



Behavior and Genetic Variability of the Maremma-Abruzzese Sheepdog in a farm: a Case Study

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Abstract: The Maremma-Abruzzese Sheepdog is a traditional Italian livestock guardian breed valued for its low predatory drive and strong territorial instincts. This study integrates behavioral and genetic perspectives through a case study conducted on a farm located in Viterbo province, Lazio (Italy). Ten animals were considered, on which field observations of pack structure, adolescent development, and human-dog interaction were conducted. Pedigree analysis was also performed to compute inbreeding coefficients and to analyse genetic variability. Results highlight the critical role of early imprinting, adult role modeling, and responsible breeding strategies in maintaining both behavioral suitability and genetic health. Although all the ten animals analyzed showed low levels of inbreeding ($F < 0.15$), the pedigree analysis revealed individuals with much higher coefficients, underlining the importance of genetic monitoring. Overall, the findings emphasize the need for integrated ethological and genetic management to ensure the long-term viability of this semi-feral guardian breed.

Key Words: Maremma-Abruzzese Sheepdog; behavior; inbreeding; pack structure.

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Introduction

Livestock guardian dogs (LGDs) have played a crucial role in pastoral systems for millennia across Europe and Asia, protecting herds against large predators through deeply ingrained instincts and early-life imprinting on livestock. Among these breeds, the Maremma-Abruzzese Sheepdog represents one of the most emblematic Italian examples. Traditionally employed in the regions of Maremma, Tuscany, and Abruzzo, this dog has long been valued for its ability to safeguard sheep from wolves, symbolizing the enduring coexistence between humans, agriculture, and wildlife (Breber, 1990).

The breed has been shaped by both human selection and natural pressures, leading to a distinctive temperament: proud, autonomous, and primarily motivated by a strong protective drive towards the members of its affiliative group, the flock and the humans it bonds with, rather than by a strictly territorial instinct. Given the breed's transhumant origins and its continuous movement alongside the flock, the defense of a fixed territory is secondary to this affiliative bond. The Maremma-Abruzzese does not relate to humans through strict obedience, but rather through a bond of mutual trust and compromise. As highlighted by breed clubs and breeders, this dog perceives humans more as respected partners than as superiors to be blindly obeyed, a trait that underpins its reputation as "proud and incorruptible". This noble independence, combined with calmness and reliability, has ensured the breed's continued functionality as a working guardian in both traditional and modern settings.

Historical accounts trace the presence of large white guardian dogs in Italy back to Roman times, when authors such as Varro and Columella described their role in flock protection (Bellini et al., 2022). Over centuries, the Maremma-Abruzzese became closely tied to the culture of transhumant pastoralism, maintaining its functional and morphological integrity. According to classical ethological frameworks (Coppinger & Coppinger, 1978; 1983), LGDs are defined by three core traits: attentiveness (the ability to remain close to the flock), protectiveness (the ability to actively respond to threats), and trustworthiness (the absence of predatory behavior toward livestock). These traits remain central to the Maremma-Abruzzese, whose defense strategy is

based not on aggression but on deterrence, often appearing suddenly from within the flock to confront potential predators.

Early imprinting is essential in shaping these traits: traditionally, puppies are placed with livestock at a very young age to foster recognition, bonding, and protective behavior. The result is a dog whose entire existence is defined by the defense of its flock (Bellini et al., 2022). However, recent work also shows that crossbreeding can compromise these behavioral consistencies. In their study on mixed-breed dogs derived from Maremma-Abruzzese lineage, Bellini et al. (2022) documented heterogeneous behavioral outcomes, with some individuals exhibiting aggression or inadequate protective behavior, highlighting the importance of maintaining genetic and behavioral typicality through selective breeding.

This unique ethological niche, characterized by autonomy, intelligence, and mutualistic cooperation, makes the Maremma-Abruzzese both effective and complex as a working guardian. While behavioral aspects of LGDs have been well documented (Coppinger & Coppinger, 2001; Coppinger et al., 2015), integrated studies that combine ethological field observations with genetic monitoring remain limited. The purpose of the present work is to investigate, through a case study at a Farm located in Viterbo Province (Italy), how behavioral ecology and genetic management intersect in shaping the functionality of the Maremma-Abruzzese Sheepdog as a livestock guardian. Specifically, our goal was to document pack dynamics, adolescent development, and human-dog interactions, while simultaneously evaluating levels of inbreeding within the population. By integrating these perspectives, this study provides applied insights into the sustainability of the breed in real farm contexts and offers recommendations for balancing tradition, animal welfare, and long-term viability.

Materials and Methods

Animals and Behavioral Observations

Behavioral observations were carried out at a farm in Lazio, Italy, on a group of ten dogs consisting of seven adults and three young individuals between five and eight months of age. Farm management followed standard practices, including gradual introduction to visitors and supervised interactions with livestock.

