CURRENT CONDITION AND CONSERVATION OF THE HABITAT 7220* (PETRIFYING SPRINGS WITH TUFA FORMATION) WITHIN NERA GORGES – BEUȘNIȚA NATIONAL PARK AND SITE OF COMMUNITY IMPORTANCE

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Abstract . *Some Natura 2000 habitats, including 7220* (Petrifying springs with tufa formation – Cratoneurion), are sensitive to variations in climatic factors, respectively to the reduction of water intake. This priority habitat, closely related to the limestone rocks, has a linear or punctiform distribution, along the springs and rivers. The patches included in the 7220* habitat represent a significant part of natural patrimony of the Nera Gorges–Beuşnița National Park (NG-BNP), equally (considering some minor differences in their areas) a site of community importance (SCI – code ROSCI0031) and a special protection area (SPA – code ROSPA0020). Subsequent to field researches, conducted under a Sectoral Operational Programme-Environment (SOP-Envi), we present here data about the spatial distribution of 7220* patches, pressures and threats upon them, and conservation measures proposed as a part of a national park, SCI and SPA integrate management plan. The areas of petrifying springs with tufa formation are partially included in nature reserves and represent hot spots of biodiversity. The habitat patches were found as active tufa deposits in the beds of Nera, Miniș, Bei, Șușara, Ducin, Cremenița, Valea Mare and other minor tributaries to these rivers, as well as inactive tufa deposits mainly on Moceriș and Ducin rivers. Threatened at European scale, the habitat in this area was in good condition, until 2016. Since then, the conservation status of the habitat has worsened within the NG-BNP. The pressures and the threats are diverse. The conservation measures, proposed and thenceforth included in the integrate management plan, concern: maintaining the water regime of the streams and rivers, pollution prevention and control, interdiction to tufa (travertine) exploitation, reduction of forestry and agriculture negative impacts on this sensitive habitat. Special attention must be paid to the impact caused by the increasingly intense tourism. The application of conservation measures and habitat monitoring are important, especially for this national park for which springs, rivers, and waterfalls with travertine are the most visible tourist attractions.*

Keywords*: tufa, Natura 2000, 7220*, Nera Gorges–Beuşnița, conservation measures.*

INTRODUCTION

Habitat 7220* (Petrifying springs with tufa formation – *Cratoneurion*) is listed in Annex I of Habitat Directive 92/43 / EEC, being preserved in 18 Natura 2000 sites in Romania. At the European level, 1558 sites are designated for this habitat type (https://eunis.eea.europa.eu/habitats/10150). The total area in Europe is 427,352.4 km^2 (according to the report for the period 2013-2018), and in Romania, 2,600 km^2, of which 2,200 km^2 in the Alpine region and 400 in the Continental region.

Calcareous tufa represents a deposit of calcium carbonate (limestone) modelled by the action of carbon dioxide (carbonic acid) rich waters. The formation of these deposits is conditioned by the presence of the limestone substrate, by a constant water intake, even if sometimes reduced, waters rich in carbon dioxides. Depending on their current age and condition, there are inactive tufa fossil deposits and actively-depositing travertines (ONETE *et al.*, 2014).

Both terms, *travertine* and *tufa*, are used to describe this habitat, but there are certain features based on which some authors differentiate the geomorphological formations: "travertine" is used for the deposits formed within thermal springs and "limestone tufa" represents limestones of non-thermal springs (GOLUBIĆ *et al*., 2008; PENTECOST, 2005, in CANTONATI *et al*., 2016).

Although often used interchangeably, in contrast with travertine, the term "tufa" designates deposits consisting dominantly of calcite, typical of karstic areas; tufa deposits are produced "from ambient temperature, calcium bicarbonate-rich waters which are characterized by relatively low depositional rates producing highly porous bodies with poor bedding and lenticular profile, but containing abundant remains of microphytes and macrophytes, invertebrates and bacteria" (CAPEZZUOLI *et al.*, 2013). The term "tufa" relates more to a soft and poorly consolidated variety of travertine, containing organic material (COUVREUR *et al.*, 2016). Even so, the definitions are problematic because there are several variables that nuance this habitat, not just the water temperature or porosity of deposits. For this reason, CANTONATI *et al*. (2016) decided to use formulas such as "deposits of Limestone-Precipitating Spring (LPS) neutrally as spring associated limestones (SAL)".

