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NOTE

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Assessing the distribution of elusive non-game carnivores: are hunters valuable informants?

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Abstract

Public surveys can be valuable tools to collect information on wildlife distribution. Our objective was to improve the knowledge on the distribution and expanding areas of the Egyptian mongoose (*Herpestes ichneumon*) in central Spain by using an on-line questionnaire to hunters. We assessed the reliability of information that hunters provided by comparing it with reports from wildlife professionals. Our results show a high overall congruence but significantly different information provided by hunters and professionals on the distribution of the Egyptian mongoose, suggesting that both sources provide unique data for the management of non-game species. For example, hunters reported greater mongoose presence than professionals in areas to the east of Toledo and Ciudad Real provinces, for the whole distribution and core area of the species, suggesting that hunters could help to detect other areas where the species exists. Overall, our findings stress the importance of engaging hunters in wildlife conservation, as they can share valuable information on wildlife species, including those that are not hunted.

KEYWORDS

distribution, Egyptian mongoose, hunters, non-game species, questionnaire, records

Improving understanding of the distributions of wildlife species is important for their management and conservation (Barea-Azcón et al. 2006). Multiple methods are used to assess the distribution of wildlife species including capture, sign surveys (e.g., footprints, scats), direct observation, motion-sensitive cameras, and questionnaire surveys of experts (Kluever et al. 2015). Most of these methods entail high costs and effort, including the cost of cameras, salary of professionals, or cost of field surveys, which in many cases are unaffordable (Parry and Peres 2015, Cretois et al. 2020, Werenkraut et al. 2020, Nicosia et al. 2021).

Alternatively, collaboration with the public (e.g., citizen science projects), can help to reduce the costs and collect data more efficiently (Lasky et al. 2021). For example, the usefulness of the information provided by citizens to update the distribution maps of wildlife species is increasingly recognized (Shirk et al. 2012, Crall et al. 2015, Werenkraut et al. 2020). Such data can be collected through open-access web or cell phone applications that allow citizens to record observations of various species (e.g., iNaturalist, eBird; Robinson et al. 2018). In addition, data can be gathered through questionnaires sent to the general public or to particular stakeholders that come into contact with wildlife frequently, such as outdoor recreationists, hunters, or farmers (Werenkraut et al. 2020). Public surveys may generate large amounts of information about the target species with relatively low effort, thus reducing the cost of wildlife monitoring (Lepczyk 2005, Parry and Peres 2015, Werenkraut et al. 2020, Nicosia et al. 2021).

One potential limitation of this approach is the unknown reliability of the information obtained because of the risk of species misidentification (Miller et al. 2012, Egna et al. 2020). Some methods can reduce this limitation, such as checking the reliability of responses by asking the interviewees to identify the species in pictures (Wiggins et al. 2011, Clare et al. 2019, Balázs et al. 2021). Species misidentification is expected to be less likely in the case of hunters because their activity implies direct contact with nature and knowledge of wildlife species and behavior. Previous studies demonstrated that hunters may provide valuable information regarding the relative abundance and distribution of game species (Miller et al. 2013, Bauder et al. 2021). Their role as informants for non-game species has received less attention in the literature (Linares et al. 2020).

Previous studies reported statistically significant differences between the reports provided by hunters and professionals on Egyptian mongoose (*Herpestes ichneumon*) occurrence (Linares et al. 2020). Linares et al. (2020), however, did not control for hunters' knowledge of the mongoose and their survey of professionals covered only a relatively small part of the study area. Although the Egyptian mongoose is not a game species in Spain, hunters may be aware of its presence, as they often consider it as a threat to small game species such as European rabbits (*Oryctolagus cuniculus*) and red-legged partridges (*Alectoris rufa*; Recio and Virgós 2010, Martínez-Jauregui et al. 2017). The diurnal behavior of this carnivore (Palomares and Delibes 1993) also makes it relatively easy to observe during hunting activities.

In this study, we assessed whether hunters could provide reliable information on a non-game carnivore species, the Egyptian mongoose, which occurs across most of the territory in Portugal (Bencatel et al. 2019) and in central-western Spain (Descalzo et al. 2021). We compared hunters' reports with data obtained from wildlife professionals in central Spain. We also attempted to differentiate between the whole distribution in the region of Castilla-La Mancha (CLM), the core area, and the expansion area (i.e., marginal areas) of the mongoose to identify possible geographic differences in the information provided.

