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NOTES UPON THE FLORA OF THREE VALLEYS IN THE IRON GATES NATURAL PARK, ROMANIA

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ABSTRACT. *The study of flora in natural parks is a continuous and ongoing requirement for identifying the status of ecosystems. In this context, we aimed to investigate the flora in three valleys of the Iron Gates Natural Park, including taxonomic assessment, life-forms, eco-physiological analysis, and a list of invasive species. In the summer of 2022, we identified 80 taxa in 35 families in the Ogradena Valley, 103 species in 52 families in the Slătinicul Mare Valley, and 122 taxa belonging to 44 families in the Vodița Valley. The best-represented family was Asteraceae. In the three valleys, 11 invasive species were identified. The species with the highest shares were mesophytic, mesothermal, and thermophilic, as well as nitrophilous and eutrophilous. Regarding life-forms, hemicryptophytes and phanerophytes are the predominant types.*

KEYWORDS: *invasive species, ecological condition, life-forms, protected area, taxonomical assessment.*

INTRODUCTION

Plants can be grouped into classes of life forms based on their similarity in structure and function (Muller-Dombois & Ellemberg 1974), where a life form is characterized by the adaptation of plants to specific ecological conditions (Mera et al. 1999). Species diversity is closely related to habitat structure, with more complex habitats hosting higher biodiversity (Bell et al. 1991). The Iron Gates Natural Park (IGNP) is part of this European network of protected natural areas (Rozylowicz et al. 2021), aiming to conserve endangered, vulnerable, or threatened plant and animal species, as well as their natural environment, in close connection with the development of the local community (Nicula et al. 2012). It holds a complex system of rivers, ponds, ditches, and floodplains, all bordered by mountains (Goia & Oprea 2014). With an area of 115.655 ha, the IGNP hosts a significant amount of biodiversity (Rozylowicz et al. 2019, IGNP Management Plan 2020). The IGNP has been intensely studied especially in the last century, when the construction of the hydropower plants and the subsequent changes to the area brought together specialists from several fields to demonstrate the importance of the biodiversity of these habitats with or without anthropic impact (e.g., Csűrös et al. 1968, Sanda et al. 1968, Coldea et al. 1970, Șerbănescu & Sanda 1970, Schneider-Binder et al. 1970, Todor et al. 1971, Dihoru et al. 1973, Morariu et al. 1973, Raclaru & Alexan 1973, Popescu & Ștefureac 1976, Grigore & Coste 1978, Nedelcu & Sanda 1982, Matacă 2005, Milanovici 2012, 2014, Drăgulescu 2014, Schneider-Binder 2014, Goia et al. 2017, Urziceanu et al. 2021).

The flora of the IGNP comprises 1875 vascular plant taxa (Matacă 2005), and its study is a continuous and ongoing requirement for identifying the status of ecosystems. Moreover, identifying invasive species and monitoring their spread in protected areas is imperative, as they have the potential to significantly alter the landscape of these areas (Rai 2015, Keller et al. 2011). Chytrý et al. (2009) predicted that the Lower Danube Basin would exhibit high levels of invasion, and it would, alongside the Po River Basin, have the highest presence of neophytes in Europe. In other areas, prior to 2019, over 13,000 vascular plant species had become naturalized outside their native range (van Kleunen et al. 2015, 2019). Additionally, habitat type is considered the most significant predictor of plant invasion levels (Pyšek et al. 2010), surpassing the importance of climate pressure and propagules (Chytrý et al. 2008). This is why we have proposed contributing to the study of the flora in three valleys that cross the park on their way to the Danube: the Ogradena Valley, the Slătinicul Mare Valley, and the Vodița Valley. The hypothesis we started with was that the three valleys of the IGNP exhibit a high biodiversity of flora, with eco-physiological requirements specific to the sub-Mediterranean climate; however, invasive species are also present. To verify this hypothesis, we conducted a species inventory in the studied area to perform a taxonomic assessment of their life forms and ecology, as well as to compile a list of invasive species. The study of these valleys arose from the need to assess the current state of anthropogenic impact on the flora, particularly in terms of the disturbance caused by invasive species.

