

First report of Eurasian beaver (*Castor fiber* Linnaeus 1758) in the Republic of Moldova

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Abstract. The first Eurasian beaver colony was discovered in Lower Prut Nature Reserve, located in the Republic of Moldova, approximately two centuries after the extinction of the beaver in the area. The accidental discovery of these new territories occupied by the Eurasian beaver demonstrates that the Eurasian beaver population in southeastern Romania has been expanding rapidly from 2003 and continuously towards the East by occupying favorable habitats in the meadows of the main watercourses and their tributaries. The possible dispersal routes followed by the Eurasian beaver to reach this area are exposed and presented in this paper, as well as potential future areas which may be colonized by the Eurasian beaver in Romania and the Republic of Moldova. The habitat conditions and the interaction with other wildlife species, which benefit from the natural colonization of beavers in the study area, were described and compared with other biogeographic conditions. This paper is a key step in describing and listing *Castor fiber*, a protected species, in the Republic of Moldova.

Keywords: Eurasian beaver, dispersal, Lower Prut Biosphere Reserve, habitat conditions, Republic of Moldova.

Introduction

The Eurasian beaver (*Castor fiber*) is constantly expanding in Europe and Asia. The reintroduction programs of the species, which have been carried out in various parts of Europe, and the rate of natural population growth have led to an increase in the number of individuals and the territorial expansion of the Eurasian beaver (Halley et al. 2020).

About 20 years after the reintroduction of the Eurasian beaver in Romania and about nine years after the species was first reported in the Danube Delta (Kiss et al. 2012), the beaver extended its territory on the Prut River. Thus, the natural colonization of beaver was confirmed for the first time in the river basin of the Prut in the Republic of Moldova after more than 200 years since extinction.

At the beginning of the 19th century, the local extinction of the Eurasian beaver population was caused both in Romania and in the Republic of Moldova by the same factors as in the rest of Europe. The main causes of extinction were attributed to humans, beavers being hunted excessively for fur, meat, and castoreum (secretion of the anal gland). At the same time, there were indirect causes of extinction, such as habitat reduction, draining of swamps, and canalizing of watercourses (Halley et al. 2020, Ionescu et al. 2010).

In the Republic of Moldova, the Eurasian beaver was not the subject of a scientific study in the past, so we do not have reliable data on the former presence of the beaver; neither historical data nor archaeozoological evidence attesting to the former presence of Eurasian beaver in Moldova. The Eurasian beaver probably disappeared from the actual territory of the Republic of Moldova in the 19th century, as well as in Romania, and it is presumed that the year of the beaver extinction is 1824 (ROMSILVA 2013). However, considering the archaeozoological evidence discovered on the Romanian territory in the immediate vicinity of the Romanian-Moldovan border, in the area of the Prut River, we can certainly argue that the Eurasian beaver used at least

the lower Prut meadow. Therefore, the Republic of Moldova belongs to the historical distribution area of the Eurasian beaver.

The nearest evidence of the former presence of the beaver in our study area was some archaeozoological discoveries dating from the Bronze Age, from Foltești and Stoicani villages (Haimovici 1972). In the Bronze Age, human settlements were located in the ancient meadow of the Prut river, and archaeological remains of beaver bones were discovered during excavations. These ancient settlements were located at a distance of 10 to 15 km from our study area, where the presence of the Eurasian beaver was confirmed.

Although there have been no campaigns to reintroduce the beaver in the Republic of Moldova and the presence of the species in Moldova was not known, this is the first report after about two centuries (Wrobel 2020, Halley et al. 2020, Institute of Zoology, Academy of Sciences of Moldova 2020 - pers. comm.).

Material and Methods

Study area

The study area consisted mainly of the Lower Prut Biosphere Reserve (147.71 km²), a protected natural area located on the lower course of the Prut River, including Lake Beleu and its surroundings, in the southwest of the Republic of Moldova. Lake Beleu and a network of ponds and canals are part of Lower Prut's natural protected area.

