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## **Heterogeneity in the allocation of reintroduction efforts among terrestrial mammals in Europe**

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HAL Authorization

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2 **Heterogeneity in the allocation of reintroduction efforts among**  
3 **terrestrial mammals in Europe.**

4

5 **Charles Thévenin, Aïssa Morin, Christian Kerbiriou, Francois**  
6 **Sarrazin, Alexandre Robert.**

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8 **Biological Conservation, Elsevier, 2020, 241, pp.108346.**

9

10

11 **Abstract**

12

13 Reintroductions offer a powerful tool to reverse adverse anthropogenic impacts on biodiversity  
14 by restoring extirpated populations within the indigenous range of species. Reintroductions  
15 have become popular and have been increasingly used over the last decades. However, this  
16 species-centred conservation approach has been criticized for being taxonomically biased and  
17 for focusing on large and charismatic species. Studies investigating taxonomic biases in the  
18 allocation of reintroduction efforts at large scale generally consider taxonomic bias within and  
19 among higher taxa (e.g. vertebrates, plants), by comparing the number of reintroduced species  
20 within a taxon to its prevalence in nature. Here, we show that the bias is even more striking  
21 when accounting for the differences in the number of implemented programs among

22 reintroduced species. We conducted a comprehensive search of the peer-reviewed and grey  
23 literature to inventory reintroduction programs of European terrestrial mammals. We identified  
24 28 species that have been reintroduced at least one time. For each reintroduced mammal, we  
25 extensively searched two literature search engines and found 414 relevant publications, which  
26 described 375 distinguishable reintroduction programs implemented in Europe from the early  
27 20<sup>th</sup> century to 2013. We used the number of implemented programs and the number of  
28 associated publications to investigate the distribution of reintroduction efforts among species.  
29 Our results show a substantial heterogeneity in the allocation of reintroduction efforts, with  
30 68% of implemented reintroductions in Europe involving only three species: the beaver (*Castor*  
31 *fiber*), the Alpine ibex (*Capra ibex*) and the European bison (*Bison bonasus*).

32

33

## 34 **Introduction**

35

36 Biodiversity is under more severe threats than perceived when considering population declines  
37 and losses, rather than focusing only on species extinction (Ceballos, Ehrlich, & Dirzo, 2017).  
38 Effective conservation strategies are therefore required to reverse the dramatic shrinkage in  
39 species' geographical ranges, in order to support evolutionary trajectories in biological systems,  
40 as well as sustainable ecosystem functioning and services (Sarrazin & Lecomte, 2016).  
41 Reintroduction is the process of re-establishing a population in the indigenous range of a species  
42 where it has been extirpated (IUCN/SSC, 2013). Reintroduction is a popular restoration tool,  
43 as it moves towards the proactive return of locally extinct species into the wild if protective  
44 measures are not sufficient to ensure the return of the species. Reintroductions have been used  
45 for over a century, and the number of implemented programs, as well as the number of species  
46 involved have increased over the past decades (Seddon, Armstrong, & Maloney, 2007; Swan  
47 et al., 2016).

48 One interesting question in reintroduction biology is whether the accumulation of local  
49 reintroduction efforts have the potential to benefit to a wide array of threatened biodiversity at  
50 large taxonomic scale, which is not possible if most programs focus on, e.g., a few charismatic  
51 species. Using a database of reintroduction programs worldwide, yielding a total of 699  
52 reintroduced species of plants and animals, Seddon, Soorae & Launay (2005) showed that  
53 vertebrate species were over-represented with respect to their prevalence in nature. Among  
54 them, reintroduced species were mostly mammals and birds, whereas fish were under-  
55 represented. More recently, similar biases within reintroduced mammals in Europe was  
56 uncovered, with a disproportionate list of reintroduced Carnivores and ungulates relative to  
57 their prevalence in the European assemblage of terrestrial mammals (Thévenin et al., 2018).  
58 These studies showed that reintroduction efforts are taxonomically and phylogenetically

59 clustered within mammals, which is necessary to appreciate potential biases in reintroduction  
60 efforts. However, these studies focussed on the distinction between those species that have been  
61 reintroduced (at least once) vs. those that have not been reintroduced, without consideration for  
62 actual numbers of programs for each species. Here we provide a more in-depth look at the  
63 distribution of the number of implemented reintroduction programs per species. We focused on  
64 the list of 28 species of European terrestrial mammals that we identified as reintroduced at least  
65 once (Thévenin et al. 2018). For each species, we searched the ISI Web of Knowledge database  
66 and used Google Scholar search engine to identify reintroduction programs implemented over  
67 the past century. We described the heterogeneity in the implementation of population  
68 restoration programs and their reporting among European reintroduced mammals. The dataset  
69 we compiled allowed to explore the temporal and geographic distribution of reintroduction  
70 efforts in Europe.

