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RESEARCH

Cost-effectiveness of lures in attracting mammals: a large scale camera-trapping field test on European species

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Abstract
The cost-effectiveness of different attractants during camera trapping surveys has been seldom evaluated. To contribute in filling this knowledge gap we (1) compare the effectiveness of a suite of attractants in detecting widely distributed mammals in Europe and (2) evaluate the cost-effectiveness of these attractants, by calculating the costs associated to reach a specific monitoring objective. We conducted a large-scale field experiment across four study areas in central and northern Italy, encompassing a variety of environments, from lowland forest to alpine beech forest. We focused on comparing the following low cost and readily available attractants: sardines, peanut butter, a commercial lure and we used a camera with no attractant as control, collecting data on a suite of small to large mammals. We found that for seven of our 13 target species detectability varied with the type of attractant used. Specifically, sardines proved to be the most effective attractant for canids and the porcupine, peanut butter was most effective for mustelids but was avoided by the roe deer, whereas the commercial lure was the most effective with red deer. Through a power analysis combined with a cost function analysis we were able to show striking differences in the cost-effectiveness of the different methods, sometimes in the order of magnitude of tens of thousands of euros, which strongly emphasizes the critical importance played by the choice of whether to use an attractant or not and the type of attractant to be used.

Keywords Attractants · Detection probability · Occupancy models · Power analysis · Monitoring

Introduction

While there is widespread consensus on the fact that camera-trapping is revolutionising the way we study wildlife (Rovero and Zimmermann 2016; Steenweg et al. 2017; Kays et al. 2020) less consensus exists on how to deploy such cameras. In particular, the use of attractants is debated (Rovero and Zimmermann 2016; Stewart et al. 2019). Clearly, both approaches have pros and cons, such as attractants increasing detection probability and thus statistical power, but also luring or, instead, repelling animals, thus possibly altering species-habitat relationships and abundance estimation (Rovero and Zimmermann 2016; Wearn and Glover-Kapfer 2017, 2019).Certainly, the decision of adopting attractants or not depends on the objectives, scales of the study, target species (and single-species vs. community monitoring), as well as resources available.

Our goal here is to contribute in developing an optimal use of attractants. A wide variety of attractants have been used in the past such as sardines, synthetic fatty acid scent, salmon oil, meat, valerian extract, etc. (Mills et al. 2019; Steenweg et al. 2019; Buyaskas et al. 2020; Fidino et al. 2020; Sebastián-González et al. 2020; Iannarilli et al. 2021). Some times these are used as bait (i.e. the animal consumes the attractant; Sebastián-González et al. 2020; Rendall et al. 2021) or more often these are used as lures (no consumption) (Buyaskas et al. 2020; Avrin et al. 2021). The effectiveness of an attractant is inevitably species-specific, but some attractants such as sardines or skunk-based essences are clearly amongst the favorites of researchers (and

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animals) (Gommper et al. 2006; Buyaskas et al. 2020; Avrin et al. 2021). A bias does exist however, whereby attractants have been widely tested in North America (Steenweg et al. 2019; Buyaskas et al. 2020; Avrin et al. 2021; Iannarilli et al. 2021), whereas the effectiveness on European species has been tested less and clear winners have not emerged yet. Most importantly, rigorous testing requires the ability of researchers to infer actual *selection*, rather than just *use* (Manly et al. 2002), which implies that a use-availability design needs to be adopted. In a use-availability design all lures are available to be detected within relatively short distance (Buyaskas et al. 2020), whereas with other study designs attractants are compared among sites relatively far apart (Ferreras et al. 2018; Ribeiro and Bianchi 2019; Heinlein et al. 2020), therefore background noise is introduced in the study as the use itself depends on the probability that a species was present close to the specific attractant being tested. In such cases, inference is limited to the probability of use of an attractant, but not on the actual selection of it.

An additional knowledge gap within the field is the lack of a rigorous assessment of the cost-effectiveness of different techniques. In particular, quantifying the differential costs associated with different attractants is important and warrants special consideration. We are not referring to the cost of the attractant itself, but rather on the economic consequences of differential detectabilities. Specifically, to obtain a specific statistical power an effective attractant will require a lower sample size (i.e. number of sites to be surveyed) than a less effective one, and thus monitoring a given species with a highly effective attractant may result significantly cheaper than a less effective one.

Our goal here is to contribute filling these two knowledge gaps. Specifically our objectives are:

1. To compare the effectiveness of a suite of attractants in detecting a suite of widely distributed European mammals.
2. To evaluate the cost-effectiveness of these attractants, by evaluating the costs associated to reach a specific management objective.

To achieve our objectives we conducted a large-scale field experiment across four study areas in central and northern Italy, encompassing a variety of environments, from lowland forest to alpine beech forest. We focused on comparing the following low cost and readily available attractants: sardines, peanut butter, a commercial lure for canids and *Martes* spp. and a control camera (no attractant, Fig. 1).