It is known that, often, this priority habitat covers reduced, punctual or linear surfaces in the springs area and along the streams with water rich in carbon dioxide. Characteristic geomorphological formations can have impressive ages. Normally, tufa formation is a continuous, difficult to notice process even in larger time intervals. However, cases of stagnation or even dissolution were reported, in the conditions of altering the biotic and abiotic parameters, in correlation with anthropic factors (QIAO *et al*., 2016; ŠILJEG *et al*., 2020).

The features and conservation status of Habitat 7220* are significantly influenced by slope, macronutrient levels and canopy cover by tree canopies. Species diversity is inversely related to phosphate levels (LYONS & KELLY, 2016).

Cratoneuron commutatum (*Palustriella commutata*) and *C. filicinum* are moss species that dominate these petrifying springs, but there are other moss species and also other species groups characteristic of this habitat (*Cyanobacteria* like *Rivularia*, green algae like *Oocardium stratum*, Diatoms, some vascular plants, of which often *Brassicaceae*) even if differences exist depending on the geographical position, altitude and climate, substrate, water chemistry, slope, exposition, canopy cover, type of adjacent vegetation, waterless period, water speed, soil accumulation, litter deposit (CANTONATI *et al.*, 2016; COUVREUR *et al.*, 2016, BRUSA & CERABOLINI, 2009; BĂDĂRĂU, 2013; COLDEA, 2008; MOUNTFORD *et al*., 2008).

In Natura 2000 sites in Italy, BRUSA & CERABOLINI (2009) identified the following groups of photosynthetic species: lichenized *Ascomycota*, *Cyanophyta*, *Rhodophyta*, *Xanthophyta*, *Chlorophyta*, *Marchantiophyta*, *Bryophyta*, *Polypodiophyta*, *Pinophyta* and *Magnoliophyta*. The presence and abundance of moss species is particularly influenced by water chemistry, slope, canopy cover, eutrophication being the main factor responsible for habitat deterioration. In 67 Belgian travertines, bryophytes richness is negatively related specially to canopy cover and PO4 and *Palustriella commutata* is more frequent when the slope is steeper and tends to decreases when canopy cover is higher (COUVREUR *et al.*, 2016).

Among fauna species, literature quotes more frequently: *Diptera*, *Gammaridae*, *Austropotamobius torrentium*, *Salamandra salamandra*.

Habitat features, in terms of its surface in some European countries, various correspondences between classification systems, diagnostic species, characteristic, dominant or important species, habitat description following the European and Romanian Manual for the interpretation of Natura 2000 habitats, but also the description of corresponding Romanian

habitats (R5417 and R5419) and their vegetable associations are presented as a review by ONETE *et al*. (2014).

In the wider frame of the karst landscape, petrifying springs with tufa formation is a habitat often spectacular, with a special aesthetic value through the geomorphological forms appreciated by tourists (waterfalls, lakes, travertine thresholds), but also with high scientific importance, some sites being Included in UNESCO World Heritage, as is the case of a surface in our study area. The limestone-precipitating springs (CANTONATI *et al*., 2016) is the central image of some popular tourist destinations, known all over the world (ŠILJEG *et al*., 2020).

The Site of Community Importance ROSCI0031 – Nerei Gorges – Beușnița is at the same time a Special Protection Areas (ROSPA0020) and National Park. The limits of these protected areas overlap, for the most part, being included in the Continental biogeographical region, with a total area exceeding 42,000 hectares, including 6 Nature Reserves (IUCN I category), including the Nature Reserve Nerei Gorges – Beușnița (established in 1943).

