



## Commentary

## The strange case of beaver return in Italy: origins and management

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### Abstract

The Eurasian beaver (*Castor fiber*) became extinct in Italy between the end of the 16th century and the beginning of the 17th century. A few animals were recorded at the border with Austria in 2018 and 2020. Between 2021 and 2023, beavers were reported in six Central and Southern Italy areas at more than 350–400 km from the nearest colonies. Following an official position by the Italian Mammal Society, this paper aims to explore the possible origin of these nuclei, suggests their removal and provide an analysis of the concerns and management recommendations. Given the distances between beaver locations in Central and Southern Italy and the rapid appearance of numerous small nuclei with few individuals in just a couple of years, the most plausible explanation is multiple unlawful releases. Unplanned and unauthorised reintroductions are unacceptable in terms of a sound wildlife management approach and represent a dangerous precedent stimulating further unlawful release of mammals. Therefore, we urge competent authorities to remove these animals from the field.

## Introduction

Conservation translocation involves the deliberate movement of organisms from one site to another to gain a benefit for species and populations (IUCN/SSC, 2013). Among these actions, the boldest are reintroductions, where species are returned to part of their historical range from which they have disappeared (Armstrong and Seddon, 2008). Reintroductions can be an effective conservation tool but are complex to implement, even from a bureaucratic point of view, and they often present difficulties that can undermine their success (Berger-Tal et al., 2020). For this reason, the International World Union for Conservation of Nature (IUCN), the recognized global authority on the status of nature, produced specific guidelines for reintroductions and other conservation translocations (IUCN/SSC, 2013), including disease risk analysis related to movements of animals from one area to another (IUCN/SSC, 2014). Risks in a translocation also include the many ways the released animals will impact the biotic communities, the ecosystem functions, and the human activities in the destination areas. Consequently, according to IUCN guidelines, a previous consultation

of the main stakeholders and local communities is also fundamental to assess their level of acceptance of the target species and avoid conflicts that might compromise the success of the whole project. Therefore, these conservation operations must be carefully planned, involving experts from different scientific fields, and competent authorities.

Reintroduction projects play a crucial role in the large-scale recovery of formerly persecuted species. One such example is the Eurasian beaver (*Castor fiber*), a species that has suffered significant population declines due to human activity in Europe. Thanks to numerous reintroduction projects, the beaver is now making a widespread comeback (Halley et al., 2021). However, some of the reintroductions were unplanned and illegal actions. The Eurasian beaver became extinct in Italy between the end of the 16th century and the beginning of the 17th century (Pratesi, 1978; Amori, 1993; Salari et al., 2020). After more than 400 years, following the expansion of the reintroduced population in the Danube, the return of beavers in Italy was first documented in 2018 and in 2020 in north-eastern Italy (Pontarini et al., 2019; Pucci et al., 2021). In 2021, the presence of beavers was unexpectedly recorded at a few isolated and distant locations in Central Italy, in Tuscany and Umbria (Pucci et al., 2021; Mori et al., 2021), located more than 350 km from the northeastern Italian boundary with

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Slovenia and Austria. The authors of the articles reporting this discovery suggested the possibility that beavers did not arrive in Central Italy by natural dispersal but as the result of escape from captivity or voluntary releases. Consequently, the Italian Mammal Society (ATIt - Associazione Teriologica Italiana, [www.mammiferi.org](http://www.mammiferi.org)) organised a workshop (Rome, 29 September 2021) to review the available data on the Eurasian beaver in Italy and neighbouring countries and evaluate possible pathways of arrival of the species in Central Italy. As a result of the workshop, ATIt prepared and approved a position statement on this topic ([www.mammiferi.org/posizione-ufficiale-di-atit-sulla-gestione-dei-nuclei-di-castori-eurasiatici-in-centro-italia](http://www.mammiferi.org/posizione-ufficiale-di-atit-sulla-gestione-dei-nuclei-di-castori-eurasiatici-in-centro-italia)), which has been shared with the national and local bodies in charge of wildlife management. Afterwards, beavers were also discovered in southern localities: in 2023, new records were reported from the Abruzzi region and along the Volturno River at the border between Molise and Campania regions (Capobianco et al., 2023).

Following the position statement by the Italian Mammal Society this paper aims to explore the possible origin of the animals recorded in Central and Southern Italy and provide appropriate management recommendations based on the outcomes of the investigations.

### The Eurasian beaver

The historical range of the Eurasian beaver extends from the Iberian Peninsula and Great Britain to eastern Siberia (Batbold et al., 2021). Following overexploitation for fur, meat and the oil produced by its peri-anal glands (*castoreum*), at the beginning of the 20th century, the species survived only with eight small and fragmented populations (Nolet and Rosell, 1998). In the 1900s, the species recovered in many European countries (Wróbel, 2020) and it is now listed as Least Concern in the IUCN red list (Batbold et al., 2021). Recovery has been promoted by legal protection – the species is listed in Annex II and IV of the Habitat Directive 92/43/EEC, except for the Finnish and Swedish populations, listed in Annex V – and the implementation of reintroduction projects at large geographical scales, coupled with the species capacity to disperse across the hydrographic network (Halley and Rosell, 2003; Halley et al., 2021).