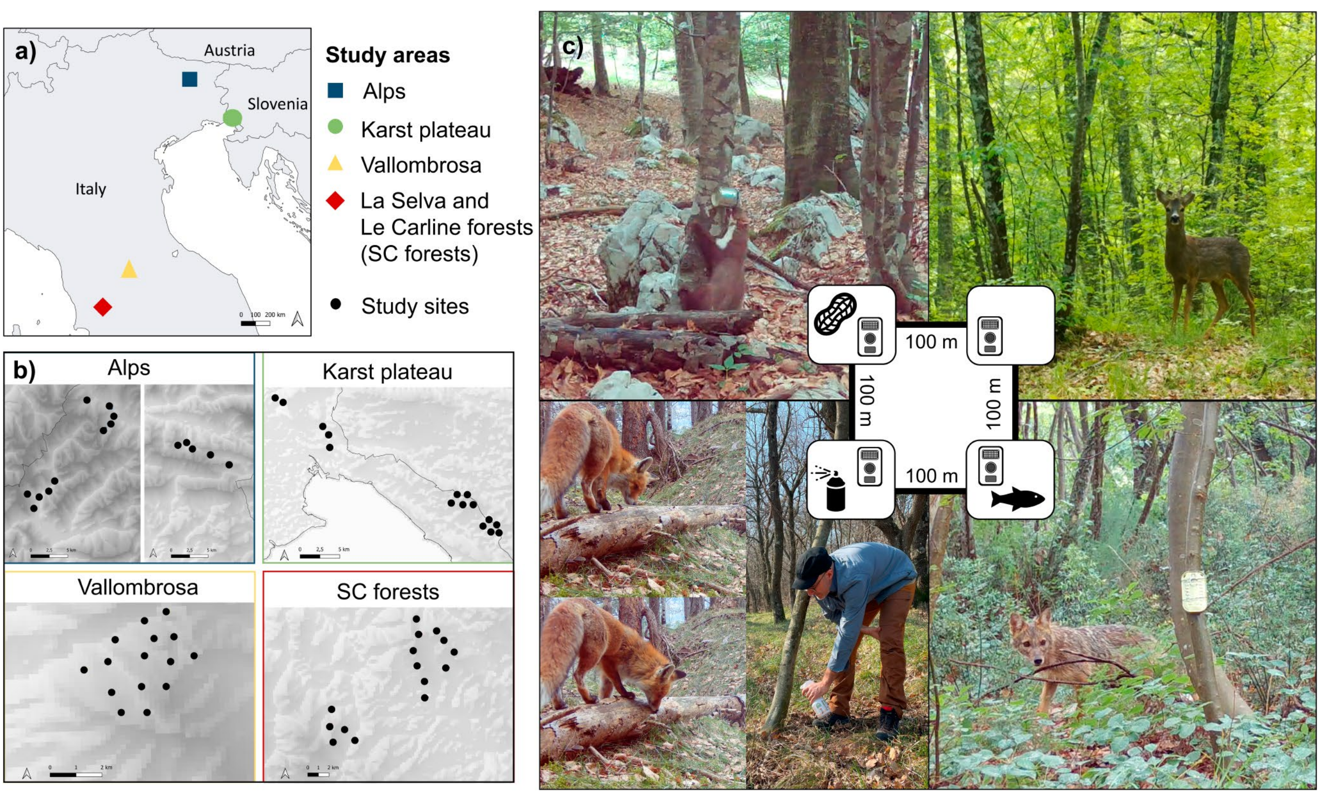

Fig. 1 Study areas and study design. The study was conducted in four areas located in central and northern Italy **(a)** and it encompassed 60 sites **(b)** and 240 camera trapping stations. **(c)** Each site included four stations positioned at the four vertices of a square and each station included either a treatment (sardine lure vs. peanut butter vs. commercial lure) or a control camera (no treatment). Sites were distanced ca. 1 km whereas stations were distanced 100 m

Materials and methods

Study areas

Our study was conducted in 4 study areas: the Karst plateau (Friuli Venezia Giulia region), the Alps (Friuli Venezia Giulia region), the La Selva and Le Carline forests in the Province of Siena (Tuscany) and the Biogenetic Natural Reserve of Vallombrosa area (Tuscany) (Fig. 1). All of these areas are characterized by predominantly deciduous forests, with dry woodland dominated by *Quercus cerris* and *Q. pubescens* in the Karst region and in La Selva and Le Carline forests, *Fagus sylvatica* forest in the Alps. La Selva and Le Carline hills are also characterized by the presence of conifers dominated by *Pinus nigra*, *Castanea sativa*, *Q. cerris*, and *F. sylvatica* in Vallombrosa, where the sampling area also included the presence of conifers such as *Abies alba*, *P. nigra* and *P. sylvestris*. The climate in these areas ranges from continental to mild sub-Mediterranean in the Karst, with an average annual temperature of 13 °C and annual rainfall of 1385 mm; in the Alps, the average annual temperature is around 9 °C and rainfall is abundant, ranging from 1500 to 3000 mm/year. The La Selva and Le Carline forests have Mediterranean climate with an average annual temperature of 15 °C and annual rainfall of 750–1600 mm. Similarly the Vallombrosa forest has a Mediterranean climate, with an average annual temperature of 9.7 °C and annual rainfall of 1200 mm concentrated in the fall and winter seasons.