The most famous springs, rivulets, rivers and waterfalls here are also renowned tourist attractions: Beușnița Waterfalls, Ochiul Bei Lake and Văioaga Waterfall, in the tufa steps of Beiului Valley, Șusara and Moceriș Waterfalls and, last but not least, the Bigăr Waterfalls in the Minișului Gorges, considered among the most special and beautiful waterfalls in the world (http://www.theworldgography.com/2013/01/unique-waterfalls.html). The most important of them are also included in nature reserves, the first established in 1943, being high biodiversity areas due to the karst substrate and sub-Mediterranean climate influences. From a cultural-historical point of view also, these areas has an invaluable value, being a region where the Roman Empire, the Hungarian, then the Ottoman and the Habsburg rules left their traces over the traces of human habitat and fossils in caves from the Palaeolithic (35,000-40,000 years ago), including the famous Bone Cave in the Basin of Miniș, in which some of the oldest remains in Europe of modern man (TRINKAUS *et al*., 2003) were discovered.

Thus, the establishment of the National Park in 2000 and, subsequently, its inclusion in the Natura 2000 network, aims to protect these areas with very high conservation value. Habitat 7220* is semi-shaded, located on the background of thermophilous beech forests on limestone, with waters that are well oxygenated and rich in carbonates, with slopes varying from almost vertical in the case of waterfalls, to very low, where water meshes are formed. The main risks for this habitat are the reduction of the water level, especially in the summer months, when the waterfalls are dry because of the low water flow, and the insufficiently controlled tourism affecting the habitat, especially through trampling.

Because of the sensitivity of this habitat, monitoring its conservation status, implementation and observance of appropriate protection measures are mandatory. The purpose of this paper is to signal the amplification of the anthropogenic impact, with the massive increase in the number of tourists, as well as the reduction of the water level because of the climate trends correlated with existing waters and the use of which should be re-analysed by competent authorities. On the other hand, some national reports or guides do not include Nerei Gorges–Beușnița on the list of areas containing this habitat, despite the fact that some tufa morphologies (waterfalls, lakes, small dikes) are well known, even outside the country, making information update necessary.

MATERIAL AND METHODS

The inventory and mapping of the habitat was carried out throughout the protected area (Nerei Gorges–Beușnița National Park), between 2012-2016, starting from the springs area and following transects along the valleys. GPS coordinates were recorded and the extension of the habitat (measured or estimated area, length and width of springs, streams or

waterfalls with limestone tufa), slope, exposition, canopy cover, litter and organic matter, respectively, active tufa or inactive deposit, neighbouring habitats and species encountered (with population information). For plant species, the nomenclature follows The Plant List (http://www.theplantlist.org); for habitats, the Interpretation Manual of European Union Habitats - EUR28, the Romanian Manual for Habitats Interpretation (GAFTA & MOUNTFORD - coord. (2008) and the description of Romanian habitats (DONIȚĂ *et al.*, 2005, 2006).

Anthropogenic impacts were noted with (low, medium, high) intensities and coded according to http://cdr.eionet.europa.eu/help/natura2000 (List of threats and pressures), and the conservation status was considered favourable (FV), unfavourable – Inadequate (U1) or unfavourable – bad (U2), as appropriate. The database was used to interpret the distribution of species and habitats using ArcGIS 10.4, respectively for overlapping limits, surface calculation, distribution and intensity of anthropogenic impacts.

Anthropogenic impacts, habitat preservation status and application of management measures were monitored during 2016-2021.

RESULTS AND DISCUSSION

In the natural protected area Nerei Gorges–Beușnița (including SCI and SPA, national park and nature reserves), Habitat 7220* was mapped on an area of 51.5 ha, including inactive deposits located in the immediate vicinity of springs and streams with active limestone tufa formation. As features of the habitat, in this area, to note its distribution along the springs, streams and rivers mostly in forest areas, shaded, on the background of beech forests in the 9130 habitats (*Asperulo-Fagetum* beech forests), 9150 (Medio-European limestone beech forests of the *Cephalanthero-Fagion*), 91K0 (Illyrian *Fagus sylvatica* forests – *Aremonio-Fagion*), 91V0 (Dacian Beech forests – *Symphyto-Fagion*), but also of ravine forests and steep slopes of the type of habitat 9180* (*Tilio-Acerion* forests of slopes, screes and ravines) and, less, on the background of the 91L0 (Illyrian oak-hornbeam forests – *Erythronio-Carpinion*) and 91M0 (Pannonian-Balkanic turkey oak – sessile oak forests). On the banks of water courses, so also the Habitat 7220*, 91E0* is distributed – Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*: this is the habitat responsible for shading limestone tufa areas, but also for the aesthetic double value of the two habitats (NICOLIN *et al*., 2014; Figure 1). Sporadic, on the flatter surfaces, are also patches of the habitat 6430 (Hydrophilous tall-herb fringe communities of plains and of the montane to alpine levels), but in the areas of gorges, steep slopes and waterfalls we meet the 8210 habitat (Limestone rocky slopes with chasmophytic vegetation). Last, but not least, the karst substrate and tufa formations are related to Habitat 8310 – Caves not open to the public, very well represented in this protected area.

