et al.*, 2002, Draper *et al.*, 2005, Laouzazni *et al.*, 2018, Zaza *et al.*, 2018) with a particular interest in the bryophytes of Jbel Bouhalla. As part of the updating of an exhaustive list of the bryoflora of Morocco, this study is carried out in a still unexplored area of the Rif Mountains.

At the level of the Mediterranean basin, plant biodiversity in Morocco ranks second after Turkey with 20% of endemism rate (Fennane and Ibn Tattou, 1998, Rankou *et al.*, 2013). Given the diversified wealth of natural resources available in Morocco, a Master Plan for protected areas was developed in 1996 by the High Commission for Water and Forests and Fighting against Desertification (HCEFLCD) to conserve and protect the richest environment in terms of biodiversity, thus identifying 154 sites of biological and ecological interest (SIBE) at the national level. Among these remarkable

sites, we find the SIBE of Brikcha, area of our study, characterized by ecological, scientific and socio-economic values, SIBE is called “Bellota Forest” by local residents. Covering an area of about 670 ha (Mourgues, 2008), it contains rare and endangered animal and plant species, which are the main reasons why the Brikcha area was identified as SIBE. The plant species at its disposal represent a great ecosystem interest, namely the cork oak (*Quercus suber*), which covers most of the area of the SIBE, the kermes oak (*Quercus coccifera*), the zeen oak (*Quercus faginea*), the holm oak (*Quercus rotundifolia*) and other secondary tree species such as: cistus, arbutus (*Arbutus unedo*), lentisk (*Pistacia lentiscus*), tree heather (*Erica arborea*), oleaster (*Olea europea*), philaria (*Phillyrea angustifolia*) and myrtle (*Myrtus communis*), etc (Mourgues, 2008, Nachid, 2011).

At the level of this SIBE, there is a lack of scientific data on Bryophytes, cryptogamic plants without roots and able to colonize different substrates (rocks, tree trunk). These species reproduce through spores that are dispersed by abiotic and biotic agents: wind, water or animals

\**Author for correspondence* : E-mail: jamdahmani@gmail.com

(Castonguay, 2016). The absence of previous bryoflore studies in this region prompted us to carry out an in-depth study to identify and inventory possible species present in our study area.

