To be or not to be a superpredator: a multidisciplinary assessment of the Iberian lynx in a reintroduction social scenario

Ser o no ser un superdepredador: una evaluación multidisciplinar del lince ibérico en un escenario social de reintroducción

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Abstract

Since 2015, following reintroductions, an Iberian lynx population in Vale do Guadiana (Portugal) has been breeding and expanding, bringing changes to both ecosystems and residents’ perceptions. We describe how ecological monitoring, genetic analysis and social surveys contribute to assess this new scenario of coexistence with ecological and social repercussions. Departing from a specific case of a monitored lynx family, we present, for the first time, molecular proof of interspecific competition between lynxes and other carnivores. We assessed and compared knowledge of local key actors about the superpredator effect of the lynx previous to and following reintroduction. Data on damage experienced by livestock breeders with foxes and perceptions about it are integrated here, demonstrating how important this lynx role can be for local actors. We present proof of the killing of two foxes and a genet by lynxes through the amplification of a specific lynx DNA region and other molecular analyses carried out on saliva samples. Local actors, who previously were skeptical about the lynx’s ecological effects, do recognize its effect over other wild carnivores presently. This is a major benefit, since social perceptions have been conditioning the acceptance of the lynx, its future expansion, and the whole process of reintroduction. We also present the first documented case of a natural migrant from Doñana (SW Spain) effectively integrated and reproducing in the Vale do Guadiana population. This case study demonstrates the importance of multidisciplinary knowledge in conservation programmes and how genetics and social surveys provide complementary information for monitoring in reintroduction and, generally, conservation programs of an umbrella species.

Keywords: Lynx pardinus, molecular monitoring, reintroduction, social survey, superpredator

Resumen

La población de lince ibérico (Lynx pardinus) en Vale do Guadiana (Portugal) se ha estado expandiendo tras las reintroducciones iniciadas en 2015, provocando cambios tanto en los ecosistemas como en las percepciones de los residentes. Describimos cómo el seguimiento ecológico, el análisis genético y las encuestas sociales contribuyen a evaluar este nuevo escenario de coexistencia con repercusiones ecológicas y sociales. Partiendo del caso de una familia de linces monitorizada, presentamos por primera vez pruebas moleculares de la competencia interespecífica entre linces y otros carnívoros. Además, evaluamos y comparamos los conocimientos de los principales actores locales sobre el efecto superdepredador del lince antes y después de la reintroducción. Integramos también datos sobre los daños causados a los ganaderos por zorros y sus percepciones sobre éstos, demostrando lo importante que puede ser el papel de superdepredador del lince para los actores locales. Presentamos pruebas moleculares de la muerte de
Introduction

Multidisciplinary studies are still uncommon in conservation projects or in monitoring programs of threatened species (e.g., Esteban et al. 2016, Thompson et al. 2016). In particular, the integration of ecological and social knowledge remains scarce (Pooley et al. 2017). Social factors have been widely acknowledged as crucial determinants influencing the outcomes of conservation initiatives and the management of protected species and areas (Jiménez-Perez 2005, Catalano et al. 2019). In many cases, educational campaigns are implemented as part of conservation projects (Gusset et al. 2008). However, it is important to recognize that fundamental disparities may exist between local ecological knowledge and scientific knowledge, potentially undermining the effectiveness of conservation measures. Furthermore, attitudes towards specific species may be influenced by broader societal values and orientations towards wildlife and the natural world in general (Lopes-Fernandes & Frazão-Moreira 2016).

Despite the recognized importance of these factors, research focusing on the perceptions and knowledge gaps between scientists, technicians and local residents remains relatively scarce (Lescureux et al. 2011). This scarcity is particularly evident in rural contexts within Western Europe. Similarly, there has been limited investigation into the local discourses that emerge in response to wildlife reintroductions (O’Rourke 2014, Lopes-Fernandes et al. 2018, Delibes-Mateos 2022). Thus, a comprehensive understanding of the social dimensions of conservation efforts, especially in rural Western Europe, remains an understudied area.

In the context of wild carnivores, negative attitudes towards them commonly stem from human perceptions that predominantly categorise them as predators and competitors for small game and livestock. However, the net effect of a predator introduction has several ecological roles that can be recognized as positive, such as controlling the population size of herbivores and triggering trophic cascades (e.g., Ripple & Beschta 2012), or when they exclude more abundant meso-predators through intra-guild interactions (Ritchie & Johnson 2009).