### An ecosystem engineer

The beaver is widely considered an "ecosystem engineer" (Brazier et al., 2020) because of its ability to significantly alter the hydrology, geomorphology, biogeochemistry, and ecosystems of rivers through feeding, denning, and dam construction activities (Larsen et al., 2021; Jones et al., 1994; Rosell et al., 2005; Wright et al., 2002). Landscape and ecosystem transformations produced by beavers are mainly due to the construction of dams, which stop the water flow and increase the extent of open water. These effects of dams are more pronounced in streams, side channels of large rivers, and floodplains (Butler and Malanson, 2005; Gurnell, 1998; Laland and Boogert, 2010; Westbrook et al., 2013). Beavers build dams to maximise food supply, create water bodies deep enough not to freeze completely during winter (at higher latitudes), and as protection from potential predators. Once built, dams can be actively maintained for years or decades or abandoned and eventually get destroyed by floods or filled with sediment (James and Lanman, 2012).

The beaver is a generalist herbivore, feeding on woody plants, forbes, ferns and aquatic vegetation. Among woody species, it prefers the genera *Salix* and *Populus*, which is capable of gnawing and felling even large mature trees (Haarberg and Rosell, 2006). Beaver trophic activity can also significantly affect ecological successions and the structure and composition of plant communities (Anderson et al., 2006).

The extensive landscape-scale environmental transformations induced by the presence of the beaver involve both positive and negative effects, which have been extensively analysed in the scientific literature. The main positive effects include the stabilisation of water flows and reduction of flood risk (Neumayer et al., 2020), marked improvements in water quality (Larsen et al., 2021; Wegener et al., 2017), the creation of an interconnected matrix of wetland habitats which enhances biodiversity (Rosell et al., 2005), and increases tourist attractiveness (Auster

et al., 2020). The main negative impacts include excavation activities on hydraulic reticulation dams and increased risk of flooding (Larsen et al., 2021), impacts on agricultural activities and resulting social conflicts (Campbell-Palmer et al., 2016), reduced movement and spawning opportunities for fish (Kemp et al., 2012), impacts on vegetation (Rosell et al., 2005; Mikulka et al., 2022, e.g., Natura 2000 habitat 92A0), and the spread of zoonoses (Girling et al., 2019).

The extent to which beaver impacts are considered to be positive or negative also depends on conservation and consequently management priorities for the landscape characterising a certain area, which in turn rely heavily on the extent of changes the species can cause in specific natural and anthropogenic contexts (Larsen et al., 2021), but also in consideration of the conflicts with human activities affected by beaver presence.

### Beaver illegal reintroductions in Europe

Reintroductions of Eurasian beavers in Europe started in 1922. Early reintroductions aimed to establish populations for fur harvesting, but the conservation aim became prominent in the following decades (Halley and Rosell, 2003). First, reintroductions were conducted through hard release without planning, but later operations were properly planned. The present distribution of the Eurasian beaver results from dozens of reintroductions in at least 28 countries and natural spread (reviewed by Halley and Rosell, 2003; Halley et al., 2021). However, at least, twelve of these reintroductions were illegal (Table 1): 2 in Belgium, 5 in England, 2 in Scotland, and 3 in Spain. The following is a brief analysis of these illegal situations.

#### Belgium

In Belgium, 101 beavers (4 from the Elbe and 97 from Bavaria) were unofficially released in different areas of Wallonia, mainly in the Ardennes and Namur, between 1998-2000 (Verbeylen, 2003). The Bavarian beaver population is estimated at 35,000 animals, and it has been the primary source for most reintroductions throughout Europe since the 1970s (Halley et al., 2021). In 2000, beavers started to spread in Flanders, and the Ministry of the Flemish Government asked for a feasibility study as part of a future reintroduction project (Niewold and Rossaert, 2002). However, before any decision was taken, in 2003, 20 Bavarian (Germany) beavers were released in at least 6 locations along the rivers Dijle and Laan: this reintroduction was planned illegally, without preparing or informing the local population and other stakeholders, and without permission (Verbeylen, 2003).

#### England

Unlicensed releases of beavers in England took place along the River Otter in Devon, where these animals have been present since at least 2008, with the first confirmed reproduction occurring in 2014 (Girling et al., 2019; Halley et al., 2021). Initially, the government had planned to remove the beavers. However, in 2015, they accepted a proposal from the Devon Wildlife Trust for a five-year trial aimed at evaluating the impact of beavers on the landscape, which also included efforts to reinforce the beaver population (Brazier et al., 2020). In 2020, the government made the decision to allow the River Otter beaver population to remain in the wild. Further illegal releases of beavers leading to the establishment of populations occurred in the Tamar River, the Kent Stour, and the Wye on the Welsh border, as well as in the Somerset levels (Halley et al., 2021).