Habitat 7220*, with active limestone tufa formation, is distributed on certain sectors of Nerei, Beiului, Minișului, Șușarei, Cremeniței, Boiștei, Ducinului, Mocerișului, Lăpușnicului, Văii Mari watercourses, in the altitude range 177-744 m, associated, from the perspective of the landscape, with gorges sectors (Nerei Gorges, Minișului Gorges), waterfalls (Beușnița, Bigăr, Șușara, Văioaga), lakes (Ochiul Bei, Lacul Dracului).

The areas included in this habitat are not characterized by the presence, on the banks of the water, of numerous species of characteristic superior plants. Due to shady banks, in particular, cormophytes that may be associated with this habitat are reduced in number and abundance. In the formation of the limestone tufa, dead vegetable materials from neighbouring habitats are observed. Moss species, especially those belonging to the *Cratoneuron* genre, are abundant at allocations, but especially on heavily inclined, more aerated areas, giving the particularly aesthetic aspect of the Bigăr and Beușnița waterfalls.

The Romanian Habitats Manual (GAFTA & MOUNTFORD – coord., 2008) lists the following species for 7220*: Plants: *Arabis soyeri, Cochlearia pyrenaica*, *Pinguicula vulgaris, Saxifraga aizoides, Carex appropinquata, Juncus triglumis*. Among bryophytes: *Cratoneuron commutatum, C. commutatum var. falcatum, C. filicinum, C. decipiens, Philonotis calcarea, Catoscopium nigritum, Eucladium verticillatum, Gymnostomum recurvirostrum, Drepanocladus vernicosus, D. revolvens, D. cossonii, Bryum pseudotriquetrum*. Dominant characteristic species: *Silene pusilla, Saxifraga aizoides, Cochlearia pyrenaica* subsp. *borzeana, Pinguicula vulgaris, Doronicum carpaticum, Chrysosplenium alpinum, Cratoneuron commutatum, C. filicinum, Philonotis calcarea, Bryum pseudotriquetrum, Calliergonella cuspidata*.

The bryophytic diversity of this region, Aninei Mountains and Semenic Mountains, is remarkable, though not deeply studied (e.g., SCHRÖTT, 1972; SCAGNI & HUGONNOT, 2015). Among the Musci and Hepaticae species frequently associated with travertine / tufa in Europe, according to PENTECOST (2005), there are some species found by SCHRÖTT (1972) in the Nera Gorges-Beușnița nature reserve: *Brachythecium rutabulum*, *Cratoneuron commutatum*, *C. filicinum*, *Conocephalum conicum*, *Fissidens taxifolius*, *Plagiomnium undulatum*. Under the name *Cratoneuron commutatum* should be comprises the two species *Palustriella commutata* (Hedw.) Ochya, and *Palustriella falcata* (Brid.) Hedenas. *Cratoneurion commutati* Koch, 1928 is the alliance that includes sunny and limestone springs and streams with highly oxygen and calcium saturated waters, where incrustation processes occur (COUVREUR *et al*., 2016).

