Solutions for protection of hydrotechnical dikes in the areas populated by beavers

Claudiu PAȘCA, Marius POPA, Alexandru GRIDAN, Georgeta IONESCU, Daniel VIȘAN, Ovidiu IONESCU

1. Context

Beaver is one of the last extinct species that has been reintroduced in Romania. Between 1998 and 2003, 182 individuals of different ages were released on three of the most important rivers: Olt (91), Mureș (56) and Ialomița (35) (Ionescu 2006, Ionescu et al 2010), as a large European initiative (Gaywood 2001, Halley 2001). Thus, a former extinct species from Romania was added to the list of strictly protected species, the Eurasian beaver being mentioned in Annexes 2 and 4 of the Council of Europe Directive 92/43 EEC.

Beside the obvious success of the reintroduction action, the special qualities of the species, to modify the habitat in which it lives (Wright et al 2002), it creates numerous conflicts with the local population and the institutions that manage the surface waters in Romania (I*** 2014).

Locals complain that the species causes damage in agricultural or fruit crops, floods land (with different categories of use: agricultural, pasture, hay, forest), access roads (most secondary) and affects the banks by cutting vegetation or creating holes in the banks.

On the other hand, the water management institutions as SGA, ANIF, and the town halls accuse the beavers of posing a risk for the safety of the population by building dams, weakening the structure of the flood protection dams or clogging the drainage channels, built in the communist era.

The big challenge is the implementation of optimal management measures that will result in maintaining a level of conflicts that will be compensated by the special advantages brought by the species, by restoring wetland area. (Collen et al 2001, Dittbrenner et al 2018).

2. Beaver's ecological requirements

Beavers are highly adaptable animals, which allows them to populate very diverse habitats. Adaptability also results from the extraordinary ability to change the environment in sense of creating optimal living conditions. From this point of view, they are considered animals with the greatest capacity to transform the habitat they live in.

Although experts have established criteria for the classification of habitats for the beaver (Heidecke 1989), in practice it has been observed that, due to the high adaptive ability, beavers populate riparian habitats from all the biogeographic regions of Romania, even the less favourable (Pașca et al 2018).

However, the species requires minimal conditions to ensure its survival.

Sheltering and building of dams

Beavers are sheltering in the water banks, by digging dens that are connected to the river bed by one or more galleries. In the Romanian habitats there were observed three types of shelters (Ionescu et al 2010): **underground** (dug fully into the bank), **over ground** (built over the bank from branch fragments, and other types of material) and **mixed** (started as underground shelter and continued above the bank level). The "choice" of the type of shelter is based on local conditions: the height, the declivity and the texture of the banks. The most common are the burrows, which are made in the banks that are suitable for digging (loamy, sandy or mixt texture), as the shore has a slope of over 30 degrees, with a height of more than 60-70 cm.

Thus, on mountain rivers and streams, shelters are mostly structures made of cut branches. In grassland areas, where the soils are very sandy, numerous galleries can be seen, because their walls / ceilings fall during periods of floods if they are not sufficiently stabilized by vegetation. Both situations create stress and difficulties in establishing a permanent shelter.

Also, very important is the fluctuation of the water level. Beavers prefer stagnant waters that offer stable living conditions. In fluctuating water-level situations, they raise the level of the main room in the burrow, digging obliquely (Pașca et al 2011). So, many times, they perforate the upper part of the bank and are forced to continue building the shelter by accumulating external materials: branches, sludge, leaves, stones, vegetation, resulting in an artificial structure.

Besides permanent shelters, beavers are digging up temporary shelters, which are more numerous and used in case of danger (Valachovič 2012). They are spread relatively evenly over the entire length of the territory used.

Observations made during the past reintroduction period have shown that beavers are highly adaptable to water level fluctuations, with the exception of very strong floods occurring in the upper rivers, when very young beavers can be caught off guard and killed. Juveniles and adults do not have problems in these cases, retreating outside of the den. (Pasca et al 2011).

In order to choose the optimal solution from a functional and financial point of view, which has the effect of avoiding conflicting situations, by protection of flood defence infrastructure, several criteria have taken into account. The criteria are presented in the SWOT analysis (Table 1).