MATERIALS AND METHODS

The field trips for data collection were carried out in July 2022. The data collection was carried out in three valleys of the IGNP: the Ogradena Valley, the Slătinicul Mare Valley, and the Vodița Valley, all situated within the IGNP, which are streams that are tributaries of the Danube. The survey sections were established for each valley researched, with a total of 3 km being outlined for each valley. The configuration of the valleys studied in the IGNP is imposed on the landscape either through depression basins, such as the Ogradena-Orșova depression, or through gulfs at the outlet (Slătinicul Mare and Vodița) (Rozylowicz et al. 2019). The Ogradena Valley (44°40'10.7"N, 22°18'09.2"E) is an area with high anthropogenic activity, located near the national road DN57, with a forest road along the valley. The Slătinicul Mare Valley, located at GPS coordinates 44°41'56.1"N, 22°30'18.8"E, features a beech forest that has regenerated following logging activities. The Vodița Valley, with GPS coordinates 44°43'24.0"N, 22°29'35.0"E, is situated between the other two valleys. It features the typical eroded soil common in the park, which, in the past, was altered by the presence of an access road to human settlements, which is now entirely covered by deciduous forests (IGNP Management Plan 2020). The last two valleys connect to the European road E70. The identification of plant taxa was carried out using various identification keys. Flora R.P.R.-R.S.R., vol. I-XIII (Săvulescu 1952-1976) was used to identify and determine plant taxa, and Flora Europaea (Tutin et al. 1993) was used to standardize scientific names, for the classification of phytotaxons, life-form categories, biogeographical, ecological, and economic elements. Additionally, some published monographs on the flora and vegetation of Romania (Sanda et al. 2008) and the Database of European Vegetation, Habitats, and Flora (Chytrý et al. 2024) were consulted. Statistical processing mainly involved calculating the frequency of occurrence of the identified taxa. We also estimated the similarity/dissimilarity between the taxonomic compositions of the valleys using the Bray-Curtis index, as implemented in PAST software (Hammer et al. 2001).

RESULTS

The floristic inventory list of the Ogradena Valley included 80 taxa, classified into 35 families. The best-represented family, with the highest number of species, was the Asteraceae family, comprising 16 species, followed by the Fabaceae and Rosaceae families, each with six species (Figure 1).

A higher number of plant species was identified in the Slătinicul Mare

Valley, specifically 103 species, grouped into 52 families. The Asteraceae family was the best represented, with 10 species, followed by the Rosaceae family with eight species (Figure 2).

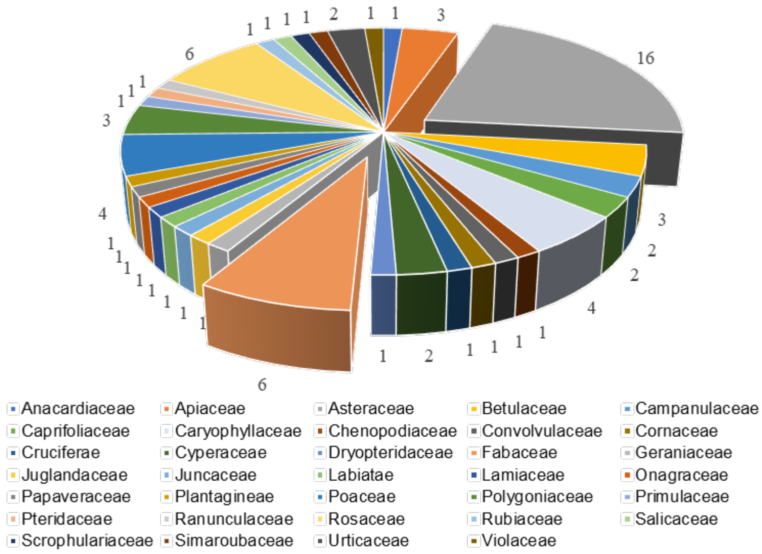

Figure 1. Number of plant species belonging to different families in the Ogradena Valley.

