

## An In-Depth Analysis of Interconnections Amongst Studbook Registries in Balearic Islands Dog Breeds

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### SUMMARY

This study seeks to evaluate the relationships within the studbook registries of endangered autochthonous canine breeds in the Balearic Islands. Employing Pearson's Product Moment Correlations and operating within the legal framework of Royal Decree 558/2001 aligned with EU standards for recognizing purebred dog breeders in Spain, patterns within the studbook were unveiled. Notably, the female Foundational Registry census displayed robust positive correlations, highlighting the significance of a solid foundational basis, particularly in females, for effective breed consolidation. Conversely, negative correlations with auxiliary registries suggest a diminished role when the foundational basis is strong. The analysis further reveals robust intra-gender relationships and strong correlations with total censuses, indicating systematic registration approaches. Surprisingly, females in the Birth Auxiliary Registry lack correlations, suggesting potential independence and underscoring the pivotal role of female censuses in breed consolidation. In conclusion, this correlation analysis offers valuable insights into studbook dynamics, emphasizing the importance of a robust foundational basis, especially concerning female censuses, in the successful evolution of endangered dog populations into standardized breeds. These findings provide guidance for studbook management and warrant additional exploration into specific registry categories, with a cautionary note that while correlation identifies associations, discerning causation necessitates nuanced interpretation and domain-specific knowledge.

### Análisis Detallado de las Interconexiones entre los Registros Genealógicos de las Razas Caninas en las Islas Baleares

### RESUMEN

Este estudio busca evaluar las relaciones dentro de los registros genealógicos de razas caninas autóctonas en peligro de extinción en las Islas Baleares. Utilizando las Correlaciones del Momento del Producto de Pearson y operando dentro del marco legal del Real Decreto 558/2001 alineado con los estándares de la UE para el reconocimiento de criadores de perros de raza pura en España, se revelaron patrones dentro del registro genealógico. Notablemente, el censo de la Fundación de hembras mostró correlaciones positivas sólidas, resaltando la importancia de una base fundacional sólida, especialmente en las hembras, para una consolidación efectiva de la raza. Por otro lado, las correlaciones negativas con registros auxiliares sugieren un papel disminuido cuando la base fundacional es fuerte. El análisis también revela relaciones robustas dentro de los géneros y fuertes correlaciones con censos totales, indicando enfoques sistemáticos de registro. Sorprendentemente, las hembras en el Registro Auxiliar de Nacimientos carecen de correlaciones, sugiriendo una independencia potencial y subrayando el papel crucial de los censos de hembras en la consolidación de la raza. En conclusión, este análisis de correlación ofrece información valiosa sobre la dinámica del registro genealógico, enfatizando la importancia de una base fundacional sólida, especialmente en relación con los censos de hembras, para la exitosa evolución de las poblaciones caninas en peligro hacia razas estandarizadas. Estos hallazgos proporcionan orientación para la gestión de registros genealógicos y justifican una exploración adicional en categorías de registros específicas, con la advertencia de que, si bien la correlación identifica asociaciones, discernir la causalidad requiere una interpretación matizada y conocimientos específicos del dominio.

### INTRODUCTION

In Nestled within the Balearic Islands, a captivating saga of canine genetic diversity unfolds against a backdrop of sun-soaked landscapes and cultural intricacies. These islands, scattered across the azure Mediterranean, serve as custodians to a plethora of dog breeds, each weaving its own unique narrative

shaped by historical influences and environmental adaptations. As stewards of these invaluable genetic lineages, our exploration delves beyond the surface of mere registry numbers, aiming to decipher the intricate genetic landscapes that define and distinguish these cherished breeds.

In the realm of canine conservation, our attention is keenly focused on endangered breeds, where the

delicate equilibrium between genetic diversity and functional traits is paramount for survival. Preservation efforts extend beyond the quantitative realm of registry numbers, demanding a nuanced understanding of the functional attributes that imbue these breeds with unique qualities, honed over generations (Verde et al. 2009) to serve specific purposes. In the Balearic Islands, as elsewhere, the essence of endangered breeds resides not solely in their genetic representation but in the preservation of distinctive traits that have withstood the test of time.

