

# cryptogamie

## *Bryologie*

2021 • 42 • 16

### Four bryophytes collected in Tunisia, new for mainland Africa

Imen BEN OSMAN, Vincent HUGONNOT,  
Serge D. MULLER & Amina DAOUD-BOUATTOUR

art. 42 (16) — Published on 29 October 2021  
[www.cryptogamie.com/bryologie](http://www.cryptogamie.com/bryologie)

PUBLICATIONS  
SCIENTIFIQUES





DIRECTEUR DE LA PUBLICATION / *PUBLICATION DIRECTOR*: Bruno David,  
Président du Muséum national d'Histoire naturelle

RÉDACTEUR EN CHEF / *EDITOR-IN-CHIEF*: Denis LAMY

ASSISTANTE DE RÉDACTION / *ASSISTANT EDITOR*: Marianne SALAÛN (bryo@cryptogamie.com)

MISE EN PAGE / *PAGE LAYOUT*: Marianne SALAÛN

RÉDACTEURS ASSOCIÉS / *ASSOCIATE EDITORS*

**Biologie moléculaire et phylogénie / *Molecular biology and phylogeny***

**Bernard GOFFINET**

Department of Ecology and Evolutionary Biology, University of Connecticut (United States)

**Mousses d'Europe / *European mosses***

**Isabel DRAPER**

Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid (Spain)

**Francisco LARA GARCÍA**

Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid (Spain)

**Mousses d'Afrique et d'Antarctique / *African and Antarctic mosses***

**Rysiek OCHYRA**

Laboratory of Bryology, Institute of Botany, Polish Academy of Sciences, Krakow (Pologne)

**Bryophytes d'Asie / *Asian bryophytes***

**Rui-Liang ZHU**

School of Life Science, East China Normal University, Shanghai (China)

**Bioindication / *Biomonitoring***

**Franck-Olivier DENAYER**

Faculté des Sciences Pharmaceutiques et Biologiques de Lille, Laboratoire de Botanique et de Cryptogamie, Lille (France)

**Écologie des bryophytes / *Ecology of bryophyte***

**Nagore GARCÍA MEDINA**

Department of Biology (Botany), and Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid (Spain)

COUVERTURE / *COVER*:

Kesra-plateau habitat of *Tortula protobryoides* R.H.Zander.

*Cryptogamie, Bryologie* est indexé dans / *Cryptogamie, Bryologie is indexed in*:

- Biological Abstracts
- Current Contents
- Science Citation Index
- Publications bibliographiques du CNRS (Pascal).

*Cryptogamie, Bryologie* est distribué en version électronique par / *Cryptogamie, Bryologie is distributed electronically by*:

- BioOne® (<http://www.bioone.org>)

**Cryptogamie, Bryologie** est une revue en flux continu publiée par les Publications scientifiques du Muséum, Paris  
*Cryptogamie, Bryologie is a fast track journal published by the Museum Science Press, Paris*

Les Publications scientifiques du Muséum publient aussi / *The Museum Science Press also publish: Adansonia, Geodiversitas, Zoosystema, Anthrozoologica, European Journal of Taxonomy, Naturae, Comptes Rendus Palevol, Cryptogamie sous-sections Algologie, Mycologie.*

Diffusion – Publications scientifiques Muséum national d'Histoire naturelle

CP 41 – 57 rue Cuvier F-75231 Paris cedex 05 (France)

Tél.: 33 (0)1 40 79 48 05 / Fax: 33 (0)1 40 79 38 40

diff.pub@mnhn.fr / <http://sciencepress.mnhn.fr>

© Publications scientifiques du Muséum national d'Histoire naturelle, Paris, 2021

ISSN (imprimé / *print*): 1290-0796 / ISSN (électronique / *electronic*): 1776-0992

# Four bryophytes collected in Tunisia, new for mainland Africa

**Imen BEN OSMAN**

Département de Biologie, Faculté des Sciences de Tunis,  
Université de Tunis El-Manar, 2092 Tunis (Tunisia)  
and LR18ES13 Biogéographie, Climatologie appliquée et Dynamiques environnementales,  
Faculté des Lettres, des Arts et des Humanités de Manouba,  
Université de la Manouba, 2010 Manouba (Tunisia)  
imanbenosmen@gmail.com (corresponding author)

**Vincent HUGONNOT**

Le Bourg, 43380 Blassac (France)  
vincent.hugonnot@wanadoo.fr

**Serge D. MULLER**

Institut des Sciences de l'Évolution (ISEM), Université de Montpellier, CNRS,  
IRD, EPHE, 34095 Montpellier cedex 05 (France)  
serge.muller@umontpellier.fr

**Amina DAOUD-BOUATTOUR**

Département de Biologie, Faculté des Sciences de Tunis,  
Université de Tunis El-Manar, 2092 Tunis (Tunisia)  
and LR18ES13 Biogéographie, Climatologie appliquée et Dynamiques environnementales,  
Faculté des Lettres, des Arts et des Humanités de Manouba,  
Université de la Manouba, 2010 Manouba (Tunisia)  
daoudamina200@yahoo.fr

Submitted on 4 February 2021 | Accepted on 27 July 2021 | Published on 29 October 2021

Ben Osman I., Hugonnot V., Muller S. D. & Daoud-Bouattour A. 2021. — Four bryophytes collected in Tunisia, new for mainland Africa. *Cryptogamie, Bryologie* 42 (16): 213-219. <https://doi.org/10.5252/cryptogamie-bryologie2021v42a16>. <http://cryptogamie.com/bryologie/42/16>

## ABSTRACT

### KEY WORDS

mosses,  
liverworts,  
floristics,  
Maghreb,  
new records.

Recent fieldwork in Tunisia resulted in the discovery of one liverwort (*Saccogyna viticulosa* (L.) Dumort.) and three mosses (*Orthotrichum bistratosum* (Schiffn.) J.Guerra, *Pseudotaxiphylum elegans* (Brid.) Z.Iwats., *Tortula protobryoides* R.H.Zander) new for mainland Africa. The localities are briefly described with a focus on habitats, accompanying species, and comments on taxonomy and variability. Conservation actions are urgently needed in Tunisia in light of rising anthropogenic pressures.