In 2015, the UK Mammal Society approved a Position statement on beaver reintroduction ([www.mammal.org.uk/2015/08/position-statement-beaver-reintroduction](http://www.mammal.org.uk/2015/08/position-statement-beaver-reintroduction)) welcoming the return of the beaver to Great Britain. Still, it did not support unlicensed releases, emphasising that these pose a risk to human and animal health, could damage the interests of nature conservation, and may also compromise the beavers' welfare. Following the recognition of legal protection status, the Mammal Society has produced a new Position Statement (20th October 2022, <https://www.mammal.org.uk/2022/10/14284/>) welcoming the return of this native species across Britain and the recent increased legal protection in Scotland and England.

**Table 1** – Areas in Europe with beaver presence resulting from illegal releases.

| Country  | Location   | Date of release / first observation | No. of animals released | Area of origin of the released animals | Source   |
|----------|--|-------------------------------------|-------------------------|--|--|
| Belgium  | Wallonia   | 1998-2000                           | 101                     | Germany                                | Verbeylen, 2003                                    |
|          | River Dijle, River Laan (Flanders)                 | 2003                                | 20                      | Germany                                | Verbeylen, 2003                                    |
| England  | River Otter (Devon)                                | 2008                                |                         | Germany                                | Brazier et al., 2020, Campbell-Palmer et al., 2020 |
|          | Tamar River  |                                     |                         |  |  |
|          | Kent Stour   |                                     |                         | Norway                                 | Halley et al., 2021                                |
|          | Wye river on the Welsh border Somerset             |                                     |                         |  |  |
| Scotland | River Tay, River Earn, Tayside                     | 2001                                |                         |  | Coz and Young., 2020                               |
|          | River Beaully (Highlands)                          | 2017                                |                         |  | Coz and Young., 2020<br>Coz and Young., 2020       |
| Spain    | Aragón River (Navarra)                             | 2003                                | 18                      | northern and southern Europe           | Calderón et al., 2022                              |
|          | Tormes River, near the Douro River                 | 2022                                |                         |  | Calderón et al., 2022                              |
|          | Guadalquivir river (Villatorres, Torreblascopedro) | 2023                                |                         |  | Burón et al., 2023                                 |
| Italy    | Ombrone and Merse rivers (Tuscany)                 | 2021                                |                         |  | Pucci et al., 2021                                 |
|          | Sansepolcro (Tuscany)                              | 2021                                |                         |  | Pucci et al., 2021                                 |
|          | Perugia province (Tevere river valley, Umbria)     | 2021                                |                         |  | Mori et al., 2021                                  |
|          | Terni province (Tevere river valley, Umbria)       | 2021                                |                         |  | Mori et al., 2021                                  |
|          | Aterno River (Abruzzi)                             | 2023                                |                         |  | Capobianco et al., 2023                            |
|          | Volturno River (between Molise and Campania)       | 2023                                |                         |  | Capobianco et al., 2023                            |

The Eurasian beaver has a protected status in England from 1 October 2022. To reduce damage to people, land management and the environment, a 5-step approach to beaver management was developed (DEFRA, 2022). The last step includes the possibility of lethal control.

**Scotland**

In 1995, the Scottish Natural Heritage started investigating the possibility of a beaver reintroduction project, which was authorised and started as a trial between 2009 and 2014 at Knapdale forest (Coz and Young., 2020). However, parallel to this official reintroduction, two accidental escapes or illegal releases occurred in 2001 in Tayside, eastern Scotland, on the River Tay and River Earn catchments and in 2017 on the River Beaully near Inverness in the Highlands (Coz and Young., 2020).

In 2012, the Minister for the Environment announced a policy of tolerance towards beavers in Tayside, pending a decision on the future of beaver reintroduction in Scotland, which was scheduled for 2015 (Campbell et al., 2012). During this time, the Scottish government initiated a trapping and relocation effort for beavers inhabiting a river near Beaully due to their illegal release. However, this project was temporarily suspended following the unfortunate deaths of two of the relocated animals (BBC, 2017). Then, in 2016, government ministers decided to allow beavers to remain in Scotland and initiated a process to reinforce the beaver population in Knapdale through additional translocations of these animals (Dowse et al., 2020).

The Eurasian beaver received protected species status in Scotland on 1 May 2019. At the same time, a Beaver Management Framework was adopted to balance the desire to allow the beaver populations to continue to expand their range naturally whilst mitigating significant detrimental impacts (NatureScot, 2021). The management framework considers a range of actions to minimise damage produced by beavers, including their licensed killing. From May 2019 to December 2022, a total of 352 beavers were killed under licence: 87 in 2019 (from May to December, NatureScot, 2020), 115 in 2020 (NatureScot, 2021), 87 in 2021 (NatureScot, 2022), and 63 in 2022 (NatureScot, 2020).