The Royal Decree 558/2001 (Alimentación 2001), enacted on May 25, regulates the official recognition of organizations or associations of purebred dog breeders in Spain. It is rooted in the need to harmonize criteria for breeds included in the European Community Treaty, particularly those lacking specific regulations. The directive aligns with EU standards, ensuring the preservation, improvement, and promotion of diverse canine breeds.

Our analytical journey pivots on the profound significance of correlations, a scientific tool illuminating the complex relationships interwoven within the intricate fabric of studbook registries. By meticulously examining the correlation matrix, we aim to decipher the relationships between registry numbers, offering insights into the dynamic interplay of breeding practices, the selective pressures influencing genetic diversity, and the overall genomic health of dog breeds in the Balearic Islands.

Moreover, the Balearic Islands emerge as a pivotal host to approximately 60 percent of the Spanish studbook registries (Navas 2022), underscoring their role as a crucible of genetic diversity within the broader landscape of Spain. This concentration not only accentuates the prominence of these islands but also positions them as a focal point for comprehending the nuanced dynamics of breed development and preservation.

Our analysis seeks to unravel the genetic interconnections within these registries, shedding light on the intricate relationships that have flourished amidst the unique socio-cultural and environmental tapestry of the Balearic Islands. As we embark on this scientific journey, our aim is to reveal the threads that bind the past, present, and future of these canine lineages, contributing to the broader discourse on genetic conservation and breed management.

## MATERIAL AND METHODS

The present paper bases upon the information derived from practical examples of officially recognised breeds and those in terms of recognition.

### COMPENDIUM: ROYAL DECREE 558/2001

#### OBJECTIVE AND BACKGROUND:

The Royal Decree 558/2001, enacted on May 25, regulates the official recognition of organizations or associations of purebred dog breeders in Spain. It is

rooted in the need to harmonize criteria for breeds included in the European Community Treaty, particularly those lacking specific regulations. The directive aligns with EU standards, ensuring the preservation, improvement, and promotion of diverse canine breeds.

#### COMPETENCE AND RECOGNITION:

**National Recognition:** The Ministry of Agriculture, Fisheries, and Food oversees national recognition, requiring organizations to have at least 35% of the national census, distributed in ten Autonomous Communities.

**Regional Recognition:** Autonomous Communities handle recognition if organizations are not nationally scoped. For Spanish breeds, recognition considers technical, socio-cultural, and historical aspects, with the origin determining the competent authority.

#### REQUIREMENTS FOR RECOGNITION:

##### ORGANIZATIONS MUST:

##### POSSESS LEGAL PERSONALITY

Maintain adequate infrastructure, including scientific guidance, documentation processes, kinship control, and economic funds.

Demonstrate capacity for genealogical controls, breed improvement, and breeding suitability.

Operate on a non-profit basis, combat aggressive behaviors, and contribute to breed conservation.

##### REGISTRATION CRITERIA:

Dogs must have registered ancestors in recognized genealogical books.

Dogs initially registered in Spain cannot be re-registered elsewhere without proof of removal.

Genealogical books consist of main and annex sections, with specific criteria for registration in each.

##### GENERAL REGISTER AND DUTIES:

A General Register is established at the Ministry, including recognized organizations. Autonomous Communities provide updates annually.

Genealogical books include main and annex sections, with a merits register for exceptional qualities.

Organizations must provide information upon request and manage aptitude test registries.

##### AMENDMENTS (DECEMBER 23, 2005):

Recognition shifts to the Autonomous Community of the organization's headquarters.

The General Registry becomes public and informative.

Adherence to racial prototypes for Spanish breeds.

Organizations must provide information to autonomous communities.

ANNEX REPLACEMENT FOR "SPANISH DOG BREEDS."

Recognition documentation transfer for existing organizations.

Resolution of ongoing procedures as per the prior regulations.

Validity of racial prototypes until Autonomous Communities regulate them.

DIFFERENT KINDS OF REGISTRIES:

MAIN SECTION

For purebred dogs with registered ancestors, identified following specific requirements, and meeting breed standards.

ANNEX SECTION

For dogs lacking complete genealogical documentation but contributing to breed improvement based on ethnic characteristics.

MERITS REGISTER

Includes animals from the main section that have passed aptitude tests, demonstrating exceptional qualities.

APTITUDE TEST

Authorized organizations may manage registries of dogs participating in aptitude tests, incorporating relevant data into genealogical records.

Endangered Breeds: The competent authority will devise recovery plans for endangered Spanish canine breeds.

