PRELIMINARY DATA ON THE FLORA OF THREE VALLEYS OF THE JIU GORGE NATIONAL PARK, ROMANIA

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Abstract. The purpose of this study was the preliminary analysis of the vascular flora in the valleys: Bratcu, Chitu, and Polatiște, in the Jiu Gorge National Park (JGNP). The flora study also aimed to track the presence/absence of the protected species *Tozzia carpathica* Woloszczak. The research took place between May and September 2022. Following this study, the species *Tozzia carpathica* Woloszczak was not identified in the studied areas. Still, following the taxonomic analysis, we identified 75 taxa from 37 families in the Bratcu Valley, 147 taxa, belonging to 47 families, in the Chitu Valley, and 113 taxa, from 47 families in the Polatiște Valley. Following the analysis of the ecological peculiarities, most of the species were meso-hygrophilous, mesophilic, mesothermic, and eutrophic. In terms of bioforms, hemicryptophytes predominated in all three valleys. The most numerous invasive species were identified in the Bratcu Valley, and the most medicinal plants in the Chitu Valley. The studies will be extended in terms of both seasonal perspective and habitats.

Keywords: bioforms, ecology, Natura 2000, protected plants, *Tozzia*.

Rezumat. Studiu preliminar privind flora a trei văi din Parcul Național Defileul Jiului, România. Prezentul studiu a avut ca scop analiza preliminară a florei vasculare pe văile: Bratcu, Chitu și Polatiște, din Parcul Național Defileul Jiului. Studiul florei și-a propus să urmărească și prezența/absența speciei protejate *Tozzia carpathica* Woloszczak. Cercetările au avut loc în perioada mai-septembrie 2022. În urma acestui studiu nu a fost identificată specia *Tozzia carpathica* Woloszczak în zonele studiate. În urma analizei taxonomice am identificat 75 taxoni din 37 familii pe Valea Bratcu, 147 taxoni, aparținând la 47 familii, pe Valea Chitu și 113 taxoni, din 47 familii pe Valea Polatiște. În urma analizei paticularităților ecologice, majoritatea speciilor au fost mezo-higrofile, mezofile, mezoterme și eutrofile. Din perspectiva bioformelor, hemicriptofitele au predominat în toate cele trei văi. Cele mai numeroase specii invazive au fost identificate pe Valea Bratcu, iar cele mai multe plante medicinale pe Valea Chitu. Studiile vor fi extinse atât din perspectiva sezonală, cât și a habitatelor.

Cuvinte cheie: bioforme, ecologie, Natura 2000, plante protejate, *Tozzia*.

INTRODUCTION

The Natura 2000 site ROSCI0063 Jiu Gorge (***. https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=ROSCI0063), with a surface of 10927.10 ha, is located in the Western part of the Southern Carpathians, between the Vâlcan Mountains, to the west and the Parâng Mountains, to the east, in the north of Gorj county and the south of Hunedoara county, in the Jiu river basin, between the altitudes of 295 m, in the Jiu Valley and 1621 m in the Vâlcan Pass, being devoid of localities. The predominant relief unit is the slope, mostly covered by beech forests (UJVÁRI, 1972; KNORN et al., 2012). The hydrological network of the park is formed by the Jiu River (30 km), between the confluence of the East Jiu with the West Jiu and the confluence with the Sadu stream, where all the other streams converge, namely: Leurzoaia, Bratcu, Runcu, Repede, Tarnița, Pate, Popii, Rau, Cerbănașu Mare, Cerbănașu Mic, Murga Mare, Dumitra, Murga Mică, Ploștina Murgilor, Strâmbuța, Chitu, Polatiște, and Liliacul, to which are added other smaller tributaries (STOICULESCU et al., 2005). A consistent research of the area was carried out in 2004, on the occasion of the identification of natural habitats and relevant species that require conservation, in the framework of the study on the establishment of the Jiu Gorge National Park (PNDJ) (11 RA/2004), carried out by the National Forestry Authority – Romsilva and the Forest Research and Management Institute. On this occasion, 10 specific natural habitats were established. The Chitu-Bratcu Natural Reservation has fir, beech, and sessile oak, with the spontaneous participation of walnuts (STOICULESCU et al., 2005). The lower areas of JGNP, in its south, were probably originally occupied by sessile oak forests, a fact highlighted by the study of leaf litter invertebrates, which may indicate the initial appearance of the forests in the region (CICORT-LUCACIU et al., 2020).