Feeding needs

As a strictly herbivore rodent, the beaver is dependent on the presence of herbaceous and woody vegetation (Nolet et al 1994, Dvořák 2013). The fact that the species is active throughout the year has led to adaptations that allow the beaver to survive out of the vegetation season with food from perennial wood species.

Thus, when the herbaceous vegetation is not available, they feed on young shoots and the younger bark of shrubs and trees they found on the banks of the water.

They prefer softwood species: poplar, willow, alder in order of enumeration, but the most common wood species present in the diet is willow, because it is widespread at national level alongside flowing waters.

For these reasons, the presence of woody vegetation on the water bank is essential for a habitat to be considered favourable to the beaver natural dispersion.

However, there are cases in which the beaver families have survived in the absence of trees or shrubs (Pașca et al 2018), in the lakes and ponds with rich hydrophilic vegetation consisting of rush and reed (*Typha* sp. and *Phragmites* sp.). In these cases, they eat very nutritious rhizomes, which ensure their survival during the winter, as long as the water does not freeze completely.

Species requirements for hydrological conditions

As a semi-aquatic species, the main important criterion is the presence of water, but not less important is the existence of vegetation in the immediate proximity of water and housing conditions (favourable structural and textural shores).

The adaptability of the species is also highlighted by the way the beaver turns apparently unfavourable habitats in optimum ones. For example, a small stream that does not meet living conditions in terms of water depth can be an optimal area if it has abundant woody vegetation, allowing the construction of dams and, implicitly, raising the water level.

Generally, beavers need water with a minimum 50-70 cm depth and 2.5-3m width, to feel safe against predators or humans. In areas where these characteristics are not ensured, they build dams to increase the surface of the available water surface area and its depth. By these works the water speed decreases, which also improves the living conditions and the protection against predators by facilitating both upstream and downstream movement and decreases the background noise produced by water leakage and facilitating the determination of the noises.

Territorial behaviour

The beaver is a monogamous mammal with very well-defined territorial behaviour.

The beaver families are composed of a pair of adult animals and offspring who have not reached sexual maturity. Juveniles remain with adults until they are two years old when they are drove away by the female. In a normal family, young beavers born in spring (2-5) and one-year juveniles (usually 2-3) born in the previous year can be found together with the adult couple.

Territory boundaries are well delimited by the use of anal secretions called castoreum. For this, the beavers create small mounds consisting of a mixture of mud / sand / vegetation over which they eliminate their own secretions. In this way the smell is kept better for a longer period of time, indicating to other specimens that the territory is busy.

Research has shown that there is a higher degree of tolerance towards the older generations of the parental family, and the beavers are more aggressive with the copies they have no kinship (beavers coming from larger distances).

Dispersion occurs both downstream or upstream, depending on habitat conditions. Travel distances of young adults looking for free territories are variable. In favourable habitat conditions the distance is smaller, 200-400m. In the previous projects, a case of long-distance dispersion occurred when a beaver specimen captured near Sfântu Gheorghe was later found (with the help of the radio-transmitter implanted in the tail) upstream of Olteni, the distance of 38 km being covered during the spring period within 2 months of the release.

The density of families is directly proportional to the quality of the habitat, mainly with the available food and the surface of the water it has at its disposal. In this context, the highest densities were observed in marshy areas, with large water surface very abundant in food.

For example, in the NATURA 2000 site Lunca Bârsei on an area of about 6 ha there are 4 families, the maximum distance between the shelters being 110m. A similar phenomenon has been observed upstream of the hydroelectric dam at Voila, along the Olt River, in a deltaic landscape.

3. Solutions to avoid man-beaver conflicts and protect the existent network of protection dams

Management solutions for conflict mitigation were developed for both North American and Eurasian beaver, the behaviour of the two species being very similar (Hammerson 1994, Busher et al 1999, Hartman

1999, Parker and Rosell 2003, Parker and Rosell 2012, Valachovič 2012, Vorel and Korbelova 2016).

In order to avoid or solve man-beaver conflicts, three categories of solutions were highlighted:

1. Solutions that have the role of preventing the installation of beavers in areas presenting risks for the human population. This can be achieved by:

a. Use of repellents / equipment for the removal of animals;

b. Elimination of woody vegetation / blocking access to food sources on the shore;

c. Paving the banks / making metal walls.