STUDY AREA

We conducted this study between 2018 and 2021 in CLM, an 88,400-km^2 region in central Spain (39°14′38.4″N 3°09′20.3″W; Figure 1A). This is a mainly flat area (696 m mean altitude) with some moderate mountain chains (max. altitude = 2,273 m), and Mediterranean climate, with contrasting dry and hot summers and mild and moderately wet winters. There is a great variety of land cover types ranging from pastures, herbaceous croplands, olive groves, vineyards, and dehesas (savanna-like formations combining pasture with intermittent cereal cultivation in park-like oak [*Quercus* spp.] woodlands) in addition to natural-vegetated areas. Croplands and dehesas predominate in the plateau and Mediterranean scrublands and forests (mainly pines [*Pinus* spp.] and oaks) in the mountains. Apart from the target species (Egyptian mongoose) 9 other wild carnivore species can be found in CLM. These include the Iberian lynx (*Lynx pardinus*), the grey wolf (*Canis lupus*), the red fox (*Vulpes vulpes*), and the European badger (*Meles meles*), among others. Hunting is a very popular activity in most of the study area.

METHODS

We designed an online questionnaire to obtain Egyptian mongoose records from hunters. The questionnaire included an initial question about the municipality in which each respondent most frequently hunted. Another part of the questionnaire addressed hunters' perceptions about potential effects associated with the

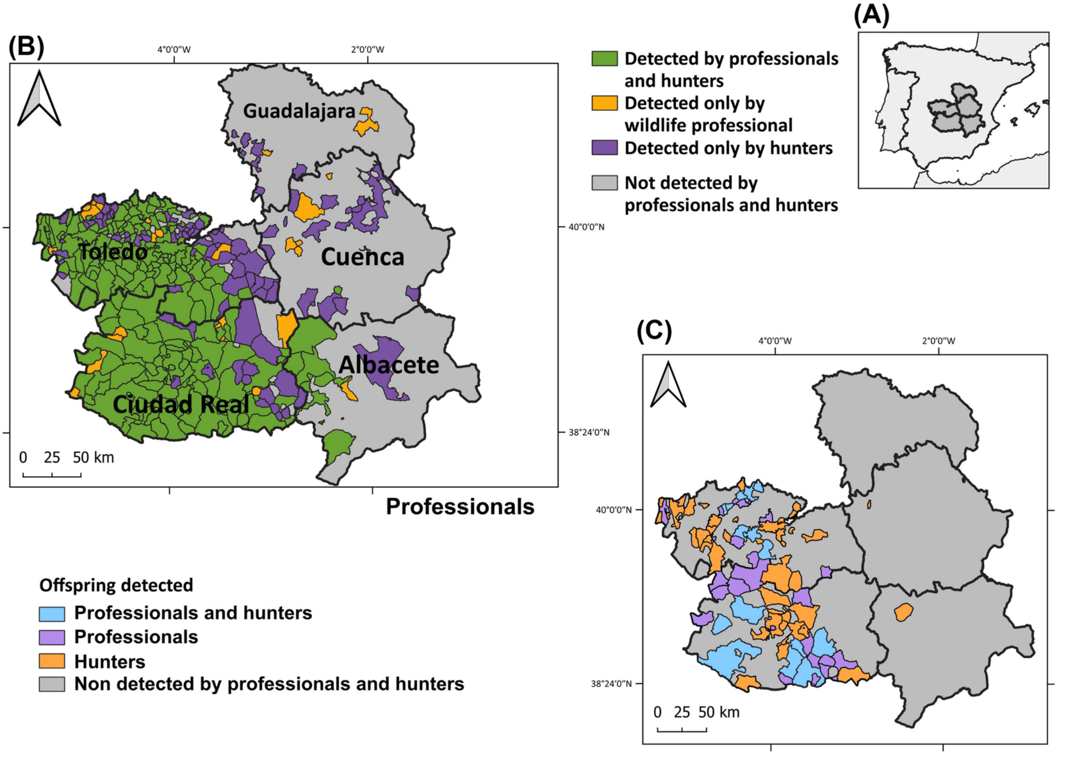

FIGURE 1 A) Location of the Castilla-La Mancha (CLM) study area within the Iberian Peninsula. B) Municipalities within CLM (central Spain) where the presence of the Egyptian mongoose was reported by hunters (this study) or wildlife professionals (Descalzo et al. 2021) in 2000–2021. C) Municipalities where offspring were detected by hunters or professionals in CLM in 2000–2021.

