SEDIMENTS AS FACTOR IN THE FATE OF THE THREATENED ENDEMIC FISH SPECIES *ROMANICHTHYS VALSANICOLA* DUMITRESCU, BĂNĂRESCU AND STOICA, 1957 (VÂLSAN RIVER BASIN, DANUBE BASIN)

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ABSTRACT

The main emphasis of this paper is on the negative effects of sedimentation on the most highly endangered fish of Europe *Romanichthys valsanicola* and the habitats of its main trophic resource *Rhithrogena semicolorata*. Some inexpensive and easy-to-implement solutions are identified and proposed (dam reservoir related recommendations for basin sediments management, forestry related recommendations for sediment basin management, basin sediments general management recommendations, riverbed ecological reconstruction approach proposal, etc.) in the paper with the same conservative purpose for *Romanichthys valsanicola* species in the actual situation of habitat loss and drastic regress of this globaly-unique fish population.

RÉSUMÉ: Impact du facteur sédimentaire sur l'espèce endémique et menacée de poisons *Romanichthys valsanicola* Dumitrescu, Bănărescu and Stoica, 1957 (Vâlsan River basin, Danube Basin).

Dans cet article l'accent se porte sur le phénomène de sédimentation trop important, qui a un impact négatif sur l'espèce de poissons la plus menacée d'Europe *Romanichthys valsanicola* mais également sur l'habitat de sa principale ressource trophique *Rhithrogena semicolorata*. Quelques solutions faciles à mettre en place et peu couteuses ont été identifiées et proposées (recommandation concernant les lacs formés par des barrages pour la gestion des sédiments, recommandation concernant la sylviculture pour la gestion des sédiments, proposition d'approche pour la reconstruction écologique des lits de rivières, etc.) dans l'article avec le même objectif afin de conserver *Romanichthys valsanicoa* une espèce unique fortement menacée du fait de la réduction de son habitat naturel et sujette à une diminution forte et globale de sa population.

REZUMAT: Sedimentele ca factor în soarta speciei endemice ameninţate de peşte *Romanichthys valsanicola* Dumitrescu, Bănărescu şi Stoica, 1957 (bazinul râului Vâlsan, bazinul Dunării).

Accentul principal al acestei lucrări este pus pe efectele negative ale sedimentării asupra habitatului celui mai ameninţat peşte al Europei *Romanichthys valsanicola* şi a resursei lui trofice principale *Rhithrogena semicolorata*. Au fost identificate şi propuse unele soluţii ieftine şi uşor de implementat (recomandări legate de managementul sedimentelor lacului de baraj, recomandări silvice legate de managementul sedimentelor din bazin, recomandări generale de management a sedimentelor din bazin, propunerea unor elemente de reconstrucţe ecologică, etc.), cu acelaşi scop de conservare a speciei *Romanichthys valsanicoa* în situaţia pierderii habitatului şi de regres drastic al acestei populaţii de peşti unici la nivel global.

INTRODUCTION

Mid-20th-century Europe: this continent with so many of the most prestigious schools of natural sciences of the world, considered the inventory of biodiversity "at home" was thoroughly well known enough such that the scrutiny of European specialists focused their continuous and vigorous professional competition in the natural sciences to the continents of Africa, Asia, South America, Australia, and Antarctica. As always, one of the most attractive prizes for the academic community, which brings great satisfaction and professional recognition, is that opportunity of scientific pioneering, the discovery of a new species! (Bănăduc, 2004)

The genus *Romanichthys*, with its only species *Romanichthys valsanicola* Dumitrescu, Nalbant and Dragomirescu, 1957 (Dumitrescu et al., 1957), was discovered only recently, however, in 1956 by Stoica M., in the Vâlsan River (terra typica), a tributary of the Argeş River/Danube Basin, on Romanian Galeş Commune territory (Bănărescu, 1964, 2005; *, 1999-2003).

The discovery of this genus and species came as a big surprise to ichthyologists in Europe and North America. The interest shown to *R. valsanicola* is due to its resemblance to a group of exclusively North American genera (Etheostomatini) from the Percidae family. Between 1957 and 1962, this fish was found in the Argeş River, where it was more numerous than in its tributary the Vâlsan (Bănărescu, 1964, 2005; *, 1999-2003). Rumors of its possible occurence in other rivers, however, were never confirmed (Bănărescu and Vasiliu-Oromulu, 2004).

R. valsanicola is a relatively small fish species (12.5 cm total length, 10.5 cm length without the caudal fin) and critically endangered (IUCN, 2008) in spite of its protection status (Bănărescu et al., 1957, 1995; *, 1999-2003; Bănărescu, 2005; Bănărescu and Bănăduc, 2007). This post-glacial relict fish species has the smallest living areal in Europe and Asia, and is considered not only the most endangered fish species of the Danube Basin but of all Europe (Maintland, 1991; Bănărescu, 2002).

The Argeş River, together with its affluents, drains the south slope of the Făgăraş Mountains. It gathers waters from a surface of 12,600 km^2 and after 340 km it flows into the Danube River (Constantinescu, 1990).