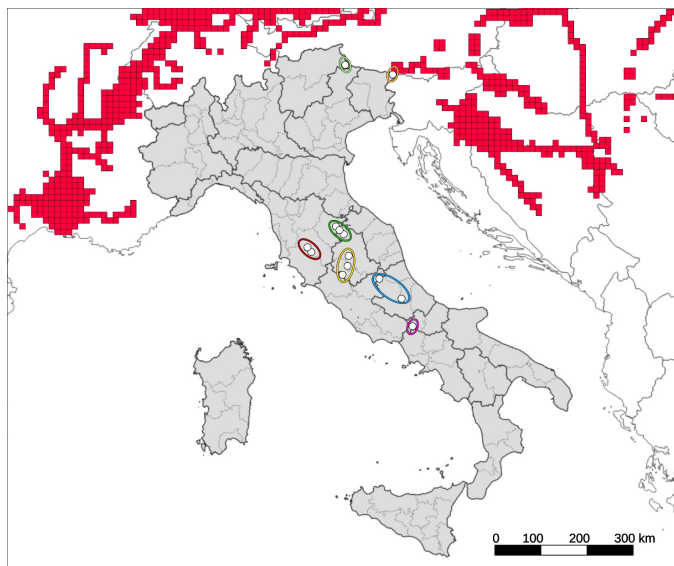
**Spain**

In Spain, 18 beavers from northern and southern European countries were illegally released in 2003 into the Aragón River (Navarra; Spain). Though the Eurasian beaver is listed in the Habitat Directive (92/43/EEC), and since it was not present in Spain when the directive was adopted, initially, the Spanish territory was not considered to be included in the natural range of the species. Therefore, the provisions of the Habitat Directive were considered not applicable to the Eurasian beaver in the country. The local authority, supported by the position of the European Commission, started an eradication project. A total of 216 beavers were removed from 2008–2017; however, the eradication was unsuccessful (Calderón et al., 2022). As a result of this failure, in 2018, the European Commission considered naturalised the species in Spain and requested the government to fulfil the Habitat Directive provisions ensuring the protection of the species (European Parliament, 2018). In 2020, with an order from the Spanish national government, the species was included in the list of species with special protection ([www.boe.es/eli/es/o/2020/11/20/ted1126](http://www.boe.es/eli/es/o/2020/11/20/ted1126)).

The presence of a second nucleus was recently reported in the Tormes River (a tributary of the Douro River), 332 km away in straight line and 611 km distance along the riverbanks from the nearest known range and attributed to an independent illegal release (Calderón et al., 2022). A third nucleus was reported in 2023 by Burón et al. (2023) in Guadalquivir river, in Villatorres and Torreblascopedro municipalities (province of Jaén).

**Italian beavers**

Although Italy is not included in the historical range of the Eurasian beaver described by Batbold et al. (2021), the species was known to occur in the country in the early Mediaeval times, with a stronghold in the Po Valley, from where it disappeared during the 16th century or the beginning of the 17th century (Pratesi, 1978; Amori, 1993; Salari et al., 2020). Across the last four centuries, the Eurasian beaver has never been observed in Italy. Its return dates back to 2018 when one individual was observed in small tributaries of the Danube drainage system in the Municipality of Tarvisio (province of Udine, north-eastern Italy)



**Figure 1** – Beaver records reported for Italy and distribution of the species in neighbouring countries. The different areas where beavers are present in Central and Southern Italy are represented as separate ellipses. Points in Tuscany and Umbria (red, green and yellow ellipses) were provided by Emiliano Mori, the others are from Pontarini et al. (2019); Pucci et al. (2021); Capobianco et al. (2023).

as a result of natural dispersal from Austria (Loy et al., 2019; Pontarini et al., 2019). In Austria, the large population results from numerous reintroductions planned in 1970-90 and from the dispersal of animals from Germany (Halley et al., 2021). In November 2020, the Eurasian beaver was also camera-trapped in Val Pusteria (near Sesto Pusteria, province of Bolzano), close to the Austrian border (Pucci et al., 2021).

In 2021, beavers were documented along two distinct river basins in Tuscany (Central Italy; Pucci et al., 2021) (Fig. 1). The first area was about 15 km long and encompassed both the Ombrone and Merse rivers in the municipalities of Civitella-Paganico (province of Grosseto) and Murlo, Monticiano, Montalcino (province of Siena), the second was near Sansepolcro (province of Arezzo). These areas are separated by over 110 km in a straight line and by 350-400 km from the nearest beaver population. After further monitoring, beavers were confirmed to be present also in the Umbria region (Fig. 2) in Val Tiberina (the Tevere river valley) in the two provinces of Perugia (municipalities of Città di Castello and Deruta) and Terni (municipalities of Guardea and Alviano) (Mori et al., 2021). In 2021, a roadkilled individual was found in the Marche region, close to the border with Tuscany (Mercatello sul Metauro, province of Pesaro Urbino). A monitoring project in Tuscany and Umbria estimated the presence of a few dozen animals in 2022 (Mori et al., 2023).