In the period 1990-2001, within the potential of the current Jiu Gorge National Park (11,127 ha) three nature reserves were formalized and the establishment of Jiu Gorge National Park was proposed (IONESCU & STOICULESCU, 2004; STOICULESCU et al., 2005).

The establishment of a national park along the Jiu River has been considered since 1989. The Chitu-Bratcu forest was first recognized as a nature reserve in 1990. A second recognition of it took place in 1994 through a government decision, at the same time recognizing for the first time the status of geological reserves for the Rafaila Rocks (1ha), the Lainicilor Sphinx Stone (1 ha), and through Law no. 137/1995, Art. 54 the third recognition was achieved for the Chitu-Bratcu Forest, respectively the second for the Rafaila Rocks, the Lainicilor Sphinx Stone. The results of the research completed in 2004 revealed the classification of the future National Park in the category of priority areas with a high value of biodiversity, establishing the classification of the national park in the landscape type "Balkan beech forests with hornbeam and linden and thermophilic elements" (STOICULESCU et al., 2005). Following this study, by Government Decision no. 1581 (2005), the Jiu Gorge was declared a National Park. The species *Tozzia carpathica* and *Campanula serrata* L., two protected species, do not appear in this study of the flora, carried out in 2004. The species *Tozzia carpathica* appears for the first time in the

Ministerial Order OMMDD 1964/2007. *Tozzia carpathica* Woloszczak (syn.: *Tozzia alpina* L. subsp. carpathica Woloszczak (Dostàl) (OLTEANU et al., 1994; BARTOK & PUSCAS, 2015) or *Tozzia alpina* subsp. carpathica (Woł.) Hayek, Fam. Scrophulariaceae, Order Lamiales, Class Magnoliopsida is a species protected by HD, Appendices II and IV, and is listed in many red lists (BILZ, 2013).

Analysing the specialized literature, it can be seen that there are some studies on the Jiu Gorge about certain groups of animals (BUSSLER et al., 2005; TOMESCU et al. 2011; ROZYLOWICZ & DRAGU, 2013; CICORT-LUCACIU et al., 2020), but no consistent research about plants, only some such as those by STOICULESCU et al., (2005) and the park's establishment report, although the area is important for biodiversity (PETRESCU et al., 2004; COVACIU-MARCOV et al., 2009; TELCEAN et al., 2017; SUCEA, 2019). This fact was later confirmed, over time, by different studies on different groups of animals, given that, for protected natural areas, the plates are extremely important, many being protected by legislation, and they exist in the site file. The imperative need to carry out some flora studies in the area led us to start this research, with three of the important valleys of the park, tributaries of the Jiu River: Bratcu, Chitu, and Polatiște, in the future we will expand the flora studies in the park, expanding the study period throughout the year, as well as the habitats. The forest in Jiu Gorge National Park (JGNP) represents an 85% proportion, which houses a great variety of herbaceous species (MANAGEMENT PLAN, 2022). Flora provides life for many animals. So, beech forests shelter a high diversity of terrestrial isopods (TOMESCU et al., 2011), and a unique relict fauna in the case of saproxylic beetles (BUSSLER et al., 2005). The wealth of fauna in JGNP suggests that we study plants in the future, as primary producers.

The present study aimed to identify a preliminary list of plant species and their ecological characteristics and bioforms, in the three valleys of the JGNP, and search for the species *Tozzia carpathica* Woloszczak.