Field experiment

This study was conducted during spring (March-June) 2023, following the approach of Buyaskas et al. (2020) who compared the effectiveness of attractants in detecting mammals in Maine (USA). At each *site* we compared three treatment lure *stations* with a control camera *station* with no lure (Fig. 1). Treatments included: (a) *sardines*: we attached tin of sardines in olive oil to a tree and perforated in the upper part, to allow the odor to spread and some oil to drip, (b) *a commercial lure* (Fuchslockmittel produced by EURO-HUNT and containing 2,5-Dimethyl-4-hydroxy-3-furanone) designed to attract foxes, martens and other carnivores and (c) a tin with two tablespoons of *peanut butter*. The open end of the tin was covered with wire mesh (1 mm side) to allow odor to spread but the peanut butter to be inaccessible for consumption (Fig. 1). The tin was positioned parallel to the ground to prevent water from filling it. Treatment and control stations were positioned at the vertices of a square, distanced 100 m from each other. Treatments were positioned in random order at approximately 30–40 cm from the ground, 3–4 m from the IR camera. Stations were meant to be dependent among each other (see below), but sufficiently far that each station was not directly visible from the other stations. Distance between sites was at least 1000 m (average distance between sites within each area = 1195 m) to approach independence among sites (i.e. reduce the chances that an individual would visit multiple sites). We deployed a total of 60 sites (15 in each of the 4 study areas) and 240 camera trapping stations in total. Within each of our four study areas we used the same camera model. Specifically, we used Browning Elite HP4 Spec-Ops for the Karst and Alps region, Bushnell Trophy Cam Aggressor No Glow for the La Selva and Le Carline area and Browning Dark Ops for the Vallombrosa areas. All the cameras are comparable in terms of detection speed and clarity of images. Cameras for the Alps region, the Karst and La Selva and Le Carline were set to record a 10 s video, whereas in Vallombrosa cameras were set to produce a sequence of 8 pictures in 2.5 s, with a delay between sequences of 1 s. Both settings were adequate to allow us to identify the species.

Detection history data were generated using 24 h time bins (12 PM to 11:59 AM), whereby if at least one video or photo of a species was detected we considered that a detection of the species for the time period (a visit to the site sensu Mackenzie et al. 2017). Cameras were left active for 14–21 days in each site, the attractants were not replenished during this time period. Cameras active for 14 days were considered to have missing visits for days 15–21 (sensu Mackenzie et al. 2017).

Data analysis

We analysed data only for species detected at > 10% of sites, which included: the golden jackal (*Canis aureus*), wolf (*Canis lupus*), red fox (*Vulpes vulpes*), *Martes* spp. (we were unable to discriminate with certainty between the beech marten *M. foina* and the pine marten *M. martes*), European badger (*Meles meles*), wild cat (*Felis silvestris*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), European hare (*Lepus europaeus*), porcupine (*Hystrix cristata*) and red squirrel (*Sciurus vulgaris*).

In the case of the golden jackal absent from Tuscany, the red deer (absent from the La Selva and Le Carline area) and the porcupine (absent from the Karst and the Alps) we included only data from the areas were the species was known to be potentially present.

We fitted single season multi-method models (Nichols et al. 2008) for each of the 13 target species using PRESENCE software (2.13.42; Hines 2006). These models allow the estimation of the following parameters: *psi* (occupancy probability of the whole station, that is the probability that a member of the target species occupies a home range and uses the landscape surrounding the survey station), *theta* (probability of presence at the immediate sampling station conditional on occupancy of the site) and *p* (probability of detection given that both the overall area is occupied and the species is in the immediate area of the survey devices). This specific model allows for dependence between the different stations (i.e. between the four cameras spaced 100 m apart) (Nichols et al. 2008). Models were ranked based on the Akaike Information Criterion score, corrected for small sample size (AICc). We followed the Information-Theoretic Approach (Burnham and Anderson 2002), therefore 2 Delta AICc was used as a threshold to evaluate relative support of a model. Predictions were based on the top ranked model and following Sutherland et al. (2023) we used 85% CI to represent uncertainty around predictions.

We followed a two stages data analysis approach. In the first stage we compared the AICc of the null model (*p* constant across treatments and control station) with the AICc of the 'method' model (i.e. detectability specific to the treatment). A null model within 2 Delta AICc of the top model implies no preference for any of the method, but also no

Table 1 Top ranking model set including all models within 2 Delta AICc of the top model for the 13 target species occupancy models of the psi = probability of presence in a site; theta = probability of presence at the immediate sampling station conditional on occupancy of the site; p = probability of detection. Area = categorical variable representing study area (Karst, Alps, Vallombrosa, La Selva and Le Carline); days = continuous variable representing days since start of the survey in a given site; method = method specific detectability