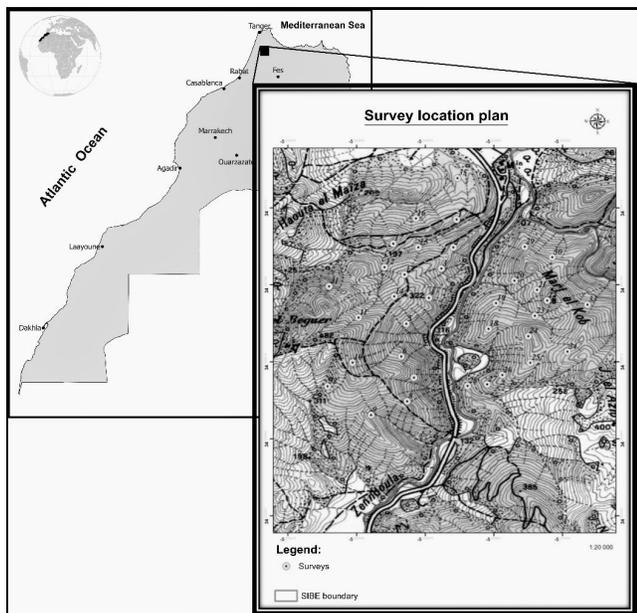
## Materials and Methods

### Study site

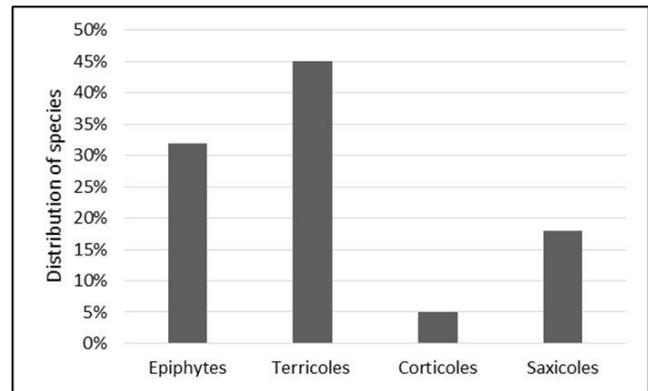
The present study was carried out in the SIBE Brikcha, located north-west of Morocco, in the southern part of the Rif's chain and specifically between the cities of Ouazzane and Chefchaouen. This sector belongs geographically to the Western Rif or more precisely to the Central-Western Rif (Fig. 1). It covers an area of about 670 Ha (Mourgues, 2008). The site has a temperate humid bioclimate and is inserted in the thermo-Mediterranean vegetation stage (Benabid, 2000). Annual precipitation varies from 450mm to 950mm and the average temperature is 24.5°C with a maximum of 47°C and a minimum of 2°C, communicated by DPA (Direction Provinciale de l'Agriculture) of Ouazzane. The altitude is between 100m and 423m. This territory is characterized by a dense hydrographic network due to numerous temporary streams and two rivers: "Oued Zendoula" and "Oued El Maleh", with a forest soil with acidic pH, brown, rich, very deep and very clayey resting on a geological substratum of sandstone and schist type. These environmental factors favor a particular biotope that assists the development and installation of bryophytes.

### Methodology

The list of species identified in the study area was

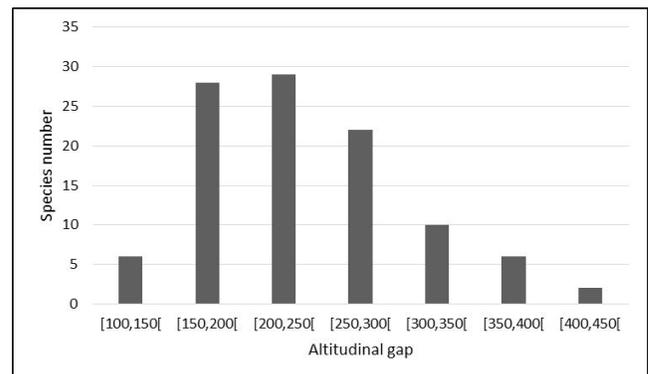


**Fig. 1:** Situation map of the 35 sampling stations carried out in the study area, forest ecosystem of SIBE Brikcha, Ouezzane region.



**Fig. 2:** Specific richness according to the lifestyle of Bryophytes in Brikcha SIBE

based on 35 stations (Fig. 1) corresponding to the sampling effort, samples (one to five) are taken at each station over a radius of about 12 m depending on the distribution of in situ bryophytes. The collection was carried out during three periods: April 2015, May 2016 and April 2017. The sampling method is systematic by following altitudes and tree formations. For each survey, the geographic coordinates (longitude, latitude, altitude) are determined using a GPS (GPS Essentials). Each sample collected was placed in a plastic bag, noting the date, precise location of the harvest, the type of substrate on which the species lives and the abundance of the species at the station: very rare species (RR: few individuals in association with other species), rare (R: abundance <10%), low abundant (PA: 10% to 25%), quite abundant (AA: 25-50%), abundant (A: 50-75%), very abundant (TA:> 75%). Then the samples are brought back to the laboratory for a macroscopic and microscopic study. The determination of the species was carried out using the following determination keys: Boulay (1884), Augier (1966), Pierrot (1982), Smith (2004) and Casas *et al.*, (2006) for mosses and liverworts and Boulay (1904) and Casas *et al.*, (2009) for Liverworts and Hornworts. The inventory is that of Ros *et al.*, (2007) for liverworts and hornworts and that of Ros *et al.*, (2013) for The mosses. The inventoried



**Fig. 3:** Distribution of the number of species according to altitude.

**Table 1:** List of bryophytes inventoried in the SIBE of Brikcha, (Ouezzane region). (Abundance in the station: very rare species (RR), rare (R), low abundant (PA), quite abundant (AA), abundant (A), very abundant (TA)).