MATERIALS AND METHOD

The taxonomic analysis was carried out on three valleys in the Jiu Gorge National Park: Bratcu, Chitu, and Polatiste, between May and September 2022. The Bratcu Valley is a grassy, open valley, different from the other two valleys, being on the western slope of the Jiu River. The sampling was carried out far upstream, 1.3 km from the Meri-Bratcu quarry, from GPS coordinates 45°13'41.1"N 23°21'35.9"E, with a distance of 2 km, with an altitude of 350-400 m. Chitu Valley (from DN 79, 45°16'16.0"N 23°22'54.0"E GPS coordinates, with a 2 km climb, with an altitude of 400 - 450 m) and Polatiște (from DN 79 45°20 '18.6"N 23°22'38.2"E, uphill 2 km, with an altitude of 600-650 m) are cooler and rocky valleys, located in very dense forests with steep slopes. The maximum altitude in all three valleys was up to 700 m. There are two climatic zones differentiated on the territory of the park: below 700 m a temperate rainy climate with precipitation occurs throughout the year, and the average temperature in the hottest month of the year is below 22 ^{0}C, while, at altitudes exceeding 700 m, maximum average temperatures between 10 and 18 ^{0}C were recorded (STOICULESCU et al., 2005). The three valleys are framed by STOICULESCU et al., (2005) in the categories of potential scientific reserves and potential natural reserves. The ecological value of these forest territories varies predominantly between: "Extremely large" and "Very large" (Bratcu Forest from UP III Bratcu and Chitu Forest, from UP IV Chitu, Bumbești Forest Administration) being insular, and "Large" (Polatiște Forest).

Determinations of plant taxa were made with determination keys directly on the ground, from the habitats of interest. Flora R.P.R.-R.S.R., vol. I-XIII (SĂVULESCU, 1952-1976) was used for the identification and determination of plant taxa. Due to the frequent changes in the nomenclature of the species, Flora Europaea was used to standardize the scientific names (TUTIN et al., 1993). For the classification of phytotaxa in different cenotic groups, categories of bioforms, and biogeographical, ecological, and economic elements, the monographs published for the flora and vegetation of Romania were consulted (DONIȚĂ et al., 2005; SANDA et al., 2008).

The Jaccard similarity indices were made with Software Past 3x (HAMMER et al., 2001).

RESULTS

The floristic inventory of the Bratcu Valley, in May-September 2022, included 75 species, from 37 families (Table 1; Fig. 1a). The best-represented family, with the highest number of species, was the Asteraceae, with 17 representatives (Fig. 1).

Table 1. Analysis of the taxa identified on the Bratcu, Chitu, and Polatiște Valleys, from the Jiu Gorge National Park.

Valley	Number of species	Number of families	Number of medicinal plants	Number of invasive plants
Bratcu	75	37	38	5
Chitu	147	47	71	4
Polatiște	113	47	59	4

Among the studied valleys, the Chitu Valley had the highest biodiversity (Fig. 1B), with 147 plant species, belonging to 47 families, also here most species of medicinal plants were identified. In contrast, in the Bratcu Valley, the biodiversity was reduced by half, the presence of invasive species was greater, and medicinal plants less. In the Polatiște Valley, we identified 113 taxa, from 47 families (Fig. 1C).

After the cessation of these activities, once the area was declared a natural protected area, the flora recovered, but there are ruderal species, such as *Ajuga reptans* L. (Lamiaceae), *Centaurea jacea* L. (Asteraceae), *Cirsium vulgare* (Savi) Ten (Asteraceae), *Galium aparine* L. (Rubiaceae), *Sambucus ebulus* L. (Adoxaceae), *Taraxacum officinale* G.H. Weber ex Wiggers (Asteraceae) and others, which certify the anthropogenic impact suffered even in the present. Even *Convolvulus arvensis* L. (Convolvulaceae), *Stellaria media* (L.) Vill (Caryophyllaceae), *Lamium purpureum* L. (Lamiaceae), among the species indicative of anthropogenic impact, were also identified in the Polatiște Valley.

Urtica dioica L. (Urticaceae), a nitrophilous species, was present in all three valleys, which indicates a discharge of urine and fecal matter.

Among the protected species, we identified the following in the Bratcu Valley: *Dianthus armeria* L. (Caryophyllaceae), *Gentiana asclepiadea* L. (Gentianaceae), Chitul Valley: *Dactylorhiza* sp. (Orchidaceae), *Cypripedium* sp. (Orchidaceae), *Anacamptis morio* (L.) R. M. Bateman, Pridgeon & M. W. Chase Orchidaceae) and on the Polatiște Valley: *Asarum europaeum* L. (Aristolochiaceae), *Gentiana asclepiadea* L. (Gentianaceae).