Behavioral observations were conducted through direct ethological observation, supplemented by daily field notes, according to standardized ethological protocols. Behavioral categories included:

Social hierarchy – monitoring access to resources, dominance/submission interactions, and adult corrections of juvenile behavior.

Adolescent socialization – recording play, imitation, and social learning processes guided by adults.

Predatory behavior – identification of stalking, chasing, or hunting attempts, with suppression by adults or humans.

Human-dog communication – evaluation of cooperative behaviors in response to calm vocal cues, gestures, and guided introductions.

Individual variability – assessment of differences in guarding aptitude across livestock species (poultry vs. ovicaprids).

Observations were conducted daily over a three-month period, with 2–3 hour sessions aligned with routine farm activities.

Pedigree analysis

The pedigree of each dog was collected by ENCI (Italian Kennel Club; <https://www.enci.it/>), and a database was built. The ten dogs together with their entire genealogy constitute the whole

population (WP). We used Pedigree Viewer software (Kinghorn, 1994) to verify whether there were any errors left in the data files. The complete genalogical structure of the whole population and the individual and average inbreeding coefficient (F), was computed using the CFC software (Sargolzaei et al., 2006). The inbreeding coefficient is the probability that at any randomly drawn locus of a given individual has two identical by-descent alleles (Wright, 1922). This parameter was calculated by the tabular method described by Meuwissen & Luo (1992).

Results and discussion

Behavioral observations on ten Maremma-Abruzzese Sheepdogs revealed a well-structured pack hierarchy, with dominant adults consistently regulating access to resources and human attention, thereby maintaining social stability. Juveniles acquired behavioral patterns primarily through play and adult correction, highlighting the importance of social learning in shaping effective livestock guardians. Instances of predatory behavior were rare and context-dependent, generally extinguished through environmental management, human intervention, and reinforcement by adult role models. Table 1 reports the number of observed episodes, average duration (minutes $\pm$ standard deviation), and contextual notes for each behavior category, including social hierarchy, adolescent socialization, predatory behavior, human-dog interaction, and guardian vigilance.

Table 1. Behavioral patterns observed in ten Maremma-Abruzzese Sheepdogs during direct ethological observations

Behavior	Category	Episodes (n)	Avg Duration (min) $\pm$ SD	Contextual Notes
Dominance	Social hierarchy	35	3.2 $\pm$ 1.1	Mainly adult-to-juvenile interactions; access to resources controlled
Submission	Social hierarchy	22	0.5 $\pm$ 0.2	Mostly juveniles responding to dominant adults
Social play	Adolescent socialization	40	7.1 $\pm$ 2.5	Primarily between juveniles and adult role models
Correction	Adolescent socialization	15	1.8 $\pm$ 0.7	Adult interventions to correct inappropriate behaviors
Predatory attempts	Predatory behavior	5	0.8 $\pm$ 0.3	Quickly suppressed by adults or humans; context-dependent
Human-dog interaction	Cooperation	28	4.0 $\pm$ 1.5	Calm introductions and guided interactions with humans
Vigilance	Guardian behavior	30	15.0 $\pm$ 5.2	Individual differences observed according to livestock species

Human-dog interactions were characterized by trust-based communication strategies – calm introductions, measured movements, and consistent vocal tones – that promoted cooperation without compromising autonomy. Owners often mediated encounters with visitors, signaling whether a stranger could be trusted and reinforcing the dogs' ability to discriminate between harmless guests and potential threats. Individual variability in guarding aptitude was observed, with some dogs demonstrating greater suitability for specific livestock species (e.g., poultry versus ovicaprids), suggesting an interplay between genetic predisposition and experiential influences.

These findings confirm classical ethological accounts of livestock guardian dogs (LGDs) as semi-feral yet cooperative partners (Coppinger & Coppinger, 1978; 2001). The corrective role of adults within the pack highlights mechanisms of social learning and supports epigenetic models of behavioral reinforcement (Coppinger et al., 2015). Observations also underline the critical importance of early socialization, as once dogs were very young (around five months of age) their capacity to acquire new social skills diminishes, making early exposure decisive in shaping adult behavior. Trust-based interaction strategies observed on this farm reflect a broader management philosophy where respect, patience, and non-invasive communication foster cooperation without diminishing autonomy. The rarity of predatory behaviors and their tendency to disappear without reinforcement corroborate the hypothesis that LGDs have been selectively bred for reduced predatory drive. Finally, the variability in aptitude for guarding different livestock species is consistent with recent applied research on Maremma crosses (Bellini et al., 2022), and underlines the importance of aligning each dog's temperament with specific management needs to preserve breed-specific traits through responsible selection.