71

## 72 **Materials and Methods**

73

74 Our primary objective here was to make an inventory of reintroduction “programs” aiming at  
75 re-establishing viable populations. Conceptually, we define a “population” based on the  
76 common biological meaning of the term i.e., a group of organisms of the same species  
77 occupying a particular space at a particular time and interacting more with each other than with  
78 individuals of the same species located at a distance they cross only through rare dispersal  
79 events (see [Berryman, 2002](#), for a general discussion, and [Robert et al., 2015](#), in the context of  
80 conservation translocations). This theoretical definition of a population is of course associated  
81 with practical difficulties in defining the boundaries of populations in the field, particularly for  
82 species with continuous distribution or where distribution data are missing. These difficulties

83 are particularly important in our study regarding the aggregation (or separation) of  
84 reintroduction programs, and also in the case of metapopulations. We consider here that  
85 individual reintroduction programs are defined at the population level. In other words, each  
86 program aims to create a population, even when that population is part of an identified  
87 metapopulation. At the population organizational level, only reintroductions are considered (i.e.  
88 attempts to restore an extinct local population), although the program could be considered as a  
89 "reinforcement" at the metapopulation level. Intended reintroductions were not included (e.g.,  
90 feasibility studies with no indication that individuals were released). We performed a  
91 comprehensive search (Swan et al., 2016) of the reintroduction and translocation-related  
92 literature to identify past and ongoing reintroduction programs implemented in the European  
93 subcontinent, including the western part of Russia and excluding Turkey. Using the list of 28  
94 previously identified reintroduced species among the IUCN list of 202 native European  
95 terrestrial mammals (Thévenin et al., 2018), we performed independent queries for each species  
96 using the ISI Web of Science database, including all indexed peer reviewed literature. Because  
97 substantial information about translocation programs can be found in the grey literature, we  
98 also run each query on Google Scholar and searched for additional references in the first 50  
99 records. We performed this search in the spring of 2016 and considered all published records  
100 available online up to May 1<sup>st</sup>, 2016. Our search terms were selected to maximize specificity at  
101 the expense of sensitivity, in order to focus on reintroductions and avoid publications relating  
102 to **reinforcements** of existing populations or mitigation translocations used to manage human-  
103 wildlife conflicts (Table 1). To account for potential taxonomic revisions over time and the fact  
104 that the species' name used by the authors at the time of publication may no longer correspond  
105 to the current name, the species search terms included both the Latin name and English common  
106 name along with all relevant synonyms available on the "Taxonomy" section of the Species  
107 Fact Sheet provided by the IUCN Red List website (available at [www.iucnredlist.org](http://www.iucnredlist.org)). For

108 example, the species search terms used for identifying translocations of Water voles (*Arvicola*  
109 *amphibius*) included the following terms: “European Water Vole” OR “Eurasian Water Vole”  
110 OR “Water Vole” OR “*Arvicola amphibius*” OR “*Arvicola terrestris*” OR “*Mus amphibius*”.

111

112

113 *Table 1: List of the terms used to identify reintroduction programs for native terrestrial*  
 114 *mammals in Europe*

<b>Category</b>	<b>Search Term</b>
<b>Species</b>	Latin name OR synonym(s) OR Common name(s)
<b>Translocation</b>	reintroduc* OR re-introduc* OR translocat* OR re- establish* Or releas* OR relocat*
AND	
<b>Motive</b>	population* OR conserv* OR restorat*
AND	
<b>Location</b>	Europe*

115 *Terms were used in the ISI Web of Science database and Google Scholar search engine to*  
 116 *identify documented reintroduction programs. \*Indicates the use of a wildcard; for example,*  
 117 *reintroduc\* can refer to reintroduction OR reintroductions OR reintroduce OR reintroduces*  
 118 *OR reintroduced OR reintroducing.*

119

120

121 We accurately screened each publication to determine which publications were relevant, that  
 122 is, which described at least one program of translocation and release of individuals that we  
 123 considered to be a reintroduction based on the intent and location of releases, i.e. the attempt to  
 124 re-establish a free-ranging population in the former range of the species where it has been

125 extirpated (IUCN/SSC, 2013). Reintroductions of mammals often involve game species  
126 (Griffith et al., 1989), and it was sometimes difficult to fully grasp whether the main purpose  
127 of the translocation would lean towards species exploitation rather than long-term conservation.  
128 Reintroductions of potential game species were included when they clearly aimed at restoring  
129 a viable population in the wild. Other cases where conservation did not seem to be the primary  
130 objective of releases were considered as restocking translocations and not integrated in our data  
131 (Supplementary Information, Table S1). Sometimes the full text was not accessible, but we  
132 included the publication if we could unambiguously extract all relevant and necessary  
133 information from the abstract. If a publication describing a reintroduction failed to provide the  
134 basic information (e.g., approximate year of first release) but explicitly mentioned other  
135 publications containing complementary information regarding the program, we extended our  
136 search to such cited literature. Some publications mentioned or described multiple  
137 reintroduction programs for a single species, usually reviewing the recovery of the focal species  
138 through time (e.g., Biebach & Keller, 2012). In such cases we considered the list of programs  
139 as described in these publications. Most of the publications we screened focused on a single  
140 species, with only seven publications mentioning or describing reintroduction programs for  
141 more than one species.