The water level in Lake Beleu and the canals varies annually and seasonally. For example, in 1990, Lake Beleu dried up completely, but the water level was 3–4 m deep the following year. The average water level is around 1–1.5 m. The water is supplied through the Manolescu and Popovici canals and is drained through the Rotaru and Nevodului canals; all canals are artificial. Local fauna and flora have been adapted to frequently changing hydrological conditions (Postolache et al. 2012).

The study area contained various categories of vegetation: aquatic, marsh, prairie, and forest. The largest areas with aquatic

vegetation and marsh were recorded in the northern and western parts of Lake Beleu. The prairie vegetation appeared in the west part of the study area, between Lake Beleu and the Prut River, where floodplain meadows were formed. The forest vegetation occupied the highest places in the study area. The biggest areas covered by willow (*Salix triandra*, *Salix cinerea*, and *Salix viminalis*) were located in the northern, northeastern part of the Lower Prut Nature Reserve. Fragments with the willow were found in the southern part and on the banks of the Prut River (Postolache et al. 2012).

Salix alba predominated the highest parts of the study area. Share of *Salix fragilis* and *Fraxinus pallsi* was less. Shrub species such as *Sambucus nigra*, *Swida sanguinea*, *Rubus caesius*, and *Ligustrum vulgare* are quite common. The grass cover is well developed; the most common are the following species: *Bidens tripartite*, *Bidens cernua*, *Ranunculus reptans*, *Potentilla reptans*, *Anthriscus sylvestris*, *Urtica dioica*, and *Dactylis glomerata* (Postolache et al. 2012).

The mammal fauna consisted mainly of small and medium-sized carnivores and ungulates, most of them specific to the meadow areas: Mustelidae (*Lutra lutra*, *Martes foina*, *Mustela putorius*, *Mustela erminea*, *Mustela nivalis*, *Meles meles*), Canidae (*Vulpes vulpes*, *Nyctereutes procyonoides*, and *Canis aureus*), Felidae (*Felis silvestris*) and ungulates (*Sus scrofa* and *Capreolus capreolus*) (Postolache et al. 2012). Although mentioned in the list of species occurring in the protected area, *Canis lupus* and *Mustela lutreola* have not been observed in the field recently (Postolache et al. 2012). No potential predators or competitors for the Eurasian beaver were confirmed in the study area. If we refer to Western Europe, Eurasian beavers were once predated by the wolf, brown bear, and lynx. The predation by other, smaller predators (e.g., foxes, dogs) is rare (Rosell & Czech 2000).

Data collection

The record of the Eurasian beaver in the Republic of Moldova and the lower meadow of Prut River was an occasional observation made following the research of other species of semi-aquatic mammals.

After the first report of the Eurasian beaver in the lower Prut meadow and the identification of the recent beaver bite marks, this area was monitored with the help of two camera traps (Moultrie M990i), yielding photo and video images of beavers.

To record the activity of the Eurasian beaver in the study area of the Lower Prut Nature Reserve transects, surveys were done by foot and boat.

The presence of the Eurasian beaver was confirmed in the transect surveys based on signs of presence: active shelters, footprints, bites, beaver paths, territorial marking, and others. Generally, the number of families and individuals can be estimated based on the density of active shelters (Ionescu et al. 2013). According to field observations and following the literature consulted, strong families are composed of 5–6 individuals (2 adults and 3–4 juveniles), but the average number is 3–4 individuals (2 adults and 1–2 juveniles), which correspond to an active shelter (Campbell et al. 2005, Rosell & Thomsen 2006). During our surveys, no active shelters were identified, so we determined the presence of beavers based on the intensity of the signs of feeding. Fresh signs were registered, ignoring felled trees that were more than a year old, whose cutting showed obvious aging.

In parallel with the application of these specific documentation methods, constant communication with the field staff from the Lower Prut Biosphere Reserve was maintained.

