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New data on freshwater lichens in Mediterranean streams

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Abstract. New chorological data on freshwater lichens in central Spain are presented. We have identified twenty-one saxicolous species resistant to periodic immersion at five localities of Montes de Toledo. Eighteen species are reported for the first time in Castilla-La Mancha territory. Remarkable extensions in the distribution range are found for most lichen species highlighting the importance of intermittent streams for lichen diversity in the Mediterranean Region.

Keywords. distribution, aquatic habitat, saxicolous lichens, central Spain.

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Introduction

Rocks subjected to periodic immersion by intermittent watercourses are colonized by diverse lichen species (Nascimbene & Nimis, 2006; Coste, 2009; Krzewicka *et al*., 2020). These rocks endure variable duration of immersion, with those close to the center of the stream being exposed much longer than those at the upper limit of the streambed (Coste, 2009; Krzewicka *et al*., 2017). In freshwater habitats lichen diversity is very low compared to terrestrial habitats, although they represent a unique fraction of understudied flora composed of a few taxonomic groups that are "specialist taxa" (Nascimbene & Nimis, 2006; Thüs *et al*., 2014; Krzewicka *et al*., 2020).

In the Iberian Peninsula only a few papers are devoted to freshwater lichens. The main contributions were led by Iris Pereira (e.g., Pereira & Llimona, 1987; 1992; Pereira *et al*., 1987) and Carlos P. Valcárcel (e.g., Valcárcel *et al*., 1999; Valcárcel & Carballal, 2002) covering specific northern and southern areas. More recently, Valcárcel & López de Silanes (2010) addressed a broader study about the aquatic species of the genus *Verrucaria*, and Romero & Navarro-Rosinés (2021) provided some notes on the aquatic lichens of the northwest. However, contributions in the inland regions of the Iberian Peninsula are restricted to a few records within more extensive studies (Sancho, 1985; Etayo, 2010; Valcárcel & López de Silanes, 2010). In this note, we include some species colonizing rocks subjected to periodic immersion by intermittent watercourses in central Spain.

Material and Methods

The study was conducted on siliceous rocks (quartzite and slate), at five specific localities of Montes de Toledo that naturally and eventually experience periods of partial or complete flow disruption during the year. It should be noted that rivers and streams in Montes de Toledo endure an intense dry season, with the streambed narrowing considerably, nearly disappearing in some places (Perea *et al*., 2015) (Figure 1).

Following literature has been used for species identification: Orange (1998, 2013), Valcárcel et al. (1999), Valcárcel & López de Silanes (2010), Coste (2011), and the online keys published in ITALIC - Nimis & Martellos (2020). We followed the suggestions of ITALIC for *Verrucaria hydrela* and *V. latebrosa*. All samples were included in MACB herbarium.

Localities of sampling: (1) Spain, Toledo: Robledo de Mazo, Lanchas gorge, 39º34'48.7"N, 4º53'42.8"W, 820 m asl, quartzites; (2) Spain, Toledo: Los Navalucillos, Chorro stream, 39º32'48.9"N, 4º38'30.1"W, 953 m asl, quartzites; (3) Spain, Ciudad Real: Horcajo de los Montes, Chorrera stream, 39º21'41.6"N, 4º36'54.3"W, 660 m asl, quartzites; (4) Spain, Ciudad Real: Navas de Estena, Boquerón del Estena, 39º29'21.7"N, 4º32'52.1"W, 650 m, slates; (5) Spain, Toledo: Hontanar, Alto Estena, 39º33'48.5"N, 4º34'59.1"W, 840 m asl, slates.

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Table 1. Species recorded in five sampling localities; (1) Toledo: Robledo de Mazo, Lanchas gorge; (2) Toledo: Los Navalucillos, Chorro stream; (3) Ciudad Real: Horcajo de los Montes, Chorrera stream; (4) Ciudad Real: Navas de Estena, Boquerón del Estena; (5) Toledo: Hontanar, Alto Estena. Substrate: Q = quartzites; S = slates. Species recorded for the first time in Castilla-La Mancha territory are marked with asterisk (*).