Overlapping of invertebrate species, fish, amphibians, reptiles and mammals with the limits for 7220* indicated that areas comprising the habitat represents biodiversity hotspots, without strict reference to the habitat surface, but also to neighbouring areas. This is also explained by the existence of Nature Reserves, sometimes long before the implementation of Natura 2000 Network in Romania. In ROSCI0031, the Habitat 7220* protects species of community importance such as *Austropotamobius torrentium* and *Cordulegaster heros*. The Eurasian otter (*Lutra lutra*) visits the habitat in search of crabs, especially at the course of the Miniș. *Bombina variegata, Rana dalmatina, R. temporaria, Natrix tesselata* and *Salamandra salamandra* are other species that can be found on the habitat surface.

The reduced width, of only 1-2 m here and there, of watercourses, limestone tufa patches, its presence in areas sometimes hardly accessible, made it difficult to accurately map this type of habitat. In Moceriș, Ducin and Cărbunari areas, there are old limestone tufa deposits, mostly inactive, whose surface is also difficult to measure, because they are covered by soil, disturbed here and there by cultivation, which is why agriculture / cultivation was included in the impact category. Even if the Habitat 7220* includes watercourses with active limestone tufa formation, they are difficult to map separately from inactive deposits located in their immediate vicinity.

As distribution, although the Habitat 7220* in Nerei Gorges–Beușnița is renowned due to its waterfalls and lakes, including among non-specialists, in the "Synthetic monitoring guides for habitats of community interests, bushes and marshlands, rocks, forests" (2014), this area is not quoted. Of the total 18 sites in Romania, 12 were selected for monitoring this habitat, i.e., 15-20 ha in the Alpine region and 3-10 ha in the continental region. From the perspective of both the surface and the distribution of the habitat, this paper can be complemented by studies subsequent to its publication. The guide states that, for some habitats, including 7220*, "the favourable reference area is very difficult to establish because of anthropogenic biota changes (destruction by drainage, desiccation, pollution), but also by natural dynamics to shrub vegetation." As a total area for which Habitat 7220* is protected in Romania, 1,160.5 ha are summed here. In the "Synthetic report on the state of conservation of

species and habitats of community interest in Romania" (2015), the conservation status for this habitat was still unknown. Currently, on https://eunis.eea.europa.eu/habitats/10150, the conservation status for 7220* in Romania still appears as an unknown.

Anthropic impacts, conservation status, and management measures

Among the anthropogenic impacts, present in the protected or estimated as such area, taking into account the trends of the last few years, some do not jeopardize this habitat, but others have a strong, growing impact.

Agriculture, through cultivation (A01) – parcels of the locals, with traditional agriculture – and through grazing (A04) is a localized impact in the Moceriș-Ducin area, its intensity being considered low because these cultures are not even in close proximity to springs and affect rather inactive deposits. However, the impact is obvious, and grazing determines in particular the erosion of the substrate.

Through forest activities, the deposit at Cărbunari is affected (Forest management - B02); deforestation can accelerate soil erosion and direct insolation on 7220* habitat. Extraction of limestone tufa (C01 – mining and quarrying) was identified on the Moceriș deposit; in the past, it was exploited and traces are now observed. Extracting limestone tufa, even unauthorized, requires monitoring. Because of its friability, any type of exploitation of these surfaces should be avoided.

Pipe lines (D02.02): on the Minișului Valley, the old pipe currently affects the habitat only from the point of view of the value of the landscape. Water captures were made for the supply of localities (J02.06.02), as in the Moceriș river directly from the spring, with the reduction in the flow rate and the change in the morphology), or for the water supply of the trout breeding facilities (J02 .06.05), as at the Bigăr Spring. In the latter case, the existence of the Bigăr Waterfalls – with the characteristic appearance of moss species, depends on the flow of water that remains downstream of this capture, just a few meters from the waterfall; at certain times, depending on the weather and timely distribution of precipitation, the water flow on the Bigăr Waterfalls is very low, causing whitening and drying of the bryophytes. Other constructions, made for various purposes (old hydrotechnical amendments - e.g., the Bei River), concrete platforms for tourists' access (Bigăr Waterfalls), trout breeding facilities (Bei, Miniș) intervene in this ensemble of petrifying water courses. Hydrotechnical waters and fittings, even if they were made decades ago, have an important anthropogenic impact, amplified by climate changes (M01 - Changes in abiotic conditions) by reducing the water flow in the summer months. The impact of climate change is readily observed especially at the Bigăr and Beușnița waterfalls, on their vertical walls, exposed to the lack of water and, in part, direct sunlight. Upstream the Bigăr Waterfall, a few hundred meters, the National Park administration has recently deforested the forest vegetation covering the Cârșa Waterfalls to include it in the tourist circuit. This spring also has an older capture and, in summer periods, the amount of water is often low.