Results

The first accidental observation of signs of beaver (bite marks) was identified on October 23, 2019, on the left bank of the main course of the Prut River (45°34'19" N 28°08'07" E). The bite marks, not fresh signs, were found on tree trunks of white willow (*Salix alba*) with a diameter of about

10–15 cm, probably because this size is to be transported more easily (Fig. 1). No other signs of beaver on the banks of the Prut River have been reported during 2019, neither by the field staff of the administration of Lower Prut Nature Reserve nor by locals.

About a year after the first observation, on November 3, 2020, fresh signs of beaver were found on the banks of the Manolescu canal (45.596253° N, 28.140223° E) in the Lower Prut Nature Reserve (Fig. 2 A, B).



Figure 1. Beaver bite marks on a white willow on the left bank of Prut River (23.10.2019; 45°34'19" N 28°08'07" E)



Figure 2 Recent signs of the presence of the Eurasian beaver on the bank of the Manolescu canal in the Prutul de Jos scientific reservation (3.11.2020, N 45.596253°, E 28.140223°). A. beaver bite marks and B. beaver footprint.

On November 16, 2020, new fresh bite marks were also identified on the bank of the Manolescu canal (45.596740° N, 28.143476° E and 45.597063° N, 28.145632° E). During December 2020 and January 2021, the number of signs of beaver presence (particularly fallen tree trunks after beaver bites) increased considerably.

The presence of beavers was also noticed by locals and

visitors (Fig. 3).

The presence of the beaver has been constantly confirmed by the camera traps installed in the areas where signs of beaver were identified; the first images of the beaver date from November 6, 2020, but the recording of beaver activity in the area continued until January 2021 and is ongoing since (Fig. 4 A, B).



Figure 3 Eurasian beaver distribution map in Lower Prut Nature Reserve, Republic of Moldova

Discussion

The origin of the Eurasian beavers identified in the Prut river meadow, the Manolescu Canal, and Lower Prut Biosphere Reserve in the Republic of Moldova is unclear, but colonization nuclei come from the Romanian territory. There were no reintroduction activities of the Eurasian beaver in the Republic of Moldova. Repopulation actions in Ukraine are remote and have no direct connection with the study area (Fig. 5).

The repopulated specimens from Romania originated from Germany, from the region of Bavaria (Ionescu et al. 2010). The newly formed population in the Ialomița increased from 64 individuals in 2009–2010 to 217 individuals in 2013–2014 (Carpathian Foundation 2014). In this favorable context, the beaver population has occupied new territories, extending along the Danube and even reaching the Danube Delta downstream, where the first clear reports date from April 2011 (Kiss et al. 2012).

Such accelerated dispersal of Eurasian beavers, shortly after colonization, has been found in other parts of Europe, showing that the Eurasian beaver is an intensely expansive species (Wrobel 2020).

Most likely, beaver individuals that entered the Prut meadow came from the population formed in the Ialomița river, Romania, where 35 specimens were released in December 2003, through a project to reintroduce the beaver in the Romanian fauna, implemented by the Forestry Research Institute from Brașov on certain sectors of the Olt,



Figure 4 Recording beaver activity using camera traps. A. front view, B. dorsal view

Mureș and Ialomița rivers. The colonization nucleus in the Ialomița in 2003 was located at about 30–150 kilometers

upstream of the confluence of Ialomița with the Danube, which favored the dispersal of the species on the Danube. In recent years, the presence of beavers has been observed across all the Danube, downstream from the confluence with the Ialomița until the Danube Delta.

The most recent reports of the Eurasian beaver have come from the Small Island of Brăila, in July 2020, where two individuals of Eurasian beaver have been reported, forming a family, located at a distance of approximately 80–100 km along the water from Lower Prut Biosphere Reserve (Romsilva, Brăila Natural Park Administration). The closest reports of beaver since the summer of 2014 were from lake

complex Somova - Parcheş, which is located only 50–60 km from the Lower Prut Biosphere Reserve. Here field teams of WWF-Romania and Rewilding Europe have captured images of Eurasian beaver individuals using camera traps. These two areas may become colonization nuclei for specimens coming to the Prut meadows.

