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A decade of progress of linear appraisal traits heritabilities in Murciano-Granadina goats

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Breeding.
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SUMMARY

The objective of this study was to evaluate the progress of heritabilities of the traits comprising the linear appraisal system in the Murciano-Granadina breed during the complete decade from December 2011 to December 2021. The estimated values for heritability were obtained from multivariate analyzes using the BLUP methodology and MTDFREML software. For 2021 heritabilities, a simple animal model was applied to records collected from 22,727 primiparous goats and 17,111 multiparous goats belonging to 85 herds. The model included the linear and quadratic and linear components of the covariates age and days in milk, respectively. The fixed effects considered in the model were herd, reproductive status, calving month and herd/year interaction. The animal was considered as a random effect. The variables studied included five characteristics related to Structure and capacity; Height at withers (EST), Body Depth (PC), Chest Width (AP), Rump Width (AG) and Rump Angle (ANG). Two traits related to dairy Structure; Angularity (ANGUL), Bone quality (HUESO). Six related to the mammary system; Anterior Insertion (IA), Rear Insertion Height (AIP), Median Suspensor Ligament (LSM), Udder Depth (PU), Nipple Placement (CP) and Nipple Diameter (DP). Finally, three related to legs and feet; Rear and lateral views of the rear legs (VPPT and VLPT) and Mobility (MOV). The heritabilities for structure and capacity characters progressed from 0.22 to 0.28 including non-convergent variables (PC and ANG) in June 2012 to values between 0.10 and 0.41 with all variables converging in June 2011. 2021. Heritabilities for dairy structure progressed from 0.18 with non-convergent variables (HUESO) in 2011 to 0.17 to 0.25 in 2021. Heritabilities for mammary system traits progressed from 0.12 to 0, 27 with non-convergent variables (AU) in 2012 to between 0.10 and 0.41 in 2021. For legs and feet, heritabilities progressed from 0.16 to 0.17 with non-convergent variables (VLPT) to 0.09 a 0.22. Genetic progress is not only evident in heritability values, but there has been a notable reduction in the standard error of heritabilities from 0.1000 (0.080-0.120) to 0.000 (0.000-0.001) from 2011 to 2021. These results provide evidence of the enhancement in the effectiveness and precision of the linear qualification system applied during the past decade and its successful integration in the breeding program of the Murciano-Granadina breed.

Palabras clave adicionales
Mejora genética.
Heredabilidad.
Conformación lechera.
Tendencias.
Razas Locales.
Error standard.

Una década de progreso de la heredabilidad de los caracteres relacionados con la calificación lineal en cabras Murciano-Granadina

RESUMEN

El objetivo de este estudio fue evaluar el progreso de la heredabilidad para los caracteres considerados dentro del sistema de calificación lineal en la raza Murciano-Granadina durante la década completa desde diciembre de 2011 hasta diciembre de 2021. Los valores estimados para la heredabilidad fueron obtenidos a partir de análisis multivariados utilizando la metodología BLUP y el software MTDFREML. Para el cálculo de las heredabilidades de 2021, se aplicó un modelo animal simple sobre los registros recogidos en 22727 cabras primíparas y 17111 cabras multíparas, pertenecientes a 85 ganaderías. El modelo incluyó los componentes lineal y cuadrático y lineal de las covariables edad y días en leche, respectivamente. Los efectos fijos considerados en el modelo fueron el rebaño, status reproductivo, el mes de parto y la interacción rebaño/año. Por su parte se consideró el animal como efecto aleatorio. Las variables estudiadas incluyeron cinco características relacionadas con la Estructura y capacidad; Altura a la cruz (EST), Profundidad corporal (PC), Anchura de pecho (AP), Anchura de grupa (AG) y Ángulo de la Grupa (ANG). Dos rasgos relacionados con la Estructura lechera; Angulosidad (ANGUL), Calidad de hueso (HUESO). Seis relacionados con el Sistema mamario; Inserción anterior (IA), Altura inserción posterior (AIP), Ligamento suspensorio medio (LSM), Profundidad de la ubre (PU), Colocación de pezones (CP) and Diámetro de pezones (DP). Finalmente, tres relacionados con Patas y pies; Vistas posterior y lateral de las patas traseras (VPPT y VLPT) y Movilidad (MOV). Las heredabilidades para los caracteres de estructura y capacidad progresaron desde 0,22 a 0,28 incluyendo variables no convergentes (PC y ANG) en junio de 2011 a valores de entre 0,10 a 0,41 con todas las variables convergiendo en junio de 2021. Las heredabilidades para la estructura lechera progresaron desde 0,18 con variables no convergentes (HUESO) en 2012 hasta 0,17 a 0,25 en 2021. Las heredabilidades para los caracteres del sistema mamario progresaron de entre 0,12 a 0,27 con variables no convergentes (AU) en 2011 a entre 0,10 y 0,41 en 2021. Para las patas y pies las heredabilidades progresaron de 0,16 a 0,17 con variables no convergentes (VLPT) a 0,09 a 0,22. El progreso genético no sólo es patente en los valores de la heredabilidad, sino que se ha dado una reducción notable en el error estándar de las heredabilidades desde 0,1000 (0,080-0,120) hasta 0,000 (0,000-0,001) desde 2011 a 2021. Estos resultados proporcionan evidencias de la efectividad y precisión del sistema de Calificación lineal aplicado y de su integración en el esquema de selección de la raza Murciano-Granadina.