Ecological monitoring is an important source of information on such relationships. The monitoring of populations of conservation concern, including reintroduced ones, has traditionally relied on telemetry and camera trapping. Nevertheless, the incorporation of molecular genetics tools offers valuable complementary approaches for non-invasive monitoring of elusive species, particularly carnivores (e.g., Waits & Paetkau 2005). Additionally, genetic identification is already being applied to study diet and predator-prey interactions (Caniglia et al. 2013, Mumma et al. 2014). Similar approaches can potentially be used to document predator-predator interactions (Ritchie & Johnson 2009), although no precedent exists so far to our knowledge.

The Iberian lynx Lynx pardinus (Temminck, 1827) experienced a significant decline across its former range in Portugal and Spain due to multiple factors, including the decline in wild rabbit Oryctolagus cuniculus (Linnaeus, 1758) populations, habitat transformation, and human-induced mortality (Ferreras et al. 1992, Ceia et al. 1998, Rodríguez & Delibes 2004). By the end of the 20th century, the Iberian lynx faced near extinction, with all populations, except those in Doñana and Sierra Morena (southern Spain), disappearing (Ferreras et al. 1992, Ceia et al. 1998, Rodríguez & Delibes 2004). In Portugal, the critical status of the species was confirmed through a national census (Sarmento et al. 2009), as well as molecular analysis of scat...
samples (Pires & Fernandes 2003), which indicated the extinction of local breeding populations by the 1990s. In the early 2000s a genetically and demographically managed captive population was established so that its reintroduction was possible (Kleinman-Ruiz et al. 2019). Transnational conservation projects triggered the process in an articulated way in both countries (LIFE+ Iberlince and LIFE Lynxconnect). Since 2015, 59 lynxes have been released in Portugal (Sarmento et al. 2017, ICNF data).

Local key actors for predator conservation are residents of natural areas who make management decisions and hold interests, which can be determinant for wild species presence (Lopes-Fernandes & Frazão-Moreira 2017, 2018). Superpredator is a term that has been used to describe either extinct top predators, such as Smilodon (Wroe et al. 2008), or introduced novel top predators that can negatively impact ecosystems (Terborgh 2015). Here, we use this term to designate the avoidance or killing, with or without predation, of mesocarnivores by native large European carnivores, which Lourenço et al. (2014) describe as lethal interactions. The lynx was previously described as excluding other carnivores, such as foxes, from their ranges (Palomares et al. 1996), and recent studies in a reintroduced area confirmed this competitive exclusion, evidencing fox avoidance of areas that had recently been used by lynxes and showing that lynx presence decreased fox abundance (Sarmento et al. 2021). However, the potential improvement of small game abundance by lynx presence may not be well known or integrated by local actors and communities where lynx occurs nowadays.

In this study, we present findings on the application of single nucleotide polymorphism (SNP) analysis to elucidate various aspects of lynx behaviour and interactions with other species. Through genetic analysis of a specific lynx family and other documented occurrences, we showcase the utility of molecular techniques in confirming carnivore killing events by lynx, assessing both inter and intraspecific relationships, individual identification, parentage assignment, and detecting interspecific competition within lynx territories. Furthermore, we explore and compare local knowledge regarding the lynx’s superpredator effect among resident key actors, both prior to and following the species’ reintroduction.

Our research was conducted through a multidisciplinary approach regarding reintroduction, accruing information from: telemetry, camera trapping, monitoring, genetic analysis, and a social survey. We aim to contribute to the continuous construction of local knowledge about lynx ecology and to have an impact on local perceptions towards the ongoing lynx reintroduction.

Material and methods

Social study

Our study area, Vale do Guadiana, located in Southern Portugal, includes the lynx reintroduction and expansion area, and encompasses 16 parishes. It presents low human density with an average of 7 to 10 inhabitants/km2. Extensive livestock breeding (mainly of sheep, with around 80,000 head of livestock) is one of the most important human activities. Rabbit density is high and hunting activities create circulation and relationships throughout the area. Landscape is dominated by large estates, and proprietors and families are interconnected socially. As part of a broader social study in this area, we analysed results from 165 interviews, 79 of which were conducted previous to lynx reintroduction, in 2012-2014 (interview questions in Lopes-Fernandes et al. 2018), and 86 post-reintroduction, in 2022. Of these, 50 were conducted in the north and south transborder expansion areas and 36 in the core reintroduction area (Natural Park of Guadiana). We also addressed the perceptions of livestock breeders (n= 79) about foxes and livestock damages experienced between 2016 and 2022 in this lynx area.

