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Farmers' perceptions towards scavengers are influenced by implementation deficits of EU sanitary policies

Fátima D. Gigante^a, João P.V. Santos^{b,c}, José Vicente López-Bao^d, Pedro P. Olea^{e,f}, Bas Verschuuren^a, Patricia Mateo-Tomás^{d,g,*}

^a Forest and Nature Conservation Policy Group, Wageningen University & Research, the Netherlands

^b Palomar – Conservation of Nature and Rural Heritage, Uva, Vimioso, Portugal

^c Health and Biotechnology (SaBio) Group, Institute for Game and Wildlife Research (IREC, UCLM-CSIC-JCCM), Ciudad Real, Spain

^d Research Unit of Biodiversity (UMIB; UO-CSIC-PA), University of Oviedo, Mieres, Spain

^e Terrestrial Ecology Group (TEG-UAM), Departamento de Ecología, Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, Spain

^f Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid, Madrid, Spain

^g Center for Functional Ecology (CFE), Coimbra University, Portugal

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ABSTRACT

Conservation regulations are instrumental for effective nature preservation, but several compliance and implementation failures jeopardize the achievement of their objectives, with strong potential to erode their legitimacy. Understanding how such deficits impact on stakeholders' perceptions is a matter of concern in pursuing truly effective tools. Here, using as case study the heterogeneous implementation of EU sanitary regulations which allow livestock carcasses to be left in situ in the Iberian Peninsula, we evaluated how uneven implementation affects farmers' perceptions towards scavengers. We interviewed 109 farmers at the border between Spain, with designated Scavenger Feeding Zones (SFZs), and Portugal, where SFZs are still under way. We detected a deficit in the implementation of European sanitary regulation and a low knowledge of this legislation by farmers (10%), which led to marked differences between countries in the perception of farmers on scavengers. Despite being expected to benefit from SFZs, Spanish farmers valued scavengers worse than Portuguese farmers. This unexpected outcome would be mediated by ca. 95% of the Spanish farmers interviewed ($n = 48$) still using the carcass collection system set after the outbreak of the mad cow disease, instead of adopting the new rules allowing carcasses abandonment at SFZs. Contrastingly, ca. 28% of the Portuguese farmers ($n = 61$) left livestock carcasses in the field without official approval. Our results support the initial hypothesis of more positive perceptions of scavengers by farmers leaving livestock carcasses in situ, while warning against assuming effective implementation of sanitary regulations in reality. Worryingly, as illustrated by the negative perception of Spanish farmers towards vultures, these implementation failures could turn out to an emergent farmer-wildlife conflict, which can jeopardize scavenger conservation.

1. Introduction

Conservation policies and laws are adopted by human institutions to slow or halt species decline and habitats degradation. Together with the integration of environmental concerns into sectoral policies (i.e. those not targeting nature conservation, but potentially affecting it, known as Environmental Policy Integration, EPI; Jordan and Lenschow, 2010), these tools have long been considered as cornerstones for effective nature preservation (Chapron et al., 2017; Trouwborst et al., 2017), and to promote sustainable development (Baker et al., 1997). However,

multiple implementation and enforcement failures jeopardize their effectiveness. Deficient integration of the best available science, interpretive uncertainty of the norms, transposition failures or lack of monitoring can erode compliance with legal instruments, hindering the achievement of their conservation objectives (López-Bao and Margalida, 2018; Mateo-Tomás et al., 2019a, 2019b; Planella et al., 2019; Sazatornil et al., 2019).

Since neither political willingness nor the correct legal implementation of laws guarantee conservation success, the environmental rule of law is expected to build on implementation to enhance

* Corresponding author at: Research Unit of Biodiversity (UMIB; UO-CSIC-PA), University of Oviedo, Mieres, Spain.

E-mail addresses: rktespejos@gmail.com, mateopatricia@uniovi.es (P. Mateo-Tomás).

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enforcement and compliance with conservation policies (UNEP, 2019). Compliance, “the degree of adherence to rules, as when a person breaks some rules but not all, or respect most of the rules but not always” (Arias, 2015), is key to ensure that conservation policies are truly effective (Solomon et al., 2015). However, non-compliance is still widespread in the nature conservation context (Gavin et al., 2010; Arias, 2015). Why individuals, groups or institutions do or do not comply with conservation legislation deliberately is complex, involving economic, social, psychological or moral reasons, among other factors, and it has attracted a remarkable research attention (e.g. Tyler, 2006; Keane et al., 2008; UNEP, 2019). Several theoretical frameworks have been even used to explain compliance, such as the Reasoned Action Approach (Fishbein and Ajzen, 2011), where compliance is suggested to be driven by behavioral, normative and control beliefs. But non-compliance can also derive from implementation deficits such as failures in communicating the legislation in force (i.e., the target group of a regulation is not aware of its existence or does not comprehend the rules; OECD, 2000; Arias, 2015). In the European Union, several types of regulatory failures have been identified (Lampinen and Uusikylä, 1998; Börzel, 2001), including serious compliance problems, where non-compliance involves not only the active violation of the norms, but also the passive failure to invoke them (Börzel, 2001).

Besides direct opposition to the norms (e.g., Holmes, 2013; Bennett and Dearden, 2014), implementation deficits and non-compliance can erode the legitimacy of conservation legislations, triggering distrust in managing authorities and undermining goals, even leading to conservation conflicts (e.g., Parenteau, 2004; Young et al., 2007; Madden, 2008; Trouwborst et al., 2015). Understanding the impacts of implementation deficits and non-compliance on stakeholders emerges therefore as a matter of concern in pursuing effective conservation policies (Solomon et al., 2015). Perceptions, i.e. “the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome” (Bennett, 2016) provide useful insights in how to improve the effectiveness of legal instruments in the complex socio-economic contexts within which conservation takes place. Perceptions summarize a myriad of factors that shape people and group opinions over time (Levine et al., 2015; Bennett, 2016). Perceptions can be negatively affected by unfavorable and/or ill-implemented policies (Bennett, 2016), eroding the legitimacy and acceptability of a conservation initiative, or the willingness to share the landscape with wildlife (Lamarque et al., 2009; Bennett and Dearden, 2014; Nyhus, 2016).

