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Protection of Farms from Wolf Predation: A Field Approach

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Abstract: The livestock sector is facing serious challenges in combatting the increasing predation of domestic livestock. In this scenario, wild carnivores, especially wolves, represent key predators. To allow the coexistence of wild and domestic animals, defense methodologies consisting of multiple integrated antipredator strategies must be tested and implemented based on the geographical management context of each farm. This study investigated the potential of a novel antipredator method (PAN, Project Farmers-Nature in Italian) in protecting livestock (goats and horses) from wolves on a farm located in the Sibillini Mountains National Park, over a three-month period (June–September 2022). The PAN field approach involved two phases: (1) interviews with farmers and inspections of how the farm and pasture are structured and (2) monitoring predator abundance using camera traps and transects in order to understand the wildlife habits. Information on predator movement around the grazing area was shared with the farmer, who was actively involved in implementing strategies to protect livestock. The stable presence of one pair of wolves was confirmed in the grazing area, placing grazing livestock at risk. The farmer was advised to strengthen the existing antipredator strategy (herd protection dogs) by introducing two trained Maremma-Abruzzese sheepdog puppies to protect his animals. The implemented actions demonstrate how professional experts can serve as a strategic intermediary between livestock and wildlife conservation in the management of the current conflicts.

Keywords: livestock farming; wolf; predations; monitoring; antipredator strategies

Citation: Guadagno, E.; Gallizia, A.; Galosi, L.; Quagliardi, M.; Angorini, A.; Trenta, F.; Ferretti, M.; Pennacchioni, G.; Roncarati, A.; Morandi, F. Protection of Farms from Wolf Predation: A Field Approach. *Land* **2023**, *12*, 1316. https://doi.org/10.3390/land12071316

Academic Editors: Javier Velázquez Saornil and Ana Hernando

Received: 20 May 2023
Revised: 22 June 2023
Accepted: 28 June 2023
Published: 30 June 2023

1. Introduction

Increasingly, the challenge of managing agriculture and wildlife, where they coexist, is becoming a major concern for farmers. Consequently, new ways of addressing it are needed to allow the continuation of outdoor breeding techniques, even with the presence of predators.

Large predators at the top of the food chain (such as bears and wolves) impact both wild ungulate populations and domestic livestock. As reported in the European Commission document "Status, management and distribution of large carnivores—bear, lynx, wolf and wolverine—in Europe", a significant number of countries denounce the difficulties in managing conflict arising from the presence of large carnivores in farming areas with livestock sector, especially sheep and goat [1].

Also in Italy, the livestock sector faces new challenges. Coexistence with wild animals, particularly wolves, causes conflict between institutions (national and regional administrative authorities) and pastoral activities [2]. Over the last 50 years, a significant increase in wolf population was found, with an estimated presence of over 3000 specimens, of

which, according to the latest ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) survey, about 2400 are distributed throughout the Apennine area [3]. However, this management constitutes a significant problem since the question of the carnivorous animal husbandry conflict is often faced not in an entirely prudent and technical way but through heterogeneous regulatory and procedural tools, not coordinated within the range of the species, and, above all, in many cases, starting from insufficient and nonobjective knowledge based on the definition of the phenomenon and the related problems [4].

In Italy, in the 20th century, the wolf was extinct in the Alps and Northern Apennine and was near extinction in Central and Southern Apennine; accordingly, farmers have abandoned any system of protection for their livestock [5]. However, in recent years, the wolf population has increased for many reasons (direct and indirect conservation measures, human abandonment of the countryside and mountains, an increase in wild prey, etc.), so farmers must be more careful (as with past transhumant pastoralism giving the right value to own animals again). Grazing management must now adjust to understand how predators operate and adapt its management to minimize risk by making evidence-based changes, such as moving herds away from key areas or clearing up carcasses.

Consequently, while certain predators are protected due to their high threat status, such as the wolf, also it is becoming increasingly problematic to sustain the economy of farms [6]. Thus, it is necessary to adopt objective, technical, and coordinated management of conflicts with human activities [4,7]. This problem must be tackled preferentially using preventive methods rather than mitigation measures that intervene following predation [8,9]. Interventions that help promote a favorable climate of coexistence between carnivores and zootechnical activities should form part of integrated monitoring-assessment-prevention-mitigation systems instead of being interventions decontextualized from this cognitive implementation process [10]. Prevention systems should also be integrated with each other. For example, the use of electric anti-wolf nets as the only antipredator strategy will easily fail as it will be insufficient if it does not take into account the type of maintenance used, the geographical context, the number and species of animals to protect, etc. The shepherd has to be constantly present to prevent the livestock from being attacked by wolves in non-fenced areas. Instead of promoting this prevention, the managing bodies maintain a predominantly passive approach to managing conflicts, such as direct compensation for economic damage suffered by the farmer [11]. This method fuels distrust of local institutions by farmers who have a low tolerance for the presence of wolves [12]. The use of fences can be much more useful when it is accompanied by guarding dogs—this should be considered necessary when the flock is transhumant (without shelter). Livestock guardian dogs have been recently studied as a method for controlling the impact of wild predators on reared animals. The behavior and movement patterns are considered important to evaluate the efficacy of reared animals' management [13,14].