From an open-ended question about biological knowledge (“Do you think lynx has an effect on these other species?”), referring to card images with other wild carnivores occurring in the area: red fox Vulpes vulpes (Linnaeus, 1758), genet Genetta genetta (Linnaeus, 1758), European badger Meles meles (Linnaeus, 1758), Weasel Mustela nivalis (Linnaeus, 1766), Stone marten Martes foina (Erxleben, 1777), Wildcat Felis silvestris Schreber, 1777 and Egyptian mongoose Herpestes ichneumon (Linnaeus, 1758), we obtained answers that were fitted into four categories: lynx has an effect (of expelling other carnivores), maybe it has an effect, it does not have an effect and does not know.

Key actors included landowners, livestock breeders, hunting and land managers, hunting guards, nature activity promoters and local council representatives. We also included individuals who
interacted directly with the species in the past before it went extinct in the region (n= 10). Interviews were transcribed and analysed through content analysis with open categorization.

**Ecological monitoring**

Two adult lynxes, one female and one male, founders of a lynx nuclei in a new area in the margins of the Guadiana River, 32 km north of the release area (Fig. 1), were monitored from 2016 to 2020. The female (“Malva”) was born in 2015 in the Spanish breeding centre of Zarza de Granadilla (Cáceres) and was released in Guadiana in February 2016, fitted with a collar with a tracking system. The male (“Mundo”) was a wild-born lynx from the Doñana population that immigrated to the area by the end of 2016, which was tracked using camera trapping (Bushnell Trophy Cam, Bushnell®). The cameras were installed in areas that were known to be used by lynxes at approximately 45-50 cm above the ground and were spaced between 200 m and 500 m apart. All cameras were programmed to be active 24 h/day and were checked at 10-15-day intervals to change batteries. The monitoring procedures of released captive born lynxes were the ones described in Sarmento _et al._ (2017).

As a result of ongoing monitoring efforts and close interaction with local stakeholders, deceased foxes and other carnivores were detected and sampled. In 2017 the carcasses of a female adult fox and three of her five-week-old cubs were located, about 180 m away from the breeding den of the female lynx. Similarly, in 2021 an adult fox was found dead near a sheep enclosure by the owner. A genet and a wildcat were further found dead in other areas of lynx territories. Samples of swabs from the lesions of all dead animals were taken and preserved in lysis buffer solution to later be analysed in the laboratory. Also, lynx faeces in “Malva’s” territory were collected and preserved dry under silica gel for individual identification and parentage assignment.

**Molecular analysis**

DNA was extracted from faeces and swabs containing traces of saliva and blood following Ramón-Laca _et al._ (2015). We then applied the lynx diagnostic assay described by Palomares _et al._ (2002). Lynx-specific primers for the mitochondrial control region were used in a polymerase chain reaction to reveal the presence or absence of Iberian lynx DNA in the samples. Negative extraction and PCR controls were included to assess the possibility of contamination during either of these steps, plus positive controls with Iberian lynx DNA. We also included another negative control consisting of fox DNA. All products were run on a 3% agarose gel stained with SYBR Safe.

For lynx individual identification and parentage assignment, we used a combination of DNA analysis and social surveys. DNA was extracted from faeces and swabs to identify the species and determine parentage. Social surveys were conducted to understand the social structure and movements of the lynxes. The surveys included historical areas and included new areas in 2022.

**Figure 1. Vale do Guadiana study area.**

Home ranges and movements of the lynxes “Malva” and “Mundo”. Social surveys before reintroduction included the historical area of Moura Barrancos and in 2022 also included Alcoutim southern area of lynx presence and reproduction.
analysis, a total of 46 autosomal and two sex-linked SNP markers were assayed with Fluidigm SNP Type technology at the SGIker Genomic Sequencing and Genotyping Unit (University of Basque Country). These autosomal markers were the most heterozygous out of 343 SNPs previously selected based on their high heterozygosity and minimal linkage disequilibrium (Kleinman-Ruiz et al. 2017). Saliva and faecal samples were genotyped 2-4 times to diminish the incidence of genotyping errors, and consensus genotypes were compared among them and with reference genotypes obtained from blood samples using GIMLET (Valière 2002). Parentage analyses were performed using Cervus 3.0 (Kalinowski et al. 2007).