The European Union (EU) sanitary regulations allowing livestock carcasses to be left in the countryside for feeding scavengers (EC 1069/2009, 2009; EU 142/2011, 2011) outline for the first time the need of reconciling public health and biodiversity conservation, and are therefore considered a major achievement towards scavenger conservation (Donazar et al., 2009; Margalida et al., 2010). As far as they counteract previous sanitary restrictions for carcass disposal in the countryside (Tella, 2001), these regulations are expected to mitigate farmer-scavenger conflicts attributed to increasing reported attacks of species such as wolves *Canis lupus* and vultures *Gyps fulvus* on livestock, due to food shortages (Margalida et al., 2014; Llaneza and López-Bao, 2015; Duriez et al., 2019). However, major drawbacks, such as slow transposition and heterogeneous implementation across and within member states have been reported, jeopardizing the effectiveness of these regulations for scavenger conservation (López-Bao and Margalida, 2018; Mateo-Tomás et al., 2018, 2019a). For example, while Spain has designated large areas where extensive livestock carcasses can be left in situ (i.e. Scavenger Feeding Zones, SFZs), Portugal is still in the process of establishing these areas, Greece lacks SFZs, and France has set feeding areas where livestock carcasses can be disposed under controlled conditions (e.g. within fences; Duriez et al., 2019; Mateo-Tomás et al., 2019a). This uneven implementation is assumed to result in different availability of livestock carcasses in the field, which has been considered in turn to affect, for example, vulture foraging patterns (Arrondo et al., 2018; but see Margalida et al., 2017). The non-existence of unified

criteria to, in this case, designate SFZs, could not only undermine scavengers' conservation, but also impact differently on perceptions towards these species, and even to intensify human-scavenger conflicts (Mateo-Tomás et al., 2018). Importantly, beyond differences in formal implementation across regions, implementation deficits leading to lack of enforcement and non-compliance by farmers could also impact on their perceptions towards scavengers. Legislation allowing the disposal of livestock carcasses for wildlife consumption would increase stakeholder's interaction with scavengers, presumably fostering the appreciation of their role as effective carcass consumers (Reson, 2012; Morales-Reyes et al., 2018; Duriez et al., 2019). Nonetheless, the potential impact of the uneven implementation of EU sanitary regulations on farmers' perceptions of scavengers has not been evaluated; even though these are key stakeholders to subsidize livestock carcasses to wildlife in compliance with these regulations.

To our knowledge, so far, there is no evaluation on the awareness among farmers on the obligations under the European sanitary regulations EC 1069/2009 and EU 142/2011, a major issue known to jeopardize compliance with regulations (OECD, 2000; Arias, 2015). Moreover, the extent to which different implementation of the same regulation may impact on stakeholders' perceptions towards wildlife has not been assessed. Here, taking advantage of the uneven implementation of EU sanitary regulations in a transboundary context between Spain and Portugal (Mateo-Tomás et al., 2018), we evaluate how these implementation pitfalls can affect farmers' perceptions towards scavengers and their conservation. We hypothesize that the lack of SFZs in Portugal would result in more negative perceptions of scavengers by Portuguese farmers (e.g. due to a lower familiarity with scavengers consuming livestock carcasses left in situ; Morales-Reyes et al., 2018; Duriez et al., 2019) than by their Spanish counterparts, who are allowed to dispose livestock carcasses in the field.

2. Materials and methods

2.1. Study area

The transboundary study area (~4500 km²) is located in north-western Iberian Peninsula, along the Douro/Duero River, the administrative border between Portugal and Spain (Fig. 1). It encompasses several protected areas, including Natura 2000 sites. A total of 70 minor local entities spatially and administratively comparable (i.e. Portuguese parishes and Spanish municipalities; Silveira et al., 2013) were considered, 31 in Portugal and 39 in Spain. These entities were included into six major administrative entities, four municipalities in Portugal (i.e. Miranda do Douro, Mogadouro, Freixo de Espada à Cinta and Figueira de Castelo Rodrigo) and two provinces in Spain (i.e. Zamora and Salamanca), within the Portuguese districts of Guarda and Bragança, and the Spanish autonomous region of Castilla y León, respectively. Despite cross-border differences due to belonging to different countries, social groups inhabiting both river banks share culture, tradition and landscape that single out the borderland (e.g. Orduna Portus et al., 2016).

The landscape at both sides of the border consists of deep valleys with steep rocky slopes and plateaus surrounding the Douro/Duero main watercourse and adjacent rivers. The plateaus host a heterogeneous mosaic of forests, scrubs, croplands, and pasturelands. Human population density ranges between 12 and 40 inhabitants/km² (IGN, 2011; INE, 2012). Extensive livestock rearing is a major activity at both sides of the international border. According to the 2018–2019 livestock official censuses, the Spanish side of the study area holds 2–3 times more cattle and sheep than the Portuguese side (i.e. 21,184 vs. 9635 cattle, 106,626 vs. 33,790 sheep, respectively; see Appendix S1), while the presence of goats is higher in the Portuguese than in the Spanish side (3688 vs. 1316 goats; Gigante et al., 2020).

