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A retrospective demographic analysis of registry-based reproductive parameters in the Sicilian Mastiff

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ABSTRACT

This retrospective study provides a demographic characterisation of the reproductive parameters of the Sicilian Mastiff (Mannara Dog) a local Italian breed recognised by the ENCI in 2014. We analysed official studbook records from 2015–2024, involving 136 whelping events from 89 bitches and 61 sires. Due to the retrospective nature of the registry data, the analysis focused on ‘registered litter size’ (puppies alive at ~25 days), which serves as a proxy for net reproductive productivity rather than prolificacy at birth. Mean bitch age at first whelping was 28.42 ± 17.33 months, with an average registered litter size of 3.96 ± 2.13 . A Generalised Linear Mixed Model (GLMM), accounting for the dam as a random effect, revealed that maternal age negatively influenced registered litter size; each additional month of age was associated with a 1% reduction in the number of pups ($p < 0.05$; CI: $-0.0143, -0.0004$). A significant seasonal trend was observed, with whelping frequencies peaking in March compared to June and July ($p < 0.05$ and $p < 0.01$, respectively). While this peak suggests a potential influence of environmental cues or breeder management preferences, the findings provide a necessary baseline for the conservation and demographic monitoring of this rural breed. Further research using prospective designs is needed to account for parity, neonatal mortality, and kennel-specific effects in this developing population.

HIGHLIGHTS

- First demographic report of the Sicilian Mastiff dog's reproductive data.
- Official ENCI studbook records from 2015 to 2024 were analysed.
- Increased maternal age is associated with smaller registered litter sizes.
- Whelping frequency showed a significant seasonal peak in March.
- Results provide a baseline for the conservation of this local Italian breed.

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Introduction

The Sicilian Mastiff, or Mannara dog, is a traditional livestock guardian breed that has historically been an integral part of the Sicilian pastoral economy. Unlike commercial breeds subjected to intensive kennel management, the Sicilian Mastiff is primarily reared in extensive rural environments, living in close contact with shepherds and livestock. These dogs typically lead an outdoor existence, exposed to natural photoperiods and seasonal climatic fluctuations, with breeding practices often guided by functional utility rather than controlled clinical intervention. Recognised by the Italian Kennel Club (ENCI) in 2014, the breed is currently managed as a developing population under conservation. At present, approximately 740 specimens

are registered in the ENCI Supplementary Registers. Because these animals are frequently located in remote mountainous or rural areas, large-scale clinical monitoring is challenging; consequently, official registry data represents the most reliable source for assessing the breed's demographic and reproductive status. While the domestic dog (*Canis familiaris*) is generally a non-seasonal breeder (Concannon 2011), the degree of reproductive consistency in rustic populations remains a subject of interest. It is suggested that the transition to modern, non-seasonal breeding resulted from reduced environmental constraints and selective pressures (Jensen 2007). In this context, the Sicilian Mastiff offers a unique opportunity to study a population that has maintained a strong link to its

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geographic origin and traditional management style. Understanding the reproductive parameters of such a population is crucial for developing effective conservation strategies, especially given local reports of variable litter viability. This study aims to characterise the reproductive profile of the Sicilian Mastiff using official ENCI studbook data (2015–2024). Specifically, we investigated the influence of maternal age on registered litter size and sex ratio, and analysed the frequency distribution of births to identify potential seasonal trends within this Mediterranean population.

Materials and methods

Ethical statement

Ethical approval was not required as the study utilised publicly accessible data from the online genealogical register of the Italian Kennel Club (ENCI). No procedures were carried out specifically for research purposes, and no animals were handled or sampled. All procedures followed Italian legal regulations (Directive 2010/63/EU) and the (ASAB 2020) guidelines for the treatment of animals in research.

Animals and data collection

We analysed reproductive records of the Sicilian Mastiff (Mannara dog) extracted from official ENCI studbooks for the period 2015–2024. The final dataset included 136 whelping events from 89 bitches and 61 sires. Breeding kennels were located in Sicily (latitude 37°20' N to 38°11' N), where dogs are traditionally housed outdoors under a natural photoperiod and fed either commercial or traditional diets (Florida et al. 2023). Since total birth data were unavailable, 'registered litter size' was defined as the number of puppies alive at the time of official registration (approximately 25 days of age).

Statistical analysis

Statistical analyses were conducted using R (version 3.6.3). Descriptive statistics were calculated for all parameters. A Generalised Linear Mixed Model (GLMM) with a Poisson distribution and log-link function was used to examine the influence of dam age on registered litter size. Overdispersion was checked to ensure model fit. The conditional coefficient of determination was used as a measure of goodness of fit. DHARMA residual diagnostics was used to analyse the residuals. A logistic regression was applied to determine if dam age influenced the pup sex ratio.

To define birth frequency distribution, whelping dates (2015–2024) and parents' birth dates (2008–2023) were analysed separately. To ensure independence when analysing parents' birth seasonality, subjects with identical birth dates were screened and excluded to avoid over-representing individuals from the same litter. A Chi-square goodness-of-fit test was performed to evaluate whether births were uniformly distributed across months. Post-hoc comparisons between peak and nadir periods were conducted using the Benjamini-Hochberg correction. Results are reported as mean $\pm$ SD, including 95% Confidence Intervals (CI) for the main effects. Significance was set at $p < 0.05$.