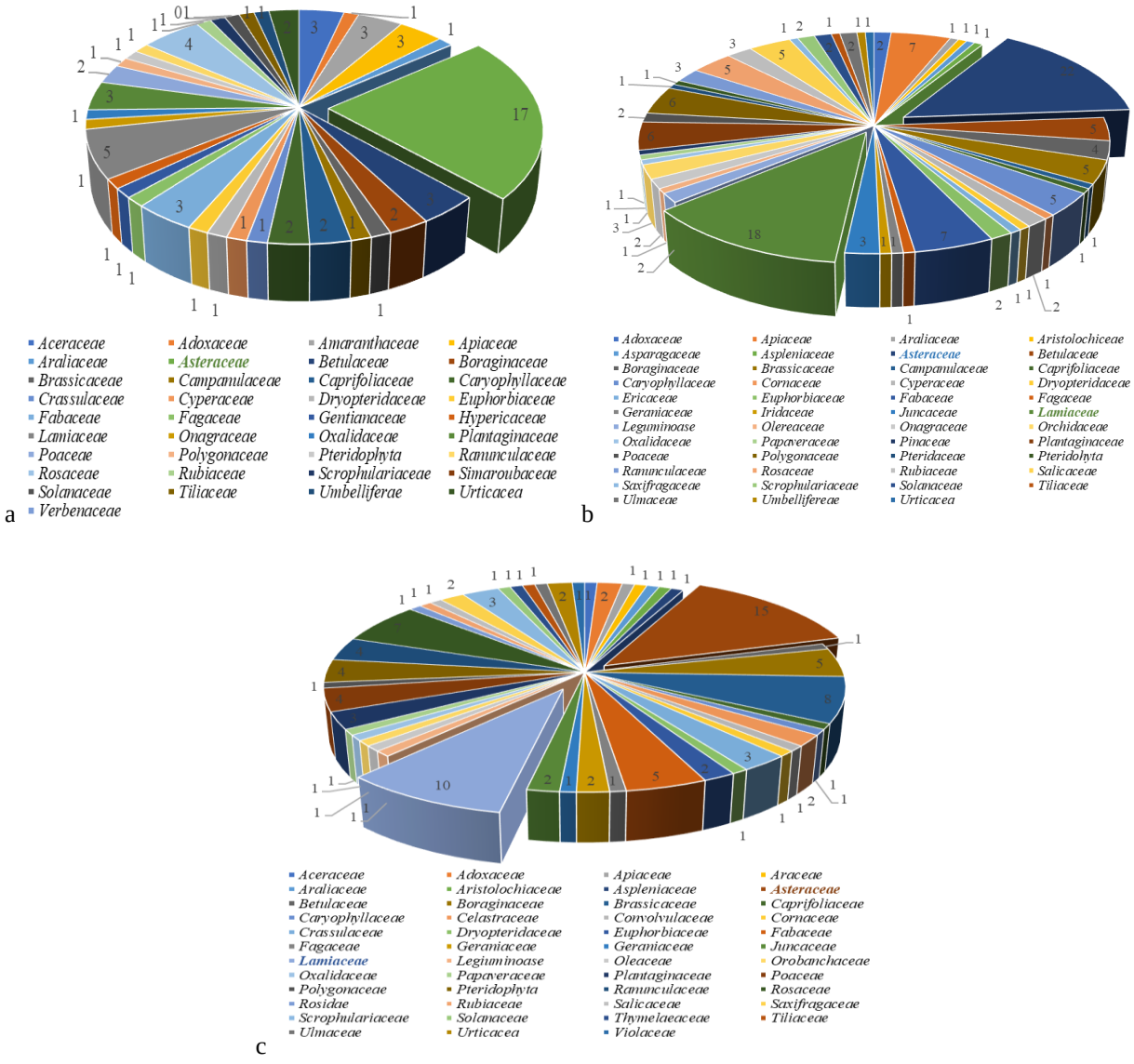

Figure 1. Taxonomic analysis of the species identified in the Bratcu Valley (A), Chitu Valley (B), and Polatiște Valley (C), in the Jiu Gorge National Park.

