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New records to the epiphytic bryophyte flora of Tunisia

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Abstract – A catalogue of 40 epiphytic bryophytes based on the study of 11 representative forests from northern Tunisia, is presented. Thirteen are new records to the country, and for them, updated maps showing their known distribution range in Northern Africa are provided. The distribution and composition of the epiphytic bryophyte communities in the study area are also commented upon.

Northern Africa / Tell Atlas / *Cryphaea* / *Didymodon* / *Fissidens* / *Neckera* / *Orthotrichum* / *Syntrichia* / *Zygodon* / *mosses* / *liverworts*

Résumé – Basé sur l'étude de 11 forêts représentatives du nord de la Tunisie, un catalogue de 40 bryophytes épiphytes de ce pays est ici présenté. Treize d'entre elles sont des nouveautés pour le pays, et des cartes montrant leur aire de distribution en Afrique du Nord, sont incluses. La composition et la structure des groupements de bryophytes épiphytes sont aussi commentées.

Afrique du Nord / Tell Atlas / *Cryphaea* / *Didymodon* / *Fissidens* / *Neckera* / *Orthotrichum* / *Syntrichia* / *Zygodon* / mousses / hépatiques

INTRODUCTION

In spite of the efforts made in the last decade (Ros *et al.*, 1999; Ros *et al.*, 2000; Cano *et al.*, 2002; Jiménez *et al.*, 2002; Draper *et al.*, 2003; Mazimpaka *et al.,* 2004, Draper *et al.*, 2005; Draper *et al.*, 2006), the bryophyte flora of North Africa is still only partially known. In Tunisia, most of the work on mosses was done before 1950, and known records were then compiled by Jelenc (1955, 1968). Unfortunately, none of these catalogues gives accurate information either on the sampled localities, nor on the ecological affinities of the species discussed. Regarding hornworts and liverworts, the most complete catalogue was published by Jovet-Ast & Bischler (1972). Subsequently some new records were added, all of them before 1978 (Ros *et al.*, 1999). All together, the checklist of Tunisian bryophytes comprises a total of 195 mosses, 87 liverworts and 4 hornworts.

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Among the outstanding gaps in our knowledge of the Tunisian bryoflora is the family Orthotrichaceae, with only five species – *Orthotrichum cupulatum* Hoffm. ex Brid., *O. lyellii* Hook. & Taylor, *O. rupestre* Schleich. ex Schwägr., *O. striatum* Hedw., and *Zygodon viridissimus* (Dicks.) Brid. –, in contrast to the rich representation of this family in Mediterranean epiphytic habitats (Lara *et al.*, 1994). This paper intends to remedy this deficiency, and to improve the knowledge of the distribution range of epiphytic bryophytes in North Africa.

MATERIAL AND METHODS

A field trip was held in the northern half of Tunisia, with the aim of evaluating the status of epiphytic bryophyte communities, and collecting epiphytic mosses and liverworts. This part of the country is subject to a Mediterranean climate, and although it can become humid in some sub-coastal and mountainous localities, it is mostly very dry or even arid. In addition, large areas of this territory have been deeply transformed due to agriculture and overgrazing. In localities where epiphytic bryophytes were found, the best preserved forests were selected for their study, in an attempt to record in full the variability of these communities. Eleven localities have been studied (Fig. 1), which are numbered and described in the following list:

1. *Quercus suber* L. forest bordering the road from Sejenane to Nefza, 10 km eastern Nefza. 120 m. 37º02'40''N/9º06'29''E. 21/03/2005. *F. Lara & E. San Miguel.*
2. Riparian forest, 10 km eastern Tabarka. 120 m. 36º57'19''N/8º55'50''E. 21/03/2005. *F. Lara & E. San Miguel.*
3. *Quercus suber* forest in the way up to Krumia. Tabarka, Aïn Draham. 120 m. 36º50'53''N8º42'58''E. 22/03/2005. *F. Lara & E. San Miguel.*
4. *Quercus suber* forest in Aïn Draham mounts. 675 m. 36º47'40''N/8º41'01''E. 22/03/2005. *F. Lara & E. San Miguel.*
5. Aïn Draham city. 760 m. 36º46'32''N/8º41'03''E. 22/03/2005. *F. Lara & E. San Miguel.*
6. *Quercus suber* forest in Jbel Bir mountain. 990 m. 36º46'12''N/8º42'06''E. 22/03/2005. *F. Lara & E. San Miguel.*
7. *Quercus suber* forest with *Q. canariensis* Willd. in Jbel Bir mountain. 970 m. 36º46'09''N/8º42'08''E. 22/03/2005. *F. Lara & E. San Miguel.*
8. *Quercus canariensis* forest in Aïn Draham mounts, 8 km south of the former locality. 970 m. 36º44'38'N/8º41'00''E. 22/03/2005. *F. Lara & E. San Miguel.*
9. Aïn Draham mounts. Bulla Regia, near Fenana. 470 m. 36º42'05''N/8º40'36''E. 22/03/2005. *F. Lara & E. San Miguel.*
10. Tebursuk city. 600 m. 36º28'00''N/9º15'00''E. 23/03/2005. *F. Lara & E. San Miguel.*
11. *Quercus ilex* L. forest in Aïn Bou Saidia. 610 m. 36º00'59''N/9º36'53''E. 27/03/2005. *F. Lara & E. San Miguel.*

In each locality, bryophyte samples were collected from the bases, trunks and branches of different phorophytes. The bryophyte nomenclature is based on Hill *et al.* (2006) for mosses, and Grolle & Long (2000) for liverworts.

For the new records, maps showing the species distribution in northern Africa are provided. These maps have been elaborated with ArcView GIS 3.2 software, and include previous reports from the bryophyte checklist of northern Africa (Ros *et al.*, 1999), and from recent studies in Morocco (Ros *et al.*, 2000; Cano *et al.*, 2002; Jiménez *et al.*, 2002; Draper, 2006). The specimens are kept in the authors'herbarium, Universidad Autónoma de Madrid.