PEARSON'S PRODUCT MOMENT CORRELA-

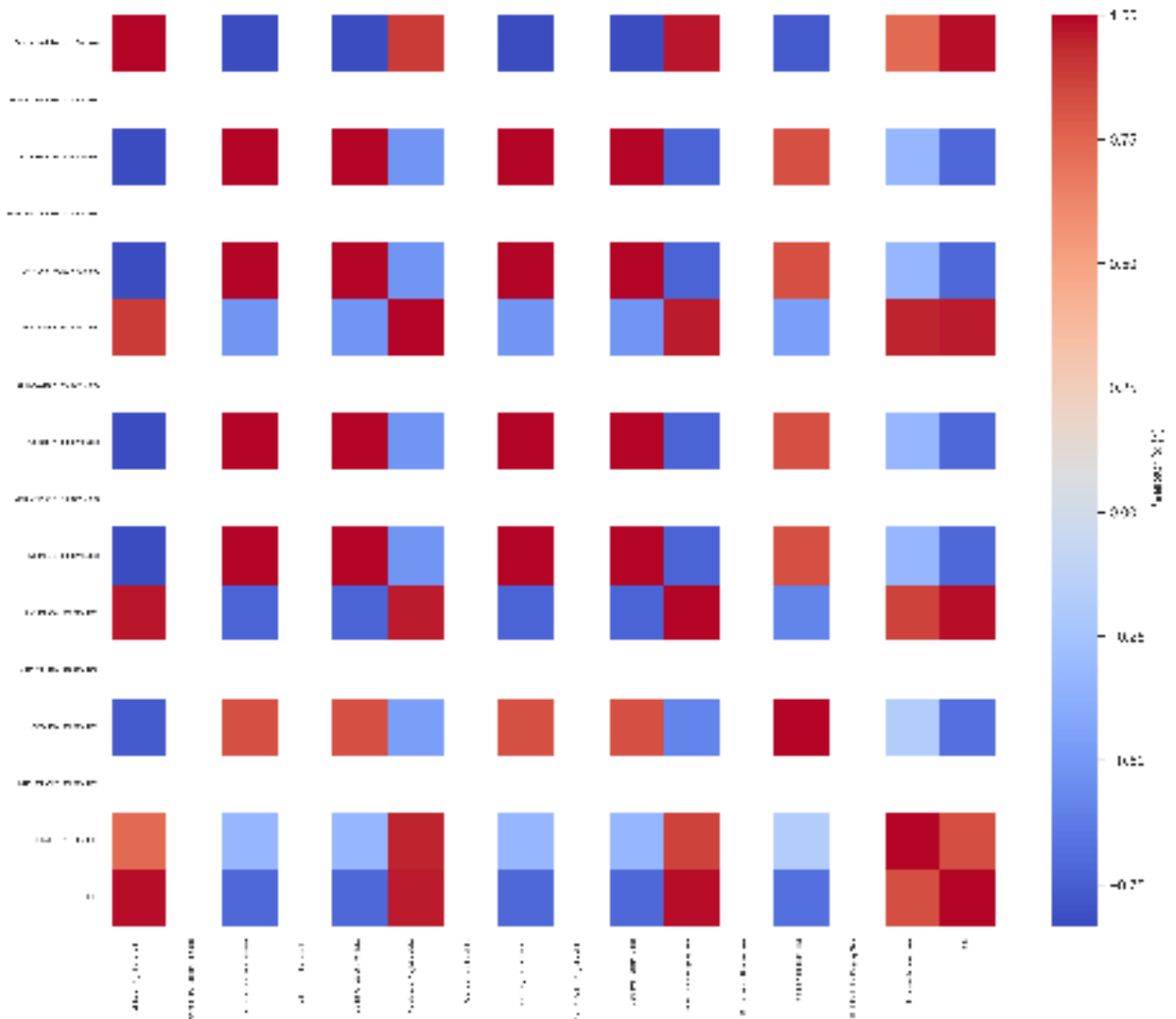


Figure 1. Pearson's Product Moment correlations across Registries in the stdubook of Balearic Dog Breeds.

## TIONS

XLSTAT Version 2014.5.03 was used to calculate Pearson's Product Moment correlations among the censuses of the different registries (Foundational, Definitve, Birth and Auxiliary. comprising a studbook separated for sex, to determine the existing relationship among them.