In 1960-1966, a big concrete dam on the Argeş River was built (Vidraru Dam with a 166 m height, which created water storage with a total volume of 465 bmil. m^3) (Constantinescu, 1990) upstream of the area populated with this fish species. The complex aftereffects of this dam resulted in a significantly modified lotic system, including habitats specific to *R. valsanicola* (*, 1999-2003; Ureche et al., 2007). Also in 1966, a dam was put into use on the Vâlsan River (basin surface 358 km^2, length 84.6 km) upstream from the *R. valsanicola* habitat areas (Truţă et al., 2016). The considerable depletion of water flow left the fish without the necessary ecological flow on the river (*, 1999-2003). In the following years the species was considered extinct, including on the Vâlsan River, however, it was later found again, but in extremely small numbers (*, 1999-2003). Upstream, the Buda and Capra streams, which form the Argeş River, also became significantly impacted by the deficient construction and management of hydro-power plants in the last few decades (Curtean-Bănăduc, 2014).

In 1989 the reservoir on the Vâlsan River was drained, which was just one of the many significant, negative impacts of the poor management of the dam on the Vâlsan River. As a result of draining the reservoir the bottom of the downstream riverbed was covered by a thick blanket of mud, which greatly deteriorated the living conditions of the aquatic organisms of the river including invertebrates and fish. In the same period, a mine shaft was opened very close to the river, just a short distance upstream from the *R. valsanicola* population. Waste was deposited into and near the river with a very bad effect on the water quality (Bănărescu and Vasiliu-Oromulu, 2004). During this period extremely few specimens of *R. valsanicola* were found. Additionally, national and international efforts to hatch and raise the fish in captivity failed, inadequate food (*Tubifex*) being one of the main reason for this failure (*, 1999-2003; Bănărescu and Vasiliu-Oromulu, 2004).

One of the basic assumptions of this paper is that understanding the *R. valsanicola* ecology and its biologically-specific characteristics can give us the chance to identify valuable clues about the key, necessary management elements needed to conserve this highly-threatened species. Highlighting just the watershed sediments issue, for example, demonstrates the effects on aquatic environments is very compex including changes to light penetration, temperature adjustment, electrolytes, organic matter, and last but not least bottom conditions (Ellis, 1936; Barnes and Mann, 1991; Ispas et al., 2020).

R. valsanicola, a small, rheophilous species, usualy lives in the strong currents of cold and clear mountain streams. It is strictly territorial having as central points of reference large boulders, typically sheltering under the same large stone or boulder during the day, and at night leading an active life seeking food (*, 1999-2003; **, 2013).

Between 1948, when the general registration of water flows in Romania began, and 1967, when the dam was built on an upper Vâlsan River section, the annual water flow of this river at the Brădet locality oscillated between two-to-three m^3/sec., occasionally reaching even four m^3/sec. In 1959, however, it dwindled to 1.5 m^3/sec. No flow downstream the dam was allowed. What little flowing water there was came from infiltrations of groundwater and additions from small tributaries downstream the dam. The water flow at Brădet dropped even further to one m^3/sec., then to 0.5 m^3/sec., and in 2000 and 2001, even less than 0.3 m^3/sec. (*, 1999-2003)!

The habit of the local people to collect rocks from the riverbed for construction should also be mentioned here (Bănărescu et al, 1995). This action led to serious repercussions on relatively less-mobile fish species (Ionaşcu and Crăciun, 2009). Now, the big stones are missing and the boulders that remain do not have enough density and dimension for good habitat and often are covered by fine sediments.

The arrangement of the teeth, the pharyngeal area, and the size of the stomach in *R. valsanicola* denotes a carnivorous and voracious species, which feeds on lotic invertebrates. The low ratio of *R. valsanicola* among the local potential trophic competitors *Barbus meridionalis* Risso, 1827, *Cottus gobio* Linnaeus, 1758, *Romanogobio uranoscopus* (Agassiz, 1828), *Romanogobio kesslerii* (Dybowski, 1862), *Squalius cephalus* (Linnaeus, 1758), *Barbatula barbatula* (Linnaeus, 1758), *Alburnoides bibunctatus* (Bloch, 1782), *Sabanejewia romanica* (Băcescu, 1943), and *Sabanejewia balcanica* (Karaman, 1922) (Bănărescu and Vasiliu-Oromulu, 2004), reveal the importance of the specific food abundance and accessibility.

R. valsanicola is mainly a nocturnally-active fish, moving constantly from place to place. Analysis of the *R. valsanicola* stomach contents shows that it feeds almost exclusively on aquatic insect larvae. The dominant rheophilic and oxyphilic insect group in the *R. valsanicola* diet is by far the mayflies, among them 78% being *Rhithrogena semicolorata* (Curtis, 1834). It is obvious that *R. valsanicola* has a strong preference for *R. semicolorata* particularly because the fish can easily find this mayfly species attached to hard surfaces in the water (Găldean et al., 1997).

Similarly with *R. valsanicola*, its main prey *R. semicolorata* usually has a microhabitat relationship with the hard substrate, being generally found on and under larger boulders. *R. valsanicolai*, with its predominantly nocturnal grazing activity, coincides perfectly with the mayfly species leaving its shelters at night to consume epibiosis on surfaces of boulders (Bauernfeind and Soldan, 2012; Curtean-Bănăduc et al., 2012). In its larval stages, *R. semicolorata* also leave their shelters at night to move around and feed on the surface of stones. Generally, these stone surfaces are covered with epibiose or a periphytal layer. This layer has a very active algal life, mainly diatoms, and is a primary food source for the mayfly larvae. When the mayfly larvae leave their shelters (crevices, stones underfaces, etc.) the larvae emerge in the primary area of *R. valsanicola* activity (Găldean et al., 1997; *, 1999-2003).