142 For each relevant publication, we extracted the year of publication, the species translocated, the  
143 approximated year of first release, and both the country and location of releases. The location  
144 of releases refers to the most precise sub-national geographic area encompassing the  
145 translocation site, and the level of precision varied substantially between publications (e.g.,  
146 province, national park, nearest town). Some publications did not provide a precise date of first  
147 release, but rather a time interval, for which, in the absence of additional information, we  
148 deduced the year of first release as the middle of the given period (e.g., if individuals were  
149 “released in the 1970s”, we considered the first year of release to be 1975). In some cases,

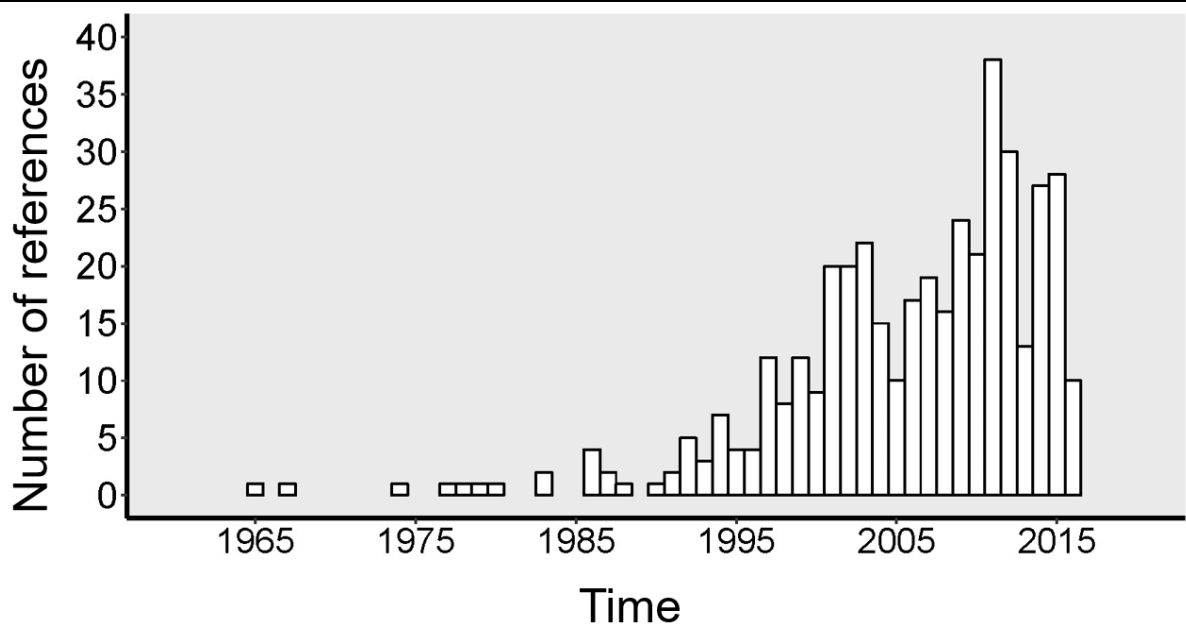
150 multiple releases were clustered into a single reintroduction program if we deemed the different  
151 release events to contribute to the same population unit, based on the location of releases and  
152 expected home range of the species.

## 153 **Results**

154

155 Our searches on Web of Science yielded 1665 unique references, and we found 318 relevant  
156 references that described reintroduction programs precisely enough (year of first release,  
157 country and location of release site). We found 96 additional relevant references through our  
158 search on Google Scholar, or by extending our search to the cited references of some articles.  
159 These 414 publications, published between 1965 and March 2016, described 375  
160 distinguishable reintroduction programs implemented between 1910 and 2013. The number of  
161 relevant publications increased over the past 30 years (Fig. 1). Reintroductions programs were  
162 implemented in 28 European countries, and most of these programs were undertaken in  
163 Switzerland (61), France (41), the United Kingdom (41) and Poland (36) (Fig. 2).