Species	Model	Delta AICc	Weight
Martes spp.	*psi*, *theta*(Area), *p*(Method)	0.00	0.63
Meles meles	*psi*, *theta*(Area), *p*(Method)	0.00	0.6
Canis aureus	*psi*, *theta*(Area), *p*(Method)	0.00	0.88
Vulpes vulpes	*psi*, *theta*(Area), *p*(Method + Days*Method)	0.00	0.45
	psi, *theta*(Area), *p*(Method)	0.52	0.35
Felis silvestris	*psi*, *theta*(.), *p*(.)	0.00	0.88
Canis lupus	*psi*, *theta*(.), *p*(.)	0.00	0.68
	psi, *theta*(Area), *p*(.)	1.74	0.28
Capreolus capreolus	*psi*, *theta*(Area), *p*(Method)	0.00	0.99
Cervus elaphus	*psi*, *theta*(Area), *p*(Method + Area)	0.00	0.80
Dama dama	*psi*, *theta*(.), *p*(.)	0.00	0.55
	psi, *theta*(.), *p*(Method)	0.45	0.44
Sus scrofa	*psi*, *theta*(Area), *p*(.)	0.00	0.56
	psi, *theta*(Area), *p*(Method)	0.55	0.43
Lepus europaeus	*psi*, *theta*(Area), *p*(Method)	0.00	0.4
	psi, *theta*(Area), *p*(.)	1.83	0.16
Hystrix cristata	*psi*(.), *theta*(.), *p*(Method + Area)	0.00	0.52
	psi theta (Area), p (Method + Area)	1.78	0.21
Sciurus vulgaris	*psi*, *theta*(.), *p*(.)	0.00	0.56
	psi, *theta*(.), *p*(Method)	1.05	0.33

avoidance. In the second stage, the effects of additional covariates affecting the probability of detection and the psi/theta were taken into account. Predictor variables included: (1) time since deployment (i.e. days) to account for trap shyness (Gommper et al. 2006; Foresman and Pearson 2017) and possible decay in the effectiveness of the lure, modeled only for *p*; we included both a simple (i.e., the effect of time being the same across all methods) and a methods specific model (i.e. slope varying across methods, which implied that, as an example, the effect of decay varied among lures) (2) *Study area*, a categorical covariate (Table 1), which was included as a predictor for both *psi*/*theta* and *p*.

To compare the cost-effectiveness of the different methods we conducted a power analysis for occupancy models following the approach developed by Guillera-Arroita and Lahoz-Monfort (2012). Specifically, the algorythms developed by Guillera-Arroita and Lahoz-Monfort (2012) can be used to estimate the number of sites to be surveyed to achieve a given power as a function of the significance level (α) and effect size (i.e. percent decline to be detected), given *psi* (occupancy probability), *p* (detection probability), and the number of visits (survey days). For this simulation we set power = 0.8 (i.e., probability of detecting a decline when it is actually occurring; (Elzinga et al. 2007), α = 0.05 (i.e. probability of detecting a decline when it is not occurring, equivalent to a making a type 1 error; (Elzinga et al. 2007), number of visits = 21 (i.e., 21 days, as adopted in this study), *psi* = 0.8 (high occupancy) and effect size = 25%. The effect size is the magnitude of the decline that we are able to detect. We chose 25% (Dri et al. 2022; Mortelliti et al. 2022) as this is not too coarse (such as 50%) or particularly sensitive (such as a 10% decline). We acknowledge that the choice of these parameters reflect arbitrary decisions, nevertheless we emphasize that the pattern of results (and implications) would not change significantly with different values.

We developed the following cost function to estimate the cost of surveying a single site. *Cost of surveying a site = Cost of batteries + Cost per km of conducting a survey + cost of one item of lure*. The total cost of a monitoring program was obtained by multiplying the Cost of surveying a site by the total number of sites required to be monitored (i.e., the output of the power analysis discussed in the previous paragraph).

For the cost of batteries we estimated a cost of 5.2€ per site/deployment, which was obtained by using a cost 2.62€ per battery (AA lithium batteries), using 6 batteries per camera with each set of batteries covering 3 deployments (i.e. 3 sites). For the cost per km of conducting a survey, we used an average value of 100 km per site (inclusive of positioning and retrieval of traps) and a cost of 0.755€ per km following the Italian Automobile Club Association guidelines. We used a cost of 1.5€ per can of sardine, 1€ per peanut butter (calculated on a cost of 10€ per can whereby 1€ is equivalent to two tablespoons) and 1.7€ for the commercial lure (based on a total cost of a bottle of 50€). In the case of using sardine and peanut butter we also included a cost of 0.5€ per site to cover the cost of metal wire.

Results

Through a total of 1047 trap nights of activation we detected 15 mammalian species (a sample of videos is included in the Supplementary Video 1). In addition to the target species listed above we detected brown bear (*Ursus arctos*) and Alpine chamois (*Rupicapra rupicapra*) in < 10% of sites. The most widespread species was the roe deer (detected in 51 sites, across all study areas) and the least widespread was the golden jackal (detected in 8 sites, only in the Karst and Alps study area, 30 sites in total). The 'method' model was the top ranking model in the case of 7 species, including two canids (golden jackal and red fox), three mustelids (badger and *Martes spp.*), two Artiodactyla (red deer and roe deer) and a Rodent (porcupine) (Table 1, Table S1, Figs. 2 and 3 and Fig. S1), whereas for the remaining 6 species it was not included in the top model set or it was, but within 2 delta AICc of the null model (Table 1). Sardines were the most effective attractant for the Canids (golden jackal and red fox) and the porcupine, whereas peanut butter was the most effective for mustelids (badger and *Martes* spp.). In the case of roe deer we found an avoidance of peanut butter (Fig. 3).