Among the common invasive species we mention: *Ambrosia artemisiifolia* L., *Erigeron annuus* L., *Robinia pseudoacacia* L. were identified on Bratcu and Chitu Valleys, *Amorpha fruticosa* L. only on Bratcu Valley, *Phytolaca americana* L., only on Polatiște, *Reynoutria japonica* Houtt only on Chitu Valley.

The indices of similarity of biodiversity (Fig. 2A) and from the perspective of medicinal plants (Fig. 2B) indicate higher values between the two valleys from the north of the gorge, namely Chitu and Polatiște. Instead, from the point of view of invasive species, a similarity is found between the Bratcu and Chitu Valleys (Fig. 2C).

The most numerous taxa were moderately moisture-loving - meso-hydrophilic or hydrophilic (Fig. 3A), light-loving - mesophilic and heliophilic (Fig. 3B), temperature-loving - mesothermic (Fig. 3C) and with eutotrophic needs towards nutrients, but also calciphytes and acidophiles (Fig. 3D). The species lists were made available to the park administration.

Hemicryptophytes predominate in all three valleys, followed by trees and shrubs, as occupants of the phanerophyte group, but there are numerous representatives, especially in the northern part of the gorge, which cannot form overwintering organs (buds, rhizomes), multiplying only by seeds, namely therophytes (Fig. 4).

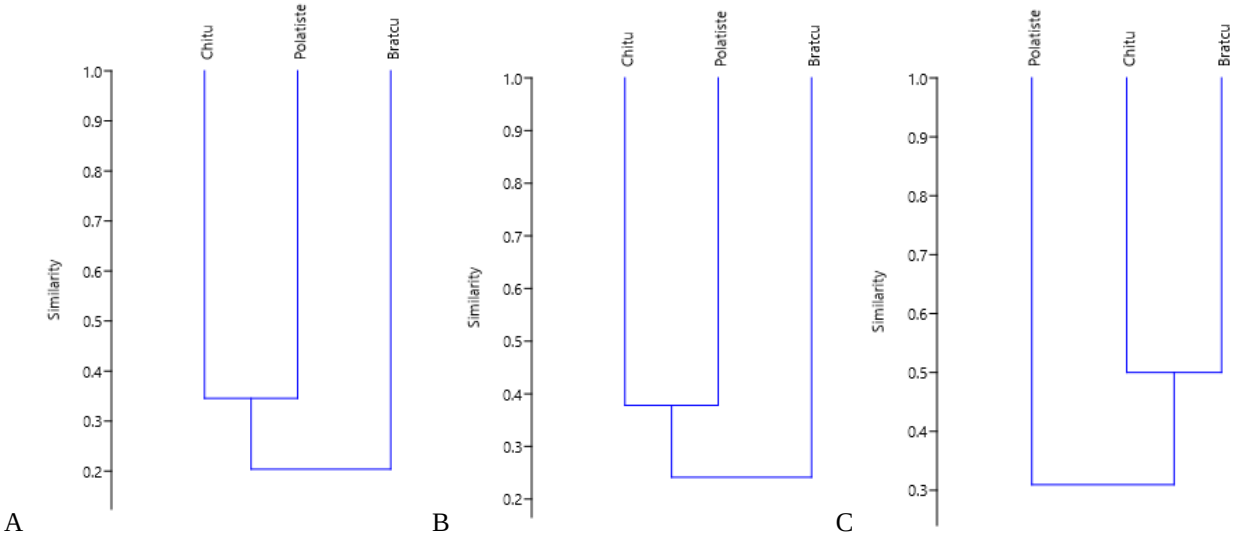

Figure 2. Jaccard similarity indices of plant species (A), medicinal plants (B), and invasive species (C) were identified in the three valleys: Bratcu, Chitu, and Polatiște, from the Jiu Gorge National Park.

