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Behavioral responses to aptitudinal tests and GPS radio-collar monitoring in mixed-breed dogs derived from crossbreeding with pure-breed Maremma-Abruzzese Sheepdog

Virginia Bellini[1], Gabriele Stagi[2], Duccio Berzi[3], Silvia Dalmasso[4], Fabio Macchioni[1], Angelo Gazzano[1], Francesca Cecchi[1*]

[1] *Department of Veterinary Science, University of Pisa*
[2] *Wildlife technician*
[3] *President of Canis Lupus Italia*
[4] *Veterinary/ethologist*

Abstract: The Maremma-Abruzzese Sheepdog (MSD) is one of the breeds belonging to the livestock guardian dogs (LGD), whose task is to protect farms from predators. In this study we considered a total of eight adult mixed Maremma-Abruzzese Sheepdogs (Mixed-MSDs) derived from crossbreeding with the Maremma-Abruzzese Shepherd LDG to evaluate their aptitude as guardian dogs through behavioral tests and GPS radio-collar monitoring. The Mixed-MSD dogs included in the study belonged to three farms located in the province of Florence (Tuscany) and were selected because they are in areas with a high risk of predation.

Out of the eight dogs analysed, five obtained positive results in both types of tests. Three dogs however did not exhibit fully suitable behaviors for pastoral use as guardian dogs. Of these, one male dog (1/8) exhibited overly aggressive behavior towards strangers. The results of this research highlighted how the Mixed-MSD dogs worked in different ways and how they implemented defence and space management behaviors that were very different from each other. These results could be due to the decision to use mixed breed dogs based only on their morphological characteristics, and to a lack of a genetic selection, which results in a lack of uniformity and typicality of the work of MSDs. Further studies are needed to extend the research including more animals knowing the crossing breed. Despite the lack of fully optimal results, the farm owner interviews showed that the use of the of Mixed-MSDs led to a decrease in predation on the farms.

Key Words: Maremma-Abruzzese Shepherd mixed dog; LDG; behavior test; GPS radio-collars.

* *Corresponding Author*: francesca.cecchi@unipi.it

Introduction

In the world of herding, two different types of dogs are used with livestock, but which perform completely different types of work, i.e. herding dogs (Coppinger & Coppinger, 2001) which move the livestock from one area to another and Livestock Guarding Dogs (Coppinger & Coppinger, 2001), whose task is to protect the flock from any predators. The Maremma-Abruzzese Shepherd dog breed (MSD) belongs to the latter category. This breed has its origins in the primitive dogs of Central Asia which then spread throughout Europe. The first evidence dates back to Roman times: already in that period Latin authors such as Varro and Columella (II and I century BC) cited the breed as a constant presence in the Roman countryside as a large white dog guarding the flock (ENCI, 2022). The Maremma-Abruzzese Shepherd belongs to Group 1 (sheepdogs and cattle dogs - except Swiss Cattle Dogs), section 1 (sheepdogs) of the Fédération Cynologique Internationale (FCI) and of the Ente Nazionale Cinofilia Italiana (ENCI).

In Italy approximately 1200 puppies are registered every year, and there are 43 official breeders distributed in 14 regions and particularly in Lazio and Abruzzo (ENCI, 2022). In fact, in Abruzzo, this dog has always been widespread and, thanks to the long tradition in the pastoralism of

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this region, its functional and morphological characteristics have remained intact. The type of function closely linked to pastoralism and pastoral life has strongly linked the MSD to the culture and traditions of the shepherds and territories of origin (ENCI, 2022). Breeding has led to the development of strong, resilient and reliable dogs with good overall health.

The behaviours considered typical of LGDs are the following (Livestock Guarding Dog (Coppinger & Coppinger 1978, Coppinger et al. 1983, Lorenz and Coppinger 1986): attentiveness (the ability to remain close to the flock), protectiveness (the ability to actively respond to any sudden stimulus such as the arrival of a predator) and trustworthiness (the absence of predatory instincts in relation to livestock). As a defense technique, the Maremma-Shepherd aims precisely to frighten away wolves by suddenly appearing in the open from the middle of the flock, where up to the last minute, it manages to blend in thanks to its white coat (www.pastoreabruzzese.it).