The results of the power analysis show how differences in required sampling effort (and costs) between the different attractants and no attractants can be dramatic (Fig. 4).

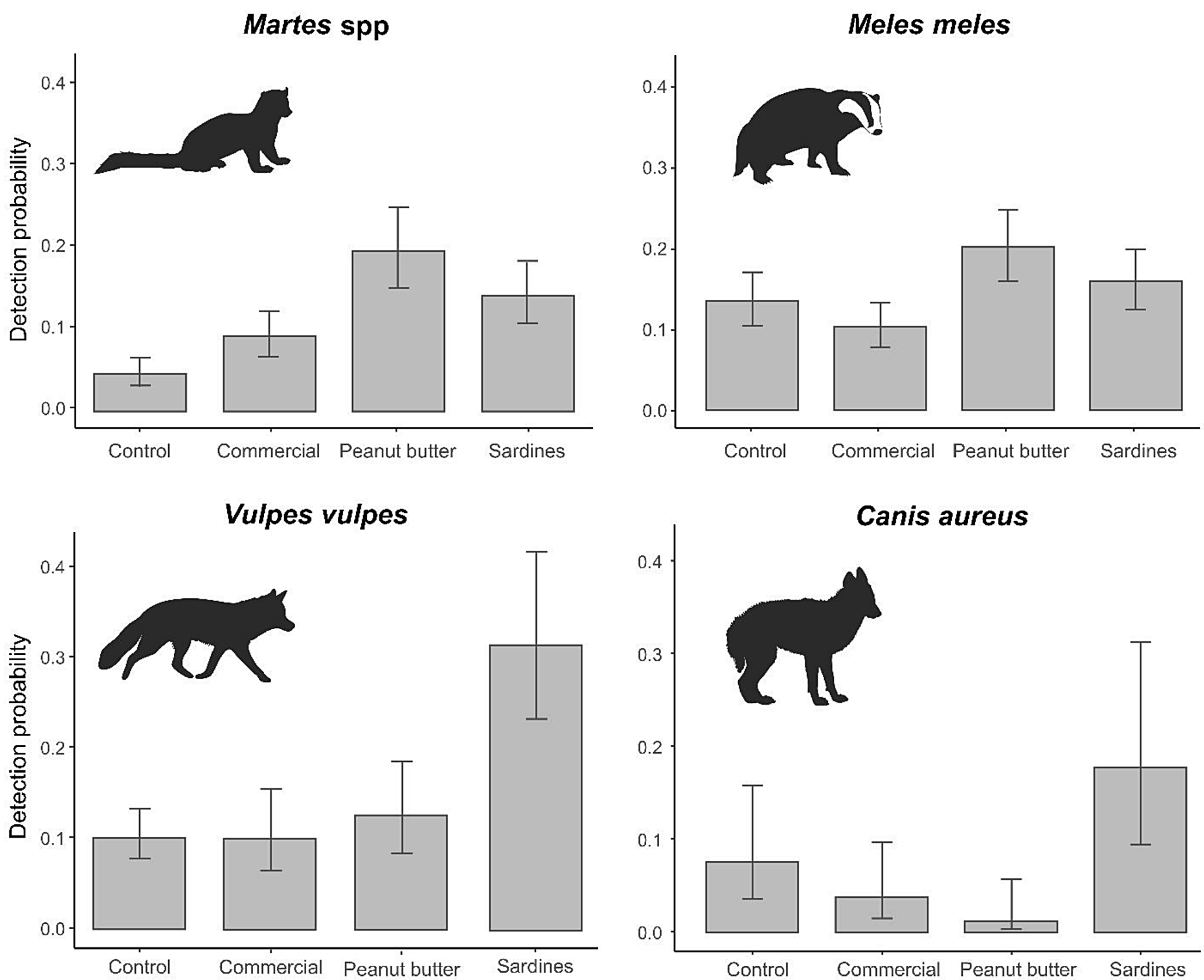

Fig. 2 Predictions from the top ranking model for species within the order Carnivora (only species with treatment included as the top model are shown). In the graph we show the detection probabilities (with 85%CI) for the three attractant tested and for the control camera (no attractant). When the top ranking model included the variable 'time since deployment' (Vulpes vulpes), we show the detection probability for day 1