In 2023, the presence of the species was confirmed in Abruzzi region along the Aterno River, close to the city of Aquila and in the municipality of Vittorito, and in South Italy along the Volturno River at the border of Molise region (municipality of Monteroduni-Roccaravindola, province Isernia) and Campania region (Capriati a Volturno, province of Caserta) (Capobianco et al., 2023).

### Origins of Central and Southern Italy beavers

The beavers observed in Central and Southern Italy could have four possible origins: a cryptic residual population, a dispersal from other areas, an escape from captivity or an unlawful release.

#### *A cryptic residual population*

The first hypothesis implies that one or more cryptic populations of European beavers survived undiscovered in Central or South Italy for more than 300 years. This hypothesis is extremely unlikely. In fact, the size of these residual populations should have been sufficient to ensure their permanence for a long time. Moreover, the stable presence of beavers in an area is easily detectable due to their recognisable signs of presence, especially trees or stems of larger bushes felled by double-

conically gnawing, gnawing traces on still-living woody plants, canal digging, burrows, lodges and bank dens, dams (Campbell-Palmer et al., 2021). Natural areas in Central Italy (e.g. Apennines) were much more anthropised in the past and nowadays rivers and wetlands are frequented and intensively monitored for fishing, biodiversity inventories, and coypu management. Therefore, it is unrealistic that an existing beaver population could be present in the area without being reported for more than 300 years.

A recent study (Attili et al., 2023) discovered that the beaver populations established in Central Italy have two haplotypes currently found in western and eastern European populations. These findings confirm that these populations were likely established from a genetically mixed stock of animals and do not support their origin from a hidden local population.

#### *Dispersal from neighbouring countries*

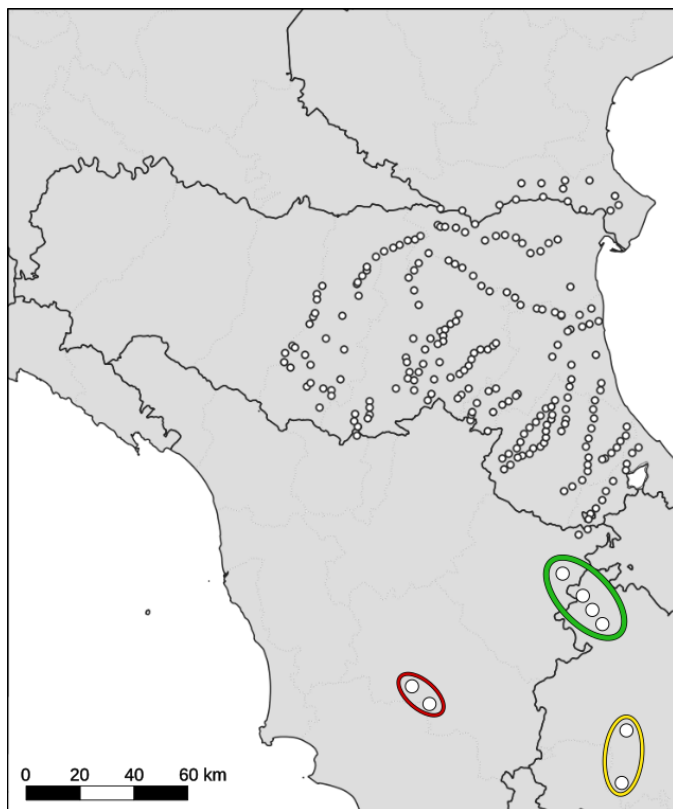
The closest extant Eurasian beaver populations occur in France, Switzerland, and Austria (Halley et al., 2021). The animals reported in Tuscany are at about 350 km the crow flies from the animals observed in eastern Italy, and about 480 km from the nearest French populations. Beavers prefer to disperse through watercourses as corridors, although they can also travel overland. Therefore, individuals dispersing from the French border or eastern Italy to Tuscany and Umbria regions would have travelled hundreds of kilometres. Further, beavers from eastern Italy should have crossed, unnoticed, the largely unsuitable, human populated, Po Valley, whereas animals dispersing from France, would then have crossed the many catchments of the northern Apennines. In these areas, human pressure is much lower, and the environment seems to be suitable for beavers, where the current is not too fast. It is, therefore, likely that any dispersing beavers would have first become established in the northern Apennine rivers. This is confirmed by the model produced by Falaschi et al. (2023), which indicates large parts of the Apennines are highly suitable for beavers.