## RÉSUMÉ

*Quatre bryophytes collectées en Tunisie, nouvelles pour l'Afrique continentale.*

**MOTS CLÉS**  
mousses,  
hépatiques,  
floristique,  
Maghreb,  
signalements nouveaux.

Des prospections de terrain récentes en Tunisie ont permis d'y découvrir une hépatique (*Saccogyna viticulosa* (L.) Dumort.) et trois mousses (*Orthotrichum bistratosum* (Schiffn.) J.Guerra, *Pseudotaxiphylum elegans* (Brid.) Z.Iwats., *Tortula protobryoides* R.H.Zander) nouvelles pour l'Afrique continentale. Les localités sont brièvement décrites en mettant l'accent sur les habitats, les espèces qui les accompagnent et les commentaires sur la taxonomie et la variabilité. Des mesures de conservation sont nécessaires de toute urgence en Tunisie, compte tenu de l'augmentation des pressions anthropiques.

## INTRODUCTION

The bryophyte flora of Tunisia has been neglected for many decades; most existing studies are old and scattered. The most significant pioneer bryological contributions were made by Thériot (1900) and Corbière & Pitard (1909). For mosses, the only available historical synthesis was that of Jelenc (1955, 1967) dealing with all of North Africa. Jovet-Ast & Bischler (1971) compiled the first checklist for Tunisian liverworts. However, since the turn of the century, new studies on the bryoflora of Tunisia have been conducted again (Pócs 2007; Draper *et al.* 2008; Muller *et al.* 2010; Campisi *et al.* 2015, Ellis *et al.* 2017, 2018, 2019, 2021; Ben Osman *et al.* 2019, 2021a, 2021b; Hugonnot *et al.* 2020). Nevertheless, in the absence of a modern national checklist, the synthesis of Mediterranean liverworts and hornworts (Ros *et al.* 2007), and that of mosses (Ros *et al.* 2013) are the most up-to-date.

The Tunisian bryoflora is still poorly known, as demonstrated by recent field surveys carried out in Tunisia's northern regions that have revealed many new species for Tunisia (Hugonnot *et al.* 2020; Ben Osman *et al.* 2021b). In this paper, we report 4 species new for mainland Africa.

## MATERIAL AND METHODS

The nomenclature follows Ros *et al.* (2007, 2013). Species not cited by Grolle (1995), O'Shea (1995), Wigginton & Grolle (1996), Ros *et al.* (2007, 2013) or Marline *et al.* (2012) are considered new for Africa. Distributional data are extracted from relevant syntheses and publications that are cited for each species.

The specimens that were collected are housed in the herbarium of the Faculté des Sciences de Tunis (TUN) and in the personal herbarium of Vincent Hugonnot. The new records are listed alphabetically and the following information is provided for each: specimens examined; distribution; floristic element; habitat; ecological comments and comparisons with other biogeographical regions; associated species; main threats and issues relating to conservation; fertility (occurrence of gametangia, sporophyte, etc.); extent of population (size of main patches in m<sup>2</sup>); taxonomic and floristic comments. Morphological observations are based on the examination of the Tunisian material.

## STUDY AREA

The new species were collected in North-West Tunisia in April 2019, specifically in Kroumiria and Hedhils (Northern Tunisian Tell), the Teboursook Mountains (Tunisian High-Tell), and in March 2020, in the Tunisian Dorsal (Fig. 1; Table 1).

The Northern Tunisian Tell is situated in the humid Mediterranean bioclimatic area (INRF 1975). Kroumiria is bordered to the North by the Mediterranean Sea, to the South by the Mejerda Valley (the country's principal permanent river flowing along a Southwest-Northeast axis), to the West by the National Park of El Kala (in the Algerian wilaya of El Tarf), and to the East by the Mogods. Kroumiria is a mountainous massif, culminating at Jbel El Ghorra (1203 m a.s.l.) on the

Algerian-Tunisian border, and is dissected by deep valleys. Geologically, it belongs to the domain of Numidian clay and sandstone flysch of Oligocene age and is the wettest region of Tunisia (1000-1500 mm/year). The vegetation is dominated by zeen oak (*Quercus canariensis* Willd.) forest in the Supra- and Meso-Mediterranean vegetation belt and by cork oak (*Quercus suber* L.) forest in the Thermo-Mediterranean vegetation belt. South of the Mogods, the Hedhils are an eroded limestone range rising no higher than 700 m and covered by degraded formations of olive trees (*Olea europaea* L. var. *silvestris* (Mill.) Lehr) and mastic pistachio trees (*Pistacia lentiscus* L.).

Further South in the Northeast of the Tunisian High Tell, the Teboursook Mountains are bordered to the North and to the East by the plains of the Mejerda Valley, to the South by the Tunisian Dorsal, and to the West by the Tessa Wadi. This hilly limestone region culminates at Jbel Gorrâa (963 m a.s.l.). It is mainly characterised by a semi-arid bioclimatic environment that becomes sub-humid in the highest areas, more exposed to humid winds (INRF 1975). The vegetation is dominated by matorrals of Aleppo pine (*Pinus halepensis* Mill.) that is associated in places with holm oak (*Quercus ilex* L. subsp. *ballota* (Desf.) Samp.).

The Tunisian Dorsal constitutes the Eastern extension of the Saharan Atlas and runs on a Southwestern-Northeastern axis. This mountain range extends over the North-Central part of the country and is characterised by generally decreasing altitudes from Jbel Chambi (1544 m a.s.l.) near the Algero-Tunisian border to Jbel Bou Kornine (576 m a.s.l.) near the Cap Bon peninsula. It presents a succession of more or less aligned limestone mountain massifs alternating with large glacis characterised by gentle slopes traversed by numerous wadis embedded in sediments. The Tunisian Dorsal is primarily located in a semi-arid bioclimatic zone, but locally, the summits of certain reliefs benefit from a sub-humid bioclimate (INRF 1975). The vegetation is dominated by Aleppo pine forests, mixed with continental red juniper (*Juniperus turbinata* Guss.), and often associated with holm oak on the reliefs.

## RESULTS

As a result of the study, we report three mosses and one liverwort new to Tunisia and mainland Africa. Based on literature counts (Ros *et al.* 2007, 2013; Ellis *et al.* 2017, 2018, 2019, 2021; Hugonnot *et al.* 2020; Ben Osman *et al.* 2021), and including the additions reported here, the bryophyte flora of Tunisia now comprises 334 taxa (238 mosses, 92 liverworts and 4 hornworts).