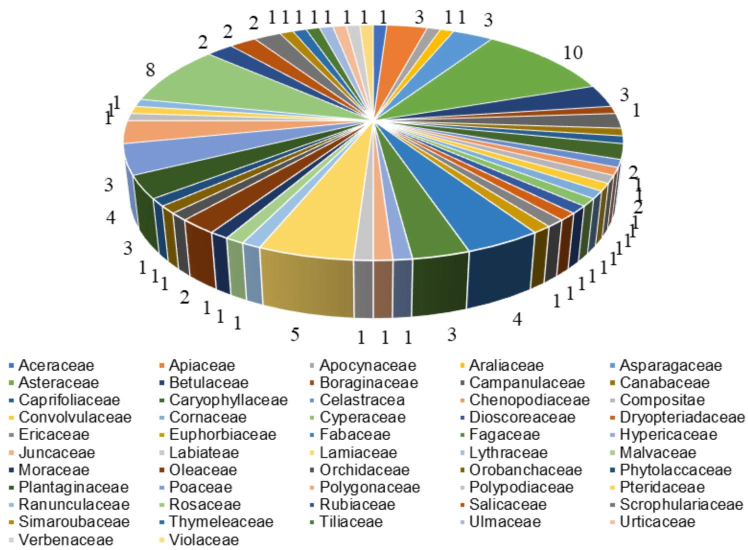

Figure 2. Number of plant species belonging to different families in the Slătinicul Mare Valley.

The highest biodiversity was found in the Vodița Valley, where we identified 122 taxa belonging to 44 families (Figure 3). The family with the highest number of taxa, as in the other two valleys studied, was the Asteraceae family, with 17 species, followed by the Rosaceae family (with 12 species), like the Slătinicul Mare Valley, suggesting a similarity between the two valleys in this respect.

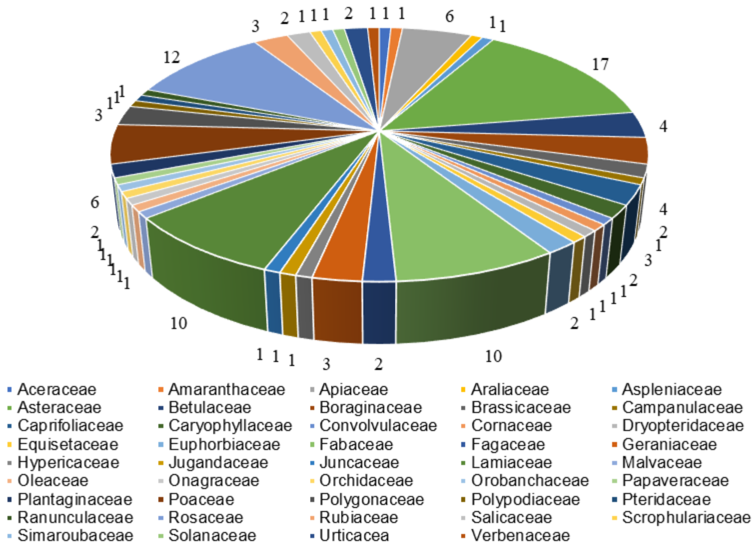

Figure 3. Number of plant species belonging to different families in the Vodița Valley.

The Bray-Curtis similarity index, for the species identified in the three valleys, shows a greater similarity between the Slătinicul Mare and Ogradena valleys (Figure 4A), with values above 0.95 in terms of the plant families present (Figure 4B). In terms of the invasive species, the Vodița and Ogradena Valleys are the most similar (Figure 4C).

Eleven plant species identified in this study within the IGNP are invasive. The highest number of invasive species was recorded in the Vodița and Ogradena Valleys, especially along the road section. *Ailanthus altissima, Ambrosia artemisiifolia,* and *Robinia pseudoacacia*, were found in all three valleys, advancing upstream from the national road DN 57 and European road E70 up the valleys. *Erigeron annuus* and *Erigeron canadensis* were found only in the Ogradena and Vodița Valleys, *Phytolacca americana* in the Ogradena and Vodița Valleys, *Amorpha fruticosa*, *Bidens frondosa*, and

Artemisia annua only in the Ogradena Valley, and *Xanthium italicum* was identified only in the Vodița Valley. The potentially invasive native species *Lythrum salicaria* was found only in the Slătinicul Mare Valley, which has the fewest invasive species.