The distance travelled by dispersing beavers leading to settlement and breeding averages 9 km/year with a maximum of 80 km (Fustec et al., 2001). To reach the areas in Central Italy, the animals would have had to overcome a distance at least 5-6 times greater. The presence of undetected beaver populations in Central and Northern Italy, acting as a stepping-stone towards Tuscany and Umbria and then in regions further south, is again unlikely. In 2022, the Italian Mammal Society funded a monitoring project in Emilia-Romagna region, i.e. an area connecting the central and northeastern parts of Italy. Two fieldworkers monitored all rivers between Modena, the Republic of San Marino and the Po Delta looking for beaver signs (Fig. 2). In total, 150 points along 23 watercourses were checked without finding any sign (Leoncini and Viviano, 2022).

However, the beavers were recorded at multiple and isolated locations in Tuscany, Umbria, Abruzzi, and at the border between Molise and Campania. These nuclei are each composed of a few animals (Mori et al., 2023). The colonisation of many areas in Central and Southern Italy, even hundreds of kilometres away from each other, without the presence of a source area with a large and consistent population, is a dynamic that is difficult to explain.

#### *Illegal reintroduction (release or escape)*

According to the EAZA database for the current and former vertebrate inventories of zoos and other public collections ([www.zootierliste.de/en](http://www.zootierliste.de/en), accessed on 03.02.2023), Eurasian beavers are kept in captivity in two areas in the provinces of Arezzo (over 100 km north to the Ombrone-Farma-Merse river basins) and Pavia (North Italy). Communicating the escape of captive individuals of wildlife species is mandatory for private citizens (the Italian Decree Law n. 150/1992) or zoological gardens (the Italian Decree Law n. 73/2005). An illegal escape implies the owners of the beavers should have communicated this event to local authorities. However, local authorities were unaware of the species' presence both in the rivers of Tuscany and Umbria and in Abruzzi, Molise and Campania. Moreover, as no authorisation for the captive breeding of beavers has been requested, beavers would have been detained without any authorisation, which is another illegal situ-



**Figure 2** – Areas monitored for beaver's presence in the Emilia-Romagna and Veneto regions, and in the Republic of San Marino (from Leoncini and Viviano, 2022, as small white dots). The different areas where beavers are present in Tuscany and Umbria Regions are represented as separate ellipses.

ation. Beavers have been detected almost simultaneously (from 2021 to 2022) in many areas spanning about 300 km along Central and Southern Italy, therefore, should be the result of multiple and almost simultaneous escapes from unknown enclosures, or from a single escape with subsequent migration to different and distant areas. In any case, this hypothesis would imply several animals being kept in captivity without any notification to the competent authorities. This hypothesis seems to be scarcely plausible, also considering that an individual escaped from captivity in northern Tuscany in the early 2000s was rapidly detected and poached (Pucci et al., 2021).

The alternative hypothesis of a deliberate release implies another violation of existing laws about wildlife kept in captivity, which prevents private individuals from releasing animals in the wild without specific authorisation from the competent authorities and related to the conservation of the species (e.g. for restocking or a reintroduction project). Anyway, the appearance in several regions of numerous nuclei with few individuals suggests multiple illegal releases planned and implemented in a few years, making this hypothesis the most realistic.

### Genetic investigation

Beavers released in Central and Southern Italy are from unknown origin. Theoretically, genetic tools can be implemented to investigate their origin. Previous studies have shown that the scattered relict populations in Eurasia at the beginning of the 20th century were genetically differentiated, sharing a few or no mitochondrial DNA haplotypes (Durka et al., 2005; Ducroz et al., 2005). More recent reintroductions, realised in several regions of Europe, have partially altered this phylogeographic signal (Frosch et al., 2014). Nonetheless, sequencing the mitochondrial control region and comparing it to publicly available sequences (i.e. GenBank) from other reference populations can allow associating the beavers present in Italy to a restricted set of current populations (see Attili et al., 2023 for a first approach). This activity, however, would not allow distinguishing between natural and human-mediated dispersal, even if it turns out that the most likely source population was one of the closest geographically (i.e. France, Switzerland, Austria). The sus-

pected beavers can derive from a local captive nucleus of foreign origin. The only way to exclude (or confirm) this option genetically would be to compare beavers in Italy with reference animals from the captive natal stock.

### Risks of illegal and unplanned reintroductions

Available data indicate beyond a reasonable doubt that the presence of Eurasian beavers in Central and Southern Italy is the result of multiple voluntary but illegal releases with the aim of reintroducing the species in this area, as it has already happened in other European countries. Although related to a species of European conservation concern, an unplanned and unauthorised reintroduction is unacceptable in terms of a sound wildlife management or conservation biology approach.