Species	Families	Substrates – Abundance	Altitudes (m)
<b>Mosses</b>			
<i>Bartramia pomiformis</i> Hedw. §	Bartramiaceae	Saxicultural (limestone and shale)– PA	209,147,265
<i>Bartramia stricta</i> Brid. §		Saxicultural (limestone and shale)– PA	209,167,194
<i>Brachythecium velutinum</i> (Hewd.) B.e.	Brachytheciaceae	Corticola (on the bark of arbutus and philaria) – R	237,232
<i>Homalothecium sericeum</i> (Hewd.) B.e		Epiphyte (cork oak, oak kermes)– AA	161,288
<i>Oxyrrhynchium pumilum</i> (Wils.) Broth		Epiphyte (philaria)– R	340,265
<i>Rhynchostegiella curviseta</i> (Brid.) Limpr. §		Epiphyte (arbutus)) – AA	250,207,232
<i>Scorpiurium circinatum</i> (Brid.) Fleisch.& Loeske§		Saxicultural (limestone and shale) – TA	193,225,234
<i>Bryum alpinum</i> Huds.		Brvaceae	Terricolous (moist clay soil)–PA
<i>Bryum argenteum</i> Hedw. §	Terricole (sunny slope)– AA		173,200,194
<i>Bryum caespiticium</i> Hedw.	Terricolous (clay soils) – PA		209,282
<i>Bryum capillare</i> Hedw §	Epiphyte (cork oak, holm oak)– TA		270,209,173,128
<i>Bryum dichotomum</i> Hedw	Saxicultural (limestone and shale) – AA		209,268
<i>Cryphaea heteromalla</i> (Hedw.) Mohr §	Cryphaeaceae	Epiphyte (lentisk, cork oak, philaria, holm oak) – AA	288,265,128,380
<i>Dicranella varia</i>	Dicranaceae	Terriculture (clay soil)– PA	194,147
<i>Pleuridiuma cuminatum</i> Lindb. §	Ditrichaceae	Terricolous (sunny clay soil)–AA	193,209,225
<i>Fabronia pusilla</i> Raddi	Fabroniaceae	Epiphyte (oleaster) – PA	268,265
<i>Fissidens dubius</i> P.Beauv.	Fissidentaceae	Terricolous (on moist and shaded clay slopes) – PA	302,329
<i>Fissidens taxifolius</i> Hedw		Terricolous (on clay slope)–PA	302,340
<i>Fissidens incurvus</i> Starke		Terricolous (on clay slope) – A	302,329
<i>Funaria hygrometrica</i> Hedw. §	Funariaceae	Terricolous (on clay and sunny slope) – TA	232,200,194
<i>Grimmia trichophylla</i> Grev. §	Grimmiaceae	Saxicola (layers of limestone and shale) – TA	225,270,167,380
<i>Hypnum cupressiforme</i> Hedw.	Hypnaceae	Corticole (cork oak, kermes oak, holm oak) – AA	234,194
<i>Pterogonium gracile</i> Sw.	Leucodontaceae	Epiphyte (cork oak, philaria)–PA	193,209
<i>Leucodon sciuroides</i> (Hedw.) Schwaegr.		Epiphyte (oleaster) – R	282
<i>Mnium affine</i> Bland	Mniaceae	Terricolous (clay soil on embankment near a water flow)–R	185
<i>Plagiomnium undulatum</i> Hedw		Terricolous (clay soil on embankment near a water flow)–PA	185,194
<i>Leptodon smithii</i> (Hedw.) F.Weber & D.Mohr		Neckeraceae	Epiphyte (oleaster) – AA
<i>Homalia lusitanica</i> Schimp.	Neckeraceae	Terricolous (clay soil on embankment near a water flow)–R	185
<i>Thamnobryum alopecurum</i> (Hedw.)		Terricolous (clay soil on embankment near a water flow)–R	185

Continue table 1...