Family ORTHOTRICHACEAE Arn.

Genus *Orthotrichum* Hedw.

*Orthotrichum bistratosum* (Schiffn.) J. Guerra

SPECIMENS EXAMINED. — Tunisia, High Tell, Beja Governorate, Delegation of Thibar: Djebba (36°28'15.20"N, 09°05'57.03"E;

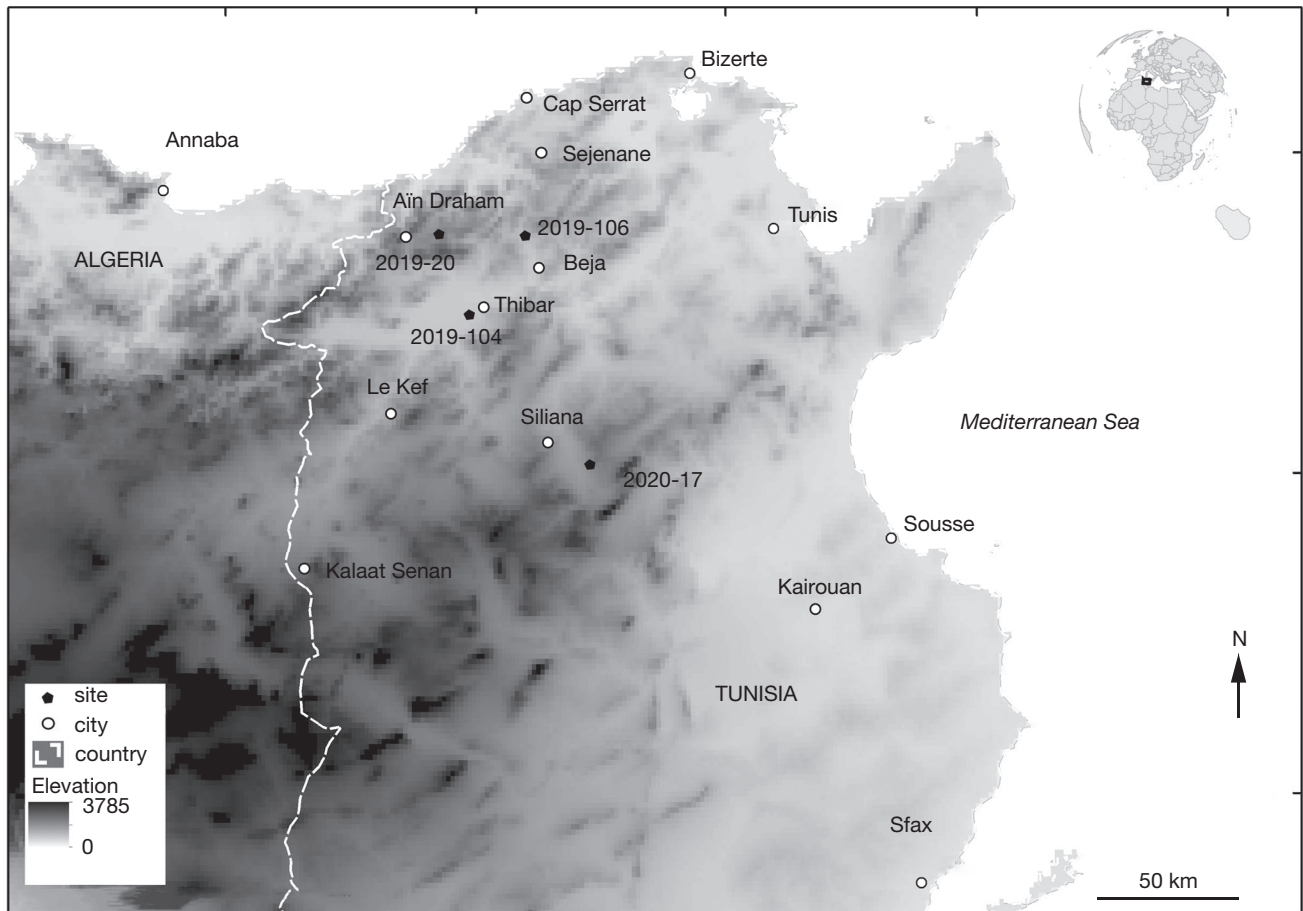


FIG. 1. — Location of the studied sites. The site code designation is given in Table 1.

620 m a.s.l.; site 2019-104), 13.IV.2019, leg. Imen Ben Osman, Vincent Hugonnot, *TUN2019-280*; Tunisia, Northern Tell, Beja Governorate, Delegation of Beja North: Jbel Zebbla (36°49'23.60"N, 09°15'36.91"E, 552 m a.s.l.; site 2019-106), 13.IV.2019, leg. Imen Ben Osman, Vincent Hugonnot, *TUN2019-281*.

DISTRIBUTION. — S Europe (France, Spain, Greece; Ros *et al.* 2013; Lara & Garilleti 2014; Ellis *et al.* 2016); SW Asia (Iraq, Israel, Syria and Turkey; Kürschner & Frey 2020).

FLORISTIC ELEMENT. — Mediterranean.

#### HABITAT

Cultivated slope (fig tree, pomegranate...) and xerophytic scrubland on dry, exposed limestone rocks. The vascular plant communities are mainly composed of grazing-resistant species. In Tunisia, *Orthotrichum bistratosum* was accompanied by mundane xerophytic taxa: *Encalypta vulgaris* Hedw., *Grimmia orbicularis* Bruch ex Wilson, *G. pulvinata* (Hedw.) Sm., *Orthotrichum anomalum* Hedw., *Syntrichia montana* Nees, *Tortella nitida* (Lindb.) Broth., *Tortula muralis* Hedw., *Trichostomum brachydontium* Bruch and *Weissia condensata* (Voit) Lindb.

At the Djebba site, tourism is particularly high and worrying since walkers may pull out moss cushions and ascend along rock outcrops, severely damaging lithophytic communities, as can be observed on site. Organising and limited public access through fencing and accompaniment by guides would be desirable.

This species had abundant sporophytes at each locality.