The MSD dog needs to have an independent character, and its main characteristics are courage, resistance, a decision-making capacity, initiative and a great sense of duty. It has a great attachment to the flock, which is always protected by the dog and is never left or exposed to any aggression. It is not very docile and malleable and a general difference in behavior towards strangers is evident. Males are more diffident and shyer, and females are more docile and sociable, easier to approach which is evident by their tail wagging and wanting to be caressed. Traditionally these dogs are placed at an early age in the stables, among the sheep, to enable them to quickly learn to recognize the individuals of the herd and to ensure that, day by day, the bond becomes increasingly stronger, until the defence of the farm is identified as the reason for their existence.

The aim of this study was to evaluate the working performance of mixed-breed adult dogs derived from the crossing with the Maremma-Abruzzese Shepherd dog (Mixed-MSD) in order to draw up a behavioral profile in reference to the context of pastoral use as a guardian dog. This research is part of a broader project funded by ENCI, which aims to select purebred Maremma-Abruzzese Shepherd dogs and to highlight the differences in behaviours with mixed breed dogs crossed with the Maremma-Abruzzese Shepherd.

Material and methods

The research was carried out between October and December 2021 in collaboration with three farms located in the province of Florence (Tuscany, Italy) and selected because they fall within the areas of high risk of predation in Tuscany.

Eight mixed-breed adult dogs derived from the crossing with the Maremma-Abruzzese Shepherds dog (Mixed-MSD) were considered. Behavioral tests and GPS (Global Positioning System) radio-collar monitoring were performed on each dog. Camera-traps were also used to detect any interactions between the dogs and the ewes and/or possible wild animals. The owners of the farms were also interviewed to understand whether the presence of dogs had reduced the predation by wolves in the area.

1. Behavioral tests and operating models -Tests designed ad hoc were performed on each Mixed-AMS dog to test the different types of interaction with other humans and animals that could occur in the area.

All the tests (Annex 1) were performed on each farm by the same operators (a wildlife technician expert in LGDs and one operator who filmed and observed each test) and using the same tools.

For the tests, the two operators were careful to always dress in the same clothes, to always walk and move naturally and normally and to always use the same equipment (a bluetooth speaker that reproduced the call of the wolf and a bike and a dog to simulate a stranger going past near the farm). The practical procedures used for the behavioral tests with a stranger were as follows:
a) with the wind against, the stranger moved slowly towards the flock which was grazing in favour

of the wind. He approached from a distance of about 250 meters;
b) the stranger approached slowly by bike;
c) the stranger approached with a dog on a leash which did not exhibit any interspecific competitive behavior;
d) call of a predator (wolf): the sound stimulus was emitted from a distance of about 50 meters.

The observations took place without changing the usual composition of the group of dogs, so as to prevent any changes that could cause abnormal behavior.

2. Movement recording via Global Positioning System (GPS) radio-collars and camera-traps - For the research, GPS radio-collars were applied to the dogs and to three ewes and three lambs to monitor their movements for 24/48 consecutive hours depending on the farm management. The principal characteristic of GPS radio-telemetry is the consistent accrual of large numbers of locations per radio-collar (or animal) through automated tracking (D'Eon and Delparte, 2005). The GPS radio-collars were programmed to take fixed point every 2 seconds. If an animal with the collar does not move more than five meters, the movement is not recorded on the map. In this way, an animal that moves seven meters in ten seconds will record three fixed points; if it moves four meters in ten seconds, there will be only one fixed point.

The collars were supplied by Bitrabi Innovation Group S.R.L. (https://bitrabi.com/). Table 1 reports the dog information (farm, sex and crossing breed) with the number of the assigned collar. The test with GPS radio-collars was repeated for each dog at least twice for each variability factor, considering different sheep or lambs and during diurnal and night activities in order to verify both the reproducibility of the test itself and the repeatability of the dog's behavior.

Camera-traps were also used to record possible interactions between the wild animals, dogs and ewes, which positioned around the night shelter fences and in the diurnal pasture.

Camera-trap data were recorded instantly at the time of the events and compared with the recordings released by the GPS radio-collars on the dogs and herd. Camera traps are commonly used in ecology because they are effective in answering questions regarding the distribution and density of cryptic and mobile species (Pettigrew *et al.* 2021).

Table 1. Information on study dogs.