Habitat is a fundamental cornerstone of fish and represent the physical and chemical features of the aquatic systems that affect survival, growth, reproduction and recruitment (Bozek et al., 2011). Ichtyofauna faces large-scale and significant negative impacts due to human changes and influences in their habitats (Cordone and Kelly, 1961; Afanasyev, 2003; Curtean-Bănăduc et al., 2006, 2007, 2018, 2020a, b; Bănăduc 2008; Trichkova et al., 2009; Telcean et al., 2011; Witkowski et al., 2013; Sosai, 2015; Popa et al., 2016; Khoshnood, 2017; Kruk et al., 2017; Marić et al., 2017; Joy, 2018; Kar, 2019; Bănăduc et al., 2020; Iordache et al., 2020).

Anthropogenically-induced impacts in *R. valsanicola*-specific habitats in recent decades have a direct influence on this fish species, as well as an indirect influence on the fish through its dominant food source, *R. semicolorata*, and other ephemeran species.

The main objectives of this study are to identify the currently modified/unsuitable types of habitats of the two species of interest, *R. valsanicola* and *R. semicolorata*, and to suggest some basin-management elements that can reduce the impact of these unwanted habitat changes, especially related with sediments issue. Notably, it was proven that elevated fine sediment input from terrestrial and aquatic sources as a result of human activity create a negative impact on aquatic ecosystems (Kemp et al., 2011). Conversely, the negative anthropogenic impacts to natural stream sediments can be reversed, too, mitigating the negative effects on invertebrates and fish communities (Ramezani et al., 2014).

Based on these objectives, it is possible over the long-term to increase individual fish numbers back to relatively similar levels in the decade from 1956-1965 along the 40-50 km stretch of water (before Cheile Vâlsanului/Vâlsanului Gorges and Vâlsănești locality) before the construction of the Vâlsan River dam.

MATERIAL AND METHODS

During July through September 2019, daily trips were made along the banks of the Vâlsan River three kilometers upstream and dowmstream from the Brădet locality. Fishermen were asked about what fish they had caught and any incidence of *R. valsanicola* was recorded.

During this period in 2019, 11 individual *R. valsanicola* fish caught by fishermen were identified and released in situ immediately. The fish were marked with a very small spot of paint for easy identification to avoid double counting in the analysis. The paint is biodegradable and dissapears in six months. It was noted that not all the fishermen could recognize this species or were aware of the high international conservation value of this fish.

As part of the analysis the habitat types where *R. valsanicola* were identified and noted, along with the species of other fish caught and identified in the survey.

RESULTS AND DISCUSSION

This paper draws attention to negative anthropogenic effects on the environment in addition to those known so far: the extraction of boulders from the riverbed for construction, poaching, pollution, and changing the dynamics of liquid flows due to the non-ecological management of the Vâlsan Dam (Stănescu, 1971; Bănărescu and Vasiliu-Oromulu, 2004; Bănărescu, 2005). Additional consideration is being given to the change of the solid flows dynamics. Harmful gusts of wind and clear-cutting of timber now occur in the Vâlsan Basin, which accentuates soil erosion and the transport of alluvial sediments downstream. There are, however, some proposed management and technical solutions to reduce these effects.

The change in the dynamics of both liquid and solid flows of the Vâlsan River as a result of the long-term aggressive human impact reveals one of the most important points of action of any management plan developed for the conservation of the species *R. valsanicola*.

In this context, the survey identified and described habitats where *R. valsanicola* were and were not caught by fishermen. The identified lotic sectors where individual *R. valsanicola* fish were caught had common characteristics of a riverbed composed of a majority of medium and large boulders and less sediment. In sectors where these boulders were missing or were very few, or if the river bed was covered by sediment, no *R. valsanicola* fish were found.

Despite that the geomorphological effects of peneplation are well known across the scientific community (Goudie, 2004) some ecological effects of this phenomenon are ignored or underestimated. Denudation with its components of weathering, organism activity, erosion, transport, and accumulation are continuous natural processes (Müller, 1968; Posea et al., 1976; Poons, 2008), whose indirect influence on fish is little-addressed in research.

The erosion of rocks and soil is a process of moving mineral and organic elements through a complex-but-natural process that has occurred for eons of time. The eroded material can cause both on-site and off-site effects (Parsons and Cooper, 2015), which can influence an ecosystem's dynamic. Massive soil erosion, usually produced under anthropogenic influence, hinders the growth of plants, agricultural yields, water quality, catchment health and recreation (Pimentel and Burgess, 2013; Najib et al., 2020).

This study holds the premise that the erosion of rock and soil surfaces influenced by slope relief, climate, water, wind, gravity, hydrographic networks, vegetation characteristics, actions of organisms, types and degrees of anthropization, and more, are factors that must be analyzed and taken into account in the complex context of the need to protect *R. valsanicola*, its habitat, and its specific trophic base.