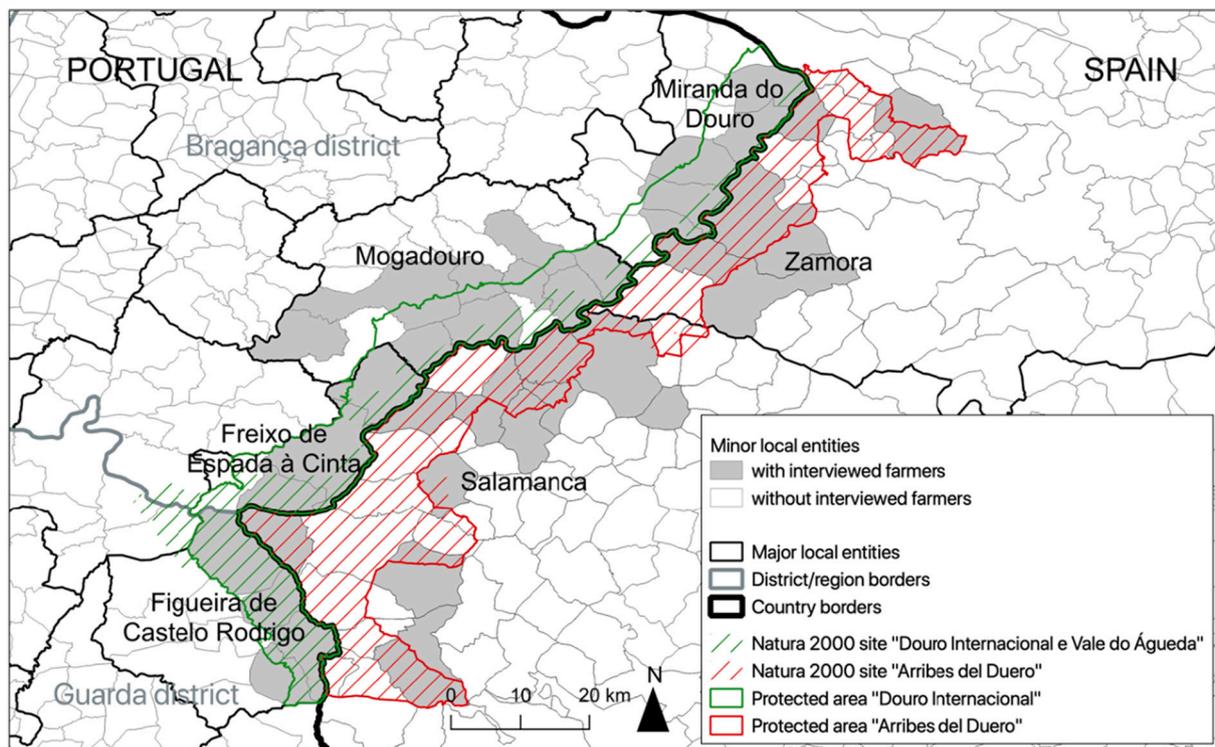


Fig. 1. Portuguese and Spanish farmers were interviewed in minor local entities (in grey; i.e. parishes in Portugal and municipalities in Spain) along the Douro/Duero River, the natural border between Spain and Portugal, where several national and international protected areas exist.

2.2. Uneven enforcement of legislation on livestock carcass management

The implementation of EU Regulations 1069/2009 and 142/2011 has been remarkably different between Spain and Portugal. Although recent changes in the Portuguese legislation provide new opportunities for leaving livestock carcasses in the field (i.e. outside artificial feeding stations; Despacho 3844/2017, 2017, Despacho 7148/2019, 2019; Diário da República 2017, 2019; see details in Appendix S2), these regulations have not been actively enforced, and SFZs do not exist, yet. Furthermore, this study was carried out well before the publication of Despacho 7148/2019 that contemplates the establishment of SFZs in the near future. Accordingly, when we interviewed Portuguese farmers, livestock carcasses should be officially either collected or buried in remote areas, such as our study area, previously declared by the competent authorities (Decree-Law 33/2017, 2017 and Despacho 3844/2017). Meanwhile, Spain transposed both EU regulations in 2011 (i.e. Royal Decree 1632/2011, 2011) and, since then, most Spanish autonomous regions (15 out of 17) have declared SFZs (BORM, 2019; Mateo-Tomás et al., 2019a). The competent authority in the Spanish study area, i.e. the autonomous region of Castilla y León, allows the disposal of livestock carcasses in the countryside since 2013 (Decree 17/2013, 2013); and farmers within SFZs must yearly apply for an official permit which limits the number of carcasses to dispose (see Appendix S2).

2.3. The scavenger guild studied

We selected ten vertebrate species considered as major scavengers in the study area according to previous studies (Mateo-Tomás et al., 2015, 2017; Palombar, 2017). We accounted for all the obligate scavengers (i.e. vultures) present in the study area (i.e. griffon *Gyps fulvus*, cinereous *Aegypius monachus* and Egyptian vultures *Neophron percnopterus*), and seven species of facultative scavengers, i.e. apex predators such as the wolf *Canis lupus*, the golden eagle *Aquila chrysaetos*, and generalists such as the red fox *Vulpes vulpes*, the common raven *Corvus corax*, the wild boar *Sus scrofa*, the red kite *Milvus milvus* and the beech marten *Martes*

foina. Vultures, golden eagles and red kites breed and forage at both sides of the Douro/Duero River, with many pairs breeding literally at the border; wolf is also present in the area, although at low densities, and common raven, red fox, wild boar and beech marten are widespread in the study area, although abundance estimates for these species are lacking (Madroño et al., 2004; Palomo et al., 2007; Equipa Atlas, 2008; Bencatel et al., 2019). See Appendix S3 for further details and references on the considered species.

2.4. Data collection

Farmers' perceptions towards the vertebrate scavenger guild were retrieved through conducting semi-structured interviews (Newing, 2010). Neutral pictures of each species (i.e. without aggressive or submissive displays) were shown to the farmers in order to identify and value them on a Likert scale from 'very harmful' (1) to 'very beneficial' (5), with 3 meaning 'neither harmful nor beneficial'. Farmers' perceptions of scavengers were codified as ordinal response variables from 1 to 5 for subsequent analyses (Appendix S4). We asked questions standardised closed questions on the knowledge and compliance with EU sanitary regulations for managing livestock carcasses, as well as on the used and preferred methods for carcass disposal. Farm and farmer characteristics (e.g. main livestock species and number of heads, age, gender, study level...) were also recorded. We also asked fixed questions where participants picked up an answer of the ones provided, e.g. perceived risk of wildlife attacks from 0 (none) to 10 (certain). Finally, we asked open questions where participants formulated their own answers, e.g. description of carcass management practices, in order to gain an in-depth realistic and complete description of farmers' perceptions (Drury et al., 2011; Rust et al., 2017).