164

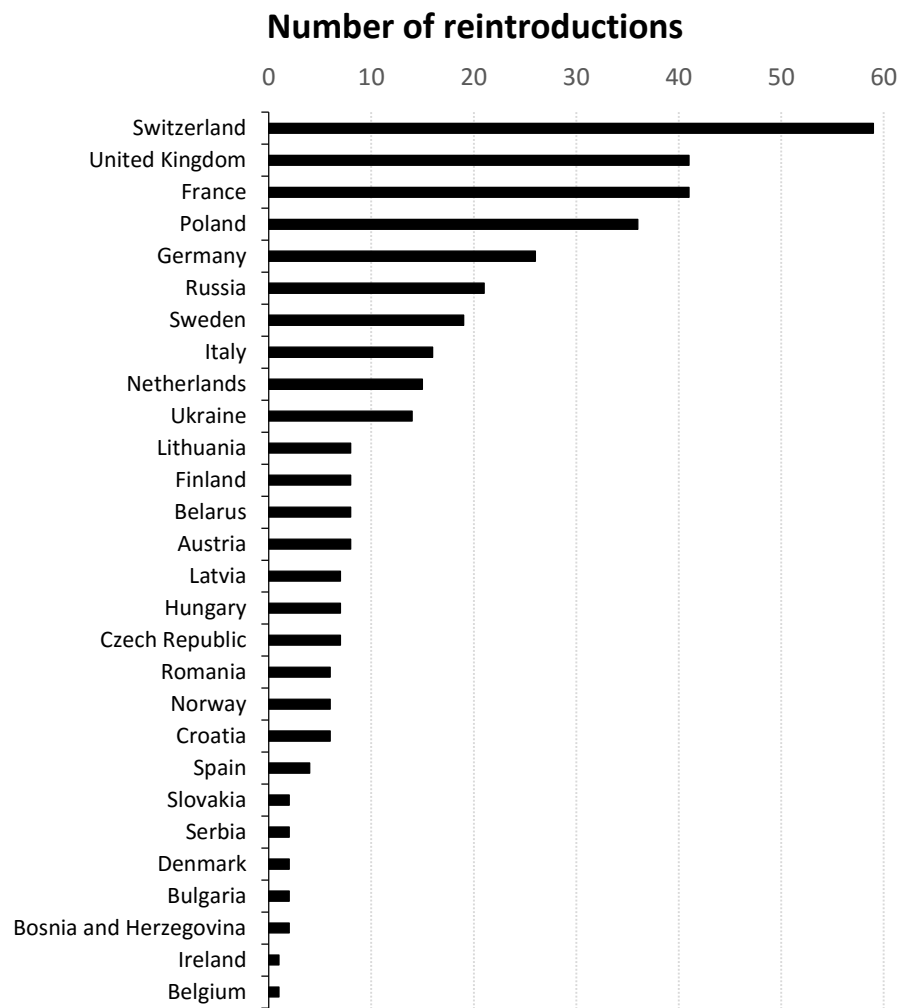


165

166 *Fig. 1: Temporal distribution of the 414 relevant publications used to describe reintroduction*  
167 *programs for native European terrestrial mammals. The number of references in 2016 only*  
168 *accounts for publications between January and March.*

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170

171 *Fig. 2: Number of reintroduction programs by countries in the European subcontinent.*

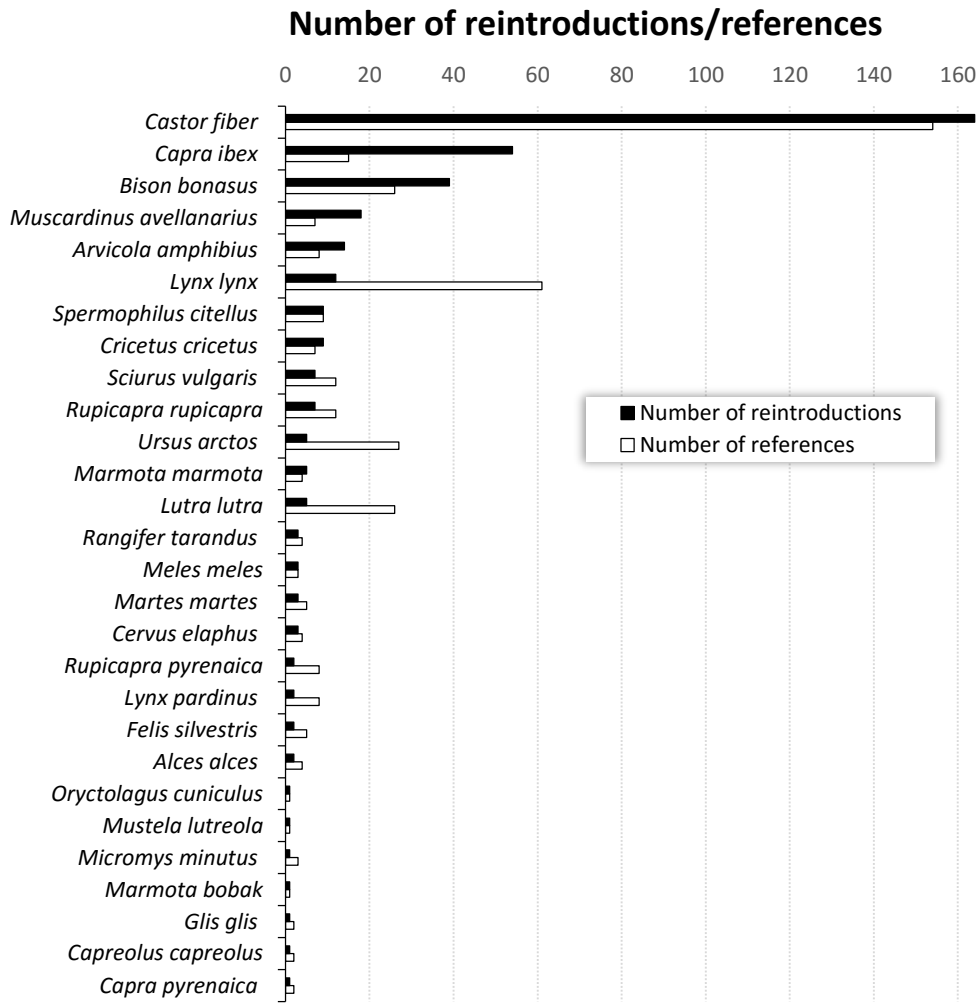
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172