2. Relocation of beaver families from risk areas

3. Measures that block the access of the beavers to the body of the dam, and have no impact on the beavers that populate the area.

From the solutions identified in the literature, a selection was made whose analysis we present below (Table 1).

Table 1. The SWOT analysis of the solutions

Technical solution	Strengths	Weaknesses	Opportunities	Threats
Paving the banks with rocks	Long-term protection effect. Low maintenance cost.	Very expensive costs of investment. High impact on the environment and landscape.	Long-term protection of areas at high risk for human-wildlife conflicts.	This solution has a permanent effect. Very high costs of renaturation.
The use of repellents	Very low impact on the environment	Very expensive maintenance costs for repellents	The opportunity to test new repellents	There is a risk that the substances will not have the expected effect.
Steel sheet pile wall	Lon- term protective effect. Low maintenance cost.	Very expensive costs of investment. Risk to be stolen.	Long-term protection of areas at high risk for human-wildlife conflicts.	This solution has a permanent effect. Very high costs of renaturation.
Buried wire mesh (fiber glass or steel)	Long lifetime for non-metallic nets and medium to long lifetime for steel mesh. Stabilization of the banks through rooting Low-capacity machines may be used No maintenance costs	High investment costs	Long-term protection of areas at high risk for human-wildlife conflicts.	For unprotected metallic meshes: corrosion
Clearcutting of riparian vegetation	Maintaining some river sectors without beavers	Increased risk of erosion, high-speed propagation of flood waves. High impact on the environment, especially on biodiversity and landscape. High maintenance costs.	Long-term protection of areas at high risk for human-beaver conflicts.	The restoration of woody vegetation by firing and the need for regular maintenance
Electric fences	Low impact on the environment	Requires recurrent maintenance High risk to be stolen Limited service life High investment and operating costs	Small scale use Short-term protection of areas at high risk	Risk of theft It may have a short-medium effect due to the necessary costs and human effort

4. Description of technical solutions proposed for implementation

Based on the bibliographic analysis of the technical solutions used by other European countries and following the discussions with representatives of the project partners in Romania, it was decided that the most suitable solution for the conditions in our country is to use metal mesh with holes of maximum 10x10cm, parallel to the watercourse between the bank and the water, to block the access of the beavers to the protection dikes on both sides. The thickness of the metal wire must be at least 3 mm, and for composite (fiberglass) nets, more than 8 mm.

The width of the net depends on the height measured from the bottom of the bed to the top level of the shore. Generally, a mesh of 1.5-1.7 m is sufficient for most situations.

The solution is suitable for situations where the distance between the dike and the river bank line is over 5-6 m and allows the mesh barrier to be located 3-4 m from the water bank without disturbing the beavers installed in the area.

The method has the great advantage of eliminating the risk of weakening the flood defence structure, while allowing the normal development of the beavers' populations. In this respect, we must mention that in the Negru River basin many tributaries have protective dikes. This compromise solution would allow maintaining the beaver's population to a level very close to the maximum, without jeopardizing the safety of the hydro-technical constructions.

5. Description of the field activities

River sectors, with length ranging from 1 to 5.3 km, were evaluated to identify the most suitable location for the implementation of the proposed solution. The following streams were analysed: Păpăuți, Estelnic, Ojdula, Zăbala, Hilib, Lutoasa, and Capolna. All analysed sectors are channelled and have flood protection dikes, to reduce the risk of flooding.

The major criteria that were followed were the existence of optimal or satisfactory living conditions, the presence of the beaver in the area and the existence of hydro-technical constructions that ensure the security of the population in the area. Another condition was for the area to be easily monitored after the end of the project.

Finally, after the completion of the field study, we discussed with the beneficiary (EPA Covasna) and it was decided that the chosen solution should be implemented on the Capolna area, being the most accessible for implementation and subsequent monitoring.

