New locality of *Adiantum capillus-veneris* (*Pteridaceae*) in Bosnia and Herzegovina

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Received: December 01, 2020 ▷ Accepted: November 21, 2021

Abstract. A new locality for *Adiantum capillus-veneris* in Bosnia and Herzegovina (B&H) is described in the paper. The species was found at the periphery of the Zenica-Sarajevo Basin, in the temperate climate belt. Considering the conservation status of the Maidenhair Fern in B&H, the new locality should be designated as a Natura 2000 site (Habitat code 7220) as soon as possible.

Key words: Bosnia, conservation, distribution, habitat

Introduction

Maidenhair Fern, *A. capillus-veneris* L., is a homosporous fern of global range. However, its distribution in Europe is limited by the oceanity of climate, because it prefers humid and sheltered places. Hence, it reaches the highest abundance in the Mediterranean (Jalas & Suominen 1972), whereas that abundance descreases inland on the continent. It has reached its northern limit in Europe, on the British Isles, thanks to the Gulf Stream influences (Ritter-Studnička 1957). There, it occurs in crevices or on tufa deposits of damp rocks (Stewart & al. 1994), but it is also naturalized on man-made substrates around the British Isles (Pryor & al. 2001). Along the southern stretch of the Alps, it occurs in the montane belt (Aeschimann & al. 2004).

On the territory of former Yugoslavia, it was detected in Slovenia, Croatia, Bosnia and Herzegovina (B&H), Montenegro and the Republic of North Macedonia (Horvatić 1967). In Slovenia, most of the localities are situated in Istra, with several in the alpine region, about 20 km into the mainland (Glasnović 2007; Dakskobler & al. 2014, 2017). In Croatia, *A. capillus-veneris* occurs along the coastline, especially on the islands (Matoničkin & Pavletić 1960; Topić & Šegulja 2000; Šilić & Šolić 2001; Ljubičić & Britvec 2006; Boršić & al. 2009; Milović 2015; Bauer 2018). According to Đug & al. (2013), its localities in B&H are scattered mainly to SE Herzegovina, in the submediterranean climate: the waterfall Kravice on the river Trebižat, tufa-forming waterfalls of Bregava river, canyon of Drežnica river, Mostar city, wellhead of Buna and Tihaljina river, at Ljubuški around the wellhead of Vrioštica, at Peć-Mlini, and on the cliffs above the stream Trmošnica at Golubić. Lasić & al. (2014) stated that association the *Eucladio-Adiantetum capilli-veneris* Br.-Bl. ex Horvatić 1934 occurs along the karstic rivers Trebižat and Lištica. So far, in Bosnia, in the temperate continental climate, *A. capillus-veneris* has been known only from few localities: Banja Luka (Ritter-Studnička 1957), Višegrad (Ritter-Studnička 1969) and Vranduk, but it had vanished from the latter in the late 1970s (Ritter-Studnička 1973).

Maidenhair Fern prefers shaded and wet rocks, caves and half-caves, especially in the tufa formations of the karstic rivers. It is a characteristic species of the class *Adiantetea capilli-veneris* Br.-Bl. 1948. The aim of

the preset research is: (i) to provide detailed description of a new locality in B&H; (ii) to inspect localities in the area that are potential habitats of the Maidenhair Fern.

Material and methods

Study area

The study area is situated along the NE perimeter of the Zenica-Sarajevo Basin, characterized by a specific geogenesis that led to the occurence of six thermomineral springs. This is the macroregion of the Bosnian highlands, with altitudes from 450 to 1300 m. Maidenhair Fern was found at the Sedra spring, on the left bank of Stavnja river, at 497 m a.s.l.

The bedrock is formed of cretaceous flysch sediments (Skopljak & al. 2017). According to Hrvatović (2006), post-orogenic Oligocene, Neogene, and Quarternary formations occur in the area. The tufa deposits are formed by dissolution of carbonates, favoured by the high water temperature and in-depth pressure, and accumulated around the spring itself. The underground is pierced by a network of karstic forms filled by thermo-mineral water. Water at the Sedra spring contains 1121mg/l of minerals, while its average temperature is +19,3 °C (Skopljak & al. 2017). The overall yield of the spring is 32 l/sec (Đerković 1982).

According to Drešković (2011), the investigated area has characteristically durable sunshine, which is below the average in B&H (1580,6 h/year), with a mean annual temperature of +9,7 °C and average annual precipitation of 785 mm.

The field study at the Sedra locality was conducted during the vegetation seasons of 2019-2020. In 2020, three more localities around the thermal springs with tufa deposits along the NE perimeter of Zenica-Sarajevo Basin were checked for occurence of the Maidenhair Fern.

The vegetation was analised according to the Zürich-Montpelliers School (Braun-Blanquet 1964). The nomenclature of vascular plants follows the Euro+Med PlantBase (Euro+Med 2006-) and for the bryophytes follows Sabovljević & al. (2008). The voucher specimen was deposited in the Herbarium of the National Museum of Bosnia and Herzegovina (SARA 52357).

Results and discussion

At the Sedra spring, the population of *A. capillus-veneris* occurs in two ecologically different microhabitats. The first one is a cave-like channel (1.5 m wide), which runs through a massive tufa ridge (Fig. 1) and ends on the other side of it, on the bank of Stavnja river. The study has shown that the channel is supplied with underground water with high concentration of Fe_2O_3, which explains why the ground is covered by orange-coloured deposits. The entrance of the channel is shaded by shrubs of *Humulus lupulus* and *Rubus fruticosus*. The population of *A. capillus-veneris* has been stable over the analised period, covering at the peak of the vegetation season about 0.25 square meters (Fig. 2).