Results

Descriptive statistics for reproductive performance and parental age are summarised in Table 1. The mean bitch age at first registered whelping was 28.42 ± 17.33 months, while the sire age at the time of first mating was 31.68 ± 25.32 months. The average registered litter size was 3.96 ± 2.13 . Regarding population management, a high percentage of bitches (58.43%) produced only a single litter during the study period, while a minority reached three or four whelping events (7.86% and 1.12%, respectively). Notably, 62% of all registered puppies originated from the dam's first recorded whelping, suggesting a relatively low reproductive turnover.

The GLMM analysis confirmed that maternal age significantly influenced registered litter size ($\beta = -0.007$; 95% CI: -0.0143 , -0.0004 ; $p = 0.044$). This negative association indicates approximately a 1% decrease in the number of registered puppies for each additional month of maternal age (Figure 1). No over/underdispersion was detected and no problem were detected by DHARMA residual diagnostics. The conditional coefficient of determination is equal to 0.13.

In contrast, maternal age had no significant effect on the pup sex ratio ($p > 0.05$).

To ensure data independence for seasonality analysis, 16 bitches and 35 sires were excluded. A significant seasonal pattern emerged ($p < 0.05$): birth frequencies for bitches, sires, and litters peaked in March, showing significantly higher values compared to the nadir observed in June and July ($p < 0.05$ and $p < 0.01$, respectively; Figure 2). The March peak accounted for 12.76% of total annual whelpings.

Discussion

This study represents the first characterisation of reproductive parameters in the Sicilian Mastiff using

Table 1. Reproductive parameters of the Sicilian Mastiff population (2015–2024).

Number of bitches	89
Number of sires	61
Number of whelping events	136
The mean age of the mother at her first registered whelping (months)	28.42 ± 17.33
The mean age of the sire at the time of mating that resulted in the bitch's first registered whelping	31.68 ± 25.32
The mean litter size for registered puppies at the first whelping	3.96 ± 2.13
Number of pups at registration	568
Male pups at time of registration	297 (52.29%)
Bitches that produced a single litter	52 (58.43%)
Bitches that produced two litters	29 (32.58%)
Bitches that produced three litters	7 (7.86%)
Bitches that produced four litters	1 (1.12%)
Puppies from bitches' first whelping	352 (62%)

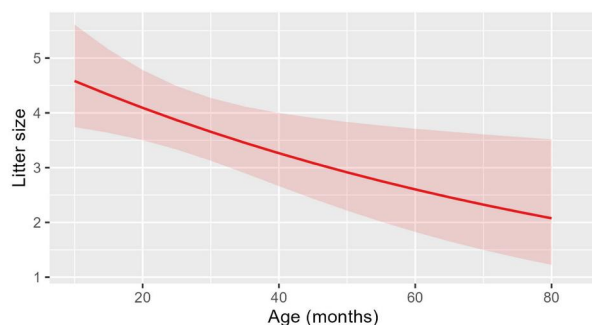


Figure 1. Predicted trend of registered litter size in relation to maternal age at whelping. The curve represents the marginal effects derived from the generalised linear mixed Model (GLMM). The shaded area denotes the 95% confidence interval. While the model indicates a statistically significant negative association ($p < 0.05$), the effect size is modest (approximately 1% reduction in registered puppies per month of maternal age) and the wide confidence intervals reflect the limited sample size of this developing population; therefore, this result should be interpreted as a preliminary demographic trend rather than a definitive measure of reproductive performance.

official registry data. The observed low reproductive turnover, with 58% of bitches producing only one litter, likely reflects the breed's primary role as a working livestock guardian dog rather than a commercial pet.

A significant negative impact of maternal age on registered litter size was identified. This decline is consistent with findings in other breeds (Borge et al. 2011, Axné et al. 2022) and may be linked to age-related uterine changes or increased pre-weaning mortality. Interestingly, this demographic trend remained consistent despite recent registry regulations and inbreeding restrictions (ENCI 2023); however, long-term monitoring will be necessary to evaluate the impact of these measures on population structure.

Regarding seasonality, the significant birth peak in March implies conceptions occurring during early winter, potentially influenced by Sicily's natural photoperiod and outdoor housing. While the precision of a

March whelping peak suggests a potential underlying seasonality, this pattern likely reflects a combination of environmental influences and specific breeder management practices—such as aligning births with pastoral cycles and favourable climatic conditions—rather than a single causal factor. When compared to the Cirneco dell'Etna—another ancient native Sicilian breed previously investigated using a similar registry-based approach (Alberghina et al. 2024) interesting demographic parallels and differences emerge. While the average registered litter size is highly consistent between the two breeds (3.96 ± 2.13 in the Sicilian Mastiff vs. 3.84 ± 2.08 in the Cirneco dell'Etna), the mean bitch age at first whelping was considerably lower in the Mastiff (28.42 months) than in the Cirneco (39.13 months). This discrepancy likely reflects different management practices, as the Sicilian Mastiff is primarily a rustic working dog integrated early into pastoral life. Furthermore, the March peak observed in this population differs from the bi-phasic peak (April and July) reported for the Cirneco dell'Etna (Alberghina et al. 2024), suggesting that functional role, hunting versus pastoral utilisation, and specific human selection history may heavily influence reproductive choices and outcomes in these local populations.