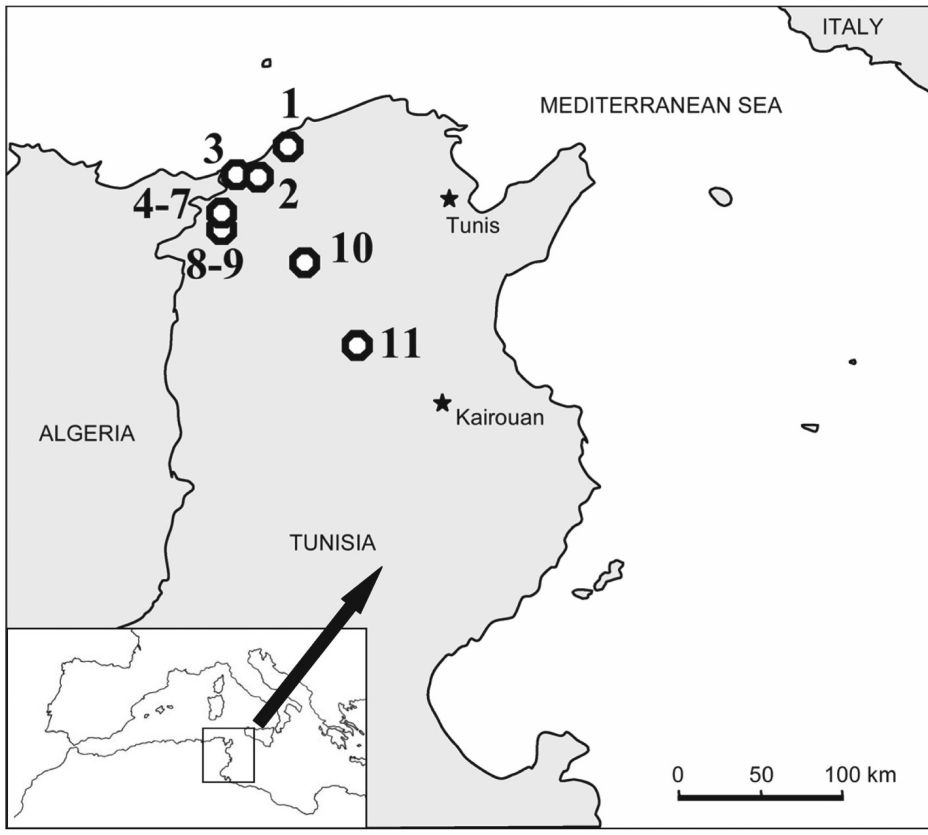


Fig. 1. Localization of the sampled sites.

RESULTS

Distribution of the epiphytic bryophyte communities in Tunisia

Most of the prospected area (the northern half of the country) lacks epiphytic bryophytes, which seems to be due to the excessively dry bioclimatic conditions of most of the Tunisian landscape. However, the eastern foothills of the Tell Atlas cordillera are subject to oceanic influences and have preserved natural forests that shelter luxuriant epiphytic bryophytes communities. Although in the lower sub-coastal lands of the north-western area the epiphytic communities are relatively poor, these become progressively richer with the altitude increase at the Aïn Draham Mountains. The maximum diversity is reached in forests dominated by *Quercus suber* and *Quercus canariensis* above 800 m a.s.l. on the northern slopes. Bryophyte communities on tree trunks and branches in these woods are luxuriant both in diversity and cover. The abundance of epiphytic bryophytes quickly decreases when descending along the southern

slopes of these mountains. Thus, towards both the south and east of this country, forests with bryophytic epiphyte communities are rare, and the few examples found are very poor in species number. Climatic limitations (most of the territory is too dry or even arid) and the loss of natural forest canopy are supposedly the causes of the scarcity and geographic concentration of the epiphytic bryophyte communities, which are mostly found in the favourable areas of the mountains sited in north western Tunisia.

Bryophyte catalogue

The liverworts and mosses are presented in alphabetical order. For each taxon, the recorded sites are given using the corresponding locality number, as well as its reproductive state (F: fertile, Fr: with sporophytes, Pr: propaguliferous), and the habitat where it was found growing. Chorological novelties are marked with * and their known distribution in northern Africa is briefly described.