Interviews were performed after obtaining the informed consent of each farmer and carried out in the local languages (Portuguese and Spanish). We initially used quota sampling selection to select farmers that carried out (semi)extensive livestock farming (i.e. their animals grazed outside at least during part of the day) of cattle, sheep or goats

and represented i) all the major administrative entities in the study area (Fig. 1), and ii) at least the 5% of the total livestock census per species (i.e. cattle, sheep and goat; see Appendix S1). We then combined convenience and snowball sampling by visiting the villages to interview those farmers found at their farms, including farmers whose contact details were previously given to us by veterinarians working in the area and by other farmers (Newing, 2010).

2.5. Data analysis

Cumulative Link Mixed Models (i.e. CLMMs; Christensen, 2019) were used to assess the existence of between-country differences in

farmers' perceptions towards scavengers, and the impact of EU sanitary regulations on such perceptions (see Appendix S4 for a detailed description of the main hypothesis tested). We tested perceptions for every scavenging species separately and also grouped according to the species trophic ecology: i) all scavenging species pooled together as "Scavengers" (10 species), ii) "Vulture" species, as obligate scavengers, including griffon, cinereous and Egyptian vultures, and iii) "Generalist" scavengers, including all the species but vultures and top predators, i.e. golden eagle and wolf (5 species). Farmers' valuations of each species group were obtained by averaging the individual assessments retrieved for each species within the group. This value was then rounded to obtain ordinal values ranging from 1 to 5 for inclusion as response variables in

Table 1

Rank (#) of CLMMs with significant variables, i.e. $P < 0.05$, obtained to explain the different farmers' perceptions towards: i) all scavengers, ii) vultures, and iii) griffon vultures in Spain and Portugal. Models testing the influence of legislation knowledge and use on farmers' perceptions are shown despite of the variable significance for comparison to our main hypothesis. Best models, i.e. within $\Sigma\omega_m = 0.95$, highlighted in bold. Major local entities (i.e. Portuguese municipalities and Spanish provinces) as random factors. See Appendix S6 for the remaining results.

#	Model	AIC	df	N	AICc	$\Delta AICc$	Model weight (ω_m)	Z value	P
Scavengers									
<i>Do farmers' perceptions towards scavengers differ between countries? YES</i>									
1	Country	150.70	5	109	151.28	0.00	0.58	5.444	<0.001
<i>Do knowledge or usage of sanitary regulations affect farmers' perceptions towards scavengers? NO</i>									
2	Legislation knowledge	152.53	6	109	153.35	2.07	0.21	0.414	0.679
	Country							5.383	<0.001
3	Legislation usage	152.53	6	109	153.35	2.07	0.21	-0.404	0.686
	Country							5.414	<0.001
-	Null model	159.90	3	109	160.29	9.01	0.00	-	-
Vultures									
<i>Does the perceived risk of wildlife damages influence farmers' perceptions towards vultures? YES</i>									
1	Vulture as harmful	250.78	7	99	252.01	0.00	1.00	-2.233	<0.001
	Country							3.360	<0.001
3	Vulture attack	275.00	7	103	276.18	24.17	0.00	-2.518	0.012
	Country							3.179	0.001
	Vulture attack: Country							-2.203	0.028
4	Wildlife as problem	276.01	7	103	277.19	25.18	0.00	-2.327	0.020
	Country							3.206	0.001
<i>Do the farm characteristics influence farmers' perceptions towards vultures? YES</i>									
2	Number of cows	273.00	7	103	274.18	22.17	0.00	-2.833	0.005
	Country							3.141	0.002
<i>Do farmers' perceptions towards vultures differ between countries? YES</i>									
5	Country	279.64	6	103	280.51	28.50	0.00	3.358	<0.001
<i>Do knowledge or usage of sanitary regulations affect farmers' perceptions towards vultures? NO</i>									
6	Legislation knowledge	281.29	7	103	282.47	30.45	0.00	0.592	0.554
	Country							3.615	<0.001
7	Legislation usage	281.48	7	103	282.66	30.64	0.00	-0.400	0.689
	Country							3.257	0.001
-	Null model	284.07	3	103	284.69	32.68	0.00	-	-
Griffon vulture									
<i>Does the perceived risk of wildlife damages influence farmers' perceptions towards the griffon vulture? YES</i>									
1	Vulture as harmful	249.11	7	98	250.36	0.00	1.00	-4.613	<0.001
	Country							3.359	<0.001
3	Wildlife as problem	280.76	8	102	282.30	31.94	0.00	-2.323	0.020
	Neighbour vulture attack							-2.312	0.021
	Country							2.574	0.010
4	Vulture attack	282.35	7	102	283.54	33.18	0.00	-2.650	0.008
	Country							3.073	0.002
	Vulture attack: Country							-2.480	0.013
<i>Do the farm characteristics influence farmers' perceptions towards scavengers? YES</i>									
2	Number of sheep	279.92	7	102	281.11	30.75	0.00	3.042	0.002
	Country							4.376	<0.001
<i>Do farmers' perceptions towards scavengers differ between countries? YES</i>									
5	Country	287.72	6	102	288.60	38.24	0.00	3.297	<0.001
<i>Do farmers' perceptions towards scavengers differ due to knowledge or usage of sanitary regulations? NO</i>									
6	Legislation knowledge	288.04	7	102	289.24	38.88	0.00	1.279	0.201
	Country							3.881	<0.001
8	Legislation use	289.70	7	102	290.89	40.53	0.00	-0.148	0.882
	Country							3.267	0.001
<i>Do farmers' perceptions towards vultures differ due to carcass management (Carcass left in situ as reference level)? YES</i>									
7	Burial	287.62	9	102	289.58	39.22	0.00	-2.033	0.042
	Collection system							-1.456	0.145
	Other methods							-2.199	0.028
	Country							2.855	0.004
-	Null model	292.09	3	102	292.71	42.35	0.00	-	-

CLMMs.