Farm	Dog Sex	Dog Collar N°	Crossing breed
1	Male	5	Unknown
1	Female	6	Unknown
1	Male	10	Unknown
2	Female	6	Unknown
2	Male	9	Pyrenean Mountain dog
3	Female	10	Unknown
3	Female	6	Unknown
3	Female	3	Unknown

Results and discussion

Livestock guardian dogs have been widely adopted all over the world by sheep farmers because predation has always been an important problem, leading to serious economic losses for the farmers. As well known the spread of the LGD as a preventive tool passes through a careful

selection of breeding stock, a monitored management of the custody and growth of the puppy in the workplace. So, it is important to identify which breeds are the most effective at deterring predators and different types of behavioral observations have been used to evaluate the basic behaviours considered typical of LGDs. This research investigated for the first time the behavior of mixed-breed dogs derived from the crossing with AMD dogs using both aptitude tests and GPS movement records. Other studies have investigated the behaviour of LGDs using only one of the two methods. For example, Zingaro et al. (2018) evaluated LGD dog behavior using GPS pet collars, while Macchi et al (2010) used scan sampling for the ethogram and behaviour sampling of interactions.

The results of our tests on dogs showed that, overall, all the considered dogs were docile in relation to the shepherd and highly accustomed to acting in groups, tending to consider sheep an integral part of the group.

ThAs regards the tests carried out with strangers, no dogs showed excessive aggression towards the stranger approaching in the presence of the owner or walking towards the grazing flock, afterwards showing an initial alert playful behavior (4/8) or estrangement and distrust (4/8). Concerning the test with the stranger on the bicycle, half of the dogs were completely indifferent while one dog, the Maremma Shepherd x Pyrenean Mountain Dog, would have bitten the stranger without the operator's quick reaction. This is a behavior strongly in contrast with the ethogram of an adult PMA which requires the dog to be chased and bitten free.

It is well known that PMA dogs show distrust towards strangers who are seen as a threat in the absence of their shepherd, who needs to be able to count on the dog's autonomy and unconditional protection of the flock.

However, it is important to underline that in one study conducted in three alpine valleys of the Turin Province by Macchi et al. (2010) of more than 1900 observations obtained from seven mixed breed subjects (all Maremma Shepherd Dog x Pyrenean Mountain Dog), only 2% of the total number of observations involved attacks towards strangers, thus highlighting the positive evaluation of these mixed breeds as guardian dogs within mountain livestock farms. At the last test, "call of the predator", 5 (5/8) dogs showed alertness and aggressiveness but staying away.

Regarding GPS radio-collars results, not all recordings will be presented as the results were highly reproducible. The movements recorded by the GPS radio collars (Figures 1 and 2), show how the three dogs of Farm 1 followed the group of sheep throughout the day, showing excellent guardian behavior.

Good results were obtained also with the male with collar 9 of Farm 2, which appeared to follow the grazing sheep (Figure 4 on the right), and then to go back and forth several times between the sheep and the stable with the lambs (Figure 4 on the left), thus protecting both groups. On the contrary, the tracks obtained for the female with collar 6, of the same farm, show how she did not follow the grazing sheep (Figure 3, right), but stayed near the stable near the lambs (Figure 3; left). Moreover, from the same photo, a very evident deviation also emerged, which did not correspond to any of the traces attributable to the movement of the flock for a period of about 4 hours during the night, from 22:40 to 2:57. This was when the dog was going out autonomously from the night shelter where the shepherd usually puts the dogs, thus not protecting any sheep belonging to the structure. The camera traps did not detect any wild or potential predators near the farm that would justify the dog's exit from the enclosure.

Non-homogeneous behaviors were also observed in farm 3 as the dogs with collars 6 and 10 moved in symbiosis with the sheep for the entire duration of the monitoring, providing constant protection to the farm (Figure 5), while the female with collar 3 (Figure 6) followed the sheep only up to the first 2 grazing areas, and then returned to guard the stable instead of the sheep.