Results

Local knowledge and perceptions about the lynx, the fox and damage to livestock

Except for a few key actors, most interviewees before reintroductions were not sure whether lynx had or not an effect over the other carnivores. Results from 2022, following reintroductions, showed that a higher percentage of key actors affirmed that the lynx has an effect in other carnivores, while the percentage of unsure actors diminished (Fig. 2). The results before and after reintroduction were statistically significant ($X^2$ test; $p= 0.009$).

Concerning the profile of the key actors, this knowledge was mostly held by those related to hunting management and nature activity promoters, before reintroduction, while after reintroduction livestock breeders were also familiar with this lynx behaviour (Fig. 3). In fact this profile showed the biggest change before and after reintroduction concerning knowledge about the lynx as a superpredator. Following reintroduction, however, a considerable number of interviewees across all profiles still declared not knowing the lynx’s effect over mesopredators. Livestock breeders are among them, with many included in the category of “maybe it has an effect”, and thus doubting lynx control over foxes and other predators that cause damage to their livestock. This affects their perception and increases negative attitudes towards lynx presence in the area, as they already experience damage from wild predators and have a mostly negative relationship with the fox. Our results from livestock breeders’ interviews and observation are summarised in the following outline:

<table>
<thead>
<tr>
<th>Percentage of livestock breeders ($n=79$ interviewed)</th>
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<tbody>
<tr>
<td>Having experienced damage due to wild predators (loss of lambs)</td>
</tr>
<tr>
<td>Attributing the damage to fox</td>
</tr>
<tr>
<td>Considering the damage significant</td>
</tr>
<tr>
<td>Considering the damage detrimental</td>
</tr>
<tr>
<td>Considering that controlling or eliminating the predator should be the best solution to avoid the damage</td>
</tr>
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These data show a high percentage of livestock breeders experiencing damage from wild predators, mainly foxes, which was significant or detrimental for sheep owners.

Ecological monitoring

Following its release in Guadiana in February 2016, the lynx named “Malva” initially remained in the vicinity of the release area for five months before moving approximately 13 km northwards to the centre of the Guadiana Natural Park, where it stayed for around three months (Fig. 1). Subsequently, in early October 2016, another northward dispersion event occurred, with the lynx using the Guadiana River margins as a corridor to cover approximately 20 km. Eventually, the lynx established a stable home range of 19 km² (95% Minimum Convex Polygon). On March 12, 2017, through direct observation using VHF tracking, it was confirmed that “Malva” had given birth to four cubs within an abandoned house.

Considering the absence of known males in the area, efforts to monitor the lynx increased through camera trapping, leading to the identification of an unidentified male. After contact with Spanish technicians (LIFE+ Iberlince), it was confirmed that the male lynx was “Mundo”, a two-year-old wild-born male from the Doñana population who was last detected there on November 6, 2016. Up to July 2017, the camera traps within the study area detected “Mundo” seven times and “Malva” with her four cubs nine times, classifying both animals as territorial. The couple successfully produced new
Figure 2. Knowledge of key actors in Vale do Guadiana historical and present occurrence area, concerning the lynx effect over other predators (n= 79 and n= 92, before and after reintroduction, respectively).

Figure 3. Knowledge about lynx's superpredator effect by profile, before and after reintroduction.
cubs in 2018. However, during that year, “Malva” and one of her cubs named “Oriana” were found drowned in the area. In subsequent years, other females and three males continued breeding within the same territory. Genetic confirmation of paternity further substantiated the genetic contribution of the male lynx originating from Doñana.

As for the adult foxes, they displayed four perforations in the skull at the level of the right frontal bone, causing immediate death, while the three fox cubs exhibited identical neck lesions at the trachea level, leading to collapse and destruction of these organs due to biting. Moreover, several antagonistic interactions between red foxes and lynxes were captured on camera traps during the monitored period (Fig. 4, https://youtu.be/BH5EpoDX1rk).