occurrence of mongoose and their preferences for different management alternatives (Delibes-Mateos et al. 2021). We assessed if hunters were able to identify the target species by showing them pictures of 4 different carnivore species: European polecat (*Mustela putorius*), Eurasian otter (*Lutra lutra*), Egyptian mongoose, and least weasel (*Mustela nivalis*). This allowed us to focus the analyses only on those hunters who were able to identify the species correctly. In regard to mongoose observations, hunters were asked if they had spotted this species, either adult or offspring, in 2 periods: from 2018 onwards and before 2018 and, if so, they were requested to mark on a map the municipality in which the observations took place. For this study we analyzed mongoose records jointly, regardless of the date of observation. Hunters who had not seen any mongoose (and thus did not report any observation) did respond to the other sections of the questionnaire (i.e., municipality where they hunted, perceptions about mongoose effects and preferences for its management). The minimum survey area included the municipalities in which all respondents hunted more frequently in CLM (Figure 2). We lacked information about the full surveyed area because we also requested that hunters provide mongoose observations from other areas outside their main hunting estates (e.g., in other estates visited less regularly or during outdoor activities). We conducted the online survey between November and December 2021.

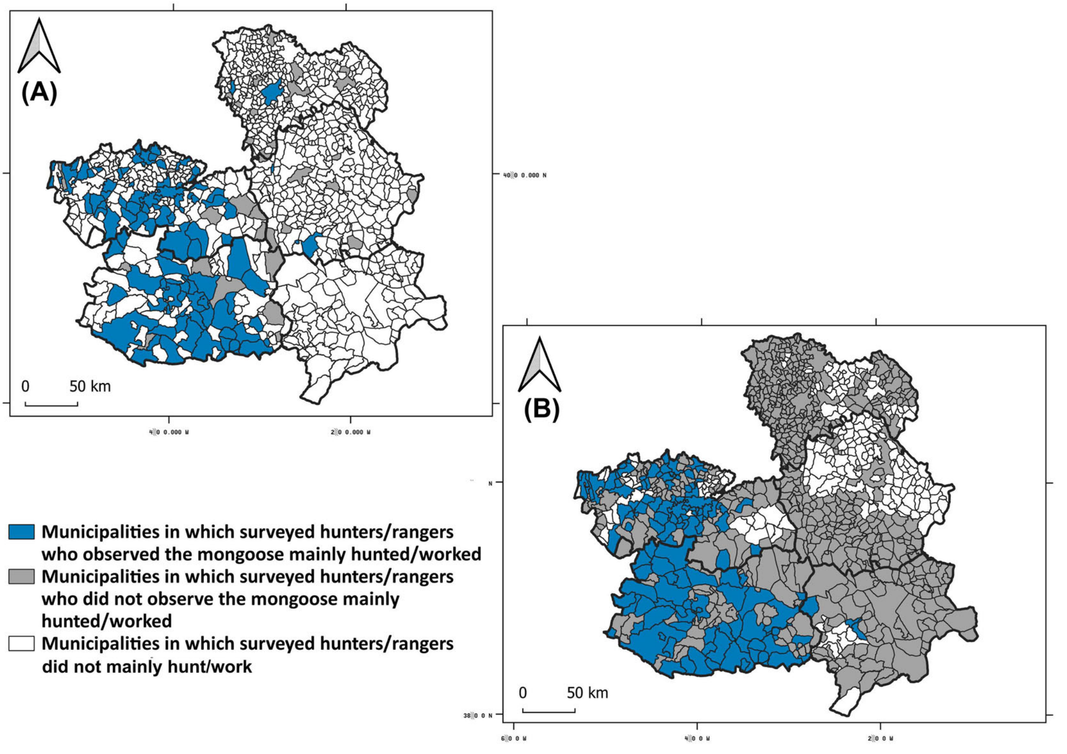

FIGURE 2 A) Municipalities in which respondents (including those who reported mongoose observations and those who did not) hunted more frequently in Castilla-La Mancha (central Spain) in 2000–2021. B) Municipalities in which environmental rangers who participated in the questionnaire about Egyptian mongoose work within Castilla-La Mancha. These would be the minimum areas surveyed by hunters and rangers. We lacked information about the full surveyed areas because both hunters and rangers also provided mongoose observations from other areas outside their main hunting or working areas (e.g., observed in other estates visited less regularly or during outdoor activities), but such areas were not specified in the questionnaire.