Table 2. Definition of behavioral responses with notes (*)

Test	n°/8
Test with owner	
Test 1: Response to owner recall	
- Indifference	3/8
- Elusive	1/8
- Collaborative: (*) immediate response	4/8
Test 2: Conducted on a leash	
- Avoidance behavior: (*) escape with jerk followed by immobilization	8/8
Test 3: Owner's physical contact/handling, microchip control and radio-collar insertion	
- Indifference	5/8
- Collaborative	3/8
Test with stranger or predator	
Test 4: Behavior of the dog upon arrival of the stranger walking in the presence of the owner	
- Alert followed by distrust	4/8
- Alert followed by sociability/gladness	4/8
Test 5: Stranger on a bicycle	
- Indifference	3/8
- Alert followed by distrust	1/8
- Alert followed by indifference	1/8
- Alert with aggressiveness but stays away from the stranger	2/8
- Alert with aggressiveness and approaching: (*) the dog tries to bite the stranger	1/8
Test 6: Stranger with dog on a leash	
- Alert followed by distrust	1/8
- Alert with aggressiveness but stays away	6/8
- Alert with aggressiveness and approaching	1/8
Test 7: Stranger approaching walking towards the grazing flock	
- Alert followed by indifference	4/8
- Alert and subsequent sociability/gladness	4/8
Test 8: Call of the predator	
- Alert followed by indifference	3/8
- Alert with aggressiveness but stays away	5/8

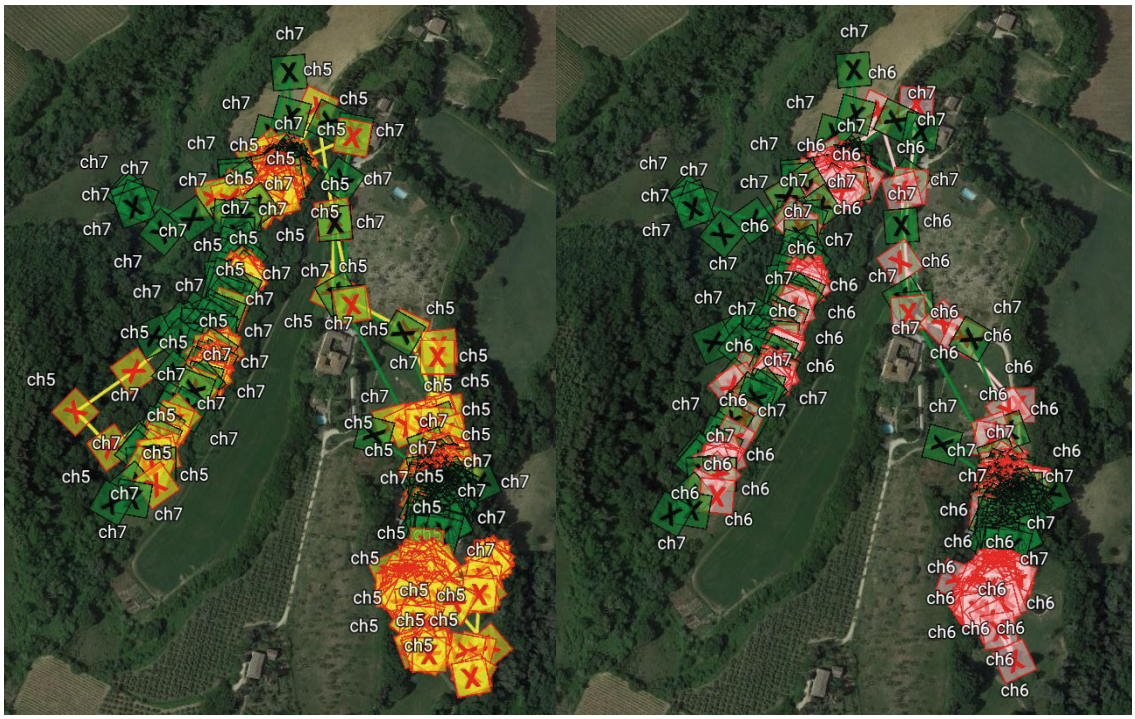

Figure 1. Farm 1: route obtained with GPS radio-collar for male n° 5, orange trace (on the left) and female n° 6, red trace (on the right) and sheep n° 7, green trace.