Reintroductions can be an effective conservation tool, but they can also have adverse ecological, sanitary and economic impacts, which can cause a negative social perception and reaction. These concerns should be identified and discussed in advance by involving local communities and authorities. International (IUCN/SSC, 2013) and national (AA. VV., 2007) guidelines require to motivate the intervention with respect to the strategy for the conservation of the target species and to assess its feasibility. Deciding when a reintroduction is an acceptable option includes a balance of the conservation benefits against the costs and risks of both the translocation and alternative conservation actions. A consultation of the main stakeholders and local populations is also fundamental to assessing the new species' acceptability. The EU Habitat Directive at art. 22 requires a consultation of the public before reintroducing species included in Annex IV of the Directive, such as the beaver. This is even more necessary for an ecosystem engineer like the beaver in highly populated areas.

Reintroducing a species that has been absent from a certain territory for centuries is challenging from an ecological and social point of view. Over such a long period of time, ecosystems have probably changed considerably due to human impact. Moreover, people have probably forgotten that the beaver or other species were part of the local natural ecosystem and may consider them as introduced, even though they are native (Coz and Young., 2020).

Reintroductions can also pose epidemiological risks, such as introducing new pathogens or amplifying those already present, with possible unpredictable effects on both animal and public health (Kosmider et al., 2013; Daszak et al., 2000; Chinchio et al., 2020). Eurasian beavers are potential hosts for various infectious diseases and parasites, including those typical of common European rodents (Girling et al., 2019). For this reason, a risk analysis was performed in Great Britain to inform projects of conservation translocation of the species (Girling et al., 2019; Donald et al., 2020). Therefore, from a sanitary point of view, neither an illegal release nor an escape from captivity of a species that has been absent from a territory for centuries is acceptable.

Finally, despite the economic value of ecosystem services delivered by beavers can be substantial (Thompson et al., 2021), it is worth mentioning that in France, since the 90s, they required high attention on wildlife, forestry and hydraulic impacts (Rouland and Migot, 1990; AA. VV., 20012; Le Lay et al., 2017) also as a result of the strong economic damages they can cause. Likewise, in the Czech Republic, Poland and Bavaria (Germany), three areas characterised by high species densities, yearly damages are approx. 187,000, 130,000 and 450,000 euros, respectively. In Denmark, where beavers were reintroduced in 1999, managing and mitigating conflicts with human activities costs around 90.000 € per year (Janiszewski and Hermanowska, 2019).

According to the Italian Presidential Decree n. 357/1997 (recently modified by Decree n. 102/2019), a specific authorisation by the competent regional administration is needed for releasing species listed in Annex D of the Decree (Annex IV of the Habitat Directive), even if for conservation purposes, and an adequate consultation of the public is also prescribed. Moreover, the National Institute for Environmental Protection and Research (ISPRA), needs to evaluate the motivations and feasibility of the project. Specific criteria for reintroducing and restocking native species listed in Annex D are defined in Annex I of the ministerial Decree of 02/04/2020. IUCN guidelines and European and national legislation agree in requiring technical procedures prior to a

**Table 2** – Positive factors (pros) that may facilitate beavers' nuclei removal in Central and Southern Italy and the challenges (cons) that could hamper the implementation of management plans.

| Pros  | Cons  |
|---|---|
| The nuclei are still geographically restricted.   | Nuclei are located in 5 regions.  |
| Every nucleus has probably no more than a few dozen of animals.   | Since wildlife management is a regional competence, it will be necessary to activate more action plans, albeit coordinated with each other.     |
| The beaver is a semi-aquatic species; therefore, its distribution is linear along the rivers. This favors the concentration of the removal effort in limited areas. | Political support from multiple regional authorities is needed, but the goal of removal may not be shared by the decision-makers of all regions |
| The signs of presence are evident, and the species can be detected even at very low density.  | Being a charismatic species, opposition to removal at local and national levels is predictable.   |

reintroduction project, highlighting that a social acceptance of translocations plays a crucial role, and these activities cannot be left to individual initiatives that are not subject to third-party oversight.

The possible reintroduction of Eurasian beavers had to be evaluated carefully because of the potential environmental impacts of the species on rivers from which they have been absent for many centuries, and cascade effects are unpredictable. A recent modelling paper (Falaschi et al., 2023) identified the areas where beaver populations are most likely to spread in the near future in Italy. However, such ecological assessments have not been conducted in the face of the illegality of the reintroduction. In any case, the study from Falaschi et al. (2023) identified the main areas of potential human-beaver conflicts, and one is located in Central Italy, where illegal reintroductions occurred.

#### **Managing illegal reintroductions**

There have been at least twelve cases of illegal reintroductions resulting in the establishment of Eurasian beaver populations in Europe. Removal efforts of a couple of these populations in Spain and Scotland have proven unsuccessful. In Spain, for instance, between 2008 and 2017, 216 beavers were removed in regions including La Rioja, Navarra, and Aragon, yet attempts at eradication ultimately failed (Calderón et al., 2022). In the case of Navarra, the estimated cost of removing 100 animals amounted to €131,000. Unfortunately, detailed information regarding the removal efforts is unavailable, making it challenging to assess the reasons behind the failure. For this reason, the project is unsuitable as a reference for future removal attempts. In some instances, as in England, illegally released beavers have been tolerated, essentially legitimizing their presence. From the perspective of those who planned the actions, these illegal releases may be viewed as successful, potentially serving as inspiration for similar actions in other countries, such as Italy. The passive acceptance of unplanned reintroductions only encourages further emulation.