CLMMs were performed separately for the following four groups of explanatory variables, i.e. i) legislation, ii) carcass management, iii) farm and farmer characteristics, and iv) wildlife (Appendix S4). Uncorrelated variables within each group (i.e. those with non-significant Pearson's correlation $P > 0.05$) were simultaneously included in CLMMs. For model selection, we used the corrected Akaike's information criterion (AICc), and the relative model weight (ω_m ; Burnham and Anderson, 2002). We ranked the models by the lowest AICc and considered that all models whose relative weights summed up to 95% ($\Sigma\omega_m = 0.95$) would contribute to explain farmers' perceptions towards scavengers. Models with lower AICc were considered as having better support, with models separated by less than two AICc units among them (i.e., $\Delta AICc < 2$) having equivalent support (Burnham and Anderson, 2002). These same criteria were then used to compare the best models obtained for each category of explanatory variables (i.e. those within $\Sigma\omega_m = 0.95$) to assess the relative importance of the different hypothesis in determining farmers' perceptions. Significant interaction effects between the explanatory variables were tested for the best models within each category. CLMMs were fitted with Laplace approximation through the "ordinal" package (Christensen, 2019) available in R Studio v.1.1.463 (RStudio Team, 2016).

Territorial and administrative units (i.e. major and minor local entities of both countries), and veterinary units or farmers' associations (hereafter ADS) were considered as simple or nested random factors within CLMMs to account for repeated measures (see Table 1 and Appendixes S5 to S7). These administrative units represent different levels of governance that influence livestock husbandry, and allow us to replicate the study within countries.

We used Wilcoxon, Chi-squared and G tests in "DescTools" package (Signorell et al., 2020) to look for differences in farm and farmer characteristics between countries.

3. Results

3.1. Farm and farmer characteristics

A total of 109 farmers, 61 in Portugal and 48 in Spain, were interviewed between December 2018 and March 2019 in 21 Portuguese parishes and 16 Spanish municipalities (Fig. 1) representing 52.8% of the 70 minor local entities in the study area. The interviewed farmers were primarily men (87.1%) with an average age of 52 years old (range: 23–80), and without significant differences between countries (Spain: mean \pm SE: 50.5 ± 1.7 , Portugal: mean \pm SE: 52.9 ± 1.7 , Wilcoxon test: $W = 1670$, $P = 0.209$). Most of them bred sheep or cows as their primary working activity, with fewer goat breeders, especially in Spain (Appendix S1). All farmer characteristics but the main professional activity were similar in both countries. Up to 20 Portuguese farmers (out of 61 farmers interviewed, 32.8%) had other economic activity parallel to farming, while only 4 Spanish farmers (8.3%) were not fully dedicated to livestock farming (G-test: 10.2, $P = 0.001$).

The interviewed farmers owned 11.5% of the livestock censused in the study area in 2018–2019, 14.1% in the Portuguese and 10.2% in the Spanish side of the border (see Appendix S1). These sample sizes were large enough to obtain representative answers as shown by the narrow confidence intervals, i.e. lower than $\pm 3.5\%$ and $\pm 4.5\%$ at 95% and 99% confidence levels, respectively, for all cases but goats in Spain (i.e., 8.6 and 11.3% confidence intervals; Creative Research Systems, 2017; see Appendix S1).

3.2. Farmers' perceptions towards scavengers

Whereas facultative scavengers, such as wolf, red fox, and wild boar, were recognized correctly by all the respondents; interviewees showed a variable level of knowledge of vulture species, from high in the griffon vulture (94.5%) and medium in the Egyptian vulture (44.2%), to low in

the cinereous vulture (23.8%). The common raven was recognized also by most of the interviewed farmers (91.7%), while only 40.4% recognized the golden eagle. The less well-known species, recognized by less than 15% of the respondents in at least one country (i.e. less than 9 in Portugal and 6 in Spain), were the red kite and the beech marten. These two species were therefore not considered for further analyses of farmers' perceptions towards scavengers.

Overall, Spanish livestock farmers showed a significantly more negative perception towards scavengers than their Portuguese counterparts (Fig. 2; Appendix S5). While in Spain all the species were considered from very harmful to neutral, in Portugal the perception of scavengers ranged from very harmful to very beneficial. All scavengers in general and generalist species in particular (i.e. 'Scavengers' and 'Generalists' groups; see Methods above), were categorized as harmful for livestock farming in Spain, while in Portugal they were qualified as 'neither harmful nor beneficial'. In Spain, 'Vultures' were closer to neutral perceptions than the other groups and/or species, while in Portugal they were considered beneficial, not only as a group but also the griffon and cinereous vultures as species. Contrastingly, the griffon vulture was considered the most harmful vulture species in Spain. Significant between-country differences in farmers' perceptions (i.e. $P < 0.05$) were also recorded for cinereous vulture, wild boar and common raven, with more negative perceptions in Spain than in Portugal. However, the interviewed farmers in both countries showed a similar negative perception towards wolves (Appendix S6). These differences in perceptions were consistent when comparisons were made between administrative units (Appendix S7), meaning that farmers' perceptions towards scavengers did not differ greatly within the same country, but between countries.

Wildlife in general, and scavengers in particular, were considered a problem for livestock farming significantly more often in Spain than in Portugal (Appendix S6). Wildlife was one of the top-three problems for 27.1% of Spanish farmers and 4.9% of Portuguese farmers. This difference was especially striking in the case of 'Vultures' as a group and as individual species, with 39.6% of Spanish farmers versus 6.6% of Portuguese farmers identifying vultures as harmful for their activity (Appendix S6).