The second microhabitat is on the opposite side of the ridge, which is a travertine cliff. The cliff is about 2 m high, with permanent water spray and shaded by an alluvial alder forest (Fig. 3). *A. capillus-veneris* has been found within the community *Eucladio-Adiantetum capilli-veneris* Br.-Bl ex Horvatić 1934. In its floristic composition, the highest abundance is shown by *Pellia fabroniana, Marchantia polymorpha, Eucladium verticillatum, Palustriella commutata,* and *A. capillus-veneris* (Fig. 4). Almost the same floristic composition has been reported by Ritter-Studnička for the locality at Višegrad (Ritter-Studnička 1969).

The vegetation around the Sedra spring is of thermophylous shrubs belonging to the order *Ostryo-Carpinetalia orientalis*. The floristic composition comprises: *Ostrya carpinifolia, Quercus pubescens, Fraxinus ornus, Acer obtusatum, Epimedium alpinum, Hepatica nobilis, Potentilla micrantha,* and *Asarum europaeum*. The locality of *A. capillus-veneris* at Vranduk is also surrounded by thermophylous shrubs (Ritter-Studnička 1973), which indicates a xerothermic microclimate in the habitat. Ritter-Studnička (1957) has specified the distribution of *A. capillus-veneris* in B&H by a mean temperature for the coldest month of +3 °C. Its continental populations are protected from freezing by the warm and humid air swirling around the thermal springs. In Europe, the most extreme habitat along these lines has been found at 1500 m a.s.l. in the spa Bagni Vecchi, where *A. capillus-veneris* has completely come out of its climate-zonal range (Ritter-Studnička 1957).

On the other hand, a study of the community in Sicily has shown its high tolerance range of long summer droughts (Puglisi & al. 2018).

Fig. 1. Opening of the channel at the road.

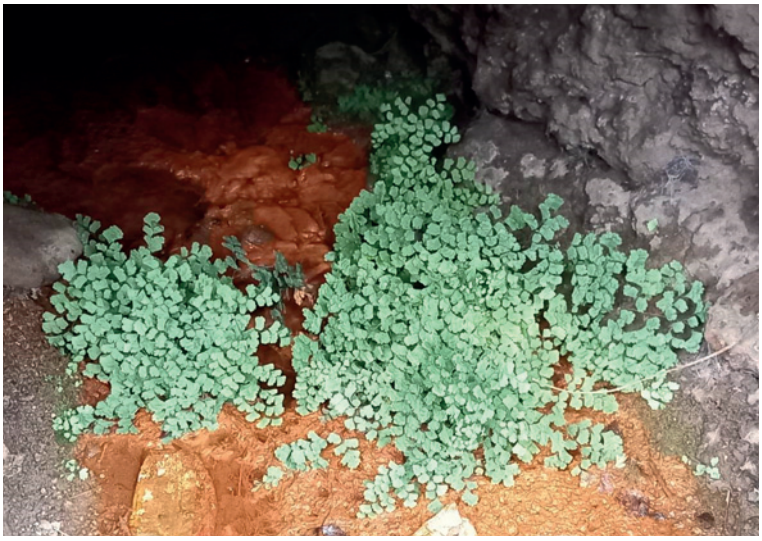

Fig. 2. The cave-like channel with A. capillus-veneris.

Fig. 3. A broader view of the microhabitat at the Stavnja river.

Fig. 4. *A. capillus-veneris* at the left bank of Stavnja river.

Fig. 5. Distribution map of *A. capillus-veneris* in B&H (new locality in orange).

During the present research, *A. capillus-veneris* has not been detected in other localities, because they were exposed to full sunlight. High light intensity leads to its extinction from the habitat, even if the other ecological factors are in the optimal range (Ritter-Studnička 1973; Puglisi & al. 2018). Thus, light functions as one of the limiting factors for the distribution of *A. capillus-veneris*, which was the reason for its disapearance from the Vranduk locality in the early 1970s.

The population at Sedra spring connects the continental populations of *A. capillus-veneris* in Bosnia, in the NW-SE direction (Fig. 5).

Apparently, its distribution follows the deep fault along the southern border of the ophiolitic zone in B&H. In this belt, patches of habitats with Tertiary flora and vegetation occur (province of the relict pine woods). In the floristic composition of the occuring plant communities, relict and rare taxa prevailed. Deil (1998) pointed out that vegetation of the class *Adiantetea* provided shelters for ancient forms of widely distributed genera and allowed them to go through the process of speciation.

According to the IUCN, the conservation status of *A. capillus-veneris* on a global scale is LC - Least Concern (Lansdown & Bilz 2018). However, its populations in B&H, especially the continental ones, are associated with tufa formations, which are recognized in Annex I of the Community Directive 92/43/EEC (Habitat code 7220) as a priority habitat. Recently, the tufa formations in the region are being exposed to severe human impact (pollution, habitat conversion, over-exploitation, climate changes), which leads to habitat loss for the tufa-associated taxa. For this reason, the conservation status of *A. capillus-veneris* in the Federation of B&H is listed as VU (Đug & al. 2013), as it is in Slovenia (Anonymous 2002), whereas in Croatia it is evaluated as NT (Nikolić & Topić 2005).

Considering all that, it is of the utmost importance to designate the Sedra spring as a new Natura 2000 site in B&H, and to set up proper conservation measures as soon as possible.

Conflict of interest. The authors declare no conflict of interest.

Acknowledgements. The authors would like to thank Prof. Edina Muratović from the University of Sarajevo for her kind suggestions and comments on the preliminary version of the paper. They are also grateful to the anonymous reviewer for the thorough revision and comments on the paper.

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