The importance of integrating phenotypic traits (like coat colour or hair texture) with genetic and demographic monitoring has been recently highlighted in other rustic Italian guardian breeds under conservation, such as the Fonni's dog (Cortellari et al. 2023). Consequently, tracking the distribution of these phenotypic and genomic traits represents a primary objective for the future monitoring and selection strategies of the Sicilian Mastiff.

This study is subject to several limitations inherent to the use of registry-based retrospective data. Notably, the lack of information regarding parity, neonatal mortality, individual nutritional status, and inbreeding coefficients precludes a mechanistic analysis of reproductive performance. Furthermore,

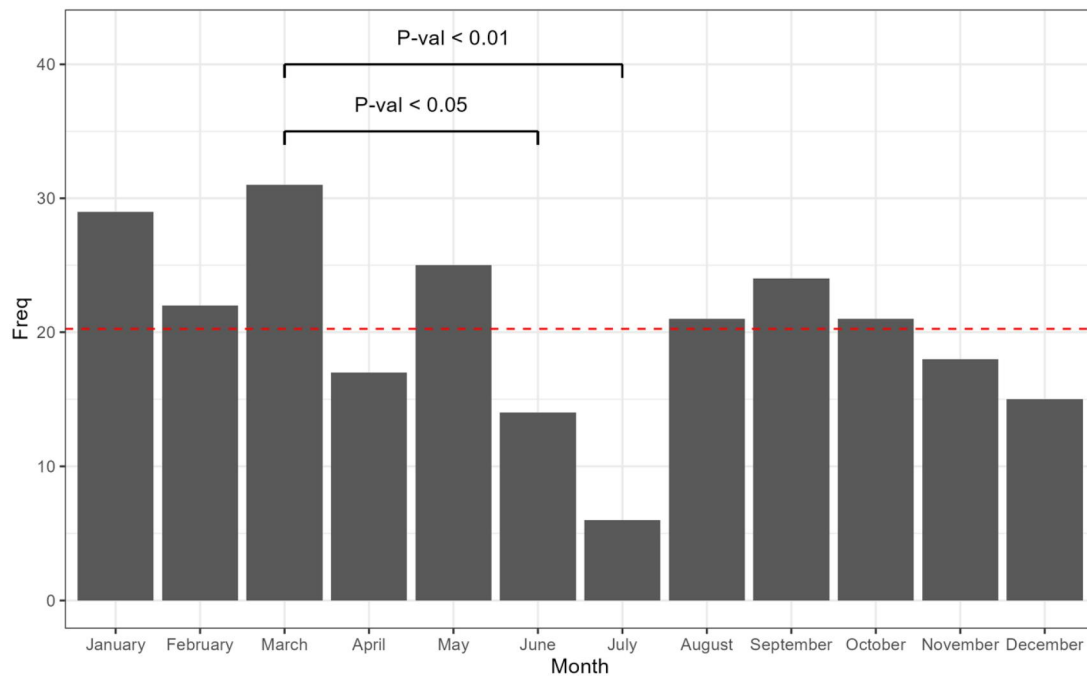


Figure 2. Monthly distribution of births (2008–2024) of Sicilian Mastiff subjects (dams, sires, and litters). The number of births is represented on the y-axis.

‘registered litter size’ at 25 days acts as a demographic proxy influenced by postnatal management and survival bias, rather than a direct measurement of prolificacy at birth. Consequently, our findings should be interpreted as a descriptive demographic baseline; these variables—particularly parity and kennel-specific management practices—represent significant confounding factors that future prospective research must account for to disentangle population trends from management-driven influences.

Conclusions

This study provides the first population-level analysis of reproductive parameters in the Sicilian Mastiff, identifying maternal age and birth month as significant factors influencing registered litter size and whelping frequency. The negative correlation between dam age and litter size highlights the importance of monitoring reproductive efficiency in ageing working dogs. Furthermore, the subtle seasonal peak in March suggests that environmental cues may still influence reproductive timing in this rustic breed. These findings offer a valuable baseline for the conservation and management of the Sicilian Mastiff. Future research incorporating genomic markers and prospective data on neonatal mortality will be essential to further clarify the interplay between ancestral genetics and human selection in shaping the reproductive adaptations of domestic canids.

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Author contributions

CRediT: **Daniela Alberghina:** Conceptualization, Writing – original draft; **Carmelo Cavallo:** Data curation, Software, Writing – review & editing; **Mauro Gioè:** Software; **Luigi Liotta:** Conceptualization, Data curation, Supervision, Writing – review & editing.

Disclosure statement

The authors declare no conflicts of interest

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Data availability statement

Data are available at [dx.doi.org/10.6084/m9.figshare.29413667](https://doi.org/10.6084/m9.figshare.29413667)

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