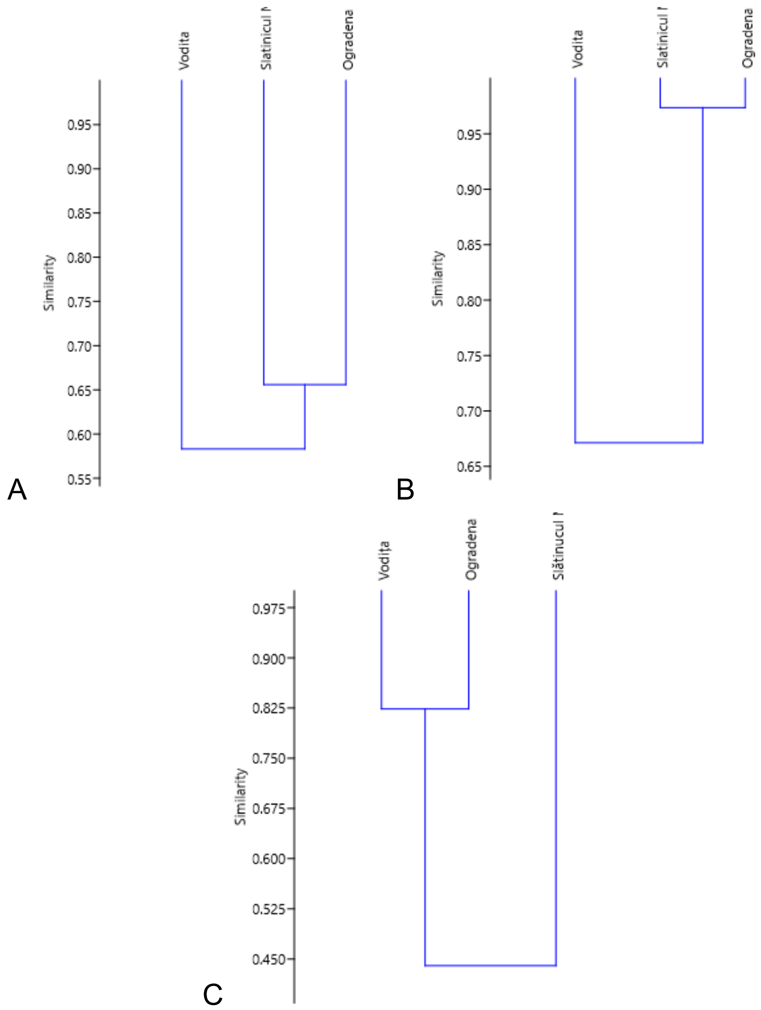

Figure 4. Bray-Curtis Index dendrograms of plant species (A), families (B), and invasive plants (C), identified in the three valleys.

From a humidity preference perspective, most species in the three valleys were mesohydrophilic and mesophilic (Table 1). The Slătinicul Mare Valley and the Vodița Valley, being close to each other, present species with similar temperature requirements, these being mesothermal (Table 1), whereas the species from the Ogradena Valley are predominantly thermophilic. The most obvious differences between the three valleys are in terms of soil (Table 1).

Table 1. Comparative analysis of the ecological characteristics of the plant species identified in the three valleys.

Abiotic factors	Moisture		Light		Temperature		Soil	
Location	Type	%	Type	%	Type	%	Type	%
Ogradena Valley	Xerophilic	2.5	Sciadophilic	1.25	Mesothermal	12.5	Oligotrophic	5
	Xero-mesophilic	18.8	Mesophilic	65	Thermophilic	77.5	Eutrophilic	25
	Mezo-hydrophilic	66.3	Heliophilic	22.5			Calciphilic	12.5
	Hydrophilic	3.8					Acid-neutrophilic	12.5
							Nitrophilic	42.5
Slătinicul Mare Valley	Xerophilic	6.9	Sciadophilic	2.9	Mesothermal	56.86	Oligotrophic	4.9
	Xero-mesophilic	22.5	Mesophilic	44.1	Thermophilic	19.61	Eutrophilic	25.5
	Mezo-hydrophilic	44.1	Heliophilic	23.5			Calciphilic	11.8
	Hydrophilic	3.9					Acid-neutrophilic	12.7
							Nitrophilic	12.7
Vodița Valley	Xerophilic	10.7	Sciadophilic	4.1	Mesothermal	74.59	Oligotrophic	3.3
	Xero-mesophilic	31.1	Mesophilic	58.2	Thermophilic	18.03	Eutrophilic	4.9
	Mezo-hydrophilic	45.1	Heliophilic	30.3			Calciphilic	5.7
	Hydrophilic	8.2					Acid-neutrophilic	4.9
							Nitrophilic	3.3

Most species in the Ogradena Valley are nitrophilous (42.5%), indicating the anthropogenic impact of the area. The Vodița Valley has the fewest species with special requirements related to soil reaction, with only 27 species out of 122 identified having special soil requirements, most of which are calcareous, rock plants (Table 1). In terms of bioforms (Fig. 5), hemicryptophytes predominated, especially in the Ogradena Valley, followed by phanerophytes in all three valleys.