Occupied habitats in Romania are located in the basins of the rivers the Olt, Mureş, and Ialomița, the Danube basin downstream of the confluence with the Ialomița and the Somova-Parcheş complex area of the Danube Delta, as well as in the north in the Tisa river basin (the rivers: Lăpuş, Vişeu, Tisa).

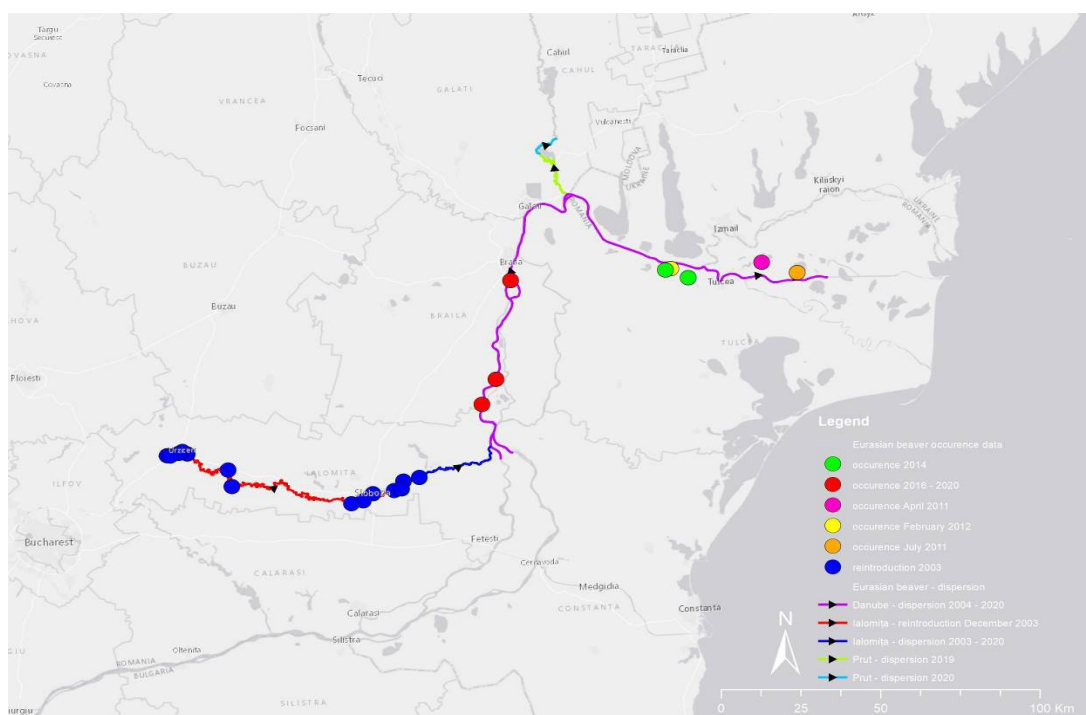


Figure 5 Eurasian beaver possible dispersal route map

The habitat conditions in this recently colonized area of the Prut meadow were optimal for the development of a new Eurasian beaver colony: the flow of the Prut and the canals are slow, and the water level is without fluctuations. Beavers prefer slow-flowing rivers and calm waters such as ponds or lakes with a water level deep enough to allow them to swim to feed and dive to escape predators (Ionescu et al. 2010). If the water is not deep enough, the beavers will build dams. To build their burrows and galleries on the shore, beavers need relatively high shores of 1.5–2 m, a condition that was met in the study area, along the Prut River, and partially on some canals. However, if the height of the shore is not high enough, beavers only build an underwater entrance to the shore to enter the den that will protect them from terrestrial predators. Beavers pile up branches and twigs above the entrance hole to hide the entrance, but also as food supplies (Müller-Schwarze & Sun 2003).