173 The allocation of reintroduction efforts per species was highly heterogeneous, with the number  
174 of programs ranging from only one reintroduction up to 164 (Fig. 3). Only six out of 28 species  
175 were involved in more than ten reintroduction attempts, and the median number of  
176 reintroduction programs per species was three. The beaver was the most reintroduced mammal

177 in Europe and has been involved in more than 40% of all the reintroduction attempts we  
178 identified, followed by the Alpine ibex (54 programs, 14%) and the European bison (39  
179 programs, 10%). The reporting effort per species was evaluated by considering the ratio of the  
180 number of publications over the number of programs for each species. Low values of this ratio  
181 indicate that relatively few publications described numerous reintroduction programs. This was  
182 the case for the 5 most reintroduced species in our dataset (*Castor fiber*, *Capra ibex*, *Bison*  
183 *bonasus*, *Muscardinus avellanarius*, *Arvicola amphibius*), with the lowest ratio being the  
184 Alpine ibex with 54 reintroduction attempts described using only 15 publications (ratio = 0.28).  
185 In contrast, some species have generated a substantial amount of publications relative to the  
186 number of releases, as exemplified with 5 reintroduction programs of brown bears (*Ursus*  
187 *arctos*) being described in 27 publications (ratio = 5.4). At higher taxonomic level, the  
188 distribution of reintroduction programs and associated references within the different orders of  
189 terrestrial mammals of Europe is significantly different from that expected on the basis of the  
190 number of described species in each order ( $X^2 = 506.68$ ,  $d.f. = 5$ ,  $P < 0.001$ ;  $X^2 = 379.55$ ,  $d.f. =$   
191  $5$ ,  $P < 0.001$ ; respectively) (Fig. 4). Closer examination of taxa reveals that Artiodactyla is  
192 clearly over-represented both in terms of implemented programs and associated publications  
193 (Pearson residuals of +18.77 and +9.91, respectively). On the other hand, the Carnivora order  
194 shows a contrasting pattern: Carnivores are slightly under-represented when considering the  
195 number of implemented programs (Pearson residuals of -2.32) but are over-represented when  
196 considering the associated publications (Pearson residuals of +11.82) (Fig. 4).

197

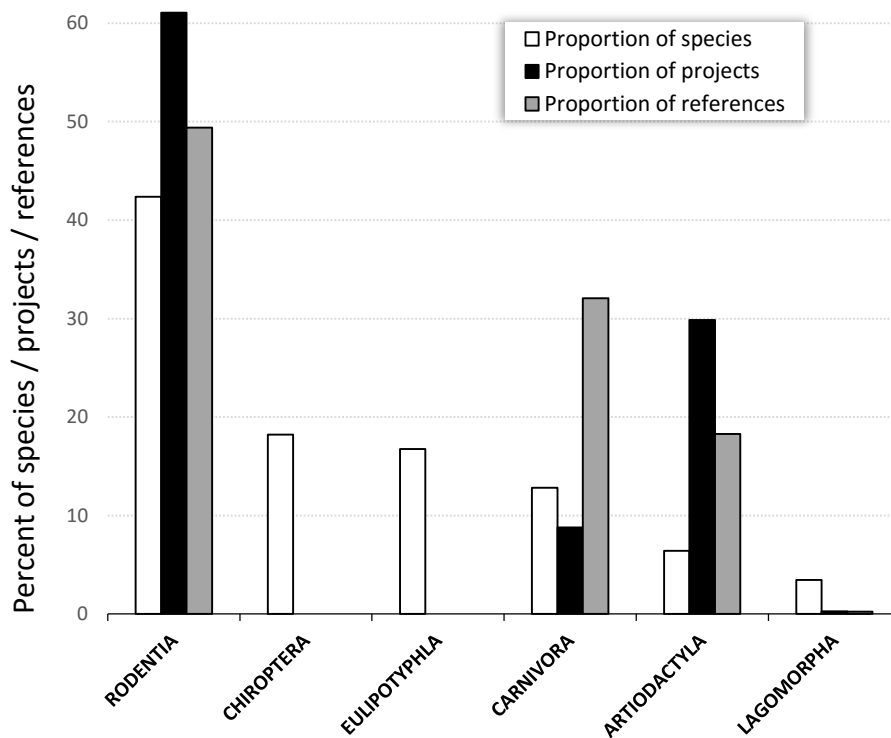


198

199 *Fig. 3: Number of reintroduction programs (black bars) and associated references (white*  
 200 *bars) for the 28 terrestrial mammals reintroduced in Europe. Because some publications*  
 201 *described reintroductions for different species, the total number of references here is larger*  
 202 *than the number of unique references.*