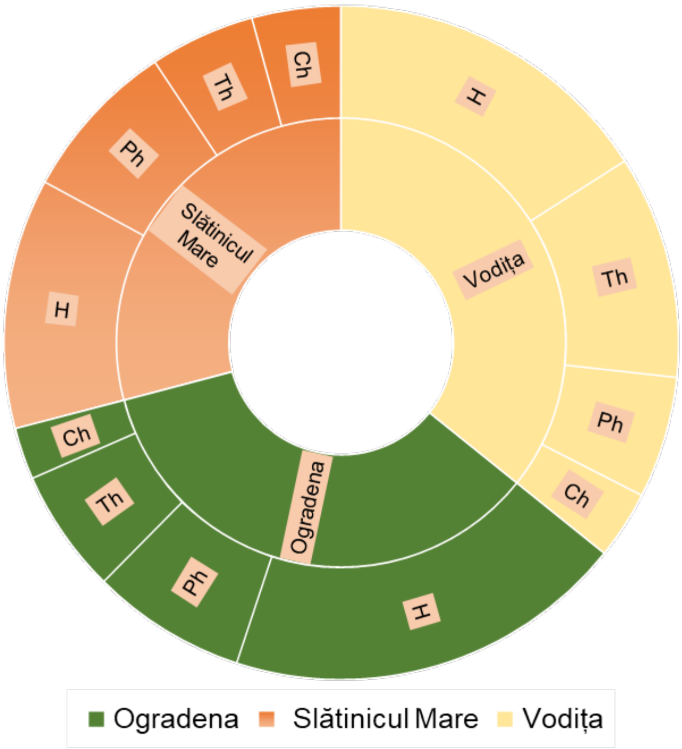

Figure 5. The floristic life-form spectrum of the tree valleys
(Ph- phanerophyte; Ch- chamaephyte; H- hemicryptophyte;
Geo – geophyte; Th- therophyte).

DISCUSSION

The Ogradena Valley is an area with high anthropogenic activity, generated by the proximity of Eselnita, a locality with numerous tourist resorts, situated near the national road DN57. It is an essential roadway in the IGNP and a pathway for invasive non-native species, such as *Ailanthus altissima*, which is a significant stressor factor for *Cotinus coggygria* thickets (IGNP Management Plan 2020). Moreover, we must consider the low floristic diversity of this valley (80 taxa). One explanation for this situation would be the specific anthropic impact caused by a few dwellings and a forest road along the valley. A second reason for the low species richness of the surveyed territory is its geomorphological peculiarities, specifically its substantial depth, characterized by a high degree of woodland in some areas, which results in a wet and cold climate.

The Slătinicul Mare Valley traverses a forest that has been regenerated after logging activities (IGNP Management Plan 2020). Despite human activity, including tourism and the introduction of invasive species, the area is home to several species of interest, such as *Ruscus aculeatus* and *Ruscus hypoglossum* (IGNP Management Plan 2020), which we have also identified. In Serbia, between 2013 and 2016, Anđelković et al. (2022) investigated invasive alien plants (IAPs) in the Danube Basin, which is known for its high levels of plant invasion. The authors found that the dominant vegetation on site and the agricultural practices in proximity were significant predictors of the invasion level, while roads, railway lines, and housing areas were not related to the invasion level (Anđelković et al. 2022). The total number of IAPs per site was negatively correlated with altitude, whereas the abundance of *R. pseudoacacia*, *Helianthus tuberosus*, and *Reynoutria* × *bohemica* was positively correlated with altitude (Anđelković et al. 2022).