#### COMMENTS

*Orthotrichum cupulatum* Brid. var. *bistratosum* Schiffn. was raised to species rank by Guerra (1985) and this status has been confirmed by Lara & Garilleti (2014). *Orthotrichum bistratosum* is characterised by immersed sporophytes with cryptopore stomata, spreading exostome, uniformly bistratose lamina in the apical half of leaves, partially bistratose to unistratose to base. The leaf margins occasionally appear swollen with 3-4-stratose patches. The typical jet-black colour may be much less pronounced in Tunisian material than in material from other parts of its range. We have verified that this characteristic is not associated with the more unistratose patches of lamina and therefore consider it to be linked to phenotypic variation.



TABLE 1. — Location and bioclimatic characteristics (INRF 1975) of the species' collecting sites.

Taxon	Site	Bioclimate	Region
<i>Orthotrichum bistratosum</i> (Schiffn.) J.Guerra	Djebba (2019-104)	Temperate subhumid	Teboursouk Range (N.E. High-Tell)
<i>Orthotrichum bistratosum</i>	Jbel Zebba (2019-106)	Lower humid	Hedhils (Calcareous Northern Tell)
<i>Pseudotaxiphyllum elegans</i> (Brid.) Z.Iwats.	Oued Zen (2019-20)	Upper humid	Kroumiria (Sandstone N Tell)
<i>Saccogyna viticulosa</i> (L.) Dumort.	Oued Zen (2019-20)	Upper humid	Kroumiria (Sandstone N Tell)
<i>Tortula protobryoides</i> R.H.Zander	Kesra (2020-17)	Subhumid altitude fresh	Tunisian Dorsal

Family HYPNACEAE Schimp.  
Genus *Pseudotaxiphyllum* Z.Iwats.

*Pseudotaxiphyllum elegans* (Brid.) Z.Iwats.

SPECIMENS EXAMINED. — Tunisia, Kroumiria, Jendouba Governorate, Delegation of Fernana: Oued Zen (36°48'43.08"N, 08°50'41.33"E; 368 m a.s.l.; site 2019-20), 04.IV.2019, leg. Imen Ben Osman, Vincent Hugonnot, *TUN2019-282*.

DISTRIBUTION. — Widespread in Europe, rare in the Mediterranean region (Ros *et al.* 2013; Hodgetts & Lockhart 2020); Tristan da Cunha (Ochyra & Plášek 2020); Asia (E Russia, Turkey; Afonina 2004; Cherniad"eva 2012; Ören *et al.* 2012); N and S America (Hoe 1979; Ireland & Buck 2009; Ireland 2014).

*Pseudotaxiphyllum elegans* is also mentioned in "Afr 1" (which corresponds roughly to North Africa) by Wijk *et al.* (1964), but it is not cited either in the checklist of Northern Africa (Ros *et al.* 1999) and the Mediterranean region (Ros *et al.* 2013), nor in O'Shea (1995). Therefore, we consider this record as doubtful.

FLORISTIC ELEMENT. — Pan-Holarctic, having a strongly disjointed suboceanic boreo-temperate range in the Northern Hemisphere (bipolar species).

HABITAT

Transitional zone between alder riparian gallery and zeen oak forest on the higher banks of a permanent wadi and on soil between sandstone rocks. The forest canopy is composed of *Alnus glutinosa* (L.) Gaertn., *Quercus canariensis* and *Ilex aquifolium* L.

The habitat of *Pseudotaxiphyllum elegans* in Tunisia is similar to that in Europe (Blockeel *et al.* 2014). This species usually occurs in acid forest stands where it grows on soil around the bases of trees, on sheltered banks, and also commonly on and among rocks, both on raw humus and over bare surfaces. The alder swamps and riparian forests of Kroumiria are known to host a variety of vascular plants with Northern affinities, as previously emphasised by Braun-Blanquet (1953). The occurrence of several sterile bryophytes of Northern-Oceanic affinity in the Oued Zen Valley (*Heterocladium flaccidum* (Schimp.) A.J.E.Sm., *Isothecium myosuroides* Brid., *Lophocolea fragrans* (Moris & De Not.) Gottsche, Lindenb. & Nees, etc.) offers a strong argument for the ancient origin of these populations associated with sexual depletion (Hugonnot *et al.* 2020).

REMARKS

At present, the Oued Zen Valley is legally protected (National Park of Oued Zen), but illegal cutting trees by local residents could threaten this site of high conservation value.

The Tunisian population of *Pseudotaxiphyllum elegans* was sterile. It was present only very locally over a few cm<sup>2</sup>, the population consisting of several tenths of stems.

COMMENTS

The Tunisian specimens do not deviate significantly from European ones. They are typically small, with strongly *Plagiothecium*-like complanate leaves, have filamentous pseudoparaphyllia and caducous axillary branchlets (Cano 2018).

Family SACCOGYNACEAE Heeg  
Genus *Saccogyna* Dumort.

*Saccogyna viticulosa* (L.) Dumort.

SPECIMEN EXAMINED. — Tunisia, Kroumiria, Jendouba Governorate, Delegation of Fernana: Oued Zen (36°48'43.08"N, 08°50'41.33"E; 394 m a.s.l.; site 2019-20), 04.IV.2019, leg. Imen Ben Osman, Vincent Hugonnot, *TUN2019-61*.

DISTRIBUTION. — Mediterranean (Ros *et al.* 2007) and W Europe including Macaronesia (Hodgetts & Lockhart 2020); SW Asia (Kürschner & Frey 2020).

FLORISTIC ELEMENT. — Oceanic Southern-Temperate.

HABITAT

*Alnus glutinosa* riparian gallery, on higher banks of a permanent wadi, on earth-covered sandstone rocks.

The West European ecology of the species seems to concur with the unique Kroumirian population known to date. *Saccogyna viticulosa* is typical of shaded habitats, found in damp ledges, banks, and among rocks in wooded low-lying ravines, in areas where some water seepage typically exists (Blockeel *et al.* 2014).

It has been observed as sterile stands (no gametangia or sporophyte) as is usual in oceanic Europe. This species occurred abundantly as dense stands of shoots that covered several m<sup>2</sup>.

This isolated North-African population is probably relictual (see *Pseudotaxiphyllum elegans*). The threats are essentially linked to illegal woodland exploitation.

COMMENTS

A large and unmistakable leafy liverwort, growing as extended prostrate mats, with opposite leaves and large orbicular-acuminate underleaves (Paton 1999).

Family POTTIACEAE Hampe  
Genus *Tortula* Hedw.