In Spain, hunting takes place in >85% of the territory and hunters invest millions of hours in the field each year (Miller et al. 2013). Spanish hunters have to obtain an official license to hunt. A list of contacts of hunters is not publicly available because of regulations on personal data protection. For this reason, we distributed the questionnaire through social networks such as Twitter and Facebook, and relied on a snowball procedure (i.e., initial contacts distributed it among secondary contacts; Oñate and Peco 2005). Initial contacts included the main hunting associations and the hunting federation in the study area, the administrator of a very popular hunter website, and some key hunters who had collaborated with our research team in previous projects.

Hunters reported mongoose observations and we compared them with information provided by wildlife professionals. Such information consists of records of the Egyptian mongoose collected by researchers and technicians and observations provided by environmental rangers through an online questionnaire conducted in 2018. These records were part of another study, and the methods used are described in Descalzo et al. (2021). In brief, 467 rangers provided information on mongoose occurrence or absence in >90% of the municipalities in the study area (which cover 81.2% of the CLM area). Similarly to the hunters' exercise, rangers were requested to mark in a map whether they had seen the mongoose inside their working areas or outside these areas (Figure 2) in the year of the survey and in previous years. The temporal mismatch between the questionnaire surveys of hunters and rangers may be a potential limitation of this study. Nevertheless, to avoid such potential limitation, at least partially, researchers and technicians who carry out fieldwork in CLM were requested to provide additional opportunistic records of the mongoose, which included direct observations, road-killed individuals, and animals photographed by motion-sensitive cameras for 2018–2021 (Descalzo et al. 2021), which was not addressed in the rangers' survey. For this study, we used all the observations reported by hunters and professionals (rangers, researchers, technicians) regardless of the date of observation; overall, we considered Egyptian mongoose records for 2000–2021.

We compared the distribution of mongoose records provided by hunters who identified the species correctly and wildlife professionals at the municipality scale in the following spatial frameworks: all CLM; the core area, which we considered to be within Toledo and Ciudad Real provinces according to previous distribution maps (Descalzo et al. 2021); and the new area apparently colonized by the species (i.e., marginal area), which included surrounding provinces such as Guadalajara, Cuenca, and Albacete. We analyzed the agreement between both groups of informants in the core area (established area of the mongoose) and the marginal area. We used the Epitools software (Sergeant 2018) for calculating the overall proportion of agreement (OPA), the proportion of positive agreement (PPA), and the proportion of negative agreement (PNA) for all spatial frameworks (CLM, core, marginal), according to the following equations:

$$OPA = \frac{a + d}{a + b + c + d} \tag{1}$$

$$PPA = \frac{2a}{2a + b + c} \tag{2}$$

$$PNA = \frac{2d}{2d + b + c} \tag{3}$$

where a represents the frequency of agreement of positive events (here, number of municipalities where both hunters and wildlife professionals reported the mongoose presence), b is the number of municipalities where only hunters reported mongoose presence, c is the number of municipalities where only wildlife professionals reported mongoose presence, and d is the number of municipalities where none reported mongoose presence. We also used the McNemar's chi-squared test in R (R Core Team 2020) to test for significant differences between the information provided by hunters and wildlife professionals (Zar 2014).

RESULTS

We received 232 responses from 105,000 registered hunters in CLM, and 190 of them identified the Egyptian mongoose correctly. The latter provided 1,224 mongoose records in CLM. Municipalities in which respondents hunted more frequently covered a smaller area than those in which rangers who engaged our survey worked (30.4% vs. 81.2% of the CLM area, respectively; Figure 2). Most of these municipalities were within Toledo and Ciudad Real provinces, whereas the questionnaire to rangers covered nearly all the region (Figure 2). The Egyptian mongoose was detected by hunters, professionals, or both in 305 out of the 921 existing municipalities in CLM (33.12%). In 216 of those municipalities, the species had been detected by wildlife professionals according to Descalzo et al. (2021), and in 264 by hunters (Table 1; Figure 1). For all the study area, the OPA between information provided by hunters and professionals was 85.9%, the PPA was 72.9%, and the PNA was 90.5%. Despite the high overall (positive and negative) agreement between both sources, the McNemar test indicated that hunters and professionals provided significantly different records of the Egyptian mongoose occurrence in CLM ($P < 0.01$; Table 1).