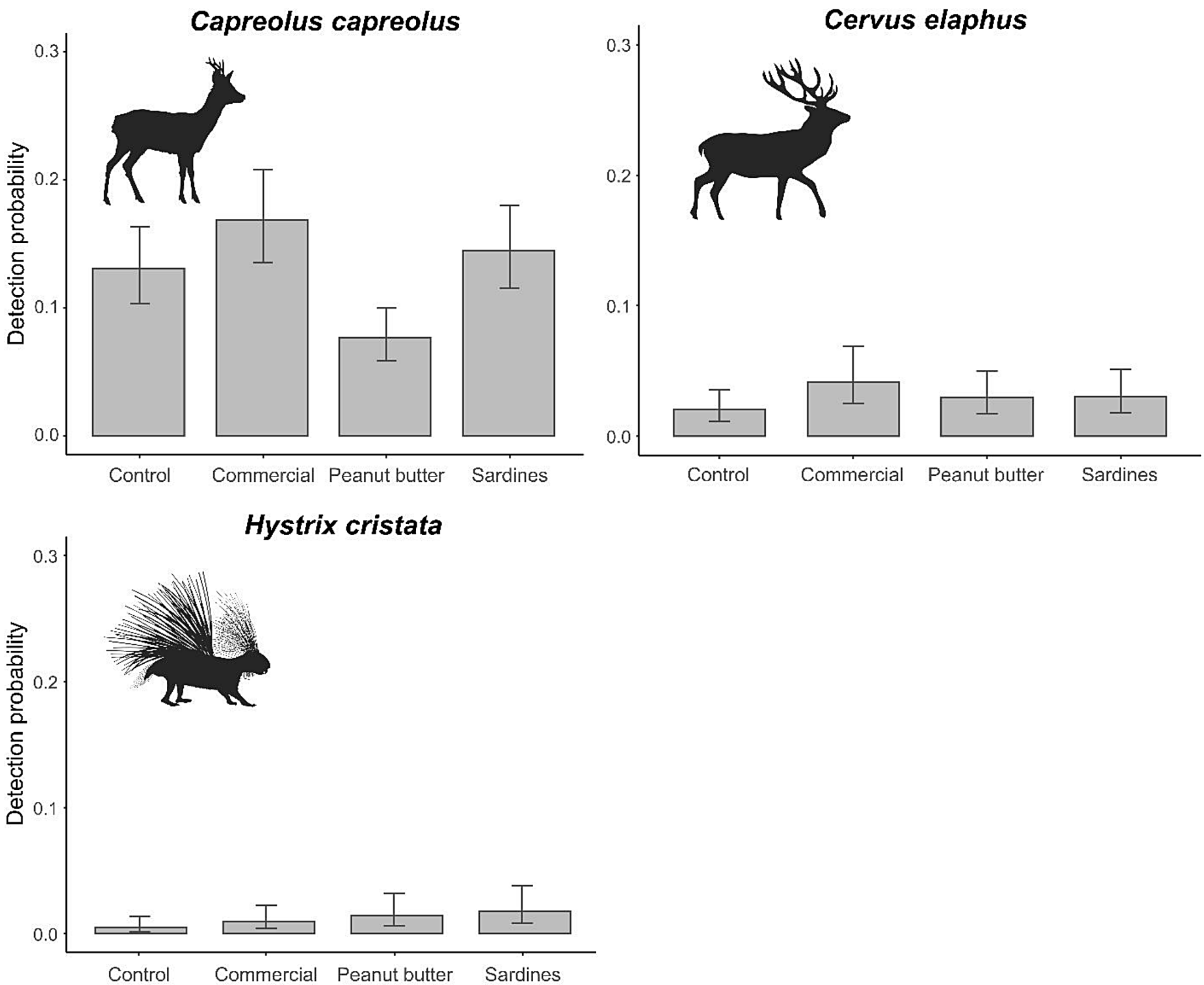

Fig. 3 Predictions from the top ranking model for species within the order Artiodactyla and Rodentia (only species with treatment included as the top model are shown). In the graph we show the detection probabilities (with 85%CI) for the three attractant tested and for the control camera (no attractant). When the top ranking model included the study area variable (Cervus elaphus and Hystrix cristata), we show the detection probability for Vallombrosa

As an example, in the case of the *Martes* spp. monitoring protocol, using peanut butter will require 82 sites (6744 €) as compared with a camera without attractant requiring 486 sites (or 39244 €).

Discussion

Through our large scale field experiment we found that for seven of our target species detectability varied with the type of attractant used. Specifically, sardines proved to be the most effective attractant for canids and the porcupine, peanut butter was most effective for mustelids but was avoided by the roe deer, whereas the commercial attractant was the most effective with red deer. Our power analysis showed dramatic differences in the cost-effectiveness of the different methods, which strongly emphasizes the critical importance played by the choice of whether to use an attractant or not and the type of attractant to be used.

Sardines as an attractant

Sardines are a widely used attractant due to their low cost, strong odor and ease of use (a pinched tin of sardines can be used as a lure rather than bait) (Avrin et al. 2021; Siegfried et al. 2024). We acknowledge that sardines may be difficult to use in areas with high density of bear, such as in North America, but proved to be effective in Italy, despite the high density of wild boar in some of our study areas. Indeed