## RESULTS

### PEARSON'S PRODUCT MOMENT CORRELATIONS

**Figure 1** shows a heatmap reporting correlations across registries and genders in the studbook. As suggested by the scale, the more intense the red colour is the larger positive correlations between element pairs is as well. On the contrary the more intense the blue colour is the larger the blue correlations across elements and features is as well.

### INTERPRETATION OF VALUES:

#### POSITIVE CORRELATION

Values close to 1 in the correlation table indicate a strong positive correlation. This implies that as one variable increases, the other variable tends to increase as well. In the context of this data, for instance, a high positive correlation between Foundational Registry Females and Foundational Registry Males (0.781) suggests that as the number of females in the Foundational Registry increases, there is a corresponding increase in the number of males in the Foundational Registry.

#### NEGATIVE CORRELATION:

Values close to -1 signify a strong negative correlation. This indicates that as one variable increases, the other variable tends to decrease. An example in the table is the negative correlation between Foundational Registry Females and Birth Auxiliary Registry Females (-0.500). This suggests that as the number of females in the Foundational Registry increases, there is a decrease in the number of females in the Birth Auxiliary Registry.

#### ZERO CORRELATION:

A correlation of 0 implies no linear relationship between variables. For instance, Birth Auxiliary Registry Females has zero correlation with all other variables in the table. This suggests that the number of females in the Birth Auxiliary Registry does not have a linear relationship with the numbers in other registry categories.

#### KEY OBSERVATIONS:

##### FUNDATIONAL REGISTRY FEMALES:

Positive correlations with Foundational Registry Males, Total, and Birth Auxiliary Registry Total indicate that when the number of females in the Foundational Registry increases, there is a tendency for the

numbers in these other categories to increase as well.

Negative correlations with Birth Auxiliary Registry Females and Birth Definitive Registry Females imply an inverse relationship, suggesting that as the number of females in the Birth Auxiliary Registry and Birth Definitive Registry increases, there is a decrease in the number of females in the Foundational Registry.

##### AUXILIARY REGISTRY FEMALES:

Positive correlations with Auxiliary Registry Males and Total suggest a consistent trend between the numbers of females and males or the overall total in the Auxiliary Registry category.

Negative correlations with Foundational Registry Females and Definitive Registry Females suggest an inverse relationship with these categories.

##### BIRTH AUXILIARY REGISTRY TOTAL:

A strong positive correlation with Foundational Registry Total and Birth Definitive Registry Total indicates a simultaneous increase in numbers in these categories.

##### DEFINITIVE REGISTRY MALES:

Positive correlations with Foundational Registry Males, Total, and Definitive Registry Females suggest a tendency for these variables to increase together.

Negative correlations with Birth Auxiliary Registry Males and Auxiliary Registry Males indicate an inverse relationship.

### INSIGHTS:

#### INTRA-GENDER RELATIONSHIPS:

The strong correlations within genders (both for females and males) suggest a consistent pattern in registration between different registry types for each gender. This could be indicative of a systematic approach to registration within each gender category.

#### TOTAL REGISTRY RELATIONSHIPS:

The strong positive correlations of the "Total" category with various subcategories suggest an overall alignment or coherence in the registration patterns across different types of registries.

##### BIRTH AUXILIARY REGISTRY FEMALES:

The lack of correlation with any other category indicates potential independence or a lack of a linear relationship between the number of females in the Birth Auxiliary Registry and other registry types. Further investigation into the nature of this registry might provide valuable insights.

## DISCUSSION

This study delves into the intricacies of studbook dynamics, utilizing Pearson's Product Moment Cor-



relations (Puth, Neuhäuser & Ruxton 2014) to elucidate relationships among different registries and sexes in endangered dog breeds from the Balearic Islands. Figure 1 acts as a visual guide, employing a heatmap (Filzmoser et al. 2018) to showcase the strength of correlations—red hues indicating positive correlations, while blue hues reveal negative correlations. Foundational Registries (MURCIANO) censuses, either for males or females, are decisive in the consolidation of total censuses of breeds. This denotes the fact that the strongest the bases of a dog population, the more solid is the possibility of consolidation of this population as a breed.