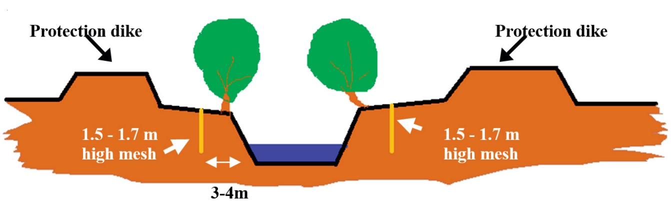

Fig. 1. The schematic diagram of the solution implemented (cross section)

Fig. 2. Capolna Creek before measure implementing

6. The technical solution implemented

Fig. 3. Inserting the mesh into the ditch

After analysing and consulting the beneficiary and the project partners in connection with the proposed technical solutions, agreed that the optimal solution of conflict management in connection with the flood defence infrastructure is the burial of a galvanized metal mesh with meshes of maximum 10x10cm and wire thickness about 3mm. The net will have a length of 500 m on each shore and a width (depth of burial) of 1.5 m.

Fig. 4. The area of implementation on Capolna River

The ditch was made at a distance of 3-4 m from the shore so that the existing beaver's dens will not be disturbed. The soil resulting from the excavation will be temporarily stored in the ditch's side, to be easily accessible during the refill phase. Later it will be carefully compacted in the trench, avoiding damaging the net, and leaving no holes.

From the suggested location, for the implementation of the pilot measure, it was chosen the Capolna creek, being considered more accessible for both, implementation and easier monitoring in the future.

The measure was implemented as a pilot study, and its effectiveness will be monitored in the following two years. Annually, observations will be made about the degree of corrosion of the net to determine the lifetime of the materials used.

7. Conclusions

The use of buried metal nets is an opportunity to solve two very important problems: to protect the hydro-technical dams against the animals that create holes in the ground (beaver or other species such as fox, badger, etc.), and to allow the free development of the beaver population, in accordance with the natural carrying capacity of the habitats.

One of the few disadvantages of this solution is the implementation cost which is very high (~25,500 €/

km) and that is why the method is feasible if there are no alternatives to resolve conflicts in areas of high risk for the population. However, considering a lifespan of at least 25 years, we consider that the investment is acceptable because during usage of the net the dam won't be affected.

The efficiency is guaranteed owing to the fact that the barrier created will ensure the safety of the protection dam on the long term, the mesh also having the role of stabilizing the shore in case of natural erosions.

The costs are reduced considerably if they are provided from the design stage of the new dams, as a distinct stage in the construction phase. By using fiberglass nets, the investment will have a long-term effect (estimated to be about 500 years).

The solution applied in this study is the first in Romania and represents a success in terms of collaboration between institutions that apparently have contrary interests: the Water Management System (SGA), on the one hand and the Environmental Protection Agency Covasna (APM), and the National Institute for Research and Development in Forestry, INCDS Marin Drăcea, on the other hand.

Financing

This article is a result of the study: *"Identification of optimal management solutions for human-beaver conflict situations (Castor fiber) and their implementation in a pilot area of the Negru River watershed, in connection with the maintenance of the human population's defence infrastructure against floods",* part of CAMARO project.

References

Busher PE, Dzieciolowski RM, 1999. Beaver Protection, Management, and Utilization in Europe and North America. Springer Science and Business Media LLC

Collen P, Gibson RJ, 2000. The general ecology of beavers (*Castor* spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish–a review. *Reviews in fish biology and fisheries*, 10(4): 439-461.

Dittbrenner BJ, Pollock MM, Schilling JW, Olden JD, Lawler JJ, Torgersen CE, 2018. Modeling intrinsic potential for beaver (*Castor canadensis*) habitat to inform restoration and climate change adaptation. *PLoS ONE* 13(2): e0192538.

Dvořák J, 2013. Diet preference of Eurasian beaver (*Castor fiber* L., 1758) in the environment of Oderské Vrchy and its influence on the tree species composition of river Bank Stands. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 61(6): 1637-1643.

Gaywood W, 2001. A trial reintroduction of the European beaver (*Castor fiber* L.) in Scotland. In: Czech A, Schwab G (eds): The European Beaver in the new millennium. Proceedings of second European Beaver Symposium, 27-30 September, Bialowieza, Poland. Carpathian Heritage Society, Krakow, 39-43.

Halley DJ, Roseil F, 200l. Current distribution, status and patterns of spread of the Eurasian beaver, *Castor fiber*, and the implications for management. In: Czech A, Schwab G (eds): The European Beaver in the new millennium. Proceedings of second European Beaver Symposium, 27-30 September, Bialowieza, Poland. Carpathian Heritage Society, Krakow, 15-24. https://brage.bibsys.no/xmlui/handle/11250/2438072

Hammerson G, 1994. Beaver (*Castor canadensis*): Ecosystem alterations, management and monitoring. *Natural Areas Journal* 14: 44-57.