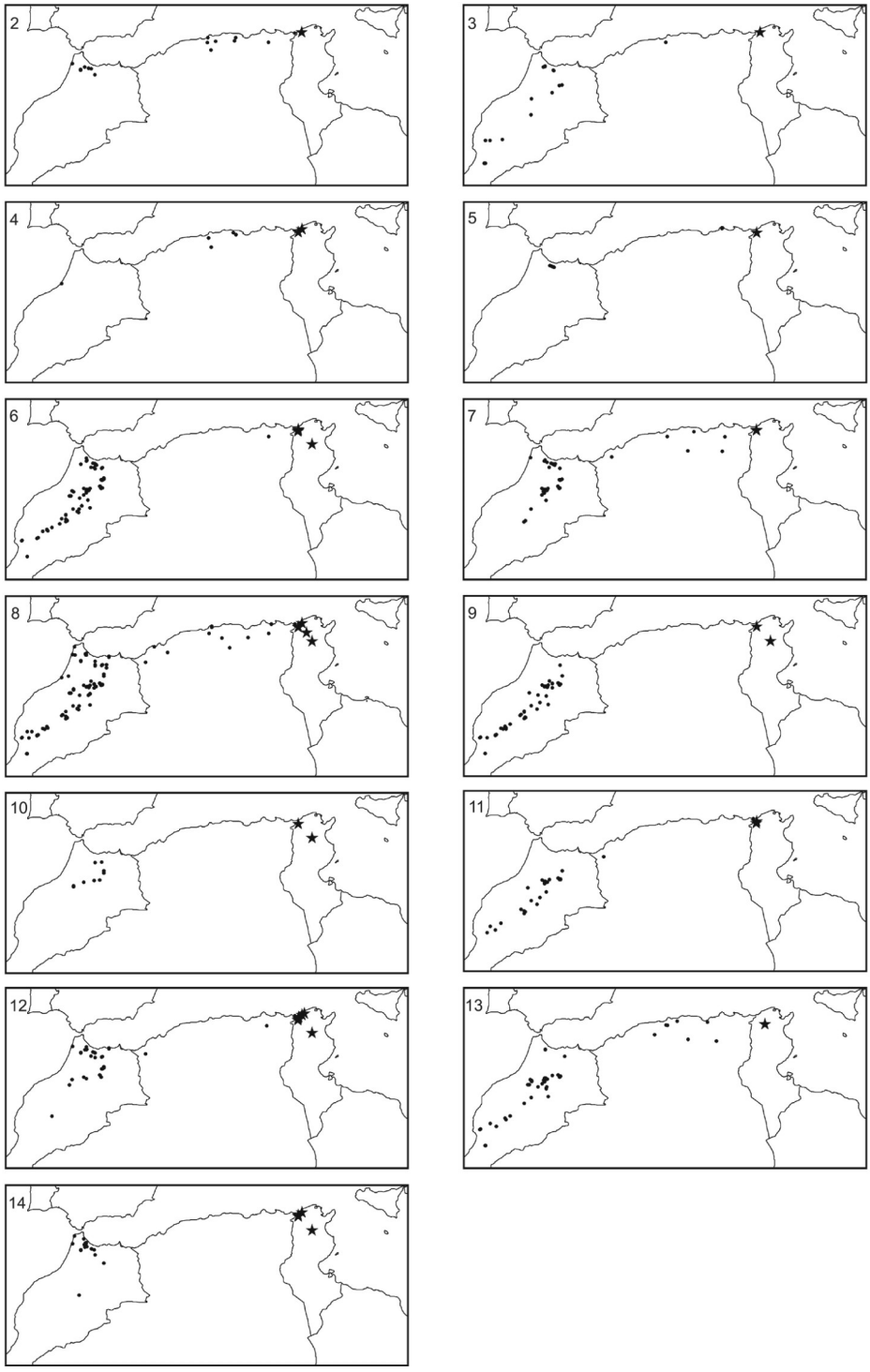
Marchantiophyta

***Frullania dilatata* (L.) Dumort.** – 1, 2^{Fr}, 4, 6^{F}, 7, 8, 9, 11^{F}. On bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.
***Lejeunea cavifolia* (Ehrh.) Lindb.** – 8. On tree bases of *Quercus canariensis*.
***Metzgeria furcata* (L.) Dumort.** – 4, 6, 7, 8. On trunks and branches of *Quercus suber*, *Q. canariensis* and *Arbutus unedo* L.
***Porella obtusata* (Taylor) Trevis.** – 4^{F}, 6, 8. On tree bases, trunks and branches of *Quercus suber*, *Q. canariensis* and *Arbutus unedo*.
***Radula complanata* (L.) Dumort.** – 6^{Fr}, 8^{F}. On tree bases, trunks and branches of *Quercus suber*, *Q. canariensis* and *Arbutus unedo*.
***Radula lindenbergiana* Gottsche ex C.Hartm.** – $2^{Pr, F}$, $4^{Pr, F}$. On tree branches of *Quercus suber*, and trunks of *Q. canariensis* and *Olea europaea* L.