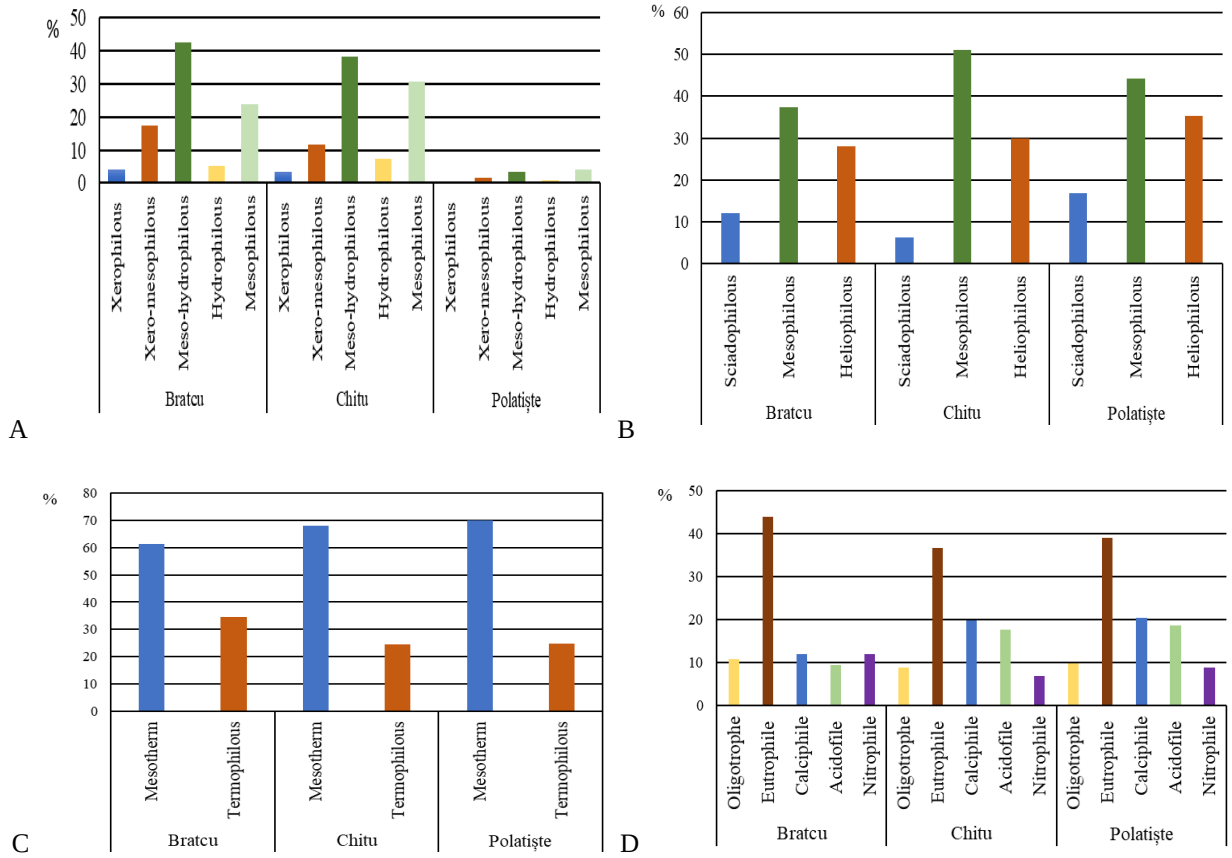

Figure 3. Ecological analysis of the taxa identified in the Bratcu, Chitu, and Polatiște Valleys, from the Jiu Gorge National Park, according to humidity (A), light (B), temperature (C), and soil reaction (D).