Hartman G, 1999. Beaver management and utilization in Scandinavia. Busher P.E., Dzieciolowski R.M. (eds.): Beaver Protection, Management, and Utilization in Europe and North America. Springer Science and Bussiness Media LLC.

Heidecke D, 1989. Okologische Bewertung von Biberhabitaten. Saugetierkd. Inf., Jena, 3, H. 13, S 13-28.

Ionescu G, Ionescu O, Pașca C, Sîrbu G, Jurj R, Popa M, Vișan M, Popescu I, 2010. Castorul în România. Monografie. Ed. Silvică, București.

Ionescu G, 2006. Reintroducerea castorului în România, teză de doctorat, Univ. Transilvania din Brașov.

Maringer A, Slotta-Bachmayr L, 2006. A GIS-based habitat-suitability model as a tool for the management of beavers *Castor fiber. Acta theriologica* 51(4):373-382.

Nolet BA, Hoekstra A, Ottenheim MM, 1994. Selective foraging on woody species by the beaver, and its impact on riparian willow forest. *Biological Conservation* 70(2): 117-128.

Paşca C, Ionescu G, Popa M, Ionescu O, Ionescu DT, 2011. Aspects regarding water level fluctuation influence on European beaver (*Castor fiber*) eco-ethology - case study. Proceedings of Bien. Int. Symp. Forest and Sustainable Development, Brașov, Romania, 15-16th Oct. 2010.

Pașca C, Popa M, Ionescu G, Ionescu O, Vișan D, Gridan A, 2018. Distribution and dynamics of beaver (*Castor fiber*) population in Romania, 8th International Beaver Symposium, Book of abstracts. p 30.

Parker H, Rosell F, 2003. Beaver Management in Norway: a model for Continental Europe? *Lutra* 46(2): 223-234.

Parker H, Rosell F, 2012. Beaver Management in Norway. A Review of Recent Literature and Current Problems. HiT Publication no. 4/2012. Telemark University College.

Valachovič D, 2012. Manual of beaver management within the Danube river basin. http://www.danubeparks.org/files/888_beaver_manual.pdf

Vorel A, Korbelova J (eds.), 2016. Handbook for Coexisting with beavers. Czech University of Life sciences Prague. Prague.

Wright JP, Jones CG, Flecker AS, 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. *Oecologia* 132, 96–101 https://doi.org/10.1007/s00442-002-0929-1.

I* 2014**. Analiza stării de conservare a speciei *Castor fiber* la nivel național. Universitatea Transilvania din Brașov. Raport final.

II* 2017**. Analiza serviciilor oferite de ecosisteme cu *Castor fiber*. INCDS Marin Drăcea, Secția Cinegetică Brașov. PN16330207.

Abstract

The beaver is one of the last extinct species that has been reintroduced to Romania, as a large European initiative, in an attempt to restore the species range in Eurasia.

After two decades in which the population has grown steadily, in many areas where the number of beavers has reached the capacity to support the environment, human-beaver conflicts have begun to be reported.

As an irony of fate, one of the fiercest battles takes place between two great builders: the beavers, as a restorer of wetlands and representatives of institutions that deal with the regulation or channelization of running water. Such a hot zone is the Black River watershed.

The study is aiming to identify possible solutions for dam protection against the beavers' destructive potential and to implement the most appropriate of these. In order to do this, buried nets were used to block the access of the beavers to the protection dikes. This solution was applied on the Capolna River, within the CAMARO project, and proved to be suitable for solving two very important issues: to protect the hydrotechnical dikes against the animals that create holes in the ground (beaver or other species such as fox, badger, etc.), to allow the free development of the beaver population, in accordance with the natural carrying capacity of the habitats.

The works were carried out on a sector of 500 m, on both banks being buried metal nets in a vertical position, at a depth of 1.7 m.

The costs of this solution are very high (25,500 €/km), but it ensures the protection of the hydrotechnical constructions on medium or long term, so that it is certainly a veritable variant to solve such problems.

Keywords: *Castor fiber*, man-beaver conflict, beaver management in Romania, good practice guidance