Fine sediments drifting in the flow of water exist throughout the watershed in the study area. These floating sediments are held in suspension in the water column as long as water flows have the necessary volume and speed to keep sediments from dropping to the riverbed. With low flows, reduced volume, and minimal velocity the sediment will accumulate. The transport and accumulation of silt, sand and even gravel causes problems by changing the rocky hard substratum of river beds to a more soft, sandy or muddy substratum.

It is critical understand that while the erosion of the basin, river banks, and river bed in the study was in a natural dynamic, this process of transport and accumulation was in balance. The lotic system was in a natural dynamic, helping it to qualitatively and quantitatively preserve its processes by offering natural services to the local biota and the riverine human communities. When human activities in the watershed started to have effects over a certain level of impact, it was reasonable to see the lotic system reaction, including changes in its biotope and biocoenosis structural elements.

The increase in the accumulation of sediments in some river sectors is a signal of a decreasing water-flow volume and speed in the river. The reduced capacity of the Vâlsan River to transport even normal/natural quantities of sediments coming into the basin, on top of sediments produced by human activities in the basin (removing the sand of the dam reservoir and the sills, clear cutting forests without immediate afforestations, non-compliant skid roads, erodible dirt roads, banks modification, riparian vegetation destruction, and even using bulldozers to “clean” the riverbed, etc.) along with natural events, like destructive gusts of wind, caused the increasing quantity of sediments in the river basin.

Although the survival of this fish species in such a small area is a kind of “natural miracle,” the desperate need for a more applicable, carefully-executed and sustainable conservation measure needs to be widely known and acknowledged if we want to avoid the extinction of this species. In this unfortunate context, the appearance of windfalls and possibly negligent logging activities, can be something unbearable for this threatened fish species.

The biological and ecological needs of the most endangered fish species of Europe, *R. valsanicola*, and of its main trophic base, the species *R. semicolorata,* requires a strict sediment management regime, especially of the fine sediments. These fine sediments usually do not come from riverbed erosion but rather from upstream sub-basins, resulting in the most negative effects on macro and micro habitats used as shelters as fine sediments are transported in the water to both temporary and final deposits along the river.

It is worth noting that among the human activities that have a direct negative impact on soil erosion and indirectly on aquatic communities of lotic systems, unsustainable forest exploitation is right at the top, in company with land cultivation and overgrazing. In the upper Vâlsan River basin only unsustainable forestry and overgrazing are significantly present.

It should also be noted that in recent decades the sediment transport capacity of the local hydrographic network has been constantly exceeded due to the impact of human activities on one hand and climate changes on the other. The effects are visible (overcolmatation) on the minor riverbed and the associated biota.

In this general and specific conservation context, the present work proposes a set of management and technical measures, to enhance efforts to protect the *R. valsanicola* species natural sanctuary.

Sediment management general measures proposal recommendations

Reservoir-related recommendations for basin sediments management

The silting phenomenon in storage lakes/reservoirs, which are sediment sinks, is a natural, global, physical phenomenon which cannot be avoided. Also, the normal evolution of oligotrophic to mesotrophic and finally the eutrophic state of these lakes due to sediment accumulation leads to habitat changes and influences the downstream effluent lotic system physico-chemical and trophic status.

These effects may be retarded, however, in the following ways:

– extraction/clearing of the Vâlsan River storage lake/reservoir and transportation of the fine sediments (sand and mud) to specifically identified and designated storage sites far downstream, along with a ban on washing sediment deposits by discharging them downstream into the river, this being to stop spillage of all sediments and sludge by periodic clearing of the lake bottom;

– between dredging the lake bottom, mitigating downstream sedimentation effects by periodically covering the lake-bottom sediment with plastic or rubber sheeting materials;

– equipping the front barrier of the concrete dam (the upper part of the barrier of the concrete dam) with specially-designed and constructed mobile elements (an inflatable rubber dam or a gated dam without bottom sills under one meter high) so that, during large flows – where the alluviums' transport is so prevalent – the lake's outflows of sediment will match near-natural levels;
– another solution, which is a variation on the previously proposed solution, is diminishing silting by using weirs, with adequate adapted dimensions, so that in flood conditions escaping sediments will be kept to natural levels;
– an alternate solution, which might offer remarkable results, is that of creating some outside-of-river-bed storage lake, in which the flowing water will always be channeled except during the flood periods. This solution may be achieved with: a permanent or mobile diversion dam, a headrace, and a storage lake, with the main course of the river keeping its own route and the remainder of the water flow and discharge transported away during flood periods;
– all the existing torrents's fitting-out and soil erosion control works, in the lake basin should be achieved (Tecuci, 1993).