This context is even more crucial when livestock is reared in protected areas, such as the Sibillini Mountains National Park in Central Italy. This area is characterized by a notable abundance of surface waters, with a lot of fluvial and articulated torrential networks and a series of lakes located at the foot of the mountain complex; some natural reservoirs are also at high altitudes. A significant environmental variety, such as summit pastures on the highest hills and deciduous woods, is mixed with coniferous trees. Secondary pastures, deriving from the abandonment of crops and riparian woods, often forming tunnel structures, correspond to remarkable biodiversity in terms of fauna and vegetation. Of extreme interest are some of the numerous species of mammals present in the Sibillini Mountains, with large carnivores such as the wolf (*Canis lupus italicus*) and the bear (*Ursus arctos marsicanus*). The presence of ungulates is also important, among which the Abruzzo chamois (*Rupicapra pyrenaica ornata*) stands out, recently reintroduced, and currently with a consolidating population. The red deer (*Cervus elaphus*) and the common roe deer (*Capreolus capreolus*) are present while the wild boar (*Sus scrofa*) is considered invasive species. In terms of medium carnivores, the fox (*Vulpes vulpes*) is ubiquitous and encountered with increasing frequency in urban areas due to its opportunistic nature. Based on these as-

sumptions, a study was performed in an area of the Sibillini Mountains National Park, Central Italy (Province of Macerata), with the aim to test a sustainable defense protocol of livestock from the wolf impact, considering farm management, grazing geographical context, use of tools, and direct and indirect observation. In-field acknowledgment and appropriate recommendations will be useful to the farmers working in a relationship with the wild environment.

2. Materials and Methods

2.1. Study Area

This study was conducted on a medium-sized family-run goat farm rearing small ruminants (n. 70 goats) and horses (n. 21). The farm is located within the territory of the Sibillini Mountains National Park, Municipality of Visso, Italy (42°55′48″72 N, 13°5′17″88 E). During winter (November to March), the animals are managed in stables located in town. However, from spring to autumn (April to October) the animals are transferred to Monte Cardosa (800 to 1818 m a.s.l., Figure 1) where the farmer has about 35 ha of pasture.

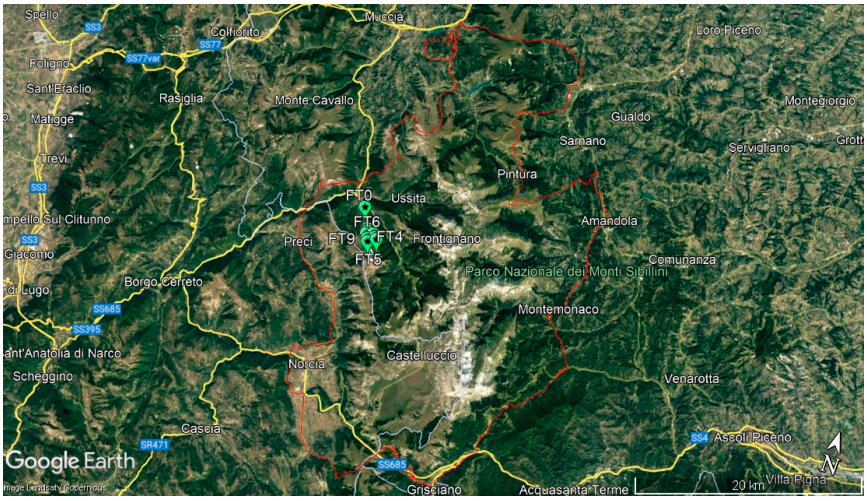

Figure 1. The Sibillini Mountains National Park is surrounded by a red line. The green flags indicate the study location and represent the area where the camera traps are located. Map data ©2022 Google.

The current study was carried out in this area from 15 June to 15 September 2022. The study area has a surface of 210 ha.