3.3. The role of uneven implementation of EU sanitary policies

It is worth mentioning that only 11 out of the 109 farmers interviewed (10.1%) knew the national or sub-national regulations enforced for livestock carcass management in their respective countries: 3 in Portugal (5%) and 8 in Spain (16.7%). Even less farmers (i.e. three, 2.8% of the total farmers interviewed) have adhered to the sanitary regulations allowing them to leave livestock carcasses in situ to feed scavengers, 1 in Portugal (1.6%) and 2 in Spain (4.2%). The Portuguese farmer had adhered to the regulations in place that allowed him to have a feeding station within the farm (see Appendix S2). Consequently, no significant effects of knowledge or use of the enforced regulations were detected on farmers' perceptions towards scavengers (Table 1; Appendix S6). However, the type of carcass management used by farmers (which is ultimately determined by the enforced sanitary regulations) did affect their perceptions of vultures. Farmers who left dead livestock in situ had a more positive perception of griffon vultures than those who buried or used other methods of livestock carcass disposal like scavenger feeding stations (Table 1) regardless of the country (i.e. non-significant interaction between country and method of carcass disposal).

Spanish farmers declared to use the livestock carcass collection system as the main method for carcass management (95.8%), while in Portugal livestock carcasses were reported to be mainly buried (54.1%). The main motivation underlying these carcass management methods was in both cases that they were perceived as 'mandatory' (97.8% in Spain and 69.7% in Portugal). Surprisingly, despite the fact that the Spanish legislation allows livestock carcasses being left in situ, a significantly higher percentage of Portuguese farmers (i.e. 27.9%)

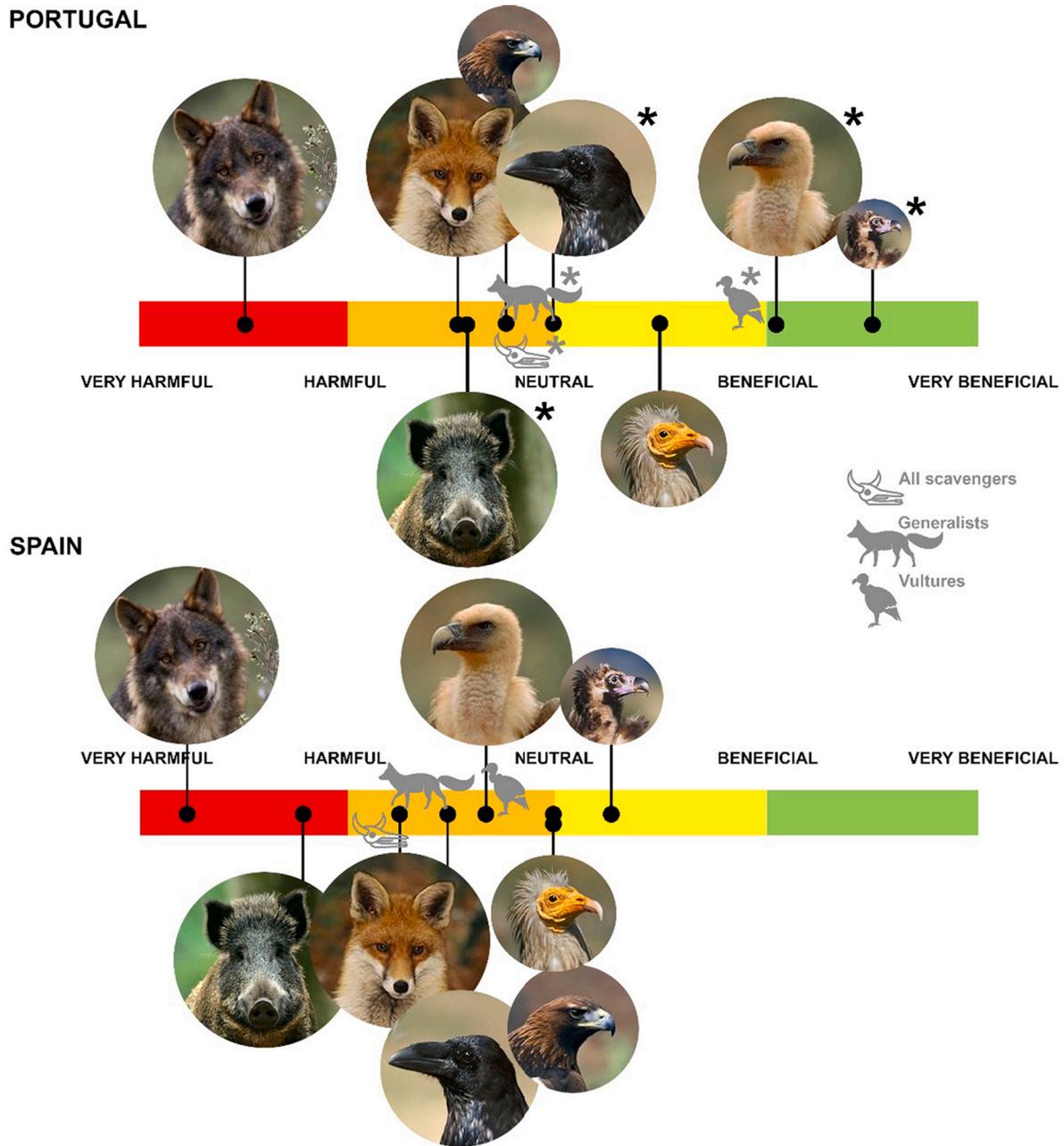


Fig. 2. Significant differences (asterisks) in farmers' perceptions towards all scavengers, vultures, and generalists' groups were found between countries (i.e. Portugal and Spain) in the transboundary study area. At species level, significant differences were recorded for the griffon and cinereous vultures, the wild boar and the common raven (see main text and Appendix S5 for further details). The size of pictures denotes the percentage of farmers who correctly identified each species (i.e. from 16.4% for the cinereous vulture to 100% for the wolf, red fox and wild boar). Icons by Ana María Lora Macias, Felix Brönnimann and Abby, from the Noun Project. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

declared to leave livestock carcasses in the countryside (even when recognizing this as a non-legal practice), with only the 6.3% of farmers in Spain using this method of carcass disposal (Chi-squared test, $X^2 = 8.1, P = 0.004$).