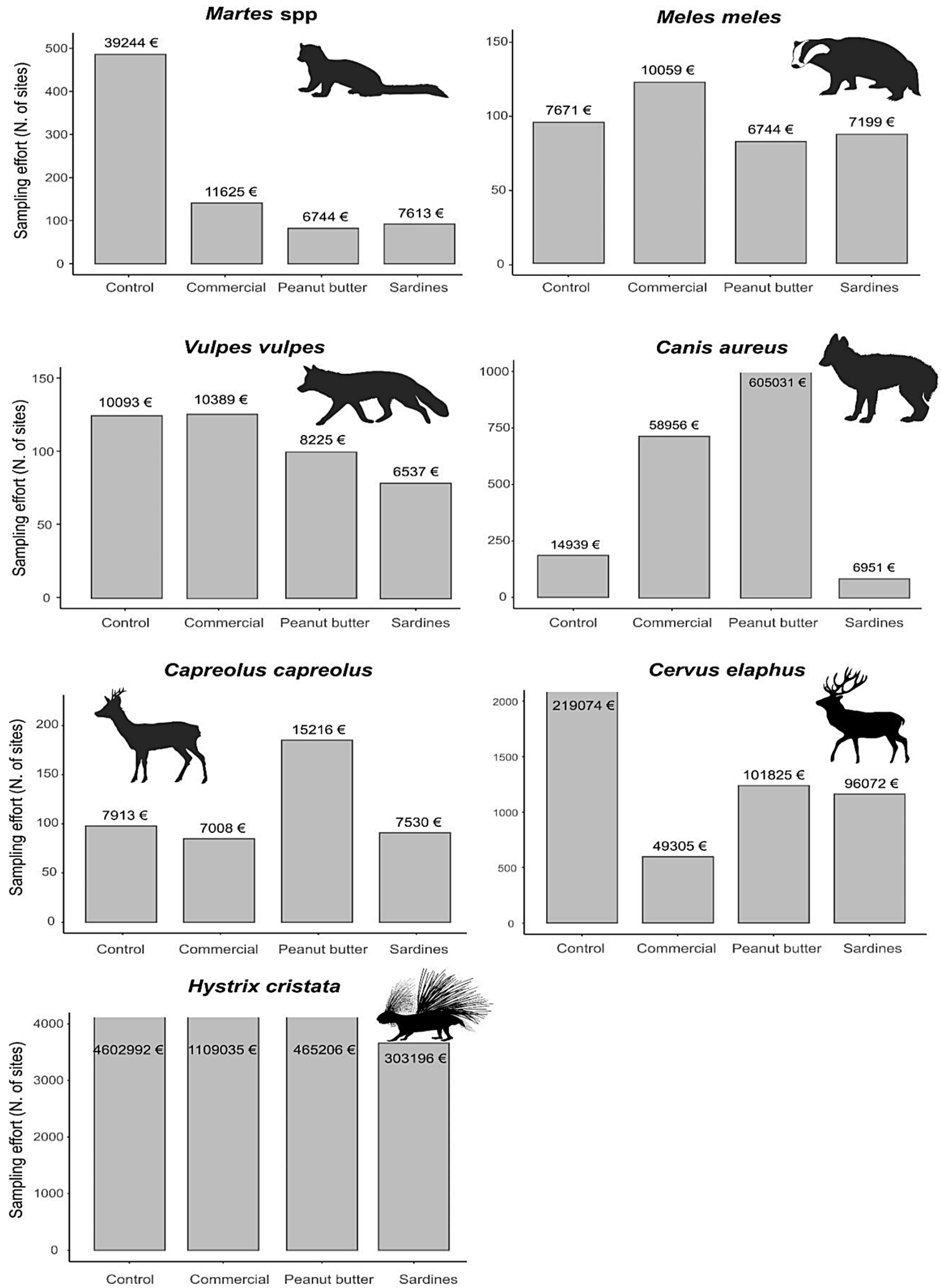

Fig. 4 Predicted sampling effort (number of sites) and associated cost (in €) to detect a 25% decline of the target species (with an α = probability of type 1 error = 0.05 and power = probability of detecting a change when this is actually occurring = 0.8). Sampling effort and costs for Cervus elaphus and Hystrix cristata were estimated using the probability of detection of Vallombrosa, while for Vulpes vulpes the sampling effort and costs were estimated using the probability of detection of day 1

100% of our deployed sardine cans were retrieved after 2–3 weeks, despite attacks conducted by several species.

Peanut butter as an attractant

The effectiveness of peanut butter with the mustelids (badger and *Martes* spp) was not surprising given the omnivore based diet of these species (Boitani et al. 2010). Instead, the avoidance of peanut butter observed for the roe deer is intriguing. This pattern is unlikely to be an indirect avoidance of predators, since jackals avoided peanut butter too, and wolves showed no preference for any lure. We suspect this result could be possibly caused by the container used (Fig. 1), which may possibly result as scary for some species. However we note that the materials, size and brightness of the container are very similar to the can of sardines, which was not avoided by any species. We suggest further studies to be conducted to clarify this pattern.

Effectiveness of the commercial lure

The commercial lure proved to be relatively ineffective, including on fox and *Martes* spp., which are supposedly the main target of this attractant. Interestingly, the red deer showed a positive association with this attractant. Besides curiosity, it is possible that the musky odor may resemble some natural resource or gland secretion (Lawson et al. 2000; Boitani et al. 2010) thus eliciting some kind of positive reaction by this species. We note that no species avoided this attractant, nevertheless, as shown in Fig. 2, it did not outperform any of the other attractants, which is in line with previous studies using this attractant (Cozzi et al. 2022).