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203



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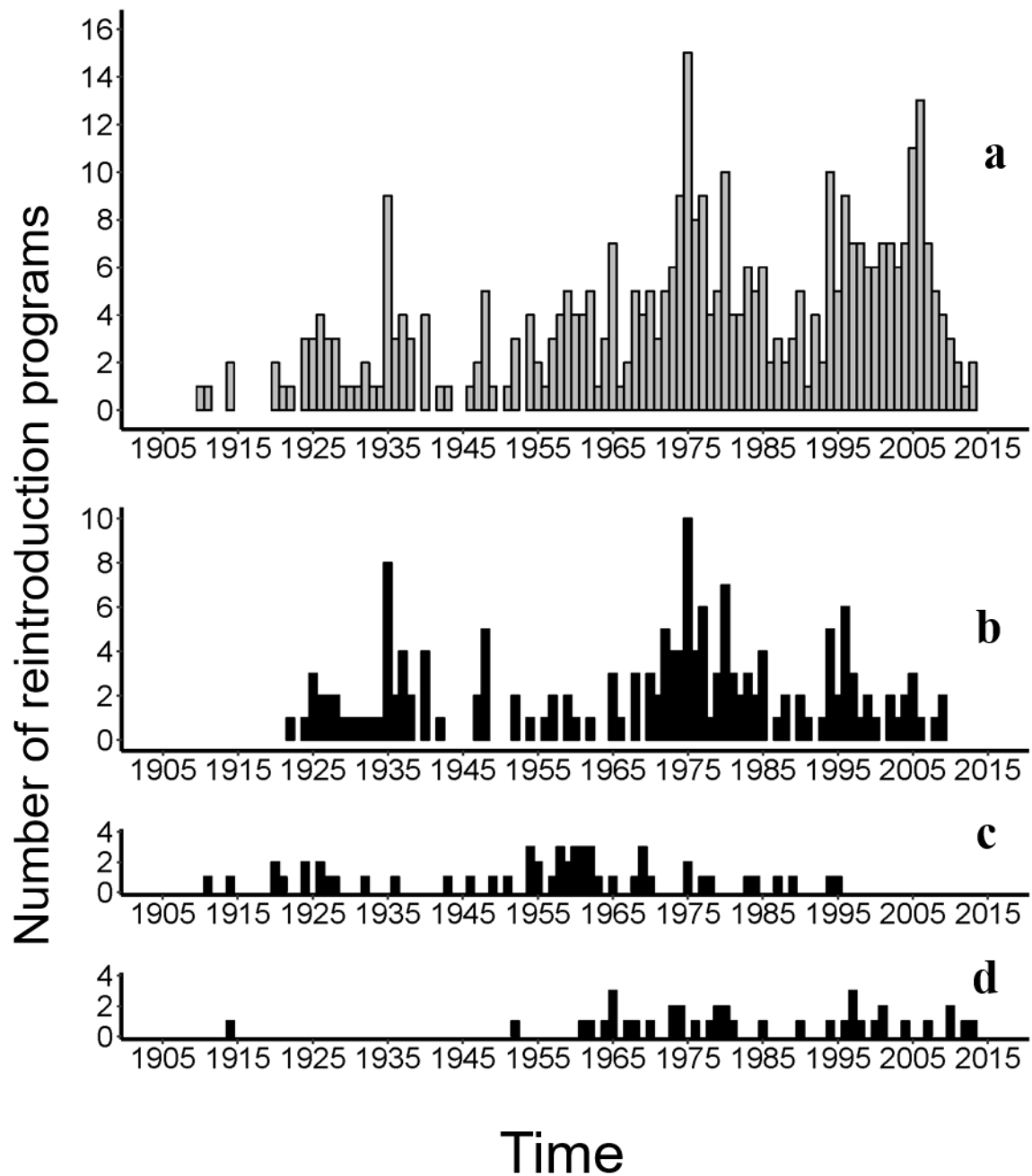
205 *Fig. 4: Proportion of species out of the 202 European terrestrial mammals per taxonomic*  
 206 *order (white bars) compared to the proportion of reintroduction programs (black bars) and*  
 207 *the proportion of associated references (grey bars).*

208

209 The two oldest programs in our data are the reintroduction of the red squirrel (*Sciurus vulgaris*)  
 210 into Epping Forest, Ireland, in 1910 (MacKinnon, 1978), and the reintroduction of the Alpine  
 211 ibex in Graue Hoerner, Switzerland, which started in 1911 (Stüwe & Nievergelt, 1991; Biebach  
 212 & Keller, 2012). The number of reintroduction programs has increased throughout the time  
 213 period (Fig. 5a), and the apparent diminution in the number of reintroduction programs from  
 214 2006 onward can be attributed to a time lag between releases, data collection and any associated  
 215 publication (Fazey, Fischer, & Lindenmayer, 2005; Swan et al., 2016). For most of the first half  
 216 of the 20<sup>th</sup> century (up to the late 1950s), reintroductions of terrestrial mammals in Europe  
 217 mainly involved beavers or Alpine ibex (51 and 28 programs respectively, out of 86). The other

218 species reintroduced in this time period were the above mentioned red squirrel, the elk (*Alces*  
219 *alces*; Schönfeld, 2009; Świsłocka et al., 2013), the brown bear (Buchalczyk, 1980) and the  
220 reindeer (*Rangifer tarandus*; Røed et al., 2014). When considering the three mostly  
221 reintroduced species in our data, we can see that beavers have benefited from a consistent and  
222 continuous reintroduction effort throughout the entire time period considered (Fig. 5b).  
223 Reintroductions of Alpine ibex mostly occurred in the first half of the time period (the last  
224 release in our dataset occurred in 1995), with a cluster of programs around the centre of the  
225 study period (1950-1970) (Fig. 5c). Most of the restoration of free-ranging populations of the  
226 European bison took place in the past 60 years (Kraśńska & Kraśński, 2013) (Fig. 5d).