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<i>Orthotrichum cupulatum</i> Hoffm.	Orthotrichaceae	Epiphyte (cork oak, green oak)–TA	268,200
<i>Orthotrichum diaphanum</i> (Gmel.) Schrad		Epiphyte (cork oak, green oak)–RR	237,232
<i>Orthotrichum tenellum</i> Bruch		Epiphyte (cork oak, green oak)–TA	268,200
<i>Barbula unguiculata</i> (Huds.) Hedw.	Pottiaceae	Terricolous (moist clay soil)–AA	161,186
<i>Didymodon luridus</i> Hornsch.		Saxicola (layers of limestone and shale) – PA	292,200
<i>Pleurochaete squarosa</i> (Brid.) Lindb.		Terricolous (clay soil) – TA	161,207
<i>Timmiella barbuloidea</i> (Brid.) Monk §		Saxicola (layers of limestone and shale) – TA	194,268,234,147
<i>Tortula laevipila</i> (Brid.) de Not.		Epiphyte (cork oak, green oak)–AA	250,268
<i>Tortula muralis</i> Hedw. §		Epiphyte (cork oak, green oak)–TA	250,282,225,268
<i>Tortella nitida</i> (Lindb.) Broth		Saxicultural (limestone and shale)–PA	225,265
<i>Tortella tortuosa</i> (Hedw.) Limpr.		Saxicultural (limestone and shale)–PA	329
<i>Trichostomum crispulum</i> Bruch		Saxicultural (limestone and shale)–PA	186,194
<i>Trichostomum brachydontium</i> Bruch		Saxicultural (limestone and shale)–PA	302,232
<i>Sematophyllum substrumulosum</i> (Hampe) E. Britton	Sematophyllaceae	Corticole (arbutus, philaria, heather) – PA	358,380
<b>Liverworts</b>			
<i>Reboulia hemisphaerica</i> (L.) Raddi	Aytoniaceae	Terricolous (clay soil on embankment near a water flow) – R	186,207
<i>Cephalozia bicuspidata</i> (L.) Dum	Cephaloziaceae	Terricolous (clay soil on embankment near a water flow) – PA	147
<i>Cephaloziella turneri</i> (Hook.)	Cephaloziellaceae	Epiphyte (Aleppo pine) – A	303
<i>Corsinia coriandrina</i> (Spreng.)	Corsiniaceae	Terricolous (moist clay soils)–TA	288,270
<i>Fossombronia angulosa</i> (Dicks.) Raddi §	Fossombroniaceae	Terricolous (moist clay soil)–A	237,173,185,194
<i>Fossombronia caespitiformis</i> de Not.		Terricolous (moist clay soil)–A	237,234
<i>Frullania dilatata</i> (L.) Dum	Jubulaceae	Epiphyte (lentisk, arbutus)–R	268
<i>Lejeunea cavifolia</i> (Erh.) Lindb	Lejeuneaceae	Epiphyte (lentisk) – TA	303,292
<i>Lunularia cruciata</i> (L.) Dum. §	Lunulariaceae	Terricolous (wet earth) – TA	209,268,282,194
<i>Metzgeria furcata</i> (L.) Dumort	Metzgeriaceae	Epiphyte (philaria)–R	185
<i>Oxymitra incrassata</i> (Brot.)	Oxymitraceae	Terricolous (under the rockrose)–R	303,423
<i>Radula complanata</i> (L.) Dum.	Radulaceae	Epiphyte (cork oak, lentisk)–AA	358,270
<i>Riccia ciliata</i> Hoffm.	Ricciaceae	Terricolous (under the rockrose)–PA	194,167
<i>Sphaerocarpos michelii</i> Bellardi	Sphaerocarpaceae	Terricolous (moist clay soil)–R	185,167
<i>Targionia hypophylla</i> L. §	Targioniaceae	Terricolous (moist clay soil)–TA	161,193,423,186
<b>Hornworts</b>			
<i>Anthoceros punctatus</i> L.	Anthocerotaceae	Terricolous (clay soil) – R	340,380
<i>Phaeoceros laevis</i> (L.) Prosk.		Terricolous (clay soil) - TA	340,380

§: most represented species in the studied site (frequency).

species are presented successively by mosses, liverworts and hornworts by families and in alphabetical order.

## Results

The bryoflore inventory of the forest ecosystem of SIBE Brikcha has identified 60 taxa including 43 mosses, 15 liverworts and 2 hornworts. They are divided into 32 families and 47 genera: 17 families and 31 genera for mosses, 14 families and 14 genera for liverworts and single family and 2 genera for hornworts. These species are found on different substrates present in this SIBE

(rocks, soil, bark and tree trunks, etc.) with a more or less variable overlap. They are grouped in table 1.

Analysis of the main families shows that Pottiaceae occupy the first place with 10 species (16.66%), followed by Brachytheciaceae and Bryaceae with five species each (8.33%). Fissidentaceae, Neckeraceae and Orthotrichaceae are each represented by three species (5%). The families of Leucodontaceae, Mniaceae, Fossombroniaceae and Anthocerotaceae contain 2 species each (3.33%). While the rest contains only one species each representing the remaining 38.33% of the

inventoried bryophytes. Examination of the Bryoflora of this environment reveals the presence of 47 genera of which Bryum is the richest genus with 5 species. The genera Fissidens and Orthotrichum are represented by three species each, then two species in the genera Bartramia, Tortula, Tortella, Trichostomum and Fossombronia. The rest of the genera are monospecific. The bryoflore identified in the study area is located on five different types of substrates, of which the terricolous procession is very largely dominant, followed closely by the epiphytes (approximately 45% and 32% respectively), followed by the saxicolous 18% of the overall diversity of the site and then the corticols that are rare in this site with only three species (Fig. 2).