2.2. Application of the PAN Method

The actions performed in the current study replicated those of a national initiative called "Project Farmers-Nature" ("PAN," in Italian), which was conceived by the Center for Ecology and Biodiversity of the Apennines (CSEBA) based on "Project Wolf Ethology" (PWE) [15]. The PAN method has already been applied with satisfactory results [16].

This field method involves the use of several steps: investigation of managerial and social components of the farm, investigation of an anthropic component within the study area (e.g., human population, presence of institutions and associations such as the National Park Authority and other farms), and investigation of environment and pastures. The protocol is based on passive defense (electric fences), active defense (use of dogs to protect livestock), and broad interviews with the farmer aiming at knowing the predator, its habits, its eco-ethology, its use and control of territory, and predatory techniques.

The study area was mapped based on direct observations as well as the movements of the herd and its most frequented areas during the day. The farmer was interviewed using an oral survey to obtain information on the farm status (hectares used for grazing, arable land), the farm management (movements pattern), prevention methods (fences,

terminals, permanent presence of shepherd), and previous interactions with predators (year and a number of predations). Two neighboring farmers were also interviewed to verify the reliability of the information provided by the farmer involved in the study.

During the whole period of the study, regular briefings were conducted with the farmer in order to be able to better follow the livestock's state and the predations.

Based on the PAN method, the study area was explored, and the surrounding area was checked via three steps: (1) detection of natural parameters; (2) identification of observation posts; (3) and perimeter formation.

Step (1), concerning natural parameters, included the following: canid presence, watering points, and transit routes for wildlife detected through naturalistic observation of the area, conducted by fieldwork. Based on these surveys, four exploration transects were delineated and checked at regular intervals (every 7–9 days, depending on weather conditions) to collect data on the presence and movement of predators (feces, footprints, animal carcasses, etc.). The surveys were carried out through an initial inspection, lasting one day, where the grazing area was identified and its perimeter was covered in search of signs of the presence of the wolf. Wolf activity was measured during the night as the sum of wolf recordings during the interval between 08:00 p.m. and 08:00 a.m. One of the transects overlapped with the path leading to the top of the mountain (the grazing area), two transects were in the pasture, and the fourth transect was along the car route to the main pasture area (Figure 2).

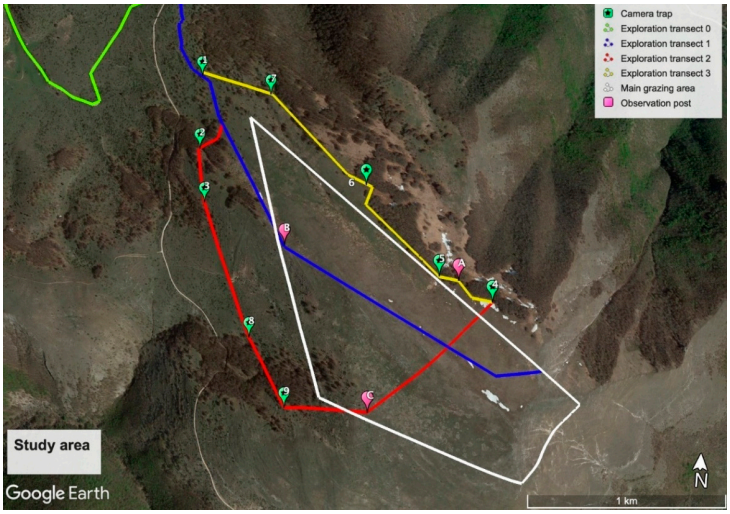

Figure 2. Locations of the main grazing area, transects, observation posts, and camera traps in the research area. Map data ©2022 Google.

Step (2) was based on observation posts along the transects delineated and geolocated for conducting observations. Direct observations were performed using professional binoculars (Nikon Action EX 7x50 CF, Nikon Corporation Japan, Tokyo, Japan). Indirect observations were carried out using nine camera traps (Annew 1080p infrared LED Colorway, Amazon EU S.a.r.L., Seattle, WA, USA). Camera traps were battery-operated and contained microSD cards to store data.

Step (3), regarding the perimeter formation, was carried out using the nine camera traps that were positioned to create a semicircle (Figure 2) around the main grazing area. The angle of view of each camera trap was 120°, while the distance between every camera was several meters (Table 1), and the average altitude was 1553 ± 83 m.

Table 1. Distance between each camera trap.

Camera Trap Number	Distance (m)
1–2	274
2–3	200
3–8	504
8–9	261
9–4	804
4–5	190
5–6	396
6–7	488
7–1	271

The detection of carcasses and/or remnants of animals was carried out and geolocated using Google Earth. The discovered dead animals were identified, sampled, and removed.