**Molecular analysis**

While carrying out the molecular analysis of bite swaps from dead foxes (2017 and 2021) and a genet (2020), a lynx-specific product represented by a band of 130 bp was observed in the positive lynx control but not in the fox control, confirming the efficacy and specificity of the assay (Fig. 5). The same lynx-specific product was amplified from three out of four extracts of swabs tested (internal sample numbers 1, 3 and 4) (Fig. 5). This result indicates the presence of lynx DNA in those extracts. No lynx-specific product was observed in negative extraction and PCR controls, confirming that positive results are not due to contamination during the lab procedures. The presence of Iberian lynx DNA in the samples supported the interpretation that the carnivores were indeed attacked and killed by an Iberian lynx.

Results from further molecular analyses using SNPs

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**Figure 4.** Details of a video of “Malva” in pursuit of a red fox.

**Figure 5.** Results of the lynx-diagnostic PCR applied to DNA extracts obtained from swabs of fox bites. The observation of the lynx diagnostic product indicates the presence of Iberian lynx DNA and identifies it as the killer of the foxes (samples 1, 3 and 4).
proved that the saliva sample collected in one of the dead foxes was a male lynx with a novel genotype ("Malva’s" genotype was already known). Further comparisons against the genotype of “Esencia”, father of the immigrant lynx “Mundo” (data from LIFE Iberlince project), strongly supported “Mundo” as the most likely source of this saliva sample from fox bite. Taken together, these findings suggest that the lynx responsible for the killing of the foxes was the male “Mundo”. Faeces collected at "Malva’s" territory were assigned to either “Malva”, "Mundo” (matching the saliva sample) or were identified as novel genotypes, likely from “Malva’s” offspring. Parentage assignment performed on these novel genotypes revealed “Malva” and “Mundo” (saliva sample nr. 4) as their most likely parents, with a 95% confidence level. This indicates that “Mundo” and “Malva” shared territories in the area, mated and gave rise to living offspring.

Other carnivores, a genet and a wildcat, were found dead during 2020 in other lynx territories. Molecular confirmation of lynx’s authorship was obtained for the genet but not for the wildcat. There was further evidence, from observation and testimonies of local managers in Guadiana, that other lynxes eliminated two other foxes and a polecat (Mustela putorius Linnaeus, 1758).

**Discussion**

The antagonistic behaviour exhibited by the Iberian lynx towards medium-sized carnivores has been documented in previous ecological studies (e.g., Valverde 1957, Palomares et al. 1996). These studies have observed the exclusion and/or killing of red foxes and mongooses within lynx territories (Palomares et al. 1996). However, prior to our research, these observations had not been confirmed through molecular analysis, and similar cases had not been previously documented in Portugal. In our study, we were able to provide evidence of the killing of a red fox by a migrant male lynx, which subsequently established a territory and successfully mated with a resident female. This observation confirms antagonistic interactions between Iberian lynxes and red foxes, resulting in the elimination of a family group of foxes from the site.

The observed episode could potentially be attributed to the male lynx perceiving a threat to the breeding female lynx, leading to the elimination of the fox family group. The superpredator nature of the Iberian lynx appears to be inherent in all individuals, as evidenced by the elimination of red foxes, even in areas with limited lynx occupancy (as in this case, where only a couple and their cubs were present). Palomares & Caro (1999) documented cases of interspecific killing among carnivores, while Creel (2001) presented factors influencing competition among individual carnivores. Our findings suggest that offspring protection may be an additional factor triggering interspecific killing, although none of the aforementioned studies specifically address this aspect. It is hypothesised that, by eliminating foxes and other carnivores, a lynx ensures the safety of its cubs and enhances local food availability.

Recently developed SNP markers can be successfully used to monitor lynx presence and reproduction from non-invasive samples (Kleinman-Ruiz et al. 2017). The case study stated here has provided new information about behaviour and inter-specific interactions, but it also illustrates the power of combining non-invasive sampling with molecular analyses using novel and flexible SNP markers to monitor a reintroduction case. Molecular analyses can make a critical contribution to the overall monitoring of lynx occurrence and reproduction (e.g., Palomares et al. 2017, Lucena-Perez 2018) in new territories and remnant populations. They should therefore become an integral component of the set of tools used for the monitoring and management of Iberian lynx reintroduction, including livestock damage occurrences where lynx can also be the offender, although this occurs usually at a lesser rate than other predators (Garrote et al. 2013).