Garbage and solid waste (H05.01): the accumulation on these rivers is observed after increasing and decreasing water levels, even if waste resulting from tourism activities is generally eliminated; the collection system can be improved throughout the protected area in local communities and tourist areas.

Outdoor sports and leisure activities, recreational activities (G01): anthropogenic impact that has greatly increased in recent years, because of the tourist promotion of the Bigăr Waterfalls. In some areas, this impact is high because of uncontrolled tourism. Visitors have access to Bigăr and Beușnița waterfalls, in Ochiul Bei Lake, on the limestone tufa steps of Beușnița, which are some of the places already changed because of the influx of tourists. In addition to entering the waters, precisely on the priority habitat, with limestone tufa in active

formation, tourists also affect neighbouring habitats through free access without arranged paths, resulting in the appearance of sheep trampled vegetation; soil erosion leads to its accumulation in Ochiul Bei Lake, which gets cloudy because of suspensions and disturbing sediment because of trampling. Frequent climbing on waterfalls (especially seen at the Beușnița Waterfalls), given the friability of the limestone tufa, endangers their integrity. Compared to this type of anthropogenic impact, all 7220* areas are sensitive and require urgent control, regulation and monitoring measures. Trampling (G.05.01) by tourists tends to become the major impact, present on important areas containing this habitat. Nautical sports (rafting, descent in kayak) should not be allowed in deep water areas and generally where there are limestone tufa accumulations.

Therefore, it is important to monitor over time, as impacts on the habitat, the captures on the Miniș and Bei rivers, made for the supply of trout breeding facilities. Along with them, and for all other captures, finding alternative solutions, according to the preservation needs of the Habitat 7220*, needs to be done as soon as possible. It is well known that reducing waters can negatively influence the process of active formation of travertine and even maintaining it (ONETE *et al.*, 2014). The cumulative effect of climate change with other anthropogenic impacts can cause rapid, reversible changes – maybe – in thousands of years, on petrifying springs and limestone tufa formations on the course of these waters. Last, but not least, tourism produces negative effects in very short time.

Other impacts affecting this type of habitat (CANTONATI *et al.*, 2016; GUITIÁN *et al.*, 2020; ONETE *et al.*, 2014; Report under the Article 17 of the Habitats Directive for 2007–2012), in Romania and worldwide, are not noted in this protected area or their impact is still low: eutrophication, phosphorus pollution, invasion by alien plants. In recent years, a project of micro-hydropower plant has been attempted on the Nera River, upstream of the entry into the National Park. Here, but also on the Nera River upstream or downstream of the protected area, the construction of micro-hydropower plants should be excluded if the conservation of this habitat and its biodiversity is desired. New surface water captures and any kind of dikes should not be allowed on the rivers' surfaces containing this type of habitat. The existing ones require control and regulation as a debit so that the Habitat 7220* does not remain without water; in periods of drought, the use of waters for other purposes should be prohibited.

OPREA *et al.* warned, since 2007, on another area in Romania (Cheile Șugăului–Munticelu Nature Reserve), where the 7220* habitat – "a complex biological-biochemical, hydrogeological-mineralogical and petrogenetycal system" – is in danger because of older water captures, and also because they intended to make new ones, which would have led to the drastic reduction in the flow in the 7220* habitat. In fact, that industrial project has been achieved, the source is still captured and the habitat degrades from year to year, in the absence of water, with all the specialists' efforts to stop this investment. The lack of clear legal regulations, harmonized with European ones, or their preferential application, political influence, financial interests, lack of respect for specialists' views characterize this country and does not contribute to adequate preservation of Natura 2000 habitats, some created in thousands of years of evolution, as is the case for limestone and travertine tufa, destroyed in just a few years through the wrong interventions, especially by water captures.