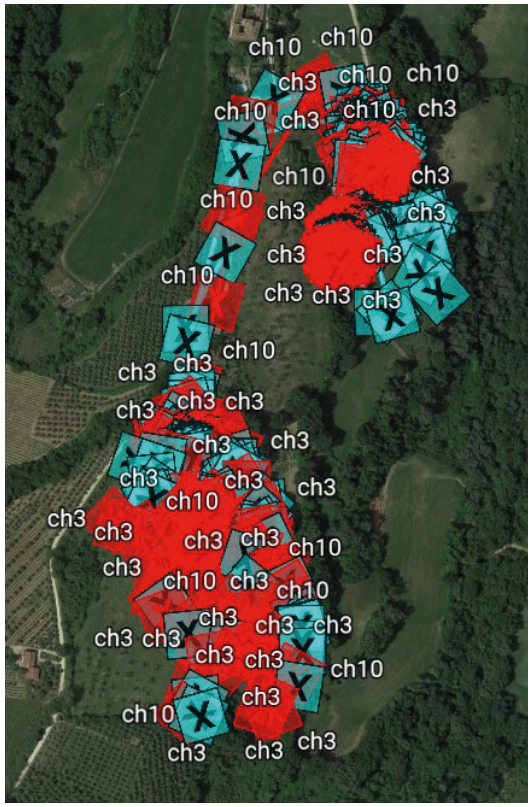

Figure 2. Farm 1: route obtained with GPS radio-collar for male n° 10, blue trace and sheep n° 3, red trace.

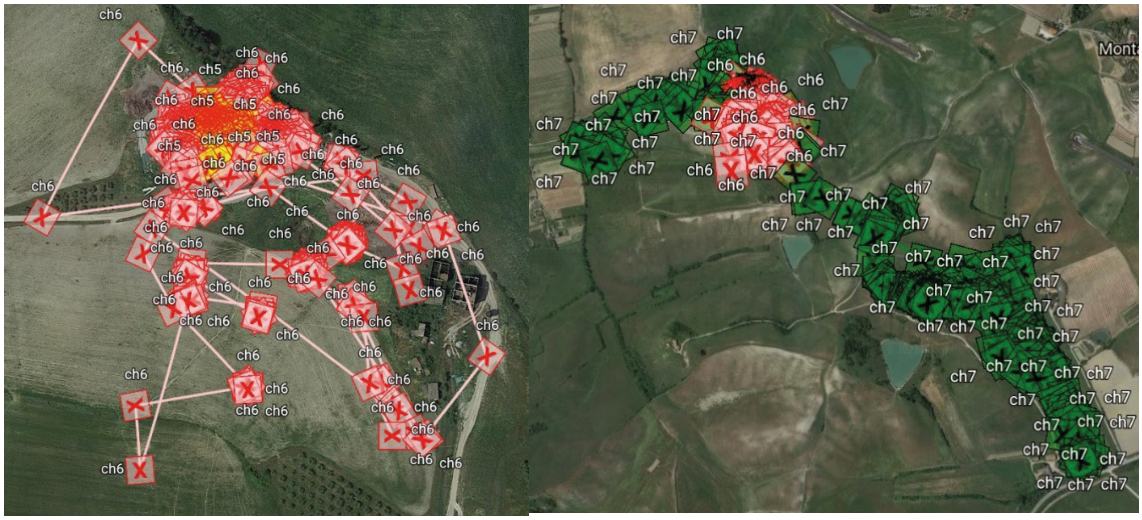

Figure 3. Farm 2: route obtained with GPS radio-collar for female n° 6, red trace, with lamb n° 5 in the stable, yellow trace (on the left) and with sheep n° 7, green trace (on the right).