The proportion of positive agreement was also high between both groups in the core area of the mongoose distribution (i.e., western CLM; Figure 1). In that case, the mongoose was detected by hunters and professionals in 173 municipalities out of 306. It was detected only by hunters and only by professionals in 70 and 29 municipalities, respectively, whereas it was not detected by any informant in the remaining 34 municipalities (Table 1). For this core area, the OPA was 67.6%, the PPA was 77.7%, and the PNA was 70.7%. The McNemar test also indicated that hunters and professionals provided significantly different records of the Egyptian mongoose occurrence in the core area ($P < 0.01$; Table 1). In the marginal area, the mongoose was only detected in 2 out of 615 municipalities by both informants, in 19 municipalities only by hunters, and in 12 municipalities only by professionals; it was not detected by any informant in the remaining 582 municipalities (Table 1). For this marginal area, the OPA was 95.0%, the PPA was 11.4%, and the PNA was 97.4%. The McNemar test indicated that there were not significant differences between the records provided by hunters and professionals in the marginal area ($P = 0.281$; Table 1).

TABLE 1 Numbers and percentages of municipalities in which wildlife professionals and hunters detected and did not detect the Egyptian mongoose in the Castilla-La Mancha (CLM) region (921 municipalities), the core area of the mongoose distribution within CLM (306 municipalities within Toledo and Ciudad Real provinces), and the marginal area of the mongoose distribution within CLM (615 municipalities within Guadalajara, Cuenca and Albacete provinces) in central Spain during 2000–2021.

	Wildlife professionals	
Area	**Detected**	**Not detected**
CLM region		
Hunters		
Detected	175 (19.0%)	89 (9.7%)
Not detected	41 (4.4%)	616 (66.9%)
Core area		
Hunters		
Detected	173 (56.5%)	70 (22.9%)
Not detected	29 (9.5%)	34 (11.1%)
Marginal area		
Hunters		
Detected	2 (0.3%)	19 (3.1%)
Not detected	12 (1.9%)	582 (94.7%)

DISCUSSION

The Egyptian mongoose was detected by both wildlife professionals and hunters in a high number of municipalities within CLM, corresponding mostly to the area with established mongoose populations (the core area: Toledo and Ciudad Real provinces), thus where they would likely be more easily detected. There was an overall congruence between both groups of informants regarding the main distribution area of the Egyptian mongoose in all CLM, suggesting that both sources of information may be valuable to compile records of occurrence of a non-game wildlife species. Despite this high overall congruence, our analysis reported statistically significant differences between mongoose occurrences provided by both informants, which could be related to hunters reporting the presence of the Egyptian mongoose in municipalities where the species was very rarely detected by professionals. For instance, professionals recorded mongoose observations in fewer municipalities (Descalzo et al. 2021) within CLM than did hunters (Figure 1B; Table 1). Most of these additional municipalities were placed in eastern areas of Toledo and Ciudad Real provinces, and in some areas of the eastern provinces of CLM (Figure 1B). This suggests that hunters may provide additional information on the distribution of a non-game species, and that it would be beneficial if hunters were given opportunities to participate in citizen science-style ecological monitoring projects (Locke et al. 2019). In agreement with our results, Galván et al. (2021) reported that 2 databases containing observations of birds that were obtained by citizen science volunteers and professionals were different but complementary, although they did not assess the knowledge about the target species reported by citizen science volunteers.