Forestry-related recommendations for sediment basin management

Numerous forestry management measures are already part of the Romanian legislation (Ministry Order 1540/2011) (Stăncioiu et al., 2008; Bucur, in verbis) and if they are adhered to in the field they can be effective conservation management measures.
– the forest stands' vertical and horizontal structure should be as close as possible to its natural model (multi-layers, groups, and patches) in order to reduce soils being destabilized because of slope characteristics, loss of moisture, loss of large canopy cover, loss of root strength, etc. The preferred management regime should be irregular shelterwood or a selection system;
– permanent watercourses will be protected by commercial intervention with a minimum 50-meter-wide stripe on both sides of the watercourse. Inside these stripes, minimal conservation fellings can be allowed if they are strictly needed. The cross-over, in accidental or extraordinary cases when it cannot be avoided, will be made over the shortest distance on installations adopted to keep the water clean and soil erosion at minimum;
– riparian forest and the natural bushy and grassy, local vegetation and flora will be strictly protected;
– any timber harvesting or transport activity is recommended to take place on a frozen substrate, covered by snow and/or ice and on well-maintained forestry roads with a layer of mineral aggregates on top of the road;
– the network of forestry roads must be optimally dimensioned – maximum efficiency with the minimum amount of damage;
– existing roads should be preserved and maintained in order to avoid or minimize erosion, sediment transport and accumulation in the area;
– building of new forestry roads should be avoided;
– ecologically friendly, low-impact logging technologies (oxen, horses, cableway-skidders) are always preferred;
– timber will not be removed from forests during or after precipitation while the soil is moist;
– skid-roads will always be designed, built and monitored in order to avoid soil-erosion as much as possible, ensure the protection of permanent and temporary watercourses, and protect remaining trees;
– sensitive areas like potential land-slide zones, talus, cliffs, steep slopes, etc., will be identified, protected (excepted from logging), and monitored;

– it will be prohibited to store timber (even for short periods of time) in the riverbed, on its banks, and on the minimum 50-meter-wide protection stripes adjacent to both perennial and ephemeral waterways. All the vegetation within the protection belts shall remain intact;
– intervention cuttings will be applied in openings with a diameter up to a tree height, from which the old trees can be completely removed;
– timber harvesting will not exceed 10% of the volume of the stand (exceptions can be allowed in special accidental situations, for example windfalls and/or snowfalls, etc.), and the harvest volume will be correlated with the condition of the stand, the dynamics of natural regeneration, and with assigned conservation requirements;
– logging techniques will be adopted to minimize the level of injuries to the remaining trees and soil;
– if there are stands in which the natural regeneration is very difficult or stands are affected by calamities, replanting or direct sowings will be carried out using only seminological material of local origin or, if not possible, from identical ecotypes;
– timber harvesting access corridors should run parallel to the lotic and lentic ecosystems;
– pioneer species will not be extracted as they are important for soil improvement;
– illegal logging will be controlled with the aim to eradicate illegitimate logging activities;
– during logging and timber transport activities, sediment traps will be installed on the main watercourses (with around 500 m distance between them), and will be cleaned as often as necessary, with their evacuation/transport in areas that do not influence the degree of sedimentation in waterways;
– construction/monitoring/maintenance of drainage ditches for liquid and sediment flows from the transport routes designed to manage excessive and rapid precipitation events that are characteristic of the mountain area;
– installation of sediment traps (with around 500 m distance between them) on ditches used to evacuate liquids from the transport routes, cleaned as often as necessary, with the anticipation that the proposed sediment traps will stop, or at least diminish, the potential of these channels networks to be an unwanted sediment delivery system directly to downstream water bodies;
– leafy branches and debris left over from the logging will be placed on remaining stumps;
– full reforestation of the watershed with canopy projection over 0.8 (to reduce the kinetic energy of raindrops on the soil surface, surface runoff from precipitation, air currents, solar radiation, and minimize large temperature differences, etc.) and subsequent forest management regime;
– excluding human activity in the riverbed of watercourses and preserving permanent or temporary riparian wetlands as natural sediment traps during periods of increased precipitations and high flows;
– the construction of new bridges, if needed, should not narrow the waterway to avoid increasing water speed and its capacity for erosion and sediment transport to downstream sectors;
– ecological restoration of sediment deposits formed at high waters in the riparian areas by fixing sediments or planting on sedimentary areas will prevent sediments from moving downstream in subsequent episodes of high flows;
– efforts should be made to favor existing flora, undergrowth, shrubs, and the herbaceous bed;
– it is acceptable to intervene with sowing or planting in critical areas;
– leaving the stumps in situ;
– controlling waste management;
– closing the basin to any other hydrotechnical works of any type that do not align with an optimum basin sediment management.

The proposed management regime needs to be officially recognized, and social, environmental, and economic objectives need to be assigned to the forest in the watershed (e.g. the dam on Vâlsan River, an ecological preservation area established for the protection of this endangered species, etc.). For immediate action, however, measures such as a credible forest management certification scheme (like FSC®) could be an efficient solution.

Basin sediments general management recommendations

Sediment control in the basin is specifically important for water quality in the basin, but indirectly sediments cause other problems. Sediments are not pure can be attached to or carry additional contaminants. To avoid such situations different measures can be implemented:

– monitoring slopes, torrents, banks, etc., particularly those prone to accidental or permanent erosion;
– in areas with significant accidental erosion, the effects of erosion can be decreased with blankets, rugs, geotextile materials, sandbags, gravel bags, plastic materials dams, etc., until the situation is stabilized through ecological reconstruction;
– creation of thick, vegetated fencerows, due to their role as traps for sediments and nutrients;
– prohibit the extraction of mineral resources in the basin and instead offer access to other sources of materials for construction to local populations;
– prohibit damming or regulating riverbeds with hydrotechnical works, with the exception of debris basins, settling ponds, and other similar structures which can catch sediments, which can then be regularly cleaned up;
– suspend tourist paths through areas where the vegetal layer needs to be preserved or improved;
– roads should not interfere with the buffer stripes, off-road vehicles will be banned;
– prohibition on burning vegetation and trimmings;
– fire will be allowed only in specially arranged areas located outside forests;
– any burning of vegetation and trimmings will be done only with the approval of the competent authorities and with the prior notification to the public services for emergency situations;
– banning grazing and watering domestic animals in the forest and, as much as possible, in other areas that drain in the basin to mitigate the impacts of soil compaction, decrease water infiltration in the soil, increased runoff, and erosion;
– use specially-selected (rocky) areas in wider and shallow channels for cattle, goats and sheep to use for drinking to avoid trampling down the vegetation, river bank erosion, water turbidity, sediment accumulation downstream, and consequently increasing riverbed erosion, etc.;
– domestic animals will be prohibited until grasses are restored to a normal level;
– in pastoral lands, grazing will be regulated to avoid the destruction of flora, soil compaction and the onset of erosion phenomena and will even be prohibited in sensitive periods or areas;
– the transhumance activities of animals including passing through, grazing and overgrazing, watering, etc., should be avoided or at a minimum guided and monitored to avoid erosional impact;
– the disposal and storage of sawdust and other waste is strictly prohibited;
– dragging wood around riverbeds and storing wood in and arround riverbanks is prohibited;
– a ban on unorganized tourism;
– a ban on the replacing forests and pastures with intensively-used agricultural lands;
– small farms are preferable to large, industrial farms;

– the runoff from mines and mines deposits should be isolated from the water network;
– natural water filtration areas and detention ponds should be promoted and used in localities and by contrast hard surfaces, which increase runoff and the transportation of sediments should be minimized, especially hard surfaces associated with the construction of buildings and roads;
– monitoring the ecological status of what are considered sediment-sensitive fish (*R. valsanicola*) and macroinvertebrate (mayflies, especially *R. semicolorata*) and use the results as an indication of qualitative and quantitative sediment changes;
– the realization of a basin conservation management plan, which includes sediments management, for the Vâlsan Basin, for *R. valsanicola* conservation in a first phase, and later for the Argeş Basin, with the same main objective of extending the areal of this fish species.

Riverbed e**cological reconstruction approach proposal**

Understanding the effects of hydro-morphological pressures created by the presence of transversal works on rivers is of great importance (Kay and Voicu, 2013; Voicu et al., 2020).

Due to the transversal constructions made on the Vâlsan River, especially the dam from Brădetu, the flow downstream from this dam does not offer the volume and speed of water flow necessary for the optimal functioning of the studied lotic system in its natural regime, and consequently an insufficient flow for an optimum habitat of *R. valsanicola*.

Both the clogging and the drastic decreasing in number, and in some sectors the total lack of boulders has led to the habitat of *R. valsanicola* and its main trophic base destruction.

A pilot ecological reconstruction project is recommended on a one-kilometer-long stretch of the Vâlsan River. Based on performance results after a few years of monitoring if this action is enough to successfully attract and sustain a permanent *R. valsanicola* community, then this type of ecologic reconstruction can be extended along the river.

A semi-circular transversal section of riverbed must be built in the existing riverbed of the Vâlsan River, on which 90% of the downstream flow, at low flows resulting from the Brădetu accumulation, must be redirected, as a refugee habitat for the fish (Fig. 1).

The riverbed must be made of cement and expanded clay, and boulders need to be abundant in the upstream sector of the river (Fig. 1).

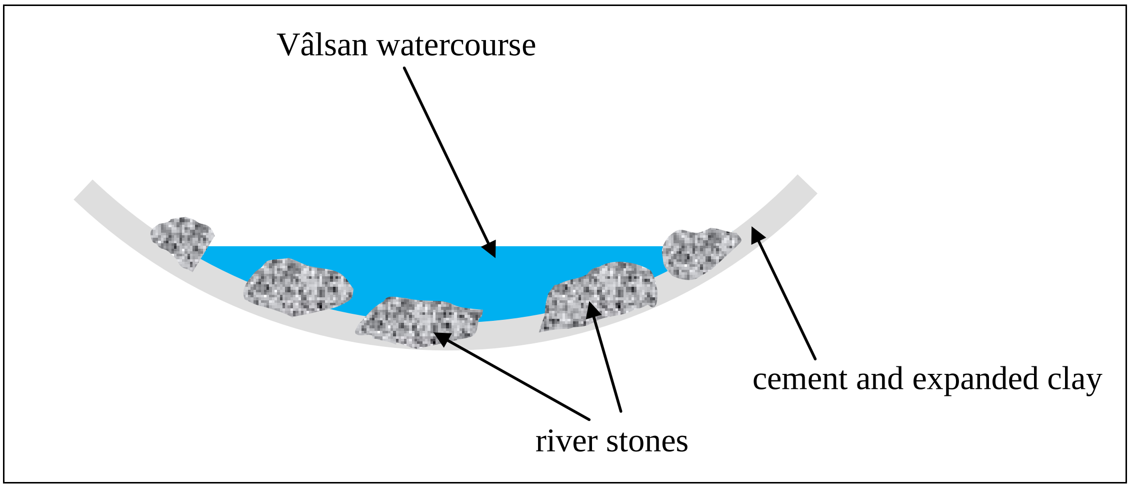

Figure 1: The new reconstructed riverbed with fixed boulders in a mixture of cement and expanded clay at the base (transversal section).