*Tortula protobryoides* R.H.Zander

SPECIMEN EXAMINED. — Tunisia, Tunisian Dorsal, Siliana Governorate, Delegation of Kesra: Kesra-Plateau (35°49'31.03"N, 09°21'50.13"E, 1069 m a.s.l.; site 2020-17), 11.III.2020, leg. Imen Ben Osman, Vincent Hugonnot, TUN2020-7.

DISTRIBUTION. — Widespread in Europe including Macaronesia, rare in the Mediterranean region (Ros *et al.* 2013; Hodgetts & Lockhart 2020); W Asia (Kürschner & Frey 2020); NW America (Zander & Eckel 2007).

FLORISTIC ELEMENT. — European temperate.

HABITAT

In grykes of horizontal karstic pavement, on a compacted substrate, in a ruderal habitat, subjected to strong overgrazing. The vascular vegetation comprises a rupicolous community anchored on rock outcrops, mixed with a very degraded holm oak forest (*Quercus ilex* subsp. *ballota*) characterised by numerous grazing-resistant species.

In Europe, *Tortula protobryoides* also grows in calcareous habitats on compacted soil, chalky banks, tracks, and paths, and chalky soil disturbed by roads (Blockeel *et al.* 2014). In Tunisia, associated species are ruderal: *Bryum argenteum* Hedw., *Didymodon acutus* (Brid.) K.Saito and *Microbryum* Schimp. spp.

Tunisian colonies were fertile (a few sporophytes present). The species was very scattered, with only a few stems.

As a pioneer species, *Tortula protobryoides* may certainly benefit from being trampled by grazing stocks, but for the Tunisian population, overgrazing is particularly intense and may not be compatible with the long-term conservation even of taxa adapted to disturbance. Monitoring would be desirable in such a situation to determine whether *T. protobryoides* can withstand such destructive grazing.

COMMENTS

*Tortula protobryoides* is mainly characterised by sporophytic characters. It has a relatively short seta, making ovoid urn slightly exceeding upper perichetial leaves, and stegocarpic capsules, with rudimentary peristome and persistent rostrate operculum (Guerra 2006).

DISCUSSION

Tunisia is a small country, covering 163 610 km<sup>2</sup>. This is the equivalent of only 6.87 % of the surface of Algeria and 36.64 % of that of Morocco. Moreover, Tunisia is less topographically and latitudinally extended than these two countries (Bernard 1937; Troin 1985). It is therefore unusual to report four bryophyte taxa new for Africa in the smallest and physiographically least diversified Maghreb country. Tunisia is undoubtedly very much underexplored from the point of view of its bryoflora, and much remains to be done before we can evaluate its true bryological richness.

The newly recorded taxa were collected from radically distinct habitats in contrasting ecological situations that raise specific conservation issues. *Pseudotaxiphyllum elegans* and *Saccogyna viticulosa* occur on stream margins in forested valleys. Given their distinctive habitat, they have until now been relatively free from anthropogenic pressure. Unfortunately, these types of habitats now face multiple threats. After the 2011 Tunisian popular uprising, the near absence of forestry service controls led to massive illegal logging (Souli, <https://www.vice.com>, 2016; Kalboussi, <https://nawaat.org>, 2020). The situation has recently deteriorated during the Covid-19 lockdown (Raynal, <https://reporterre.net>, 2020).

Overgrazing is the second principal threat to natural habitats in North Africa (Swift 1996; Winslow & Thomas 2007) leading to desertification in arid regions (Nedjraoui & Bédrani 2008). This affects the habitat of *Tortula protobryoides*, which is severely degraded by wandering cattle and sheep that are penetrating increasingly and illegally into protected areas.

By contrast, *Orthotrichum bistratosum* is a rock-dwelling species that may be less affected by anthropogenic activities given the inaccessibility of its habitat. Unfortunately, sites – waterfalls, impressive cliffs, etc. – that are attractive to tourists are also sites of high bryodiversity. Touristic activities may cause damage either directly (trampling, pollution, etc.) or indirectly (construction of pathways, cliff stabilisation, etc.).

In this context of excessive pressure on bryophyte habitats, a new checklist of Tunisian bryophytes is urgently needed. Using this as a starting-point, the IUCN threat status could be evaluated for each taxon and a Red List drawn up with the hope of conservation actions in the near future.

Acknowledgements

Financial support was provided by LR18ES13 Biogéographie, Climatologie Appliquée et Dynamiques environnementales, FLAHM, Université de la Manouba, Tunisia. We thank the *Direction Générale des Forêts, Ministère de l'Agriculture et des Ressources hydrauliques et de la Pêche de Tunisie* and the local population for fieldwork authorisations and facilities, M. Calboussi (Tunisia Ecotourism Network), A.M. Gammar, Z. Ghrabi-Gammar and I. Ben Haj Jilani for help with fieldwork, and D. Glassman (Washington, United States) for editorial assistance. We also thank T.L. Blockeel and an anonymous reviewer whose helpful comments that were greatly appreciated. This paper is contribution ISE-M n° 2021-094 SUD.

REFERENCES

- AFONINA O. M. 2004. — *Moss Flora of Chukotka*. Komarov Botanical Institute of the Russian Academy of Sciences, Sankt Petersburg, 259 p. (in Russian).
- BEN OSMAN I., HUGONNOT V., MULLER S. D. & DAUD-BOUATTOUR A. 2019. — A contribution to the study of hornworts and liverworts in Tunisia: a checklist and ecology of Kroumirian species. *Cryptogamie, Bryologie* 40: 271-287. <https://doi.org/10.5252/cryptogamie-bryologie2019v40a21>