	Locality, substrate				
Species	**1Q**	**2Q**	**3Q**	**4S**	**5S**
**Aspicilia aquatica* (Fr.) Körb.	X				
**Buellia spuria* (Schaer.) Anzi		X			
**Caloplaca diphyodes* (NyI.) Jatta				X	X
Catillaria chalybeia (Borrer) A. Massal.	X		X	X	X
**Dermatocarpon leptophyllodes* (Nyl.) Zahlbr.		X			
Dermatocarpon luridum (Dill. ex With.) J.R. Laundon				X	
**Dermatocarpon meiophyllizum* Vain.	X	X	X		X
**Hydropunctaria scabra* (Vězda) C. Keller *et al.*	X				
**Ionaspis lacustris* (With.) Lutzoni	X	X			
**Lobothallia melanaspis* (Ach.) Hafellner				X	
**Polyblastia quartzina* Lynge		X			
**Porina chlorotica* (Ach.) Müll. Arg.	X	X			
**Rinodina fimbriata* Körb.				X	
**Stautothele fissa* (Taylor) Zwackh	X	X			
Verrucaria aethiobola Wahlenb.	X	X	X	X	X
Verrucaria elaeomelaena (A. Massal.) Arnold			X		
**Verrucaria funckii* (Spreng.) Zahlbr.		X			
**Verrucaria hydrela* Ach.	X	X			X
**Verrucaria latebrosa* Körb.			X		
**Verrucaria pachyderma* Arnold	X	X			
**Verrucaria praetermissa* (Trevis.) Anzi	X		X	X	X

Results

We have identified 21 species resistant to periodic immersion (Table 1). Quartzite rocks hosted a higher species richness because they represent a stable substrate, hard and difficult to erode, while slates are more brittle, suffering greater erosion that hinders lichen colonization. The genus with the highest number of species was *Verrucaria* (seven species), and similarly to other contributions, most of the species listed, together with *Hydropunctaria scabra,* were associated with rocks near the center of the stream. These species were immersed during most of the year and are considered to be typical aquatic lichens that disappear as the distance to the streambed increases (Krzewicka *et al*., 2017). The intermediate band located between the center of the stream and the adjacent riparian zones was mainly occupied by *Ionaspis palustris* (Figure 2A) and *Staurothele fissa* (Figure 2B) accompanied, to a lesser extent, by *Aspicilia aquatica*, *Caloplaca diphyodes, Rinodina fimbriata*, *Lobothallia melanaspis* and *Verrucaria* sp.pl. This band experiences longer periods of flow disruption and hosts the highest diversity of freshwater lichens (Thüs *et al*., 2014). In addition, the species of *Dermatocarpon* were growing on intermittently inundated rocks by colonizing small cracks and cavities. Finally, a group of species (*Buellia spuria*, *Catillaria chalybeia*, *Polyblastia quartzina* and *Porina chlorothica*) were mainly associated with the adjacent riparian zone characterized by longer periods of flow disruption and, consequently, shorter immersion periods.

The scarcity of data on freshwater lichens in inland Iberian regions highlights the chorological interest of this study in which 18 species have been recorded for the first time in Castilla-La Mancha territory (Table 1). These species include *Aspicilia aquatica* and *Caloplaca diphyodes* that were only known from a few localities in the northern half of the Iberian Peninsula (Llimona & Hladun, 2001; Etayo, 2010); *Dermatocarpon leptophyllodes* and *Hydropunctaria scabra* that were recently reported for the first time in the northeastern Iberian Peninsula (Olariaga, 2021; Romero & Navarro-Rosinés, 2021, respectively); *Lobothallia melanaspis*, a scarce species only known from Madrid, Asturias and Huesca (Earland-Bennett *et al*., 2006 in Burgaz 2006; Van den Boom & Etayo, 2014; Etayo, 2010, respectively); and *Polyblastia quartzina* and *Rinodina fimbriata* that were previously recorded in some northeastern locations (Hladun & Font, 2018). Besides, some species (*Dermatocarpon meiophyllizum, Ionaspis lacustris, Stautothele fissa*) were more frequent in the northern half of the Iberian Peninsula, being less common in the central

Figure 1. Mountain stream in the study area (39º32'48.9"N, 4º38'30.1"W, 953 m asl, 16/09/2022).

Figure 2. A, *Ionaspis lacustris*; B, *Staurothele fissa*. Bar = 0.5 cm.

and southern territories (Llimona & Hladun, 2001). Furthermore, *Verrucaria* species were more frequent in the northeast and northwest, where most studies on freshwater lichens were conducted (Llimona & Hladun, 2001; Valcárcel & López de Silanes, 2010; Romero & Navarro-Rosinés, 2021). For example, *Verrucaria latebrosa* was previously recorded from three locations in the northern half of the Iberian Peninsula (Sancho, 1985; Valcárcel & López de Silanes, 2010).

The finding of many of the species included in the list has led to a substantial increase in the knowledge of their distribution range, expanding to territories in the interior of the Iberian Peninsula, which reflects the importance of intermittent rivers and streams for lichen diversity in the Mediterranean Region.

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Authorship contribution

GA: conceptualization, research, methodology, management of the project, data gathering, writing (first draft, review and editing); MV: research, data gathering, resources, visualization, writing (review); GFG: research, resources, writing (review); PH: research, data gathering, resources, writing (first draft, review and editing).

Conflict of interest

None.

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