Contrasting with the most used methods, respondents in Spain considered scavenger feeding stations as the ideal method for livestock carcass management (39.6%), although leaving carcasses in situ and the collection system were also highly accepted (33.3% and 25.0%, respectively). Respondents in Portugal, on the contrary, preferred the livestock carcass collection system (36.2%), but leaving carcasses in situ and burying livestock carcasses were also highlighted notably (31.0% and 24.1%, respectively). For 29.2% of the Spanish farmers and 41.0% of the Portuguese farmers, the method used for carcass management

matched the preferred one, with no significant differences between countries (CLMM, $Z = 1.5, P = 0.123$). However, neither the valuation of the method of carcass management currently used nor its coincidence with the method preferred had a significant effect on the perceptions of farmers towards scavengers (Appendix S6). No significant interactions were retrieved among the explanatory variables included in the best models for this category.

3.4. Other factors affecting farmers' perceptions towards scavengers

Farmer characteristics only explained significant differences on their perceptions towards wolves. In particular, older farmers and farmers with lower education level perceived wolves as more harmful species

(Appendix S6). Regarding the farm characteristics, the number of cattle in a farm negatively affected farmers' perceptions towards vultures, i.e. the higher the number of cows a farmer had, the more negative their perception of obligate scavengers (Table 1). Contrastingly, the number of sheep owned by a farmer positively impacted their perception towards griffon vultures (Table 1), while the opposite effect was found for the common raven (Appendix S6). No significant interactions were retrieved among the explanatory variables included in these models.

The number of dead animals at a farm in the last calendar year (i.e. 2018) had a negative effect on farmers' perceptions towards 'Generalists' scavengers as a group (Appendix S6). Farmers that highlighted wildlife or vultures as one of the top three problems for livestock farming had a more negative perception of both, vulture species in general and the griffon vulture in particular (Table 1). Those farmers who reported having suffered attacks from vultures in 2018 also had a more negative perception of vultures and of griffon vultures, especially marked in Portugal (i.e. significant interaction with country; Table 1). Farmers who had heard of vulture attacks to their neighbors' livestock had a more negative perception of vultures too, especially of the two larger vulture species (i.e. griffon and cinereous vultures). Lastly, the perceived risks to suffer wildlife attacks to their livestock or the livestock of their neighbors (i.e. 'Risk perception' and 'Neighbor Risk Perception', respectively) had negative effects over the farmers' perceptions towards wolves (Appendix S6), meaning that those farmers that perceived higher risk of wildlife attacks had a more negative view of this species, but not of the remaining scavengers (Table 1 and Appendix S6).

3.5. Comparison of factors affecting farmers' perception of scavengers

Among the different models tested, the country of the farmer was identified as the most important factor explaining farmers' perceptions towards the guild of 'Scavengers', followed by legislation knowledge and use (Table 1). These three models were within the set of best models (i.e. $\Sigma\omega_m = 0.95$; Burnham and Anderson, 2002), with weights $\omega_m > 0.20$. Contrastingly, perceiving vulture as a harmful species for livestock farming was the only best model (i.e. $\omega_m = 1.00$) explaining farmers' perceptions towards 'Vultures' as a group, and towards the griffon vulture as a single species (Table 1).

4. Discussion

The heterogeneous implementation of EU sanitary regulations has been previously identified among European countries and Spanish autonomous regions (Mateo-Tomás et al., 2018, 2019a), recommending further transboundary comparisons. Our results highlight remarkable between-country differences in farmers' perceptions towards scavengers. The absence of differences in perceptions among administrative units within the same country provides further support for the observed between-country differences (Appendix S7). However, contrary to our expectations, based solely on the formal implementation of the EU Regulations 1069/2009 and 142/2011 in both countries, we recorded more positive valuations of scavengers by Portuguese than by Spanish farmers, who are allowed to leave livestock carcasses in the field since 2013 (Appendix S2). This unexpected outcome may be partially due to the scarce knowledge that the interviewed farmers had about the sanitary regulations (i.e. 10.1%). Lack of awareness of implemented legislations is acknowledged as a major factor behind enforcement and compliance failures (OECD, 2000; Arias, 2015). Such lack of awareness may explain why carrion management by Spanish farmers does not seem to respond to the options available under the current legislation, which allows fallen livestock to be left in situ, but to the previous one compelling the removal of carcasses. In fact, ca. 95% of the Spanish farmers interviewed declared to use the carcass collection system set after the outbreak of the mad cow disease. On the other hand, we observed a lack of enforcement of the current sanitary regulations adopted in Portugal, since ca. 28% of the farmers recognized to leave

livestock carcasses in the field without any approval and official supervision according to the legislation in force (i.e. Decree-Law 33/2017 and Despacho 3844/2017). Therefore, this implementation deficit of EU sanitary policies (which determine the method allowed for carcass disposal) could explain the overall more positive perception of scavengers by Portuguese farmers (Fig. 2), agreeing with our initial hypothesis of farmers who left carcasses in situ holding a more positive perception of the guild (see below), and highlighting the importance of the correct enforcement of environmental regulations on the ground. This situation is particularly striking in Spain, where most interviewed farmers were positive to dispose livestock carcasses in the field (i.e. in feeding stations or in situ). Worryingly, a potential consequence of the current situation is the rise of an emergent conflict between farmers and some scavenging species, as illustrated by the negative perception of farmers towards vultures in Spain.

Spanish farmers were often torn between assigning griffon vultures the beneficial (i.e. due to rapid carcass removal) or harmful category (i.e. in relation to attacks on livestock). Moreover, some of them declared to have a good valuation of vultures in the past, which is becoming negative in recent times. This wide range of perceptions captured in Spanish farmers has been previously noted for other scavenging species (e.g. ravens, wolves; Morales-Reyes et al., 2018), but not for the griffon vultures. Dualistic views on vultures have been also registered in Namibia, but their perception as a harmful species seemed to be related to their misidentification with eagles (Craig et al., 2018). In our study area, griffon vultures were correctly identified by most farmers (94.5%). In both countries farmers who left carcasses in situ held a more positive perception of the species, probably linked to a higher familiarity with scavengers promoted by this interaction (Morales-Reyes et al., 2018; Duriez et al., 2019). This could explain the overall more positive perception of vultures in particular, and of scavengers in general, by Portuguese farmers (Fig. 2), who declared leaving carcasses in situ more often than their Spanish counterparts (27.9% vs. 6.3%, respectively). Although farmers leaving carcasses in situ held more positive perceptions towards griffon vultures than those using the carcass collection system, these differences did not achieve statistical significance, maybe due to the low number of farmers declaring to actually use the first method in Spain (6.3%).