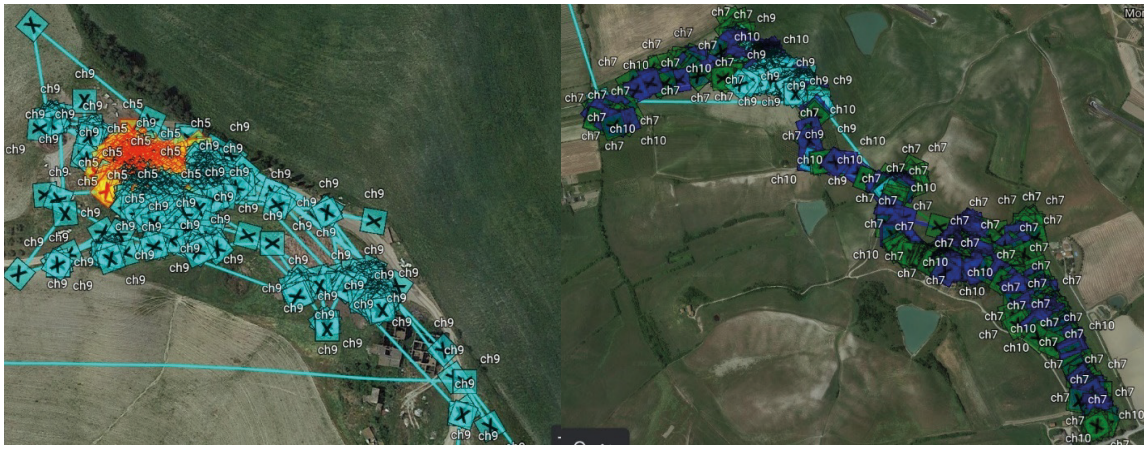

Figure 4. Farm 2: route obtained with GPS radio-collar for male n° 9, blue trace with lamb n° 5 in the stable, yellow trace (on the left) and with sheep n° 7, green trace, and with sheep n°10, light blue trace (on the right).

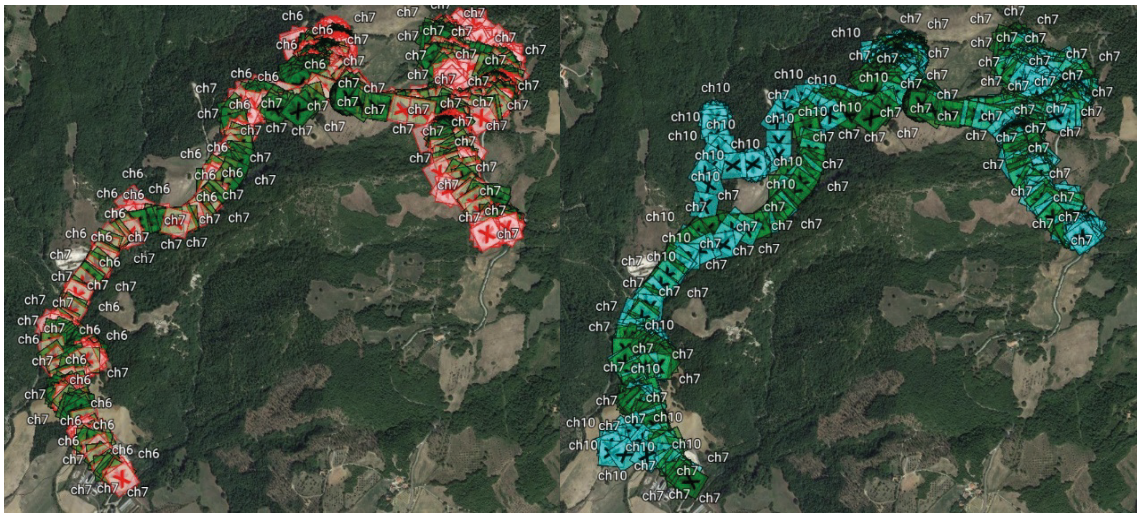

Figure 5. Farm 3: route obtained with GPS radio-collar for female n° 6, green trace, with sheep n° 7, red trace (on the left) and female n° 10, green trace, with sheep n°7, blue trace (on the right).

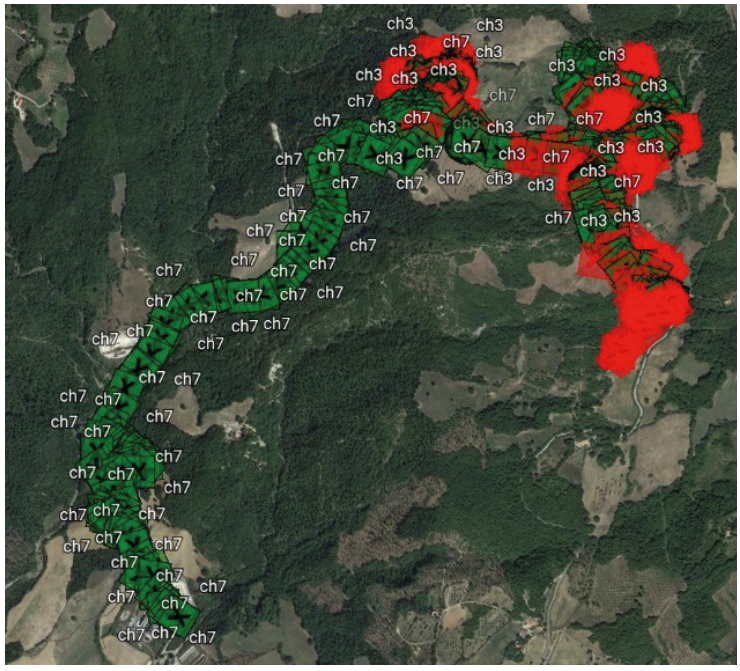

Figure 6. Farm 3: route obtained with GPS radio-collar for female n° 3, red trace, with sheep n° 7, green trace.