The red fox is one of the most common carnivores in Mediterranean ecosystems, widespread in areas where the lynx is being reintroduced. Socially, it became of practically no value for hunting purposes, and it is often controlled as vermin through trapping (e.g., Lopes-Fernandes et al. 2022a, 2022b). The interest of hunting managers and guards in fox control, a common practice throughout lynx’s occurrence areas, converges with its territorial superpredator behaviour. The superpredator effect over red fox populations has important social implications, as hunters make a considerable investment and effort to control foxes’ abundance. The negative effect of lynxes on foxes (potentially controlling this species’ reproduction
and abundance) can be seen as beneficial by local actors, as suggested by our survey results. Our social study detected many doubts originally among interviewees concerning the lynx’s superpredator capacity, but also an important change after 8 years of reintroduction. Traditional knowledge about this characteristic of carnivore control disappeared among local communities, and despite being recently disseminated by biologists and technicians, it no longer originated from personal experience. The memory of coexistence in these areas was restricted to very few individuals and no longer part of a collective knowledge. In fact, old residents, and observers of lynx in the past, seem to have known this superpredator effect (5 among 9 admitted the influence over other carnivores).

“I used to see lynxes when I was younger and was a hunter (...) we had them here but I never killed any because, well, it was a rare animal (...) In the areas where the lynx patrols, the other animals [carnivores] don’t appear much, because they are afraid of the lynx, the lynx is a strong animal (...”) (Moura-Barrancos, ex-hunter, 81 years old, 2013).

Local actors value local evidence and direct empirical experience to prove scientific claims. Socio-cultural context influences their responses and, before reintroduction, knowledge about large predators was no longer based on direct experience, since lynxes and wolves (Canis lupus Linnaeus, 1758) disappeared from these areas over 30 years ago. However, with the new coexistence with lynxes, there was a reemergence of a particular knowledge regarding the control that superpredators exert over other carnivores. The higher frequency of key actors knowing about this behaviour will influence local communities as they retain a more specialised knowledge.

The molecular evidence and individual experiences about lynx effects seem to be inducing a discussion among local actors about the Iberian lynx’s ecological role and can promote positive changes in residents’ perceptions about lynx reintroductions. Scientific laboratory results, together with local testimonies of direct experiences and observations, can be integrated into a wider understanding of superpredator dynamics and their conservation implications. This is particularly important for livestock breeders. They are among the more knowledgeable actors about non-human animals but are the ones that know less about the superpredator effect of lynx, while already suffering lamb losses due to foxes. Damage is not only based on economic losses related to the death of lambs (or kids), but also due to the extra work it requires to the manager (e.g., dealing with the ewes’ stressed behaviour and accumulated milk prone to infections, changing the flock between enclosures), as well as emotional distress and personal attachment to the animals. In this scenario of livestock damage by predators, it becomes highly relevant that local key actors are able to experience first-hand instances of lynx killing or displacing foxes and other carnivores deemed detrimental. The widespread recognition of lynx’s role as a superpredator depends on these empirical observations being shared in the community. Since livestock breeders consider that the best solution to mitigate livestock predation would be controlling the predator causing the damage (mostly foxes), the lynx becomes a natural ally. This positive benefit of the lynx reintroduction can balance the existing perception of risk and fear regarding the potential damage caused by this predator (Lopes-Fernandes et al. 2022b). New occurrences of damage to livestock caused by carnivores may need to be subjected to molecular analysis to identify whether lynxes are the cause or not. Scientific knowledge disseminated and integrated into local knowledge should have a positive effect on people’s perceptions towards the lynx. Key actors’ knowledge will make analyses of the benefits and disadvantages of reintroduction more complex, but also more informed.

The social dimension of a reintroduction process is crucial for its success, particularly in the case of a large carnivore. Non-random surveys directed at key actors have the advantage of reaching users and decision-makers in the species’ most important areas, being qualitatively representative. Through this method, we were able to assess that the knowledge about lynxes’ superpredator effect, confirmed with our molecular analysis, is progressively (but not homogeneously) being recognized by local key actors. Emphasising and clarifying specific knowledge about predator behaviour balances the importance of technical and scientific data versus local empirical knowledge, as they are both essential during the process. Our work further highlights that multidisciplinary approaches are fundamental for monitoring reintroduction programs and their biological and social impacts.
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