The reconstructed riverbed in the Vâlsan River is made of medium and big boulders (those with a green edge – Fig. 2) with approximately one meter spacing between them and random positioning, mimicking the natural riverbed sector found upstream. Some larger stones measuring meters across will be placed in the riverbed as well.

The mixture of cement and expanded clay will fix the boulders in the substrata and then these stones cannot be taken by the local residents for construction projects. The placement of the stones and boulders will be such to preserve the connectivity between the river and its hyporheic zone.

The new riverbed is well fixed to the old riverbed (and in the soil) and thus in case of flood the new riverbed will remain in place without significant damage. Minor damage can be easily repaired. In case of drought, the river water will flow only in the new riverbed, which will ensure an optimal flow for *R. valsanicola*. The water flowing through the existing riverbed will revive the insect species that feed this species of fish. If the project is respected and if quality materials are used, the new riverbed will have easy maintenance for years to come.

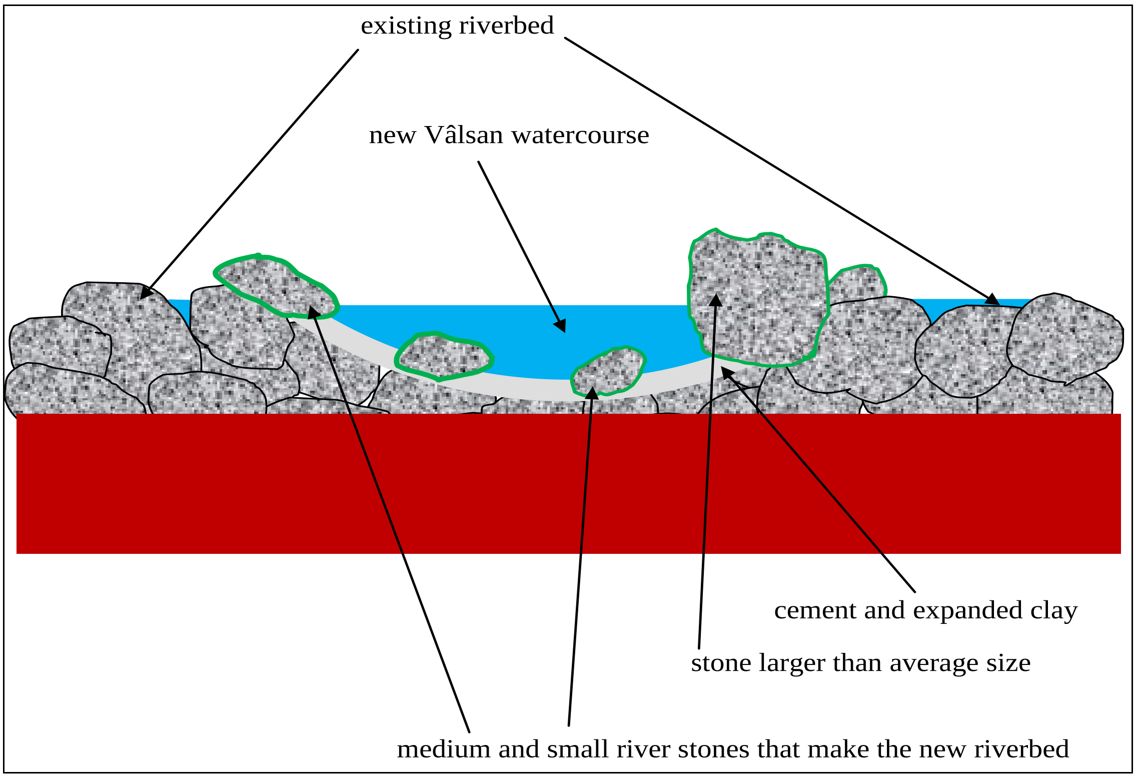

Figure 2: Positioning of boulders and stones in the reconstructed riverbed.

The minimum water flow of the Vâlsan River downstream of the Brădet Dam, due to droughts and/or bad flow management, will be redirected to the new riverbed with the help of river boulders and stones fixed to new riverbed with cement and expanded clay (Fig. 3).

These rows of stones will not reach the banks of the river, leaving space for water to enter the existing riverbed, and also room for fish to expand their lateral distribution in periods with high water levels. The flow left on the laterals of the reconstructed riverbed is of 10% of the flow when water flows are low.