Values nearing 1 denote a robust positive correlation (Quintero-Rincon, D’Giano & Risk 2020), suggesting that as one variable increases, the other tends to follow suit. As aforementioned, the substantial positive correlation (0.781) between Foundational Registry Females and Foundational Registry Males implies that an increase in female entries in the Foundational Registry corresponds to a parallel increase in male entries.

On the opposite, values approaching -1 (Ratner 2009) indicate a substantial negative correlation, suggesting that as one variable rises, the other tends to decline. The negative correlation of -0.500 between Foundational Registry Females and Birth Auxiliary Registry Females implies that as females in the Foundational Registry increase, there is a corresponding decrease in females within the Birth Auxiliary Registry. This finding may derive from the fact that when the number of females in the Foundational Registry increases, the likelihood of newborn animals from animals already registered in the population increases as well.

However, interestingly, Birth Auxiliary Registry Females, presented zero correlation to other variables, suggests a lack of a linear association with other registry categories and sexes. A correlation of 0 (Schober, Boer & Schwarte 2018) signifies an absence of a linear relationship between variables. This denotes the greater importance of female censuses than male censuses in the consolidation of a population as a breed, specially in those registries which mark the starting point of a breed and which lay the basis for the future of the efficacy of conservation strategies of such population (Scherf).

Positive correlations with Foundational Registry Males, Total, and Birth Auxiliary Registry Total imply a simultaneous escalation in these categories with an increase in female entries in the Foundational Registry. Conversely, negative correlations with Birth Auxiliary Registry Females and Birth Definitive Registry Females suggest a reduction in these categories as the number of females in the Foundational Registry increases, which in turn may derive from the fact that the more females are initially registered, that is the more solid the basis of a population is, the lower is the relevance of accessory registries (Sánchez Rodríguez & Muñoz Mejías 2003).

Indeed, these findings are also supported by the positive correlations with Auxiliary Registry Males and Total reveal a consistent trend in the numbers of females, males, or the overall total within the Auxil-

iary Registry category. Negative correlations with Foundational Registry Females and Definitive Registry Females indicate an inverse relationship with these categories.

A robust positive correlation with Foundational Registry Total and Birth Definitive Registry Total implies a simultaneous upswing in numbers across these categories. The distinction between Birth auxiliary and definitive registries is only performed autonomically, not nationally. This may be the cause for such positive correlations found.

The same was found for definitive registry in males. Positive correlations with Foundational Registry Males, Total, and Definitive (Medina & Vilas 1986) Registry Females suggest a tendency for these variables to increase together, which confirms the importance for endangered dog populations, to be supported on a solid foundational basis. Indeed, again, the more solid this foundational basis is the lowest the importance of accessory registries is as well as suggested by the negative correlations with Birth Auxiliary Registry Males and Auxiliary Registry Males indicate an inverse relationship.

Robust correlations within genders point to a consistent pattern in registration between different registry types for each gender, indicative of a systematic approach to registration within each gender category. Strong positive correlations of the “Total” category with various subcategories highlight an overall alignment or coherence in the registration patterns across different types of registries.

The absence of correlation between Birth Auxiliary Registry Females and with any other category suggests potential independence or a lack of a linear relationship between the number of females in the Birth Auxiliary Registry and other registry types. Further exploration into the nature of this registry could yield valuable insights.

## CONCLUSIONS

This comprehensive examination of correlations provides valuable insights into the underlying dynamics of the studbook, shedding light on the interconnectedness and patterns that drive breeding and registration behaviors within the studied population. Utilizing Pearson’s Product Moment Correlations unveils nuanced relationships within the studbook, providing a comprehensive understanding of registration dynamics. When dog endangered populations are supported on a solid foundational basis, specially concerning female censuses, the possibilities of success for such population to evolve into an standardized breed increase as well. This denotes the special relevance of female censuses in early stages of configuration of Standardized dog populations (breeds). Indeed, the more solid the foundational basis of a population is, the lesser are the effort to be made in accessory registries, such as the auxiliary registry. These findings offer valuable insights for studbook management and encourage further investigations into specific registry categories, fostering a holistic comprehension of

breeding patterns within the studied population. In conclusion, the correlation analysis serves as a valuable tool for identifying associations between different types of registries. However, it is important to note that correlation does not imply causation. While the table provides a starting point for understanding relationships, further exploration, and consideration of domain-specific knowledge are essential for a nuanced interpretation.

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