Bryophyta

***Brachythecium rutabulum* (Hedw.) Schimp.** – 2^{Fr}. On trunk of *Olea europaea*.
***Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen** – 2, 11. On trunk of *Olea europaea* and tree base of *Quercus ilex*.
***Bryum capillare* Hedw.** – 6, 11. On trunks of *Quercus suber* and *Olea europaea*.
* ***Cryphaea heteromalla* (Hedw.) D.Mohr** – 2. On trunk of *Fraxinus angustifolia* Vahl. Previously reported from Algeria (Ros *et al.*, 1999) and Morocco (Draper, 2006), **new for Tunisia** (Fig. 2).
***Dialytrichia mucronata* (Brid.) Broth.** – 2^{Fr}. On trunks of *Fraxinus angustifolia* and *Olea europaea*.
* ***Didymodon insulanus* (De Not.) M.O.Hill** – 2. On trunk of *Fraxinus angustifolia*. Previously reported from Algeria and Morocco (Jiménez, 2003; Draper, 2006), **new for Tunisia** (Fig. 3).

Figs 2-14. Distribution in northern Africa of the chorological novelties for Tunisia. **2.** *Cryphaea heteromalla*. **3.** *Didymodon insulanus*. **4.** *Fissidens viridulus*. **5.** *Neckera pumila*. **6.** *Orthotrichum acuminatum*. **7.** *O. affine*. **8.** *O. diaphanum*. **9.** *O. macrocephalum*. **10.** *O. philibertii*. **11.** *O. schimperi*. **12.** *O. tenellum*. **13.** *Syntrichia princeps*. **14.** *Zygodon rupestris*.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***Fabronia pusilla* Raddi** – 2^{Fr}, 5^{Fr}. On trunks of *Olea europaea* and *Melia azedarach* L.

* ***Fissidens viridulus* (Sw. ex anon.) Wahlenb.** – 2^{Fr}, 4^{Fr}. On trunk of *Olea europaea* and base of *Quercus suber*. Previously reported from Algeria and Morocco (Ros *et al.*, 1999; Ros *et al.*, 2000), **new for Tunisia** (Fig. 4).

***Grimmia pulvinata* (Hedw.) Sm.** – 6, 11^{Fr}. On tree bases and trunks of *Quercus suber* and *Q. ilex*.

***Habrodon perpusillus* (De Not.) Lindb.** – 2, 3, 5, 8, 9. On trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

***Homalothecium sericeum* (Hedw.) Schimp.** – 2, 4, 6, 8. On trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

***Hypnum cupressiforme* Hedw.** – 1, 2, 3^{Fr}, 6^{Fr}, 8, 11. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber*.

***Hypnum uncinulatum* Jur.** – 4, 6^{Fr}. On trunks and branches of *Quercus suber* and *Arbutus unedo*.

***Kindbergia praelonga* (Hedw.) Ochyra** – 1, 2^{Fr}, 4, 11. On tree bases and trunks of *Quercus suber*, *Olea europaea* and *Crataegus laciniata* Ucria.

***Leptodon smithii* (Hedw.) F.Weber & D.Mohr** – 2^{Fr}, 3, 4^{Fr}, 5, 6^{Fr}, 7, 8^{Fr}, 11. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

***Leucodon sciuroides* (Hedw.) Schwägr. var. *morensis* (Schwägr.) De Not.** – 3, 4, 6^{Fr}, 7, 8^{Fr}, 11. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

* ***Neckera pumila* Hedw.** – 6. On branches of *Arbutus unedo*. Previously reported from Algeria and Morocco (Ros *et al.*, 1999; Draper, 2006), **new for Tunisia** (Fig. 5).

* ***Orthotrichum acuminatum* H.Philib.** – 4^{Fr}, 5, 6^{Fr}, 7^{Fr}, 8^{Fr}, 9^{Fr}, 11^{Fr}. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*. Previously reported from Algeria and Morocco (Ros *et al.*, 1999; Draper, 2006), **new for Tunisia** (Fig. 6).

* ***Orthotrichum affine* Schrad. ex Brid.** – 5, 6^{Fr}, 7^{Fr}, 8^{Fr}. On trunks and branches of *Quercus suber*, *Q. canariensis* and *Melia azedarach*. Previously reported from Algeria and Morocco (Ros *et al.*, 1999; Draper, 2006), **new for Tunisia** (Fig. 7).