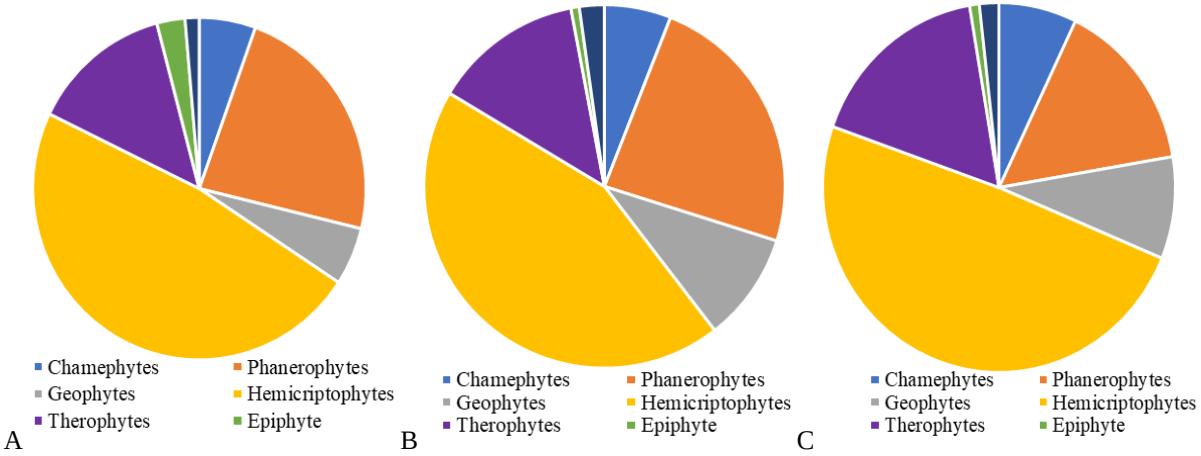

Figure 4. The percent of bioforms in the three valleys: Bratcu (A), Chitu (B), and Polatiște (C).

DISCUSSIONS

In total, we identified 223 plant species in the three valleys of JGNP, of which 97 were medicinal plants and 8 species of invasive plants. Most of the plant species in the three valleys belonged to the Asteraceae family, which is one of the largest angiosperm plant families with a cosmopolitan distribution (FUNK et al., 2005), plants having morphological, anatomical, physiological, and ecological adaptations for wide distribution, dispersal, and reproductive success (HEYWOOD et al., 2007). On the Chitu and Polatiște Valleys, to the north, there were also many species belonging to the Lamiaceae families, which also have a cosmopolitan distribution (STANKOVIC, 2020).

The valleys from the north (Chitu and Polatiște) showed higher similarity from the perspective of the taxonomic analysis of flora and medicinal plants, and the two valleys from the south, namely Bratcu and Chitu showed higher similarity from the perspective of anthropization, respectively the presence of invasive species.

In the past, about 30-40 years ago, the Chitu Valley and further south, the Bratcu Valley underwent massive exploitation of wood mass in the clear-cutting system (traces of human impact, in the form of tires, and stone walls, are still visible today). After the cessation of these activities, once the area was declared a natural protected area, the flora recovered, but numerous ruderal species indicated the anthropogenic impact suffered even in the present. The herbaceous ruderal species were in large numbers in these valleys because along them there are forest roads.

The anthropogenic impact was noticeable in the Bratcu Valley and by the presence of the highest number of invasive species, although the total number of plant species was the lowest, compared to the other two valleys. However, the number of invasive species was not very high, compared to other protected areas studied by us (personal data) and this is due on the one hand to the high level of protection offered by the National Park, the steep relief, difficult to access of the area and the lack of human settlements. The only real protection against human destruction for the remaining old-growth forests in Romania is their inaccessibility (KNORN et al., 2012).

PETRUȘ-VANCEA et al. (2023) investigated the effect of the pollution due to the European road E79 in *Fagus sylvatica* L. leaves. Air pollution near roads induced necrosis of leaves, decreased their dry mass, and large lesions in the fundamental parenchyma, periphloem sclerenchyma, and vascular bundle. The morphological aspects of leaves indicated the significant potential for resilience to air pollution, and authors reported an adaptation of the leaves by decreasing stomata size and increasing their density, but also decreasing leaf size.

Some species indicative of anthropogenic impact were also identified in the Polatiște Valley from the north of the gorge. Trends in the coverage of old-growth forests in Romania were revealed by the analysis of satellite images (KNORN et al., 2012). Following the expansion of Romania's network of protected areas once with accession to the European Union in 2007, most old-growth forests belong to protected areas. Surprisingly, however, 72% of old-growth forest disturbances are found inland protected areas, 23% including National Park, highlighting the threats they still face in these forests (KNORN et al., 2012). The cited authors reported that natural disturbances are unlikely to explain most changes in forest cover in old-growth stands and that only National Parks functioned effectively in preventing disturbances in old-growth forests.