A crucial factor of a suitable beaver habitat is the specific vegetation. Eurasian beaver prefers to colonize territories with a high density of softwood species used as food (Fustec et al. 2001). The Lower Prut Nature Reserve area had the

shores delimited by riparian forests with trees 3–30 cm in diameter, providing a high density of beaver's trophic resources such as *Salix spp.* and *Populus spp.* This area hosts sufficient forest vegetation to meet the needs of feeding and construction, for more than 20 families, given that the territory of a family measures 0.5–2 km long watercourse in optimal habitats and about 3 km long watercourse in suboptimal habitats (Stocker 1985). Six km long optimal habitat for the beaver was identified at Manolescu canal only.

The average slope of the Prut river in the study area was about 0.8%, and on the Manolescu canal about 0.5%. The longitudinal slope of the optimal watercourse for the construction of dams must be less than 6% (Stringer et al. 2018). Although the slope allows the construction of dams, the flow of the Prut and the Manolescu Canal was too high to allow this. At the same time, beavers generally prefer small watercourses for the construction of dams, and the width of the watercourses must be less than 6 m (Stringer et al. 2018), but the Prut had an average width of 35–40 m, and the Manolescu Canal of 15–20 m. Therefore, so far, no

beaver dams have been identified.

The water depth in an optimal habitat for the Eurasian beaver must be permanently over 80 cm (Ionescu 2010), a condition fulfilled in the study area, considering that the average depth of the Lake Belevu and the canals in this aquatic complex was over 1–1.5 m. Maintaining a minimum water depth is very important for the beaver, not only for keeping the entrances to the shelters below the water level but also for feeding narrow canal systems, which are used to transport the necessary wood material by water, food, and construction (Ionescu et al. 2010).

Although many habitats upstream on the Prut River, from our study area, are suboptimal habitats, the area of Lake Belevu and the Lower Prut Reservation may be further a nucleus for the colonization of the Prut Meadow from the upstream. Beaver colonies tend to settle in optimal habitats initially, occupying marginal, suboptimal habitats later on (John et al. 2010). There were many islands of optimal habitat identified in the Prut Meadow that may be colonized by the beaver if the local institutions will grant the status of protected species for the beaver on the territory of the Republic of Moldova, and there will be no conflicts with the local people that will result in poaching.

Beavers are animals that can easily adapt, survive and reproduce in different habitats, including even intensively cultivated areas that have undergone major anthropogenic changes (Nolet & Rosell 1998). Beavers can advance through the cultivated agricultural landscapes of Prut river meadow until they reach areas of extensive floodplain forest, dammed lakes, ponds, lakes, or abandoned fish ponds that abound in woody vegetation of the genera *Salix* and *Populus*, such as Colibași MD, Foltești RO, the complex of Rotunda lakes, Drachele, Badel'nik, and the Manta fisheries. These areas could represent other future nuclei of beaver colonization on the Prut River in a short time.

In the habitats of the Prut River, the beaver population may not be controlled by large predators being a strong delimiting factor (Hartman 1994). A potential natural predator could be the golden jackal (*Canis aureus*), but we have not found bibliographic sources to confirm the predation. Given the specific conditions in the optimal habitats, beavers can defend themselves from possible predators by diving when the water has a depth of more than 40–80 cm, so natural predation does not seem to be a factor that could control beaver breeding and spread in the Prut river basin.

Beavers are well known for transforming ecosystems by building dams and are therefore being used more and more frequently to restore habitats, adapt to extreme weather conditions, and re-wild for long-term man-made areas (Willby et al. 2018). therefore, many other species may benefit from the colonization of the area. Due to the ability of beavers to create new habitats, they can increase biodiversity in wetlands or contribute to the emergence of new species that will occupy newly created habitats.