227



228

229 *Fig. 5: (a) Temporal distribution of reintroduction programs of 28 species of native*  
 230 *terrestrial mammals in Europe (n = 375); (b) reintroduction programs of beavers (n = 164);*  
 231 *(c) reintroduction programs of Alpine ibex (n = 54) and (d) reintroduction programs of*  
 232 *European bison (n = 39). The distribution of reintroduction programs is based on*  
 233 *approximated date of first release.*

234

## 235 **Discussion**

236

237 Previous studies have shown that the allocation of reintroduction efforts is taxonomically (and  
238 phylogenetically) clustered by focussing on the distinction between those species that have been  
239 reintroduced (at least once) vs. those that have not been reintroduced (Seddon et al. 2005,  
240 Thévenin et al. 2018). Here we show that this heterogeneity is more striking when accounting  
241 for the number of implemented programs among reintroduced species.

242 The most reintroduced species in our dataset are the beaver, the Alpine ibex and the European  
243 bison, for which the main cause of population extirpation was overhunting (Stüwe &  
244 Nievergelt, 1991; Pucek et al., 2004). Of all reintroduced mammals, the remarkable recovery  
245 of European beavers presumably benefited from widespread reintroductions. At the end of the  
246 19<sup>th</sup> century, the species was reduced to about 1200 individuals scattered in 8 small relict  
247 populations and would have been listed then as critically endangered (Halley, Rosell, &  
248 Saveljev, 2012). Reintroductions started in 1922 in Sweden and were later implemented in 20  
249 other European countries. Early successes with remarkably little planning or monitoring  
250 confirmed the beaver as a reliable candidate for reintroductions, and may have triggered a self-  
251 reinforcing feedback for more implementations of programs over the years (Halley & Rosell,  
252 2002). Such self-reinforcing feedbacks where early reintroduction success may foster the  
253 implementation of new programs for some species may further contribute to the heterogeneity  
254 of restoration efforts among species. Incentives for restoring viable populations of beavers were  
255 initially associated to fur-harvesting and future economic gains, and later reintroductions  
256 became more motivated by ecosystem management reasons. The beaver is considered a key-  
257 stone species, which substantially impacts the structure and dynamics of aquatic ecosystems at  
258 the landscape level. Beaver's dams influences the hydrology of surrounding areas, thus altering  
259 nutrient cycles and subsequently modifies the structure of invertebrate and plant communities

260 (Macdonald et al., 1995). Such prominent and well-documented functional role of the species  
261 in its recipient ecosystem may have played a role in the disproportionate, large scale effort that  
262 was invested into its restoration.

263 Considering the number of implemented programs allows to reinterpret reintroduction biases  
264 between mammalian orders in Europe. A previous study has shown that, among mammals,  
265 Carnivores and Ungulates are over-represented in reintroduction efforts at a worldwide scale  
266 (Seddon, Soorae, & Launay, 2005). More than half of the reintroduced species of mammals in  
267 Europe are members of the Artiodactyla or the Carnivora orders, although these orders represent  
268 less than 20% of species in the European assemblage of native mammals (Thévenin et al. 2018).  
269 However, when accounting for the number of implemented programs, the pattern is clearly  
270 maintained for ungulates (30% of implemented programs), but Carnivores are no longer over-  
271 represented (8% of implemented programs). One interesting finding of this study is that  
272 reintroduced Carnivores seem to benefit from a higher reporting effort.

273 **Our results show that some reintroduced species are relatively more reported in the literature.**

274 The species with the most imbalanced ratio of the number of publications over the number of  
275 associated publications are the Eurasian lynx (*Lynx lynx*), the brown bear and the otter (*Lutra*  
276 *lutra*). Predators are charismatic species that are often employed in conservation because they  
277 can easily gather public interest (i.e., “flagship species”, *sensu* Simberloff 1998), and such  
278 societal preferences may influence the choice of study species and lead to more publications.  
279 Even though large carnivores are now recovering throughout Europe thanks to favourable  
280 legislation and increases in prey availability (Chapron et al., 2014), the reintegration of such  
281 large predators comes with many challenges that may require making adjustments to the  
282 practices of some sectors like livestock farming, forestry or hunting (Breitenmoser et al., 2010;  
283 Boitani & Linnell, 2015). Restoring populations of large predators where they have been  
284 extirpated constitutes a major challenge if adaptations to coexistence have been lost and if

285 husbandry practices have evolved. Reintroductions of top predators can have economic costs  
286 (e.g., predation on livestock) and trigger social conflicts that need to be carefully addressed and  
287 managed (Stahl et al., 2001), which is likely to generate additional research and publications.