The genetic analysis showed that most individuals presented low to moderate levels of inbreeding, with coefficients below 0.10. However, a minority of dogs exhibited higher inbreeding coefficients, largely the result of repeated use of certain sires and occasional father-daughter matings. Out of the 234 individuals included in the genealogical analysis, 65 (approximately 28%) were identified as inbred (Table 2). The distribution of inbreeding coefficients ranged from $F = 0.01$ to $F = 0.35$, with over 40% of inbred individuals exceeding the recommended threshold of $F = 0.05$ (Table 3).

Table 2. The main genealogical parameters computed for the WP

Data	n° dogs
Whole Population (WP)	234
Males	104
Females	122
Inbred animals	65
Total Sires	104
Total Dams	122
Founders	75
Full sibs groups	17
Average full sibs per family	2.06
Max	3
Min	2

Table 3. Distribution of inbreeding coefficients in the WP

Inbreeding ranges	n° dogs
$0.00 < F \leq 0.05$	20
$0.05 < F \leq 0.10$	17
$0.10 < F \leq 0.15$	10
$0.15 < F \leq 0.20$	5
$0.20 < F \leq 0.25$	6
$0.25 < F \leq 0.30$	3
$0.30 < F \leq 0.35$	4

According to Ciampolini et al. (2013), maintaining inbreeding coefficients below 0.05 is advisable to preserve long-term population viability. All the ten dogs considered were found to be inbred, with an inbreeding coefficient lower than 0.15. Although farm managers implemented preventive breeding practices that considered both genetic and behavioral compatibility, the presence of individuals with high F values underscores the importance of continuous genetic monitoring and cautious mate selection. High inbreeding levels can lead to inbreeding depression (Cecchi et al., 2018), reveal hereditary disorders (Comparini et al., 2019; Cecchi et al., 2020; Barsotti et al., 2024), and reduce overall genetic variability. Moreover, preliminary studies have highlighted the potential relevance of genetic background in age-related neurobiological processes in dogs (Ciurli et al., 2024), while the specific contribution of inbreeding remains largely unresolved (Gazzano et al., 2024). For these reasons, the analysis of genealogical data is crucial to support sustainable breeding strategies, both at the breed level (Cecchi et al., 2016) and within individual farms (Ciampolini et al., 2013; Cecchi et al., 2020). These findings therefore highlight the need for proactive breeding strategies, including the introduction of unrelated sires, the rotation of reproductive individuals, and the systematic use of pedigree-based or molecular tools to prevent the accumulation of homozygosity and to ensure both the genetic health and the working reliability of the Maremma-Abruzzese Sheepdog.

Conclusion

This case farm-based study demonstrates that the behavioral effectiveness and genetic viability of the Maremma-Abruzzese Sheepdog are deeply interconnected. Ethologically informed rearing practices – particularly early imprinting and adult role modeling – combined with responsible breeding management are essential for maintaining this breed as a sustainable livestock guardian. Integrating behavioral ecology with genetic monitoring not only ensures functional efficiency but also preserves the cultural and ecological heritage embodied by this traditional Italian breed.

An additional key consideration is the importance of monitoring consanguinity not only for physical health but also for behavioral stability. High levels of inbreeding have been associated in other breeds with inbreeding depression that can affect temperament, learning abilities, and overall behavioral balance. While this study did not identify direct correlations between inbreeding coefficients and behavioral traits, future research should address this crucial link. Establishing whether consanguinity influences behavioral characteristics would provide essential guidance for breeders and managers, helping to safeguard both the working functionality and the welfare of the Maremma-Abruzzese Sheepdog.

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Comportamento e variabilità genetica del Cane da Pastore Maremmano-Abruzzese in una azienda agricola: un caso studio

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Sintesi

Il Cane da Pastore Maremmano-Abruzzese è una razza tradizionale italiana da guardiania del bestiame, apprezzata per il basso istinto predatorio e i forti comportamenti territoriali. Questo studio integra prospettive comportamentali e genetiche attraverso un caso di studio condotto in un'azienda agricola situata nella provincia di Viterbo, Lazio (Italia). Sono stati considerati dieci animali, sui quali sono state effettuate osservazioni sul campo relative alla struttura del branco, allo sviluppo adolescenziale e all'interazione uomo-cane. È stata inoltre condotta un'analisi genealogica per calcolare i coefficienti di consanguineità e valutare la variabilità genetica. I risultati evidenziano il ruolo cruciale del precoce imprinting, della funzione di modello degli adulti e di strategie di allevamento responsabili nel mantenimento sia dell'idoneità comportamentale sia della salute genetica. Sebbene tutti i dieci animali analizzati abbiano mostrato moderati livelli di consanguineità ($F < 0,15$), l'analisi genealogica completa ha rivelato individui con coefficienti molto più elevati, sottolineando l'importanza del monitoraggio genetico. Nel complesso, le evidenze raccolte mettono in risalto la necessità di una gestione integrata etologica e genetica per garantire la sostenibilità a lungo termine di questa razza da guardiania semi-selvatica.