2.3. Tests Conducted on Guardian Dogs to Protect the Flock

The farmer involved in the study had four livestock medium-large guardian dogs, crossed with the Maremma breed (two males and two females, 1–13 years old).

Guard dog activity was periodically recorded and the presence and management of dogs were also observed. Their efficiency at work was evaluated by a behavioral test.

The applied test consisted of observing how dogs interacted (both with each other and with the herd), recording at what distance (m) from grazing animals they sounded the alarm barking, and their response to the presumed danger. The evaluation was performed for each dog separately and for all dogs combined as a group. The test was performed by an operator walking toward the herd, mimicking a supposed danger. This evaluation aimed to quantify the attitude of each dog to remain with domestic livestock, even in the absence of the shepherd [17].

3. Results

3.1. Farmer's Interview and Questionnaire Results

During the initial interview, the farmer said that he has 35 hectares of available state-owned land used for grazing in the wild and semi-wild, and that the land is in civic use with other local farmers. In the winter season, the livestock is managed in two stables, which are tensile structures located in Visso (Macerata), in a residential context, while in April–October the animals are transferred to Mount Cardosa (1818 m), applying the transhumant technique. There, the animals are kept in the wild without any fences and the presence of the shepherd is occasional, which makes the study conditions extremely difficult to manage

As far as the predations are concerned, the farmer said that both in 2020 and 2021, four goats/year were found killed by wolves which was certified by a post-mortem evaluation of the Sibillini Mountains National Park veterinarian. All predation events occurred when goats were grazing on Monte Cardosa, mainly during the autumn.

3.2. Field Observations—Direct Observations

The observation sessions (Table 2) showed the wildlife activity in the study area during the day. However, wolves were never sighted during daytime inspections.

3.3. Field Observations—Indirect Observations

Overall, 565 records of wildlife, belonging to 10 species, were obtained from the camera traps (Figure 3). Wolf sightings were 40 in total and were the third most documented species in the study area, as well as red deer (*Cervus elaphus*).

The peak of wolf activity was detected between 09:00 p.m. and 10:00 p.m. (Figure 4), immediately after the farmer finished his daily reconnaissance of the grazing site (usually carried out at 08:00 p.m.).

Table 2. Animal species were sighted during direct observation sessions.

Date	Observation Post 1	Observation Post 2	Observation Post 3
June-18	European hare (*Lepus europaeus*) Roe deer (*Caproleus caproleus*) Red fox (*Vulpes vulpes*)		
June-21		European hare (*Lepus europaeus*)	
June-28			European hare (*Lepus europaeus*) Roe deer (*Caproleus caproleus*) Red fox (*Vulpes vulpes*)
August-2		Red fox (*Vulpes vulpes*) European hare (*Lepus europaeus*)	
August-12	Roe deer (*Caproleus caproleus*)		
September-7			Beech marten (*Martes foina*)

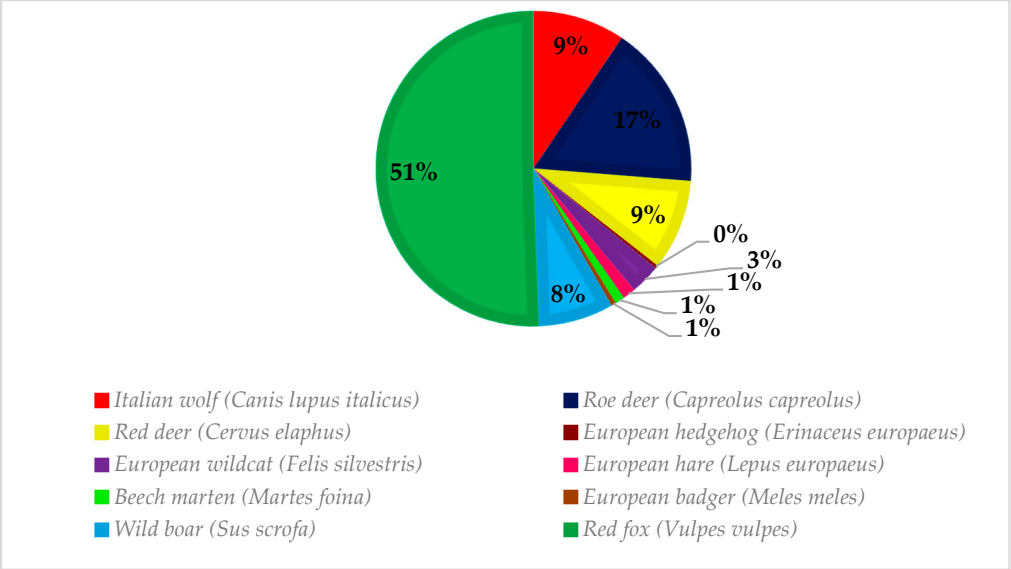

Figure 3. A total number of wildlife recorded using the camera traps.