- BEN OSMAN I., HUGONNOT V., MULLER S. D. & DAOUD-BOUATTOUR A. 2021a. — *Sphagnum subnitens* Russow & Warnst. in Tunisia and North Africa. *Journal of Bryology*. <https://doi.org/10.1080/03736687.2020.1852818>
- BEN OSMAN I., HUGONNOT V., DAOUD-BOUATTOUR A. & MULLER S. D. 2021b. — New bryophytes in Tunisia (North Africa). Part 1: Pottiaceae. *Nova Hedwigia* 113: 45-59. [https://doi.org/10.1127/nova\\_hedwigia/2021/0645](https://doi.org/10.1127/nova_hedwigia/2021/0645)
- BERNARD A. 1937. — *Afrique septentrionale et occidentale*. Géographie Universelle, tome 9, partie 1. Librairie Armand Colin, Paris, 284 p.
- BLOCKEEL T. L., BOSANQUET S. D. S., HILL M. O. & PRESTON C. D. 2014. — *Atlas of British & Irish bryophytes. The distribution and habitat of mosses and liverworts in Britain and Ireland*. 2 volumes. British Bryological Society, Pisces Publications, Newbury.
- BRAUN-BLANQUET J. 1953. — Irradiations européennes de la végétation en Kroumirie. *Vegetatio* 4: 182-194. <https://doi.org/10.1007/BF00297018>
- CAMPISI P., DIA M. G., DOMINA G. & RAIMONDO F. M. 2015. — Bryophytes collected during the 12<sup>th</sup> "Iter Mediterraneum" (Tunisia, 24 March-4 April 2014). First contribution. *Bocconea* 27: 63-68.
- CANO M. J. 2018. — *Pseudotaxiphyllum* Z. Iwats., in GUERRA J., CANO M. J. & BRUGUES M. (eds.), *Flora Briofítica Ibérica*. Volume 6. Universidad de Murcia, Sociedad Española de Briología, Murcia: 294-298.
- CHERNIAD"ÉVA I. V. 2012. — *Mosses of Kamchatka Peninsula*. Komarov Botanical Institute of the Russian Academy of Sciences, St. Petersburg, 459 p. (in Russian).
- CORBIERE L. & PITARD C. J. 1909. — Muscinées de Tunisie. *Bulletin de la Société Botanique de France* 56: 215-242. <https://doi.org/10.1080/00378941.1909.10832141>
- DRAPER I., LARA F. & MAZIMPAKA V. 2008. — New records to the epiphytic bryophyte flora of Tunisia. *Cryptogamie, Bryologie* 29: 83-91.
- ELLIS L. T., AGCAGIL E., KIRMACI M., ALEFFI M., BAKALIN V. A., BEDNAREK-OCHYRA H., CYKOWSKA-MARZENCKA B., STRYJAK-BOGACKA M., BOJACA G. F. P., FANTACELLE L. B., ARAUJO C. A. T., MACIEL-SILVA A. S., BRUNO SILVA J., CALLEJA J. A., CANO M. J., CASTILLO DIAZ J., GABRIEL R., DIAS DOS SANTOS N., ENROTH J., ERZBERGER P., GARILLETI R., HAJEK M., HEDENÄS L., HERAS P., INFANTE M., KIEBACHER T., KOCZUR A., KRAWCZYK R., KUČERA J., LÉBOUVIER M., LÜTH M., MAZIMPAKA V., VIGALONDO B., LARA F., NAGY J., NÉMETH C. S., KOVACS A., NOBIS M., WĘGRZYN M., WIETRZYK P., NORHAZRINA N., VANDERPOORTEN A., NOWAK A., POPONESSI S., GIGANTE D., VENANZONI R., PLÁSEK V., RANGEL GERMANO S., SCHÄFER-VERWIMP A., SÉRGIO C., CLARO D., GARCIA C. A., SHIRZADIAN S., AKHOONDI DARZIKOLAEI S., STEBEL A., SULEIMAN M., YONG K.-T., VIRCHENKO V. M., VONČINA G., YOON Y. J., CHOI H. G. & KIM J. H. 2016. — New National and Regional Bryophyte Records, 49. *Journal of Bryology* 38: 1-21. <https://doi.org/10.1179/1743282015Y.0000000024>
- ELLIS L. T., AFONINA O. M., ANDRIAMIARISOA R. L., BEDNAREK-OCHYRA H., CYKOWSKA-MARZENCKA B., STRYJAK-BOGACKA M., BELL N. E., BOIKO M., CALLAGHAN D. A., CAMPISI P., DIA M. G., MARINO M. L., PROENZANO F., ECKSTEIN J., ENROTH J., ERZBERGER P., EZER T., M. L. GAGANO, GINZBURG E., GÓRSKI P., GRADSTEIN S. R., REEB C., HANNOIRE C., INFANTE M., JUKONIENĖ I., KUSHNEVSKAYA E. V., LÉBOUVIER M., NAGY J., OPMANIS A., PLÁSEK V., SKOUPA Z., SABOVLJEVIĆ M. S., SABOVLJEVIĆ A. D., SHEVOCK J. R., SINGH D. K., MAJUMDAR S., SKUDNIK M., USELIENE A., VENTURELLA G., WĘGRZYN M., WIETRZYK P., YOON Y.-J., KIM J. H. & YÜCEL E. 2017. — New national and regional bryophyte records, 53. *Journal of Bryology* 39: 368-387. <https://doi.org/10.1080/03736687.2017.1384204>