From a management point of view, if the competent authorities will tolerate these illegally released Eurasian beavers, the risk of other deliberate and illegal releases of mammals will likely increase. Rewilding is the large-scale restoration of ecosystems to preserve species, habitats and natural processes. Therefore, it is a form of ecological restoration that includes removing human constructions and disturbance, creating corridors and reintroducing missing species to reinstate natural processes. However, poorly planned rewilding can have disastrous consequences for wildlife and people (Carver et al., 2021). Also, some in the scientific community have expressed concerns about some poorly designed rewilding initiatives triggering human-wildlife conflicts if the needs of stakeholders and the socio-economic contexts are ignored (e.g. large carnivores, Drouilly and O'Riain, 2021).

Considering what is illustrated in this article, we strongly criticise actions such as the one we believe may have led to the reappearance of the Eurasian beaver in Central and Southern Italy. The end of having the beaver after many centuries of absence cannot in any way justify the means, such as illegal releases. Justifying these releases for conservation purposes would lead to accepting any species release on the Italian territory: who decides what is right and what is wrong if one accepts illegality? Emulation may lead to the release of other species. What if the next species released is an invasive alien species?

We also express concern that in the near future, illegally introduced Eurasian Beaver populations in Italy may divert human and economic resources (national and international) from the conservation of native biodiversity and, in particular, freshwater ecosystems, which are among the most threatened on a global scale (Dudgeon et al., 2006) and require a remarkable conservation effort, as envisioned by the Kunming-Montreal Global Biodiversity Framework (Targets 2 and 3).

Considering that the Eurasian beavers present in Central and Southern Italy are likely the result of unplanned and unauthorised releases and following the official position of the Italian Mammal Society, we urge competent authorities to remove these animals from the field. Though the Italian law on wildlife (Law n. 157/1992, art. 2) protects all native populations of mammals and birds living permanently or temporarily in the national territory (Bertolino et al., 2023), the removal of the beavers in Central and Southern regions could be authorised by the Italian Ministry for the Environment as they originated from an illegal act (Italian Presidential Decree n. 357/1997).

Assessing the feasibility of a removal plan for beaver populations in Italy requires consideration of both the species' biology and the effectiveness of removal methods. However, it's essential to recognize that social and political factors play a pivotal role in determining the actual realisation of such projects. While producing a comprehensive feasibility report falls beyond the scope of the present paper, we have highlighted certain positive factors that may facilitate animal removal and the challenges that could hamper its implementation (see Table 2). Given that beavers are aquatic species, monitoring their presence and implementing removal measures can be directed in well-defined, limited areas. As linear landscape features, rivers, can be easily divided into removal and monitoring zones. Beavers leave conspicuous signs of their presence, ensuring the possibility of detecting the species even at very low densities. The detection of the species in areas with a very small number of animals during intensive monitoring in Italy confirms its detectability. These factors support the technical feasibility of removing the small populations of beavers in Italy.

The main challenges, however, lie in the fragmentation of the local authorities who hold regional responsibility for wildlife management and the likely opposition from organized citizen groups. Beaver populations are distributed across five regions in Central and Southern Italy. Because wildlife management in Italy is a regional competence, the national government cannot directly enforce removal plans. While the national wildlife institute (Istituto Superiore per la Protezione e la Ricerca Ambientale) advocates for the removal of the species, the involvement of various regional offices, each dependent on local political backing, adds complexity to the coordination of a national plan. The governance of the removal operation can be very critical if this objective is not fully shared and supported by decision-makers in all regions, with the risk of successful actions in some areas and stalled or ineffective efforts in others. As the beaver is a charismatic species, opposition to its removal can be expected locally and nationally. Animal welfare is an issue when it comes to the removal of animals. Acting now would involve the removal of a few dozen animals, which offers the possibility of evaluating different intervention techniques, lethal and not. It can be observed that established beaver populations are often managed to reduce their impact on human activities, and management also includes

the authorised culling of animals, as demonstrated in Scotland following legal and illegal reintroductions. The lethal removal of even a few animals per year still leads to the killing of many animals in the long term. Opposition can be particularly fervent when dealing with charismatic species, as they can be used as icons to capture the public's imagination and get support for opposition campaigns. Therefore, effective communication of the reasons behind removal interventions is crucial. Emphasizing the need to counter illegal animal releases and that decisions on reintroduction and wildlife management and, more in general, on nature restoration cannot be left to private action but must be the result of a participatory process, are key points to convey. ☞

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