At least one wolf was recorded on each camera trap inspection period, except for one date (6 July). From late August and early September (site inspections 9 and 10), the number of wolf sightings on camera traps increased (Figure 5).

In almost all records, the camera trap captured a pair (21 records) of adult wolves (male and female) or one of these two individuals (27 times). On 25 August, in addition to the usual pair, three new younger individuals were recorded passing in front of the camera traps "1" and "7". Subsequently, a pair of wolves was sighted. In 80% of cases, wolves were photographed during their movements along one of the slopes, moving up or down from the top of the mountain, where the main grazing area of the farmer's herd is located (Figure 2).

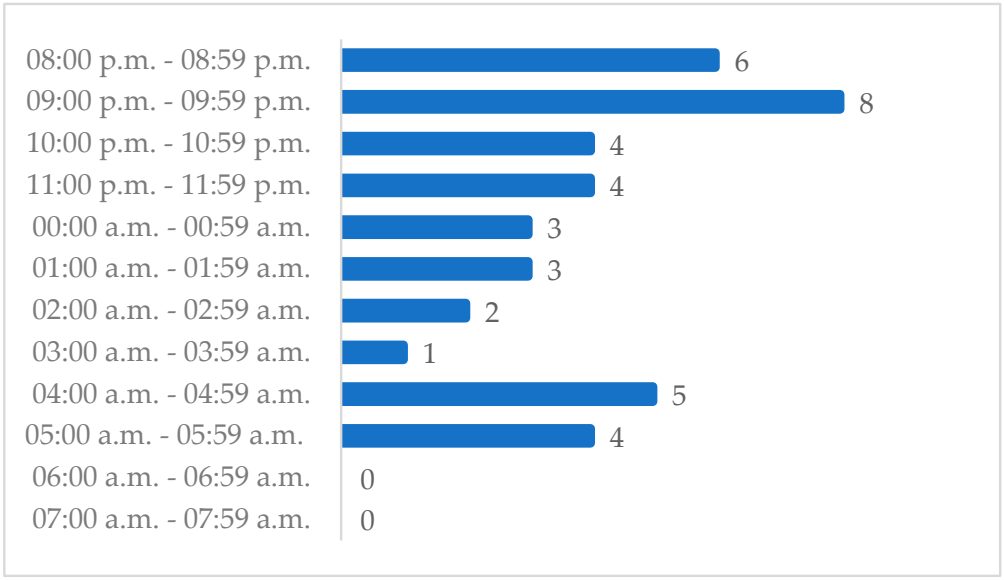

Figure 4. A time slot of the wolf activity (*n* = sum of the records) through the nighttime during the study.

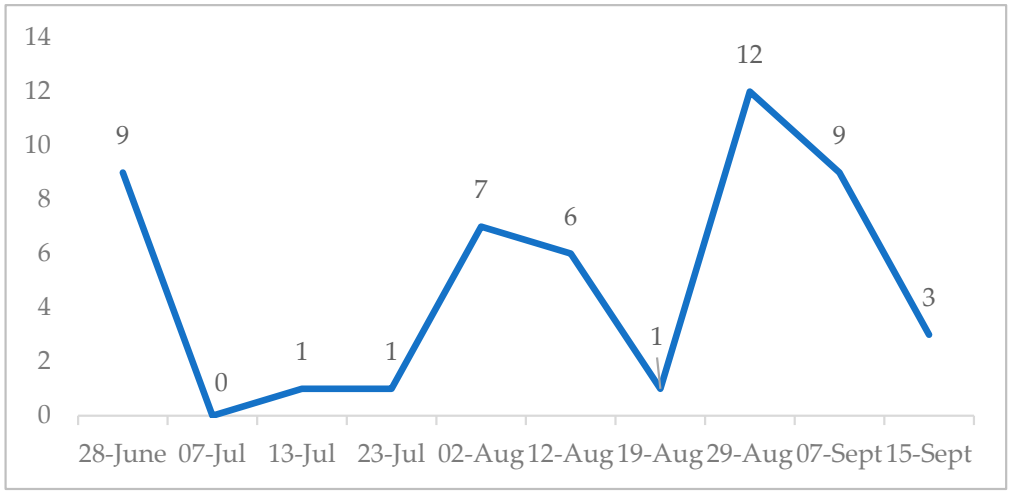

Figure 5. Camera trap inspections (number of wolf sightings) were employed over the entire study period.