Conclusions

The results of this research highlight several very positive aspects. Firstly, the farm owner interviews showed that the use of the dogs certainly led to a decrease in predation on the farms. Secondly, none of the dogs were interested in going outside the farm territory.

The results also show how the dogs worked in different ways with very different defense and space management behaviors. Out of eight dogs analyzed, five obtained positive results in both types of tests, however three dogs did not exhibit fully suitable behaviors for pastoral use as guardian dogs. In particular the dog derived from the crossing with a Pyrenean dog was shown to be aggressive.

Nevertheless, the results were obtained from the behavioral analysis of a limited number of mixed breed dogs of which in only one case was the cross breed known. However, it cannot be excluded that the results were due to a selection of the dogs used based only on the phenotypic characteristics of the dogs (all similar to the MSD), and to a lack of zootechnical and genetic selection. This translates into a lack of uniformity and typicality of the work that a Maremma-Abruzzese Shepherd dog should have. Further studies are needed to extend the research including more animals of a known cross breed.

Acknowledgments

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Annex 1. Individual dog behavioral observation sheet

Date:	*Farm:*
Dog:	*Collar n°:*
Environmental context: stable (external / internal)	*Sex*

Test with owner	Response			
	Collaborative	Indifference	Elusive	Aggressive
Test 1: Response to owner recall				
Test 2: Conducted on a leash				
Test 3: Owner's physical contact/manipulations, microchip control and radio-collar insertion				

Test with stranger or predator	Indifference	Sociable	Alert followed by sociability/ gladness	Alert followed by distrust	Alert with aggressiveness but stays away	Alert with aggressiveness and approaching
Test 4: Behavior of the dog upon arrival of the stranger walking in the presence of the owner						
Test 5: Stranger on a bicycle						
Test 6: Stranger with dog on a leash						
Test 7: Stranger approaching walking towards the grazing flock						
Test 8: Call of the predator						

Risposte comportamentali a test attitudinali e monitoraggio con radio collare GPS di cani meticci di Pastore Maremmano Abruzzese

Virginia Bellini[1], Gabriele Stagi[2], Duccio Berzi[3], Silvia Dalmasso[4], Fabio Macchioni[1], Angelo Gazzano[1], Francesca Cecchi[1*]

[1] Dipartimento di Scienze Veterinarie, Università di Pisa; [2] Tecnico faunistico; [3] Presidente di Canis Lupus Italia; [4] Medico Veterinario

Sintesi

Il Pastore Maremmano Abruzzese è una delle razze di cani da guardia del bestiame utilizzate per proteggere le fattorie dai predatori. In questo studio è stata valutata l'attitudine alla guardia, attraverso test comportamentali e il monitoraggio con radio collare GPS, di 8 cani adulti, meticci di pastore Maremmano. I cani inclusi nello studio appartenevano a 3 fattorie della provincia di Firenze, selezionate perché in un'area ad alto rischio di predazione.

Cinque degli otto soggetti hanno ottenuto risultati in entrambi i tipi di test. Tre cani non hanno dimostrato un comportamento utile come cani da guardiania. Un cane ha mostrato un comportamento estremamente aggressivo nei confronti degli estranei.

I risultati di questa ricerca rivelano che i meticci di Pastore Maremmano Abruzzese lavorano in modi diversi, manifestando comportamenti di difesa e di gestione dello spazio molto differenti. Questi risultati potrebbero essere dovuti alla decisione di usare meticci, selezionati in base alle loro caratteristiche morfologiche e non in base ad una selezione genetica.

Ulteriori studi saranno necessari, utilizzando animali di cui si conosca la genealogia. Nonostante non si siano ottenuti risultati estremamente positivi, le interviste ai proprietari delle fattorie hanno dimostrato che l'uso di questi cani meticci ha portato ad una riduzione dell'incidenza degli eventi di predazione.