So, in the Bratcu Valley, located to the south of the gorge, we recorded the fewest flora taxa and included the smallest number of families. This aspect is similar to the study on invertebrates carried out by CICORT–LUCACIU et al., (2020) which mentioned a poorer fauna, due to an increasing anthropogenic impact on the southern JGNP. So, in the northern part of the park, there are old forests, while in the southern part, the plantations have replaced the original oak forests. In the beech and birch reforestation areas, the invertebrate fauna was poorer than in the old, mature forests of the same tree species. On the other hand, although poorer compared to the mature beech forest, the recovery oak forests sheltered a litter richer in fauna, compared to plantations (CICORT-LUCACIU et al., 2020). The detritiphagous

taxa were the most affected by the flora, so in the forest plantations, more mobile taxa prevailed, with diverse trophic regimes CICORT-LUCACIU et al., (2020).

Ecologically, most species were meso-hygrophilous, mesophilic, mesothermic and eutrophic. From the perspective of bioforms, as expected, hemicrytophytes predominated in all three valleys. The research related to the ecological conditions of the species will be expanded, along with the expansion of the studies in the future. For preliminary data, we note that in the Polatiste Valley, we have identified most sciadophilous species, but also heliophilous ones, because the shadow areas alternate with those of solar exposure. However, in terms of temperature, the fewest thermophilic species were found in this valley, as the valley is much colder than the others, due to its geographical position, north of the gorge. The numerous eutrophic species, especially in the Bratcu Valley, again suggest the anthropogenic impact of the valleys, through the presence of the roads on their side, but also their history.

The differences between the environmental conditions of the north and south of the gorge are also found in the differences between the invasive species that populate the north and the south. Geographical factors are essential in the occurrence and spread of plant alien species (GRIGORESCU et al., 2020). Thus, if in the north, we identified *Phytolacca americana* L., and Chitu Valley, *Reynoutria japonica* Houtt, just in Bratcu Valley, in the south, was presented *Amorpha fruticosa* L.

P. americana L. is a large perennial plant that infests not only crops but also open forest edges and other disturbed habitats (BALOGH & JUHÁSZ, 2008). Although it is a medicinal plant, due to its unique mode of fruiting and spatial heterogeneity, it negatively affects the ecology of forests, and, through its seeds disseminated by animals that eat the fruit, especially birds, the invasion of natural ecosystems is accelerated (XIAO et al., 2022). These seeds retain their viability for decades in the soil, and an individual in favourable conditions can even reach the age of 30-40 years (BALOGH L & JUHÁSZ, 2008). This plant also manages very well water stress by increasing leaf mass (PEPE et al., 2022). Its ability to purify the environment by heavy metal accumulation, but also as a medicinal plant can be studied to contribute to the control of invasive plants (XU et al., 2023). In the south of Transylvania *Phytolacca americana* L. is up to 600 m asl (DANCI & DRĂGULESCU, 2023).

R. japonica Houtt. has spread alarmingly far into river meadows, in the last five decades, in Romania, in 2014, DUMITRAȘCU et al., (2014) reported that this plant grows mainly on the banks of rivers in the western part of the country, but in other places in Transylvania, too (DUMITRAȘCU et al., 2014) and in Southern Transylvania it climbed up to 700 m asl (DANCI & DRĂGULESCU, 2023).

A. fruticosa penetrated natural *Populus* and *Salix* forests along the Danube River and became invasive at the end of the 20th century (STĂNESCU et al., 1997). The main preference of the species for wetland habitats has been shown to have great adaptability to different environments (GRIGORESCU et al., 2020). *A. fruticosa* is a light-loving species, developing on sunny slopes (DUMITRAȘCU et al., 2011), which is why we also identified it in Bratcu Valley, because compact forests, such as those in the north of the gorge are a limiting factor for the spread of this species. The species has been observed throughout the forest road that accompanies the Bratcu Valley.

The analysis of the flora in the protected area, the ecophysiological requirements of the plants, the invasive potential of some, their medicinal role, and possible allelopathic relationships, but also with animals, especially from the perspective of seed dissemination, will be able to contribute to the optimization of its management by the administration of the park, in order to identify solutions for the conservation of biodiversity.

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