Camera trap "1" recorded a large part of wolves' movement (25%), which took place on an approximately weekly basis along the path that leads to the grazing area, which was also used by the farmer, as well as horses and cattle herds, to move to the various grazing areas. Wolves were detected less frequently at other camera traps ("3", "5", "8", and "9"). Camera trap "7" represented a little less than half (42%) of all wolf records. The same wolves were being captured by multiple traps on the same night. Intense wolf activity was recorded in the last 10 days of August at trap "7". In fact, the number of videos showing wolves during the field check on 29 August was 12, the highest number of the entire study period (Figure 6).

From week 1 of the study, the camera traps showed the presence of the wolf pair (2 records) that was recorded several times in the following weeks (19 times in total: 2 times in week 4, 3 in week 5, 1 in week 6, 6 in week 7, 5 in week 9) at camera trap "1", moving up or down the path also used by the farmer to access the herd (Figure 7). Throughout the study period, this wolf pair was recorded at least once by camera traps "3", "5", "7", "8" and "9" (Figure 6). Data analysis (following inspection made in week number 9) showed that also three other individuals were recorded in camera traps "1" and "7".

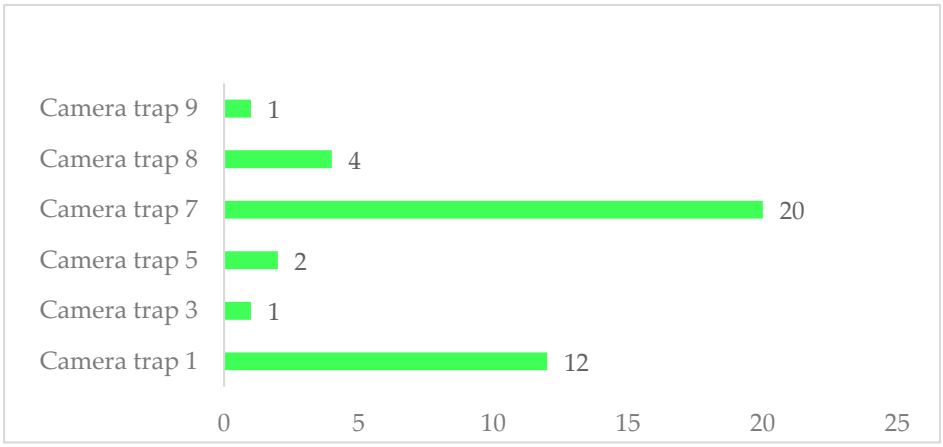

Figure 6. Records of wolves at each of the camera traps.

Figure 7. Camera traps recorded the highest number of wolf passages near the main grazing area: camera traps "1" and "7". Map data ©2022 Google.

As far as guard dog activity is concerned, videos from camera traps showed a group of two/three dogs wandering at least two times during nighttime, meaning that they did not remain with the herds they were supposed to guard. In one image, one dog from a neighboring farm had a piece of meat in its mouth, which probably was from a nearby carcass of a cow detected by the farmer (Figure 8).

Figure 8. Neighboring guard dog with a piece of meat in its mouth (camera trap 5).

3.4. Detection of Animal Carcasses and/or Remnants

During the inspections, two carcasses (goat and cow) with different dates of death were recorded (Figure 9). The examination of these carcasses showed that death was due to natural causes. The first carcass was half a goat recorded during inspection 1 in June. On that occasion, one of the camera traps was placed directly in front of the remnants, with one fox (*Vulpes vulpes*) and one wolf (*Canis lupus*) visiting it. The second carcass (a cow died during calving near the grazing area) was recorded in the last 10 days of August when the farmer reported the presence of a cow carcass from a neighboring farmer's grazing herd in the area during the briefing. In addition, we found remnants of unidentified animals in seven different locations. The remnants were found close to the camera trap "7", and corresponded to a rise in wolf sightings, including the three new individuals.