Differences among species

A clear pattern emerging from our study is also the fact that the effectiveness of attractants varied by species, which implies there is no clear winner (i.e. an attractant that will maximise the detection of a large portion of the community). The avoidance patterns observed for the peanut butter (but see considerations above) coupled with the relatively high detectability of sardines for several species, including the badger and *Martes* spp., suggest this may be the attractant providing the most detection pattern. We note the decay in detectability associated with sardines observed in the case of the red fox (Fig. S1), which needs to be considered when planning a study. As can be seen in Fig. S1, detectability decreased from 0.3 to 0.1 over a 20 day period. Possible solutions to this decay could be (a) if logistically feasible and economically sustainable, replenish the lure after some time, such as after a week, and (b) calculate sampling effort based on detectability at day 10 (half way through the survey). Nevertheless we also note that the decay in detectability was not observed for the other species.

We note that for several species we could not find convincing evidence for a positive effect of any of the treatments (Table 1). In the case of wolf and wild cat, we acknowledge the relatively small sample size (the species were detected in 9 and 10 sites respectively). In the case of the wild boar the species was relatively common (detected in 34 sites) with comparably high detectability for all methods (slightly higher for sardine and peanut butter) as well as for the control camera. These results are in line with the generalist and opportunistic ecology of the wild boar (Ballari and Barrios-García 2014).

Results of the power analysis

Our sample size estimations obtained through the power analysis (Fig. 4) show very clearly how the cost implications of choosing one attractant over another one or choosing to not use an attractant can be substantial. Indeed, in some cases obtaining a sufficient statistical power without an attractant is simply not possible, which implies that regardless of effort a given program will never be able to reach the monitoring goals or will have to re-adjust goals (such as aiming to detect a 50% decline rather than 25%, or accept a higher type 1 error; Elzinga et al. 2007). While our power analysis exercise was only an example, it underscores the critical importance played by conducting such analyses prior to commencing monitoring (Fagiani et al. 2014; Mortelliti et al. 2022; Dri et al. 2022), which will inevitably lead to a careful evaluation of what is an achievable objective, what is not (Yoccoz et al. 2001; Elzinga et al. 2007; Wintle et al. 2010) and what are the advantages and consequences of using or not an attractant. We emphasize that we conducted analyses assuming a high probability of presence (details in methods), and that differences may be even higher with lower probabilities of presence. Furthermore, we also acknowledge that the costs used to develop our cost function (details in methods) may vary between countries, but the relative differences between them would remain unchanged as the major driver of the overall cost is the number of sites to be surveyed. In other words, while the absolute cost of a monitoring program could vary, the relative differences among methods would remain very similar and thus the implications of our study are generalizable to other countries and variations in costs.

Limitations of our study

While our study was conducted over a large area, encompassing a strong latitudinal and environmental gradient, we acknowledge it was only limited to one season (spring 2023) and therefore replication across seasons and years and areas with additional species would definitely help generalize these results. We also acknowledge that we could only test 3 different attractants (but we note this is in line with similar studies). In particular it would be interesting to compare effectiveness of a skunk based lure, which is a very common, and effective, type of lure used predominantly in North America (Gompper et al. 2006; Buyaskas et al. 2020). Despite the effectiveness of skunk-based lure, we note these would be virtually impossible to purchase institutionally in countries plagued by bureaucracy, such as Italy.

Finally we emphasize that, while we explicitly and purposefully kept treatment and control stations close, it is also possible that this may have led to an increase in detectability of some treatments or the control (e.g. the species is attracted by sardines, but then ends up visiting also the peanut butter station or passing by the control camera). Nevertheless, we believe that if that were the case, differences among treatments would be sharper for the 7 species included in Figs. 2

and 3, and possibly more species would be included in the list of species affected by attractants. Indeed, we caution readers on applying our detectability values to other studies since in some cases the actual detectability may be lower.

Conclusions

Through our study we were able to identify (a) the most effective attractant for a suite of mammalian species and (b) underscore the potential implications for a monitoring program of the choice of different attractants. Specifically, our study showed that sardines are particularly effective with canids, but also effective with mustelids, thus proving to be the most 'generalist' attractant, particularly suited for multi-species studies, with the added benefit that they do not seem to be avoided by any of the species. We add to previous knowledge by showing that the economic benefits of using sardines, which can lead to savings in order of tens of thousands of Euro. Peanut butter-based attractants are particularly advantageous for mustelids, nevertheless they are particularly ineffective for some species, such as the jackal and the roe deer, which makes them less suitable for multi-species studies. Camera trapping is reshaping the way we study mammals in the field, our findings help emphasize the importance of conducting careful cost-effectiveness evaluations and pilot surveys before embarking in long-term monitoring programs.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10344-024-01840-0.

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Author contributions A.M., R.B. and F.F. designed the study, all authors collected the data, A.M. led the data analysis and drafted the paper with input from all authors.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval Research was conducted in line with italian laws regarding wildlife research (LL457/1992). Landowner permission was obtained priori to camera trap deployment.

Competing interests The authors declare no competing interests.

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