288 Our search of the literature is certainly not exhaustive, but we believe that our data provide a  
289 good and representative proxy of the allocation of reintroduction efforts for European terrestrial  
290 mammals. Publication biases in conservation and reintroduction research have been  
291 documented, and show that some species receive disproportionate attention, and that successful  
292 translocations are more likely to be published than failed ones or those with uncertain outcomes  
293 (Fischer & Lindenmayer, 2000; Clark & May, 2002; Fazey, Fischer, & Lindenmayer, 2005;  
294 Bajomi et al., 2010; Miller, Bell, & Germano, 2014; Troudet et al., 2017). While our results  
295 provide a highly indicative description of reintroduction efforts for native European terrestrial  
296 mammals, we acknowledge that our data on reintroduction programs partly reflect publication  
297 effort and are likely to underestimate the number of programs implemented throughout Europe.

298 Another issue lies in the access to past publications, and how terminology evolved over the  
299 years. Some documentation of reintroduction attempts implemented several decades ago may  
300 have yet to be digitalized and indexed, and programs that have been recently implemented  
301 might not have yet been described in the literature. Additionally, reporting of reintroduction  
302 efforts at a continental scale is challenged by gaps and heterogeneity in the collection and  
303 compilation of information related to restoration attempts. First, language may greatly influence  
304 the spatial distribution of our European data. We only considered sources written in English,  
305 and we suspect that we might have missed a substantial amount of information written in the  
306 native language of the reintroduction team. For example our search yielded 4 reintroduction  
307 programs in Spain over the last century, while Perez et al. (2012), who conducted an extensive  
308 review of translocation programs in Spain, taking into account Spanish language  
309 documentation, found 9 translocation programs implemented from 1996 onwards. Studies have

310 shown that the availability of information on biodiversity is unevenly distributed around the  
311 world (Boakes et al., 2010), and that data availability is positively associated with country  
312 wealth and the proportion of English speakers (Amano & Sutherland, 2013). The high number  
313 of reintroductions found in the United Kingdom can also be explained by insularity, as species  
314 will have lower probabilities of natural recolonization after extinction, so that reintroduction  
315 becomes a valuable conservation option. The spatial distribution of our data is also greatly  
316 influenced by previous compilations and reviews of reintroduction programs in some areas. For  
317 example, 48 out of the 59 reintroductions identified in Switzerland involved the Alpine ibex,  
318 and 40 of these were mentioned in Biebach & Keller (2012). Similarly, 23 out of the 36  
319 reintroduction programs we identified in Poland involved the beaver, which were all mentioned  
320 in one study on the expansion of the species in Europe by Kasperczyk (1987). Another source  
321 of variability in the spatial distribution of mammal reintroductions in Europe could be the list  
322 of nationally extinct mammals in European countries. Such conservation priorities at the  
323 national scale could further shape the distribution of reintroduction efforts at the continental  
324 scale.

325 In this study we used the number of implemented programs and the number of associated  
326 publications to estimate the reintroduction effort per species. This is only one way to assess  
327 how efforts are distributed in population restoration programs, and further studies are needed  
328 to explore other aspects such as the financial costs of programs, information on release  
329 strategies (number of individuals and number of release events), or how much effort was  
330 invested to insure habitat quality before release.

331 Over the past 30 years, the development of reintroduction biology has advocated for an  
332 improvement of reintroduction practice and implementation. Managers need to collect and use  
333 all available information to improve reintroduction design and benefit from knowledge  
334 accumulated through past attempts to restore populations (Sarrazin & Barbault, 1996; Ewen &

335 Armstrong, 2007; Armstrong & Seddon, 2008; IUCN/SSC, 2013). One important challenge is  
336 therefore to enhance the documentation and transmission of knowledge from past  
337 reintroduction programs. Some species, or groups of species (e.g. Carnivores) of mammals have  
338 benefited from reviewing efforts describing and inventorying reintroduction programs in  
339 Europe (Stüwe & Nievergelt, 1991; Halley & Rosell, 2002; Clark, Huber, & Servheen, 2002;  
340 Krasíńska & Krasíński, 2013). Our data constitute a core contribution to the development of a  
341 webdatabase inventorying conservation translocation programs in Europe and the  
342 Mediterranean basin which will promote standardization in reintroduction reporting to improve  
343 their adaptive management (TRANSLOC webdatabase program,  
344 <http://translocations.in2p3.fr/>).

345 The reintroduction of wild mammals and particularly ungulates often emerges as a cornerstone  
346 in rewilding initiatives (Pettorelli et al., 2018; Pettorelli, Durant, & du Toit, 2019), especially  
347 in heavily anthropized landscapes such as Europe (Pedersen et al., 2019). In the rewilding  
348 framework, motivations for conservation translocations shift from species-centred actions  
349 towards the restoration of ecological and evolutionary processes at the ecosystem level, e.g.,  
350 through trophic rewilding (Svenning et al., 2016; Bakker & Svenning, 2018; Perino et al.,  
351 2019). While further advances in the definition of rewilding and its distinction from ecological  
352 restoration are needed (Derham, 2019; Hayward, Jachowski, et al., 2019; Hayward, Scanlon, et  
353 al., 2019), the evaluation of past reintroduction efforts and understanding of their outcomes will  
354 necessarily benefit to any future program aiming at restoring wildness, i.e. functional and  
355 evolutionary potential in previously altered ecosystems.

356

357

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