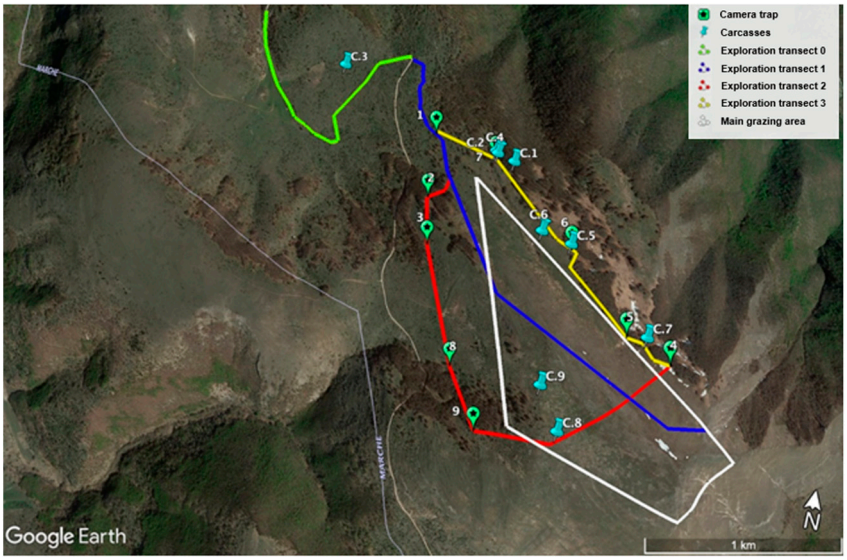

Figure 9. Location of carcasses. Map data ©2022 Google.

3.5. Tests Conducted on Dogs to Protect the Flock

Six tests carried out on guard dogs during fieldwork showed that only two out of the four individuals were sufficiently efficient in protecting the herd (Table 3). The distance of presumed danger from the herd flock at which the alarm was sounded was highly variable across the dogs, and was, in most cases, too short (50 m or less); the ideal minimum distance to activate the dog defense would be 200 m [18].

Table 3. Tests were carried out on dogs (n) and the distance at which they identified the danger, barking.

Tests Performed	Date	Alarm Distance (m)
n. 1	15 June	50
n. 2	28 June	50
n. 3	13 July	<50
n. 4	23 July	50
n. 5	2 August	<5
n. 6	7 September	150

3.6. Briefings with the Farmer

As for the PAN method application, step 3, the weekly briefings with the farmer, provided important information that allowed us to monitor the rise in wolf activity. Throughout the study, different strategic actions were recommended to the farmer to be adopted. For example, the use of electrified fences to protect the flock at night or dividing the area most frequented by wolves from the "safe" area was rejected by the farmer. He justified

this choice by the requirement of the continuous presence of staff and maintenance, neither of which coincide with the type of grazing management implemented.

However, the farmer agreed to implement the use of livestock guardian dogs by purchasing two new puppies from a bloodline specifically selected for defending livestock herds (Maremmano-Abruzzese sheepdog).

4. Discussion

The current work represents a preliminary part of a series of actions that are taking place in various Italian contexts, with the aim to optimize a protocol for the defense of farms from the depredations of wild animals, with a specific reference to the wolf. The significant increase in predator animals in the Italian territory, combined with their almost total absence in the last 80 years, has disaccustomed farmers to oppose predators' attacks on farmed animals, "letting down their guard", and exposing them to appreciable loss of animals. The PAN protocol can include both passive (electric fences, not contemplated in this study) and active defense (use of dogs suited to the defense of farmed animals). An important element of this approach was represented by the interviews with the farmer or animal handler, providing training aimed at getting to know the predator, its habits, its eco-ethology, its territory control, and predatory techniques. It also encompassed monitoring of the attracting elements (organic wastes, dead animals, and animals left close to the farms) which encourage the predator to approach a man in search of easy and immediately available food.

The current study excluded killing wolves, which is considered an unsuitable method of wolf management at the international level as recognized by the law and validated from a scientific point of view [19]. In addition, the killing of one or more specimens of the family group destabilizes the latter by inducing the tendency to prey on "easy" animals (farmed animals) rather than wild prey that are much more reactive and difficult to kill [20].

The field methods used to quantify predation risk varied with context (farm type, location, and environment) as shown in the literature [21]. In the current study, interviews integrated with field data were contemplated to inform and improve monitoring and decisions by the farmer. The recommended strategies were based on livestock management, farm activities, and location [22–26]. This study also aimed to evaluate and build a trusting relationship between the local institution in charge of managing wild and domestic animal conflicts (in our case, the Park Authority) and stakeholders (i.e., farmers) of the livestock sector through an interactive process.

In a study performed on 75 semi-extensive sheep farms in the District of Pisa, the closeness to protected areas and the presence of thick vegetation were recognized as factors able to increase chronic predation [25]. Suggested actions were aimed at ethologically destabilizing the predator (placing obstacles on the predator's usual paths to force it to change habits), providing the farmer with extra time to organize his grazing area.