In the Vodița Valley, in addition to the typical eroded soils of the park, it also comprises some acidic soil types and washed luvial, gleissed, and albic soils (IGNP Management Plan 2020). The lack of calciferous species also reflects the acidic nature of the substrate. Regarding the chemical reaction of the soil, Goia et al. (2017) report in the IGNP that the predominant euryonic elements are followed by weakly neutrophilic acidic species. From a floristic perspective, the peculiarity of the Vodița Valley was the presence of a high number of species belonging to the *Lamiaceae* family. This fact, compared to the Slătinicul Mare Valley, suggests a higher anthropic impact on this valley. This is expected, as approximately 1000 m upstream from the confluence of the Vodița stream and the Danube, there is a monastery that serves as a tourist and cultural-religious destination.

Although the number of species was higher in the Vodița Valley than in the Slătinicul Mare Valley, the number of families was lower (Figures 2, 3), as the highest diversity (regarding different specific taxa at the family level) was recorded in the Slătinicul Mare Valley (Figure 2) and the lowest in the the Ogradena Valley (Figure 1). This is caused by the high anthropogenic impact on the Ogradena Valley, which is less advanced than the Vodița Valley, and the lowest in the Slătinicul Mare Valley.

Among the invasive species, some were also reported by Goia et al. (2017). At that time, these authors reported the presence of *A. fruticosa, A. artemisiifolia, E. strigosus,* and *Paspalum paspalodes* as invasive species, while *E. annuus, Bidens vulgata, Galinsoga parviflora, Oenothera parviflora, Echinocystis lobata, Amaranthus retroflexus, Xanthium italicum* with invasive potential (Goia et al. 2017). The presence of these species in the park is already common, and even the origin of many of them is known. Thus, *A. altissima* originates from old plantations, where it was used to stabilize slopes, and due to natural multiplication and spread, the species has become more prevalent in these areas as a result of anthropogenic activity (Goia et al. 2014). In contrast, *E. canadensis* and *E. annus* expand from cultivated or abandoned arable lands. The roads are also known in the literature as a source of habitat colonization by pioneer and invasive species (Fraga et al. 2008, Silva & Passos 2017).

We also identified the black cherry (*Prunus serotina*), which, in some areas, is considered an invasive species in various European ecosystems, including open-land habitats and forests (Annighöfer et al. 2015). Its ability to dominate the forest understory hinders the regeneration of native species, which can lead to a shift in species composition, a loss of biodiversity, and alterations in key ecological processes (Annighöfer et al. 2015). Once cut, *P. serotina* vegetatively multiplies intensively, making it difficult to remove the species (Annighöfer et al. 2015). Other species with high invasive potential within the perimeter of the Banat wetlands from a list of high invasive potential species compiled by the International Union for Conservation of Nature were reported as *Reynoutia japonica, Lythrum salicaria, Conyza canadensis, Ambrosia artemisiifolia, Acorus calamus, Alopecurus myosuroides, Oxalis stricta, Phytolaca americana* (Otves et al. 2014). Communities with *Chenopodium* sp. and *Bidens* sp. have previously been reported in some rivers with banks in the Vodița Valley, Orșova, Ilovița Valley, Liubcova, Sirinia Valley, Liborajdea, Dubova, Mraconiei Valley, and the Danube Riverbank at Berzasca, as well as Cozla Pond (Goia et al. 2017, Goia & Oprea 2014).

From an ecological perspective, the taxa identified in the Slătinicul Mare and Ogradena valleys exhibited varying degrees of similarity to the requirements of moisture, light, and soil reaction compared to those in the Vodița Valley, despite the Vodița Valley's geographical location between the two valleys. On the other hand, in terms of temperature, the taxa from the Vodița Valley showed similarities with those from the Slătinicul Mare Valley, as they are mesothermal species. In contrast, the species identified in the Ogradena Valley are predominantly thermophilic. The influence of the Mediterranean climate is evident through the presence of moderately thermophilic and thermophilic species. In the Ogradena Valley, mostly species preferring nitrophilic soils were identified, followed by plants requiring eutrophilic soils. In the Slătinicul Mare Valley, a high preference for eutrophilic, nitrophilic, and acid-neutrophilic soils was recorded. The Vodița Valley had the fewest species with special requirements related to soil reaction, with only 27 species out of the 122 identified, most of them preferring calcareous or rocky soils. Thus, our study confirmed previous studies on the flora specific to the edaphic and topoclimatic conditions, with Sub-Mediterranean influences, and we did not identify any new invasive species compared to those already reported. For the study of invasive species, an analysis of the abundance of individuals would be necessary, as well as monitoring the distance at which they are present in the valleys, relative to the national road.

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