Wildlife damage on farms was a driving factor of negative perceptions towards scavengers (e.g., farmers show more negative attitudes towards large carnivores compared to other sample groups; Dressel et al., 2015). In the case of vultures, farmers declaring attacks to their livestock or to neighboring farms had a more negative perception on these species. Reporting vulture attacks was in fact highly correlated to placing vultures as one of the three most harmful species for livestock farming practices (Pearson's correlation: $r_p = 0.46$, $P < 0.01$). Our results also highlight the role of livestock practices in influencing perceptions. Cattle breeders in the study area had a slightly more negative perception of griffon vultures than goat or sheep breeders, while the latter were usually more positive towards vultures (Table 1). Compared with other European regions where vulture attacks are mostly reported by sheep farmers (i.e. Spanish Pyrenees, France; Margalida et al., 2014; Duriez et al., 2019), vulture attacks in our study area were mostly reported by cattle breeders (i.e. 9 out of 10 vs. 5 out of 10 for sheep breeders and none for goat breeders). Cattle breeders use to leave the animals in the field for longer periods without supervision (Pimental et al., 2017; Gigante et al., 2020), whereas sheep graze usually accompanied by shepherds and/or dogs, and most of the herd spend the night stalled (Gigante et al., 2020). Closer surveillance of sheep and goats would allow to detect, for example, impeded livestock well in advance to prevent wildlife attacks (e.g. during birthing; Milleson et al., 2006). The fact that cattle usually has a higher monetary value than sheep (e.g. in the study area, compensation for wolf attack on cow can be ten-fold that of sheep or goat, i.e. ~€1000 vs. ~€100, respectively; Despacho 9728/2017, 2017; BOCYL, 2019) could also explain the more negative perception of vultures by cattle breeders, since their economic losses

would be higher (Amador-Alcalá et al., 2013; Muriuki et al., 2017; see also López-Bao et al., 2013). Vulture attacks were self-reported by farmers, indirectly measuring their perception of risk (i.e. subjective judgment on the severity of a risk; Slovic, 1987) but not necessarily the real situation. Perception of risk often mismatches the rational or technical assessments of such risk (Slovic and Peters, 2006). However, risk overestimation can diminish tolerance and acceptance towards wild species (Bruskotter and Wilson, 2014), even driving negative behaviors to end up with the risk (e.g. retaliatory killing; Woodroffe et al., 2005).

Interestingly, the only perceptions that clearly did not differ between Spain and Portugal were those towards the wolves. This species was categorized as extremely harmful for livestock farming at both sides of the border, despite the low abundance of the species in the area (Pimenta et al., 2005; Saénz de Buruaga et al., 2015). The wolf is a good example of the complexity of influencing or changing the perception of a species once it is deeply ingrained in human individual and collective psyche (Kellert et al., 1996; Skogen et al., 2017). This calls attention to the need of preventing the establishment of emerging negative perceptions, such as those detected for the griffon vultures in recent times, since they could have a lasting negative impact on biodiversity conservation.

Despite the scarce knowledge shown by farmers on the sanitary regulations in force, their contrasting perceptions towards scavengers in general, and griffon vultures in particular (which were also related to the method used for carcass disposal) point to a potential impact of the implementation deficits of EU sanitary policies on farmers' perceptions. Besides previously reported drawbacks in policy implementation, such as slow transpositions and heterogeneous transboundary schemes (López-Bao and Margalida, 2018; Mateo-Tomás et al., 2018, 2019a), the lack of enforcement and compliance shown by farmers emerges as another factor jeopardizing the effectiveness of these sanitary regulations. Although some Spanish farmers may have over-reported compliance with the former regulations of carcass disposal to "safe face" (Pollnac et al., 2010), this would not affect the major results of our work showing a lack of enforcement of the current legislation that allows livestock carcasses to be left in the field.

Beyond these political dimensions, our results highlight that assuming that the legal implementation of EU sanitary regulations is equal to its correct enforcement and compliance may result in biased interpretations regarding its effectiveness for scavenger conservation (e.g. food shortages influencing scavengers foraging or attacks on livestock; Margalida et al., 2014; Arrondo et al., 2018; Duriez et al., 2019). On-ground monitoring of livestock carcasses has been recommended in order to guarantee the consecution of the major objectives of EU sanitary regulations regarding biodiversity conservation and public health (Mateo-Tomás et al., 2019b), and would be useful to ascertain the real impact of the uneven implementation of sanitary regulations on the conservation of these species (Solomon et al., 2015). On-ground work could also foster communication-based interventions to enhance the knowledge and understanding of EU regulations by farmers (e.g. Life Feeding Scavengers, LIFE 13NAT/ES/001130, CBD-Habitat Foundation, 2019), thus contributing to improve enforcement and compliance (Solomon et al., 2015) and to counteract negative perceptions towards scavengers, which can eventually erode the efforts made for the conservation of this guild.

CRedit authorship contribution statement

Conceptualization: P.M-T, F.D.G., J.V.L-P; Fieldwork: F.D.G., J.P.V.S., P.M-T, J.V.L-P; Formal analysis: P.M-T, F.D.G.; Funding acquisition: J.P.V.S., P.M-T, J.V.L-P; Project administration: J.P.V.S., P.M-T; Resources; Software; Supervision; Validation; Visualization; Writing - original draft: P.M-T, F.D.G.; Writing - review & editing: All authors.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

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