### Discussion

The Brikcha SIBE appears as a site rich in bryophytes since 60 taxa have been recorded there. There are species that are only found in a single station occupying limited areas, they are considered very rare in this ecosystem. These species are few because they represent only about 15% of the total population. These are five mosses: *Leucodon sciuroides*, *Mnium affine*, *Homalia lusitanica*, *Thamnobryum alopecurum*, *Tortella tortuosa* and four liverworts: *Cephalozia bicuspidata*, *Cephaloziella turneri*, *Frullania dilatata*, *Metzgeria furcata*. Most of them are mainly terricolous or epiphytes, except *Tortella tortuosa*, harvested on limestone rock.

The frequent taxa of the SIBE are numerous, reaching a total of 15 species or 25% (marked in table 1 by the symbol §): it is 12 mosses and 3 hepatics, present on several stations (between 3 to 4 times) in a fertile state. This distribution can be explained by the fact that spore germination increases the dispersal capacity of these species and widens their recovery surfaces. This shows that they have adapted well to the climatic conditions of the environment. The majority of bryophytic species (60%) are harvested twice, on different substrates (clay, cork oak trunks, kermes oak, holm oak, zeen oak, arbutus, philaria, heather and also on the aerial roots of lentisk tree). The bryological cortege consists essentially of terricolous communities containing 27 species (45%) most of which settle on clay soil, this can be explained by the fact that this type of substrate retains more moisture promoting the survival of this community. The epiphytes (19 species or about 32%) also have a large population compared to these plants, this may be due to the importance of shrub and tree formations in the site that favour the diversity of the epiphytes. The saxicol communities correspond to 11 species (18.33%) that develop on sandstone and shale and locally limestone.

The species found on dead wood (corticols) are represented only by 3 taxa: *Brachythecium velutinum* on arbutus and philaria, *Hypnum cupressiforme* on cork oak, kermes oak and holm oak and *Sematophyllum substrumulosum* on arbutus, heather and oak. philaria. In Mount Jbel Sidi Ali, located in the region of the study area, the species *Pleurochaete squarosa* was widely distributed (Laouzazni *et al.*, 2018), while in the SIBE of Brikcha, it is very abundant but only in two stations where it was found. Considering the altitude (Fig. 3), the highest species richness fluctuates between 22 and 29 species in the altitudinal gap varying between 150 and 300 m with a rather irregular dispersion. At the highest altitude reached on this site, only two to six species are encountered. It appears from this that the distribution of bryophytes on this site is not related to altitude but to local ecological conditions (temperature, soil and air humidity, vegetation type).

The SIBE is home to dense, climax vegetation, organized around the kermes oak (*Quercus coccifera*), the cork oak (*Quercus suber*), the holm oak (*Quercus rotundifolia*) and the zeen oak (*Quercus faginea*) and a clayey soil formed on a sandy and schistose substrates that ensure adequate moisture conditions. This environment has created microclimates favouring the establishment of bryological flora. We should also noted that some mosses live exclusively on forest species, such as: *Homalothecium sericeum* on cork oak and kermes oak, *Oxyrrhynchium pumilum* on phylar and *Bryum capillare* on cork oak and holm oak.

### Conclusion

This study allowed us to highlight a previously neglected flora, namely bryophytes, whose census has made it possible to establish a list of 60 species, the majority of which are terricolous then epiphytes. The distribution of these taxa in Brikcha SIBE depends mainly on vegetation cover, locally high moisture content and edaphic factors. The bryological cortege identified, due to its diversity, seems to be perfectly inserted in this layer of thermo-Mediterranean vegetation especially in connection with the type of substrate and the level of humidity. The stations have their own diversity in relation to the local environmental conditions. While the species richness of the site has reached 60 species, that of each station does not exceed seven species. This shows that there is a high variability of the micro-ecosystems corresponding to the stations. The biological diversity in general and bryological in particular, observed in the area, is a national patrimony that encourages the conservation and monitoring of the variability of this flora over time.

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