Analysis of anthropogenic impacts and information gathered over the last 9 years, in the Nerei Gorges – Beușnița National Park, shows that the habitat 7220* was – generally – in a favourable conservation status until 2016, the year of approval of the Protected Area Management Plan (NICOLIN *et al.*, 2016). However, the evolution of the last 5 years, in particular increasing the impact of tourism, which is insufficiently regulated locally, the visible changes of limestone tufa, waterfalls, thresholds on river courses, lakes, needs this

conservation status to be revised to at least unfavourable – inadequate (U1). The most exposed areas to this pressure are the Bigăr spring and waterfalls, the Ochiul Bei Lake and the Beușnița Waterfalls. Facilities aimed at allowing visitor access to these particularly attractive areas, commendable arrangements as an effort to promote the protected area and maintain a control of tourists, do not, however, bring benefits for this priority habitat, or they are not enough. The low human resources of the national park administration do not allow effective control of tourists' behaviour in all sensitive areas. Eco-tourism arrangements are also needed in the Beușnița Waterfalls area, at least, to avoid trampling by tourists in the habitat or on the edge of it. Visitors' education and correction of their behaviour through information, the presence of the rangers in the key points (e.g., Ochiul Bei, Beușnița Waterfalls) – throughout the tourist period – along with a good organization of the visiting infrastructure and the ecological restoration of neighbouring habitats, made with caution, could bring the habitat preservation status to optimal parameters. Returning to favourable conservation status is even more important in the context in which the Habitat 7220* has, in most European countries and at the level of all biogeographical regions, an unfavourable-inadequate or unfavourable-bad preservation (https://eunis.eea.europa.eu/habitats/10150).

It is essential to preserve the habitat surroundings and the whole hydrological system concerned (ONETE *et al.*, 2014). The maintenance of a sufficient water flow is the most effective action in conservation plans for petrifying springs (BRUSA & CERBOLINI, 2009). In addition to the integrated hydrological approach, this habitat is part of a habitat assembly, which are also biodiversity hotspots (NICOLIN & IMBREA, 2007, 2009; SCHRÖTT, 1972; PÂRVULESCU, 2007; NICULESCU *et al.*, 2014; PRUNAR *et al*., 2013), which implies a coherent conservation strategy. From a similar perspective, ŠILJEG *et al.* (2020) proposed a multiscale framework resulted in reactivation of tufa-forming watercourses, prevention of invasive vegetation regeneration (especially *Ailanthus altissima*) and achievement of sustainable conditions for the tufa formation process. "The degradation of the tufa landscape can be manifested in the reduced intensity of tufa growth, absence of tufa-forming processes, increased biomass of green algae associated with nutrient enrichment, tufa dissolution and tufa waterfall collapse." The authors also draw attention to the impact of tourists and visiting infrastructure (path construction and gravel accumulation).

CONCLUSIONS

Habitat 7220* represents the iconic image of the Nera Gorges – Beușnița National Park and it is present in areas with high biodiversity, where other habitats and Natura 2000 species are also present. The preservation of these petrifying water courses can be optimally achieved if they are viewed integrated, as part of a special hydrographic network, pursuing and controlling the main anthropogenic impacts. In a favourable state of preservation until 2016, monitoring in the last 5 years (2016-2021) allowed the observation of effects produced by tourism intensification, adding to climate change that causes water flows in this habitat, respectively at the older, still functional water captures. The cumulative effect of anthropogenic impacts asks for the revision of this conservation status, to at least unfavourable – inadequate (U1).

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Note: *During the publication of this manuscript, a part of the Bigăr Waterfalls broke away and collapsed in the Miniș River bed.*

Figure 1: Petrifying springs with tufa formation in Nera Gorges – Beușnița National Park

Active formation of limestone tufa. @ D. Stănescu

Petrified bryophytes at Ducin. @ B. Bădescu

Beușnița Waterfalls and limestone tufa steps on the Bei River. @ C. Buda

Moceriș Waterfalls and limestone tufa deposits. @ B. Bădescu

Tourist access on habitat area and low water flow in summer at Beușnița Waterfalls. @ A. Nicolin

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