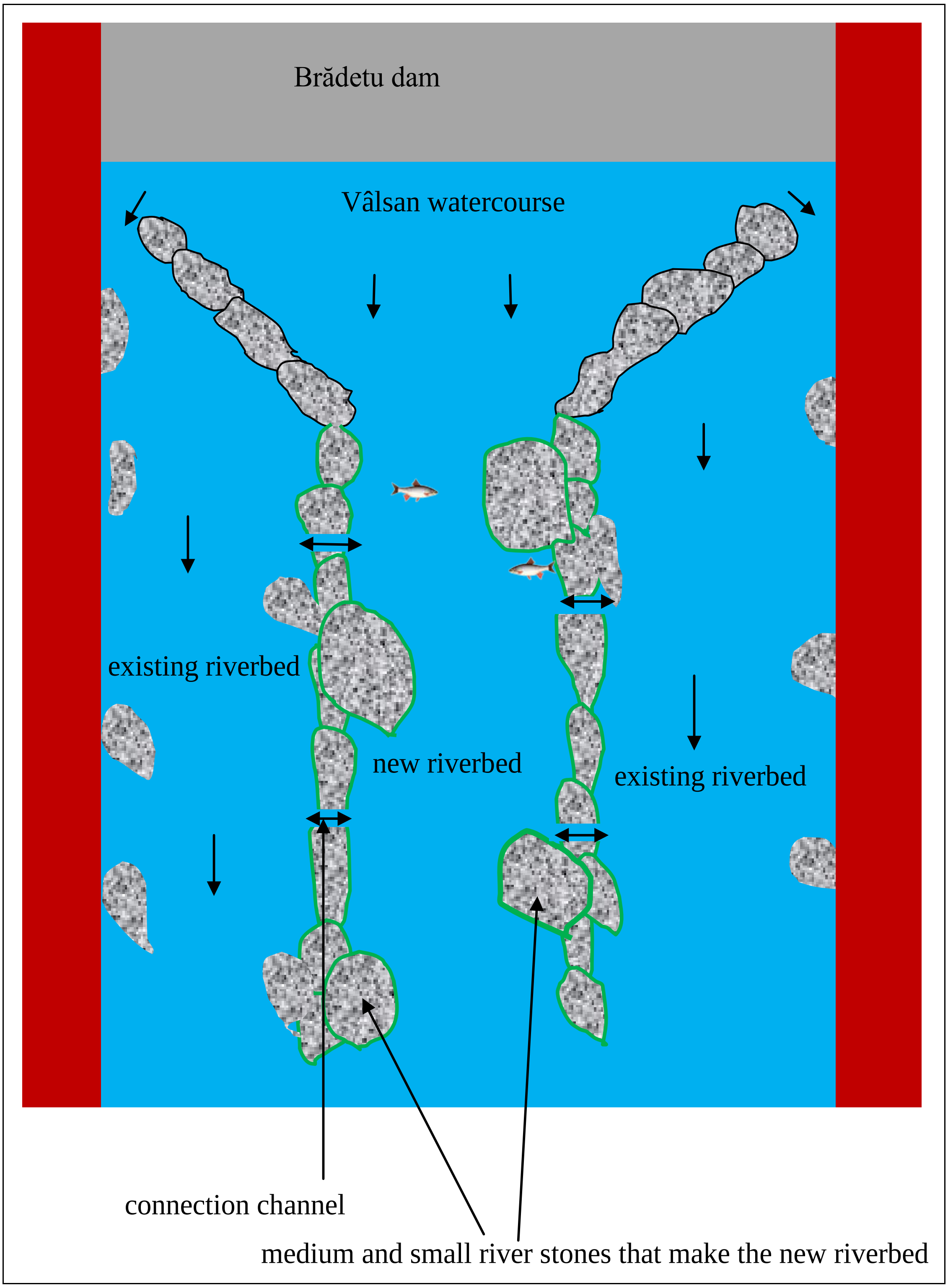

Figure 3: Upper view of the old
and newly-reconstructed core riverbed.

The reconstructed central riverbed sector should to be around one third the width of the total, actual riverbed, with one third width on the left and one third on the right of the old riverbed. Every five meters there are some 15-to-20-centimeter-wide channels that connect the old and the new riverbed (Fig. 3). Through these channels the invertebrates and fish can pass between the river bed center to lateral sectors and back at high flows, and can find shelter during low flows in the newly reconstructed center riverbed sector.

The new reconstructed riverbed center sector will have a constant flow corresponding to its size. This is needed to ensure adequate flow intensity to carry away sediment and not permit clogging or sediment covering on the boulders in case of high sediment discharges.

The sediments will be kept suspended and carry on downstream in the new water flow conditions with a sufficient water volume to keep sediments from dropping to the riverbed, even at lower water flows.

Finally, a monitoring system should include surveillance of the Vâlsan River dam water flow management, which should release a continuous and sufficient water supply for the river. In the end, the main monitoring indicator of the Vâlsan Basin will remain the ecological status of *R. valsanicola*.

CONCLUSIONS

Past research in the area of *R. valsanicola*-specific habitat has not focused on stream sediments. Poor water and land use imposed significant long-term effects on natural lotic systems, namely of a change in the physical structure and cover on fish habitat and the fish themselves. This is especially due to the human-induced, excessive increase in fine sediment in the hard riverbed habitat of *R. valsanicola*, which had a significantly adverse effect on this most endangered fish species of Europe.

Due to the need for greater understanding from authorities for a larger, permanent water volume to be released downstream from the Vâlsan Dam, or for the necessity of investments in reshaping/adapting the Vâlsan Dam to protect the most endangered endemic fish species *R. valsanicola*, fast, less-expensive solutions were offered here. To support the key decision makers, adaptative management and technical ecological elements were identified and proposed (dam reservoir-related recommendations for basin sediments management, forestry related recommendations for sediment basin management, basin sediments general management recommendations, riverbed ecological reconstruction approach proposal, etc.) to be implemented in the local basin management plan to decrease the fine sediments accumulation by stopping the excessive sediments running down from the basin, facilitate their transport downstream away from this impact area, and finally, improve the *R. valsanicola* species ecological status.

The habitat managers are required to specifically monitor the extent to which the changes in physical structures and cover for *R. valsanicola* habitat will affect this fish and its trophic base in the future.

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