Our study showed an integrated survey approach and allowed us to monitor directly and indirectly the presence of wolves in the area around the pasture, with the initial questionnaire and briefings of the farmer providing insights on wolf-livestock interactions when wolf numbers peaked [8].

The answers provided by the farmer involved in the study and the other two neighboring farmers clarified the type of farm and herd management by the owner. Their feedback also provided information on the dynamics that linked the farm to wildlife and the surrounding farms, as well as the relationship between farm owners and the park authority. It was noted that wolves were never sighted during daytime inspections, confirming their elusiveness, a typical feature of this species. In fact, the most active daytime period was recorded between 09.00 p.m. and 10.00 p.m., just after the end of the daily farmer's working activity showing shy behavior. While they did not avoid human landscapes and structures, they did not normally approach humans (human presence may keep wolves at a safe distance [21].

The direct and indirect observation methods offered continuous information on predator movement within the focal area. Over time, field data provided evidence to help improve the farmer's awareness of the problems related to the presence of wolves in the grazing area. This information allowed the farmer to manage livestock more effectively with respect to predation risk.

The highest activity of wolves, as shown on camera trap records, was observed at the end of August. During the weekly briefing, the farmer reported the presence of a cow carcass, which was then confirmed to be located near one camera trap ("7") and attracted the predators. In fact, the remnants represent food sources for wildlife [27]. Thus, the field data demonstrated the importance of removing biological material that could attract potential predators, placing the flock at greater risk. This condition was confirmed by the presence of two wolves considered stable, as both were regularly documented throughout the study period. This observation also explained the restricted "home range" use of the wolf pair, as sufficient resources (food, water, shelter) were present in the immediate area for survival.

The camera traps also provided important information on the activity of unattended guard dogs feeding on carcasses in the vicinity of the grazing area at night. This behavior showed that these dogs lacked defensive instincts to protect their herds. These observations provide strong evidence supporting the need for the farmer to choose and educate guard dogs to be highly efficient in their custodial role [28]. Moreover, it would be important and necessary to set up night shelters, even electrified, keeping the guard dogs inside.

Regarding logistic management, the implementation of many recommended measures to prevent predation was not possible because livestock was reared in the natural environment from summer to autumn in our study. As shown by Strand et al. [29], a zoning system that excludes this type of management would be useful, at least when overlap exists with the areas most frequented by predators [30].

Through maintaining direct contact with the farmer throughout the study period, it was possible to establish a relationship of strong trust, communication, and willingness to implement the management measure of acquiring appropriate guard dogs. In fact, correctly trained guard dogs assume the role of actual "farm coworkers" and must be able to replace the stable presence of the shepherd. During the cold season, the two purchased Maremmano-Abruzzese shepherd puppies were trained to stay with the goats in the stable.

5. Conclusions

The current study generated evidence-based data on the farmer's actions and involvement to safeguard his livestock from predation, highlighting the importance of farming awareness. The farmer was able to understand the importance of rapidly removing carcasses to prevent attractiveness for predators to the area, which could place the herd at risk.

Livestock farmers should learn to consider occasional loss of predated animals as an inevitable, but tolerable, business risk. To be accepted by farmers, both compensation regulations and prevention interventions must be the result of a continuous participatory process.

This research was aimed at farmers making efforts to mitigate conflicts with wolves. Thus, help of mediators (i.e., veterinarians) who help maintain the dialogue between farmers and administrative institutions is advantageous. Fieldwork is important to improve our understanding of the dynamics within each farm, as the working conditions and surrounding environment are never identical across farms. For this reason, it would be useful to conduct further trials over a longer time and replicate them on multiple farms with depredation issues to confirm similar (or different) management suggestions, involving adequate equipment and human resources.

Author Contributions: Conceptualization: E.G., A.R. and G.P.; methodology: A.G., A.A., F.T., M.F., G.P. and A.R.; investigation: E.G., A.G., L.G., M.Q., A.A., F.T., G.P. and F.M.; data curation: A.G., L.G., M.F. and F.T.; formal analysis: M.Q., M.F., G.P. and F.T.; writing—original draft preparation: E.G., L.G., M.Q., A.A. and A.R.; writing—review and editing: L.G., M.Q. and A.R.; resources: A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: All data are included in the manuscript.

Acknowledgments: The authors would like to thank the team of the Sibillini Mountains National Park and the team of operators who provided the assistance with study activities.

Conflicts of Interest: The authors declare no conflict of interest.

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