- ELLIS L. T., AFONINA O. M., ALEFFI M., ANDRIAMIARISOA R. L., BAČKOR M., GOGA M., BEDNAREK-OCHYRA H., CALLAGHAN D. A., CAMPISI P., DIA M. G., MARINO M. L., ENROTH J., ERZBERGER P., HUGONNOT V., IGNATOVA E. A., KIEBACHER T., KUČERA J., LÉBOUVIER M., MARIA G. M., ŞTEFANUŢ S., NAGY J., PÓCS T., POPONESSI S., VENANZONI R., GIGANTE D., PROSSER F., REEB C., SABOVLJEVIĆ M. S., SHEVOCK J. R., SHIRZADIAN S., AKHOONDI DARZIKOLAEI S., SOUZA E. R. F., SILVA PINTO A., SILVA J. B., LOPES S. F., TORZEWSKI K. & KAZIENKO A. 2018. — New national and regional bryophyte records, 55. *Journal of Bryology* 40: 173-187. <https://doi.org/10.1080/03736687.2018.1454161>
- ELLIS L. T., AFONINA O. M., CZERNYADJEVA I. V., IVCHENKO T. G., KHOLOD S. S., KOTKOVA V. M., KUZMINA E. YU., POTECHKIN A. D., SERGEEVA YU. M., ASTHANA A. K., GUPTA D., SAHU V., SRIVASTAVA S., BAKALIN V. A., BEDNAREK-OCHYRA H., CAMPISI P., DIA M. G., CHOI S. S., DAGNINO D., MINUTO L., TURCATO C., DRAPELA P., DUGAROVA O. D., TUBANOVA D. YA., ENROTH J., KOPONEN T., KLAMA H., ERDAĞ A., KIRMACI M., FEDOSOV V. E., HODGETTS N. G., HOLYOAK D. T., JUKONIENĖ I., KONSTANTINOVA N. A., SAVCHENKO A. N., VILNET A. A., KRIVAL E. A., KÜRSCHNER H., LAPSHINA E. D., LARRAIN J., MA W. Z., MAKSIMOV A. I., MARINO M. L., MÜLLER F., PANDE N., PARK S. J., SUN B.-Y., PIVORAS A., PLÁSEK V., PUGLISI M., SCIANDRELLO S., RAJIAN N. J., SULEIMAN M., SCHÄFER-VERWIMP A., SHEVOCK J. R., SPITALE D., STEBEL A., TAHA M. A. & PORLEY R. D. 2019. — New national and regional bryophyte records, 61. *Journal of Bryology* 41: 364-384. <https://doi.org/10.1080/03736687.2019.1673601>
- ELLIS L. T., AH-PENG C., ASLAN G., BAKALIN V. A., BERGAMINI A., CALLAGHAN D. A., CAMPISI P., RAIMONDO F. M., CHOI S. S., CSIKY J., CSIKYNÉ RADNAI É., CYKOWSKA-MARZENCKA B., CZERNYADJEVA I. V., KALININA YU M., AFONINA O. M., DOMINA G., DRAPELA P., FEDOSOV V. E., FUERTES E., GABRIEL R., KUBOVÁ M., SOARES ALBERGARIA I., GOSPODINOV G., NATCHEVA R., GRAULICH A., HEDDERSON T., HERNÁNDEZ-RODRÍGUEZ E., HUGONNOT V., HYUN C. W., KIRMACI M., ÇATAK U., KUBEŠOVÁ S., KUČERA J., LA FARGE C., LARRAÍN J., MARTIN P., MUFEEB B., MANJU C. N., RAJESH K. P., NÉMETH CS., NAGY J., NORHAZRINA N., SYAZWANA N., O'LEARY S. V., PARK S. J., PEÑARETES A. P., RIMAC A., ALEGRO A., ŠEGOTA V., KOLETIĆ N., VUKOVIĆ N., ROSADZIŃSKI S., ROSELLÓ J. A., SABOVLJEVIĆ M. S., SABOVLJEVIĆ A. D., SCHÄFER-VERWIMP A., SÉRGIO C., SHKURKO A. V., SHYRIAIEVA D., VIRCHENKO V. M., SMOCZYK M., SPITALE D., SRIVASTAVA P., OMAR I., ASTHANA A. K., STANIASZEK-KIK M., CIENKOWSKA A., ŞTEFANUŢ M.-M., ŞTEFANUŢ S., TAMAS G., BÍRSAN C.-C., NICOARĂ G.-R., ION M. C., PÓCS T., KUNEV G., TROEVA E. I., ROOY J. VAN., WIETRZYK-PEŁKA P., WĘGRZYN M. H., WOLSKI G. J., BOŻYK D. & CIENKOWSKA A. 2021. — New national and regional bryophyte records, 65. *Journal of Bryology* 43: 67-91. <https://doi.org/10.1080/03736687.2021.1878804>
- GROLLE R. 1995. — The Hepaticae and Anthocerotae of the East African Islands. An annotated catalogue. *Bryophytorum Bibliotheca* 48: 1-178.
- GUERRA J. 1985. — *Orthotrichum bistratosum* (Schiffn.) Guerra, comb. et stat. nov. *Anales del Jardín Botánico de Madrid* 42: 247-256.
- GUERRA J. 2006. — *Protobryum* J. Guerra & M.J. Cano, in GUERRA J., CANO M. J. & ROS R. M. (eds.), *Flora Briofítica Ibérica*. Volume 3. Universidad de Murcia, Sociedad Española de Briología, Murcia: 208-216.
- HODGETTS N. & LOCKHART N. 2020. — *Checklist and country status of European bryophytes*. Update 2020. Irish Wildlife Manuals 123. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland, 214 p.
- HOE W. J. 1979. — Additional New and Noteworthy Records for Hawaiian Mosses 5. *The Bryologist* 82: 79-82. <https://doi.org/10.2307/3241973>
- HUGONNOT V., BEN OSMAN I., DAOUD-BOUATTOUR A., MULLER S. D., FEDOROVA A. V., IGNATOVA E. A. & IGNATOV M. S. 2020. — A range extension of *Heterocladium flaccidum* (Schimp.) A.J.E.Sm. to Africa and Asia and confirmation of its specific sta-