* ***Orthotrichum diaphanum* Schrad. ex Brid.** – 2^{Fr}, 5^{Fr}, 6^{Fr}, 8^{Fr}, 10^{Fr}, 11^{Fr}. On tree bases, trunks and branches of different phorophytes. Previously reported from Algeria and Morocco (Ros *et al.*, 1999; Draper, 2006), **new for Tunisia** (Fig. 8).

***Orthotrichum lyellii* Hook. & Taylor** – 4^{Pr}, 5^{Pr}, $6^{Pr, Fr}$, $7^{Pr, Fr}$, 8^{Pr}, 9^{Pr}. On trunks and branches of different phorophytes especially *Quercus suber* and *Q. canariensis*.

* ***Orthotrichum macrocephalum* F.Lara, Garilleti & Mazimpaka** – 5^{Fr}, 11^{Fr}. On trunks of different phorophytes, especially on *Quercus ilex* and *Crataegus laciniata*. Previously reported from Morocco (Draper, 2006), **new for Tunisia** (Fig. 9).

* ***Orthotrichum philibertii* Venturi** – 8^{Fr}, 11^{Fr}. On tree bases, trunks and branches of different phorophytes, especially on *Quercus canariensis*. Previously reported from Morocco (Draper, 2006), **new for Tunisia** (Fig. 10).

***Orthotrichum rupestre* Schleich. ex Schwägr.** – 5, 6^{Fr}. On trunks and branches of *Quercus suber* and *Gleditsia triacanthos* L.

* ***Orthotrichum schimperi* Hammar** – 5^{Fr}, 9^{Fr}. On trunks of *Quercus suber*, *Gleditsia triacanthos* and *Melia azedarach*. Previously reported from Algeria and Morocco (Jelenc, 1955; Draper, 2006), **new for Tunisia** (Fig. 11).

***Orthotrichum striatum* Hedw.** – 4, 5, 6^{Fr}, 7^{Fr}, 8^{Fr}. On trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

* ***Orthotrichum tenellum* Bruch ex Brid.** – 1^{F}, $2^{Pr, Fr}$, 3^{Fr}, 4^{Fr}, 5^{Fr}, 6^{Fr}, 9^{Fr}, $11^{Pr, Fr}$. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber*. Previously reported from Algeria and Morocco (Ros *et al*., 1999; Draper, 2006), **new for Tunisia** (Fig. 12).

***Pterogonium gracile* (Hedw.) Sm.** – 2, 3^{Fr}, 4^{Fr}, 6, 8^{Fr}. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

***Syntrichia laevipila* Brid.** – 2^{Fr}, 3^{Fr}, 4^{Fr}, 5^{Fr}, 6^{Fr}, 7^{Fr}, 8^{Fr}, 9^{Fr}, 10, $11^{Pr, Fr}$. On tree bases, trunks and branches of different phorophytes, especially on *Quercus suber* and *Q. canariensis*.

* ***Syntrichia princeps* (De Not.) Mitt.** – 10. On trunk of *Fraxinus angustifolia*. Previously reported from Algeria and Morocco (Ros *et al*., 1999; Gallego, 2002; Draper, 2006), **new for Tunisia** (Fig. 13).

***Tortella flavovirens* (Bruch) Broth.** – 2. On trunks of *Fraxinus angustifolia* and *Olea europaea*.

***Tortella humilis* (Hedw.) Jenn.** – 11^{F}. On base of *Quercus ilex*.

***Tortula subulata* Hedw.** – 11. On trunk of *Crataegus laciniata*.

* ***Zygodon rupestris* Schimp. ex Lorentz** – $2^{Pr, Fr}$, $4^{Pr, Fr}$, 8^{Pr}, 11. On tree bases, trunks and branches of different phorophytes, especially on *Quercus canariensis* and *Olea europaea*. Previously reported from Morocco (Draper, 2006), **new for Tunisia** (Fig. 14).