Our analysis also showed that the information provided by hunters and professionals in the core area was significantly different, although the mongoose was detected in most of the municipalities within the core area by both informants, as indicated by the high OPA and PPA values in that area (Table 1). In the marginal area, hunters detected the mongoose in more municipalities than professionals (21 vs. 14, respectively; Table 1), although the McNemar test demonstrated that such differences were not statistically significant. Nonresponse bias occurs when participants are unwilling or unable to respond to a survey (Koch and Blohm 2016). In our study, most respondents mainly hunted in municipalities within the main mongoose distribution range (Figure 2), which likely suggests a lower engagement in the survey of hunters from the marginal area, who would be less motivated because of their lower interaction with (and likely knowledge of) the species. This might have resulted in an underestimation of mongoose occurrence in the marginal area, which may have also happened, at least partially, in the rangers' survey, as we obtained few responses from northeastern area of CLM (Figure 2). In contrast, it could be that either hunters or professionals would be more likely to recall instances where they saw the mongoose in unexpected areas, which might have caused an overestimation of mongoose occurrence in the marginal area. Further research would be needed to confirm any of these possibilities. The pattern observed in the core area would be supported by the presence of offspring mostly in the municipalities in which both informants detected the species (i.e., western part of the study area; Figure 1C) corresponding to the areas where the Egyptian mongoose is apparently well established (Descalzo et al. 2021). Hunters also observed offspring in a few municipalities where professionals had not seen this mongoose, but such municipalities are bordering others where the species had been detected by both groups of informants (Figure 1C).

It could be argued that hunters could have misidentified the mongoose in our survey, either unintentionally or intentionally, because the Egyptian mongoose is often perceived by hunters as a threat for small game (Martínez-Jauregui et al. 2017). We only considered the records provided by hunters who identified the species correctly to reduce this possible source of bias. In addition, the high agreement with occurrence data provided by professionals in the core area would also support the reliability of hunters' reports. A potential limiting factor of this study is that hunters were surveyed in 2021, while the questionnaire to environmental rangers was collected 3 years before. This temporal mismatch between both surveys could have skewed the estimates, as the mongoose might have expanded in the study area between 2018 and 2021, thus potentially increasing the likelihood to be observed by hunters; in other words, some records reported only by hunters could correspond to recently colonized areas from which the mongoose could have been absent when the rangers' survey was conducted. Nevertheless, we collected additional observations by professionals (including direct observations, road-killed animals, camera records) for

2018–2021, and therefore it is likely that the presence of the species in those allegedly new colonized areas would have been also detected by professionals.

Anhalt-Depies et al. (2019) reported that public collaboration projects are often used to achieve multiple scientific and social goals. In particular, collaborative wildlife monitoring at a large scale may allow researchers to improve the knowledge of the situation and perceptions of wildlife species, answering many important ecological and evolutionary research questions (He et al. 2016, Werenkraut et al. 2020). Those programs must consider the quality of the information obtained in addition to privacy protection, resource security, transparency, and trust (Anhalt-Depies et al. 2019). Our results resemble those obtained by Crall et al. (2015) who reported a high level of agreement between data provided by volunteers and professionals in regard to the trends of 5 invasive plant species. Recently, Cretois et al. (2020) suggested that hunters may constitute an important data source for biodiversity conservation in Europe because they can provide a wide range of relevant information regarding game species. Further, Miller et al. (2013) considered the data provided by hunters as a viable survey method to monitor range dynamics of grey wolves at large geographical scales. Our study suggests that hunters may also provide valuable information on the occurrence of non-game species like non-game carnivores, and particularly in areas where those species are expanding.

MANAGEMENT IMPLICATIONS

Overall, this study stresses the need to promote a more active engagement of hunters in wildlife conservation via mechanisms such as citizen science. When using citizen science, it is essential to check data quality; for example, assessing informants' knowledge about the target species is needed to reduce biases associated with misidentification. Wildlife managers are beginning to recognize the value of this approach. Such collaboration could contribute to consistent collection of information on wildlife occurrence across wide geographic areas where hunting is practiced across wide territories.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS STATEMENT

All procedures performed in this study were in accordance with the ethical standards of the institution or practice at which the study was conducted. In particular, the questionnaire and the protocol were approved by the Consejo Superior de Investigaciones Científicas Ethics Board (certificate 157/2020). Our study adhered to the basic ethical principles for conducting research that involves the participation of human subjects. In particular, hunters entered into this research voluntarily and with adequate information on the purpose of the study. In addition, each participant was informed about the safeguard of the privacy, confidentiality, and anonymity of all the information they could provide, according to Spanish law of data protection. Importantly, our research did not request any personal data, and the facts and opinions collected could not be linked to any physical person. In the first page of the online questionnaire, we requested the consent of the hunters and environmental rangers to participate after explaining the purpose of the study, measures to ensure confidentiality, and the voluntary nature of participation in the study. Finally, we added a contact information for where questions or concerns could be directed.

DATA AVAILABILITY STATEMENT

Data consist of records of Egyptian mongoose provided by hunters and professionals and such records are shown in the figures.

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