- tus. *Cryptogamie, Bryologie* 41: 265-272. <https://doi.org/10.5252/cryptogamie-bryologie2020v41a21>
- INRF (INSTITUT NATIONAL DE RECHERCHE FORESTIERE) 1975. — *Carte bioclimatique de la Tunisie selon la classification d'Emberger: étages et variantes (1/1 000 000)*. Ministère de l'Agriculture, République tunisienne, Tunis.
- IRELAND R. R. 2014. — *Pseudotaxiphyllum* Z. Iwatsuki, in FLORA OF NORTH AMERICA EDITORIAL COMMITTEE (ed.), *Flora of North America north of Mexico*. Volume 28 Bryophyta, part 2. Oxford University Press, New York, Oxford: 559-561.
- IRELAND R. R. & BUCK W. R. 2009. — Some Latin American genera of *Hypnaceae* (Musci). Smithsonian Institution Scholarly Press. <https://doi.org/10.5479/si.0081024X.93>
- JELENC F. 1955. — *Muscinées de l'Afrique du Nord (Algérie, Tunisie, Maroc, Sahara)*. Société de Géographie et d'Archéologie de la Province d'Oran, Oran, 152 p.
- JELENC F. 1967. — Muscinées de l'Afrique du Nord (Supplément). *Revue bryologique et lichénologique* NS 35: 186-215.
- JOVET-AST S. & BISCHLER H. 1971. — Les Hépatiques de Tunisie. Énumération, notes écologiques et biogéographiques. *Revue bryologique et lichénologique* NS 38: 1-125.
- KÜRSCHNER H. & FREY W. 2020. — *Liverworts, Mosses and Hornworts of Southwest Asia (Marchantiophyta, Bryophyta, Anthocerotophyta): A systematic treatise with keys to genera and species occurring in Afghanistan, Bahrain, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Sinai Peninsula, Syria, Turkey, United Arab Emirates and Yemen (inc. Socotra Island)*. 2<sup>nd</sup> enlarged and revised edition. Nova Hedwigia, Beihefte, Beih. 149. Gebrüder Borntraeger Verlagsbuchhandlung, Science Publishers, 267 p.
- LARA F. & GARILLETI R. 2014. — *Orthotrichum* Hedw., in GUERRA J., CANO M. J. & BRUGUÉS M. (eds), *Flora Briofítica Ibérica*. Volume 5. Universidad de Murcia, Sociedad Española de Briología, Murcia: 50-135.
- MARLINE L., ANDRIAMARISO R. L., BARDAT J. & CHUAH-PETIOT M. 2012. — Checklist of the Bryophytes of Madagascar. *Cryptogamie, Bryologie* 33: 199-255. <https://doi.org/10.7872/cryb.v33.iss3.2012.199>
- MULLER S. D., DAOUD-BOUATTOUR A., BELOUAHEM-ABED D., BEN HAJ JILANI I., BEN SAAD-LIMAM S., BENSLAMA M., FERCHICHI-BEN JAMAA H., RHAZI L. & GHRABI-GAMMAR Z. 2010. — Peat mosses (*Sphagnum*) and related plant communities of North Africa. I. The Numidian-Kroumirian range (Algeria-Tunisia). *Flora Mediterranea* 20: 159-178.
- NEDJRAOUI D. & BEDRANI S. 2008. — La désertification dans les steppes algériennes : causes, impacts et actions de lutte. *VertigO* 8: 1-15.
- OCHYRA R. & PLÁŠEK V. 2020. — The sinking of another Tristan da Cunha moss endemic and its phytogeographical consequences. *Acta Societatis Botanicorum Poloniae* 89: 8936 <https://doi.org/10.5586/asbp.8936>
- O'SHEA B. 1995. — Checklist of the mosses of sub-Saharan Africa. *Tropical Bryology* 10: 91-198.
- ÖREN M., UYAR G. & KECELI 2012. — The bryophyte flora of the western part of the Küre Mountains (Bartın, Kastamonu), Turkey. *Turkish Journal of Botany* 36: 538-557. <https://doi.org/10.3906/bot-1111-2>
- PATON J. A. 1999. — *The liverwort Flora of the British Isles*. Harley Books, 626 p.
- PÓCS T. 2007. — Bryophyte communities at the edge of Tunisian Sahara with the description of *Gymnostomum viridulum* Brid. subsp. *saharae*, subsp. nov. (Pottiaceae, Bryophyta). *Nova Hedwigia Beiheft* 131: 101-120.
- ROS R. M., CANO M. J. & GUERRA J. 1999. — Bryophyte checklist of Northern Africa. *Journal of Bryology* 21: 207-244. <https://doi.org/10.1179/jbr.1999.21.3.207>
- ROS R. M., MAZIMPAKA V., ABOU-SALAMA U., ALEFFI M., BLOCKEEL T. L., BRUGUÉS M., CANO M. J., CROS R. M., DIA M., DIRKSE G. M., EL-SAADAWI W., ERDAĞ A., GANEVA A., GONZÁLEZ-MANCEBO J. M., HERRNSTADT I., KHALIL K., KÜRSCHNER H., LANFRANCO E., LOSADA-LIMA A., REFAI M. S., RODRÍGUEZ-NUÑEZ S., SABOVljević M., SÉRGIO C., SHABBARA H., SIM SIM M. & SÖDERSTRÖM L. 2007. — Hepatics and Anthocerotales of the Mediterranean, an annotated checklist. *Cryptogamie, Bryologie* 28: 351-437.
- ROS R. M., MAZIMPAKA V., ABOU-SALAMA U., ALEFFI M., BLOCKEEL T. L., BRUGUÉS M., CROS R. M., DIA M. G., DIRKSE G. M., DRAPER I., EL-SAADAWI W., ERDAĞ A., GANEVA A., GABRIEL R., GONZÁLEZ-MANCEBO J. M., GRANGER C., HERRNSTADT I., HUGONNOT V., KHALIL K., KÜRSCHNER H., LOSADA-LIMA A., LUÍS L., MIFSUD S., PRIVITERA M., PUGLISI M., SABOVljević M., SÉRGIO C., SHABBARA H. M., SIM-SIM M., SOTIAUX A., TACCHI R., VANDERPOORTEN A. & WERNER O. 2013. — Mosses of the Mediterranean, an annotated checklist. *Cryptogamie, Bryologie* 34: 99-283. <https://doi.org/10.7872/cryb.v34.iss2.2013.99>
- SWIFT J. 1996. — Desertification: narratives, winners and losers, in LEACH M. & MEARNS R. (eds.), *The Lie of the Land: Challenging Received Wisdom on the African Environment*. The International African Institute, Oxford: James Currey: 73-90.
- THÉRIOT I. 1900. — *Aperçu sur la flore bryologique de Tunisie*. Monnoyer, Le Mans, 15 p.
- TROIN J. F. 1985. — *Le Maghreb, Hommes et espaces*. Librairie Armand Colin, Paris, 360 p.
- WIGGINTON M. J. & GROLE R. 1996. — Catalogue of the Hepaticae and Anthocerotae of Sub-Saharan Africa. *Bryophytorum Bibliotheca* 50: 1-267.
- WIJK R. VAN DER, MARGADANT W. D. & FLORSCHUTZ P. A. 1964. — *Index Muscorum. Volume 3 (Hypnum – O)*. International Bureau for Plant Taxonomy and Nomenclature, Utrecht, 529 p.
- WINSLOW M. & THOMAS R. 2007. — Desertification in the Middle East and North Africa: Warning signs for a global future. *Journal of Agriculture and Rural Development* 14: 10-12.
- ZANDER R. H. & ECKEL P. M. 2007. — *Tortula* Hedwig, in FLORA OF NORTH AMERICA EDITORIAL COMMITTEE (ed.), *Flora of North America north of Mexico*. Volume 27 Bryophyta, part 1. Oxford University Press, New York - Oxford: 586-603.

Submitted on 4 February 2021;  
accepted on 27 July 2021;  
published on 29 October 2021.