Given that the avifauna diversity has great importance for the Lower Prut Biosphere Reserve, the main beneficiaries of the newly created beaver habitats could be the bird species that mainly use wetland habitats. According to the scientific literature (Askins et al. 2007, Aznar & Desrochers 2008, Brown et al. 1996, Chandler et al. 2009, Cooke & Zack

2008, Ewins 1997, Grover & Baldassarre 1995, Longcore et al. 2006, Nummi & Holopainen 2014, Sikora & Rys 2004, Stringer & Gaywood 2016, Tumieli 2008), bird species frequently use beaver ponds and modified habitats. Beaver activity has been shown to positively affect the abundance of species or the overall biodiversity of birds (Stringer & Gaywood 2016). The characteristics of the aquatic habitats of beaver-created ponds, such as large areas with shallow water, are particularly important for waterfowl such as *Anatidae* like *Cygnus olor*, *Anser erythropus*, *Tadorna ferruginea*, *Netta rufina*, *Aythya nyroca* and other more common species (Brown et al. 1996).

The habitats created by beavers consist of structurally complex areas that can improve habitat conditions for birds, such as hiding nests, reducing predation, increasing food production, and ultimately providing a wide variety of exploitable ecological niches (Edwards & Otis 1999, Bulluck & Rowe 2006). The mosaic formed by different vegetation types seems to be a key component of this habitat, providing shelter for waterfowl, especially in beaver-transformed habitats (Beard 1953).

Ponds created by beaver-built dams flood and kill trees from the riparian area. Dead standing trees are an important nesting and feeding habitat for woodpecker species found in the Lower Prut area: *Dendrocopos syriacus*, *Dendrocopos major*, *Dendrocopos medius*, *Dryocopus martius*, *Picus canus*, *Picus viridis*, *Dendrocopos minor* and *Jynx torquilla* (Grover & Baldassarre 1995, Sikora & Rys 2004, Tumieli 2008). Dead standing trees are also important for raptors like *Haliaeetus albicilla* and *Pandion haliaetus* (Ewins 1997).

Habitats created by beavers provide a higher abundance of trophic resources for birds. The dams and ponds created by the beaver consist of a wide range of macroinvertebrates that are an excellent source of food for *Anatinae* (Longcore et al. 2006, Cooke & Zack 2008, Nummi & Holopainen 2014). In addition, in the habitats created by beavers, the increased abundance and diversity of fish and amphibians provide food for species such as herons (*Ardeidae*) and kingfisher (*Alcedines*) (Beard 1953, Elmeros et al. 2003).

Beaver-built habitats can support diverse vegetation that contributes to increasing bird diversity (Chandler et al. 2009) and can be an essential source of food and habitat for birds using riparian grasslands (Askins et al. 2007). Aznar & Desrochers (2008) found that riparian grasslands in beaver abandonment habitats have the greatest diversity of songbird species compared to all other adjacent riparian habitats.

The beaver has a remarkable capacity to conquer new territories and transform habitats, causing certain damages in forestry, agriculture, fish farming, communications, and other fields. For example, the breakthrough of dams against floods in the Prut meadow can have catastrophic effects on agriculture, communications, and citizens' safety, so we want to raise awareness through this paper about the complex implications of the natural colonization of the Eurasian beaver in the Prut valley.

The up-to-date information on the development of beaver colonies in the Prut River meadow will help the decision-makers to prevent possible conflicts and adopt certain management measures for Eurasian beaver, given that there is no natural factor regulating the population.

However, anthropogenic activities create certain threats for the Eurasian beaver; some are occasionally encountered in the study area and across the Prut meadow. The main ones are regularization of watercourses and hydro-technical works, deforestation of woody riparian vegetation, the presence of stray dogs in the habitats occupied by the beaver, and poaching (generally done in response to the damages created by species considered as pests).

Given that the Eurasian beaver is a species of interest for conservation, it is absolutely necessary to provide protection status on the territory of the Republic of Moldova, and its introduction in Annex no. 3 of the Law on the Animal Kingdom (LP439/1995), the list of wildlife species included in the Red Book of the Republic of Moldova.

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