DISCUSSION

The catalogue of Tunisian epiphytic bryophytes comprises 40 taxa (34 mosses and 6 liverworts), which belong to 18 families (13 of mosses and 5 of liverworts), according to Buck and Goffinet (2000) for the mosses, and Crandall-Stotler & Stotler (2000) for the liverworts. Orthotrichaceae is the best represented family, with 11 species (10 of them being *Orthotrichum* species). Other important families are Pottiaceae and Brachytheciaceae, with 7 and 4 species respectively. The remaining families are only represented by one or two species in the epiphytic habitat. The importance of Orthotrichaceae in the epiphytic habitat is common throughout the Mediterranean basin (Lara & Mazimpaka, 2001). On the contrary, Pottiaceae and Brachytheciaceae include mainly preferentially not corticolous mosses, most of which only colonize tree bases under special conditions of high moisture (Albertos *et al.*, 2005). As it has been indicated, atmospheric humidity is especially high in *Quercus canariensis* and *Q. suber* forests, where the trunks harbour types of epiphytic communities that, being typically oceanic-Mediterranean, have a luxuriance that is unusual in this area. These communities are dominated by pleurocarpous mosses, such as *Leptodon smithii*, *Leucodon sciuroides* var. *morensis* or *Pterogonium gracile*. In addition, the liverworts *Porella obtusata* and *Metzgeria furcata* are also usually abundant in these forests. Conversely, other forest types in Tunisia lack epiphytic bryophytes or harbour poor communities, mostly composed of xerophytic acrocarpous mosses.

Most of the epiphytic bryophytes included in this catalogue were already known to occur in Tunisia. However, this paper contributes to the knowledge of

the bryoflora of this country with 13 new records, most of them *Orthotrichum* species. The new records are mostly typical Mediterranean mosses, like *Orthotrichum acuminatum*, *O. macrocephalum*, *O. tenellum*, *O. schimperi*, *O. philibertii*, *O. diaphanum* and *Zygodon rupestris*. In the sampled forests, these mosses mostly grow on the youngest branches or on trunks of isolated trees in cities or road sides, where the hygrophytic taxa mentioned above disappear. This preference for higher parts of phorophytes in woods and isolated trees could explain their absence in previous catalogues.

For some of the Tunisian novelties, the new records notably increase their known distributional range in Northern Africa: *Neckera pumila* was only previously known to occur in the Moroccan Rif mountains (Fig. 5); *Orthotrichum philibertii* was known from the Moroccan Rif and Middle Atlas mountains (Fig. 10); *Zygodon rupestris* was known from various localities in the northern half of Morocco (Fig. 14); *Orthotrichum macrocephalum* had only been reported from Morocco, where it is one of the most frequent epiphytes in the Atlas mountain ranges (Fig. 9), *O. schimperi* (Fig. 11) has a known distributional area in Morocco similar to that of *O. macrocephalum*, but has also been reported from the northwest of Algeria. Some other taxa new for Tunisia, such as *Didymodon insulanus* (Fig. 3), *Orthotrichum acuminatum* (Fig. 6) and *O. tenellum* (Fig. 12), are also widely distributed in the Moroccan mountains (Draper *et al.*, 2006) but have been scarcely reported from Algeria. Their presence in the Tunisian Tell Atlas suggests that they could also be extensively represented in northern Algeria.

On the other hand, current data for some other epiphytic mosses seem to outline accurately their total distributional area in Northern Africa, the Tunisian localities being the eastern limit of their range. This is the case of *Cryphaea heteromalla* (Fig. 2) and *Orthotrichum affine* (Fig. 7). With respect to *Fissidens viridulus* (Fig. 4), *O. diaphanum* (Fig. 8) and *Syntrichia princeps* (Fig. 13), this could also be true if considering their distribution as epiphytes. Nevertheless, their ecological amplitude, that allows them to colonize other habitats than the epiphytic one, can facilitate their extension to other countries of Northern Africa.

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