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INTRODUCTION

The global visual assessment of an animal has been used since specialization in animal production began, but this assessment has the drawback that it is subjective and poorly predictive of the productive capacity of an animal. In the search for more predictive and objective methods, in 1993 the American Dairy Goat Association published the Linear Classification System for dairy goats.

In French goats, the Combined Goat Index (ICC) and Morphological Index began to be applied in October 1999. In the Murciano-Granadina breed, the first animals began to be qualified in 2010 (Fernández Álvarez, et al. (2020), due to the efforts of the National Association of Murciano-Granadina Goat Breeders (CAPRIGRAN).

CAPRIGRAN started implementing its linear appraisal system in the selection scheme of the Murciano-Granadina experimentally, beginning to qualify animals from farms belonging to its selective nucleus in 2010.

Even if data registration and the integration of the linear morphological appraisal system in the dairy goat improvement genetic program of Murciano-Granadina breed had started two years ealier (Martinez, et al. 2010), the genetic background of linear appraisal traits of Murciano-Granadina goats would not be preliminarily approached until 2011, with the first evaluation of genetic parameters and breeding values (Gómez-Carpio et al., 2012a,b).

Still the system was strongly subjetive in nature and as recently revealed, may not represent the variability found within the population of the Murciano-Granadina breed (Fernández Álvarez et al., 2021).

As a consequence, CAPRIGRAN and the AGR218 PAIDI reasearch group from the University of Córdoba set up a project with the aim to evaluate the disribution properties of zoometric linear appriasal traits within Murciano-Granadina population, to define the scales which better represent the variability for zoometric traits present in the population, to optimize and validate such scales, and to perform a comprbensive genetic evaluation of the heritable component and correlations among linear appraisal traits (Fernández Álvarez, et al. (2021).

In this context, the aim of this study is the comparative evaluation of the heritabilities of the seventeen linear traits that comprise Murciano-Granadina linear appraisal system, a decade after the first preliminary results were issued. The comparison of this value may help inferring the success of the integration and implementation of the linear appraisal system in Murciano-Granadina breeding program.

MATERIAL AND METHODS

2011's Genetic evaluation

Sample

A total of 890 animals were evaluated in the kinship matrix. Out of these, 328 animals had complete DNA-certified father and mother information, 72 had a DNA-confirmed father and 26 had a DNA-confirmed mother. In cases in which there was no genealogical information checked with DNA, the data of the parent, father or mother, was indicated as not controlled. Thus, for this genetic evaluation, a quality kinship matrix, fully certified with DNA microsatellites was used. For the genetic evaluation, a file was used productive constituted by 654 qualifications developed all of them by the same rater. Six herds that were genetically connected and that are part of the selective nucleus of the breed selection scheme were included in the analysis.

Traits

Seventeen linear characters have been experimentally scored; Height at withers (EST), Chest Width (AP), Body Depth (PC), Rump Width (AG), Rump Angle (ANG), Angularity (ANGUL), Bone Quality (HUESO), Anterior Attachment (IA), Posterior Insertion Height (ALTIP), Median Superior Ligament (LSM), Udder Width (AU), Udder Depth (PU), Teat Placement (CP), Teat Diameter (DP), Rear legs rear view (VPPT), Rear legs side view (VLPT) and Mobility (MOV).

Model

The BLUP (Best Linear Unbiased Predictors) methodology was used, applying a Simple Animal Model, using the genetic evaluation software MTDFREML (Boldman et al., 1995). The animal model used was the following:

$$y_{ijkl} = \mu + R_i + NP_j + A_k + (bE + b2E)_l + e_{ijkl}$$

where: y_{ijkl} = dependent variable; μ = population mean; R_i = herd fixed effect (6 levels); NP_j = fixed effect of the parturition number (5 levels); A_k = random additive effect of the animal; $(bE + b2E)_l$ = linear and quadratic components of the age of the goat as a covariate and e_{ijkl} = effect of random residuals.

2021's Genetic evaluation

Sample

A total of 279,768 animals were evaluated in the kinship matrix. Routine father and mother information DNA-certification is implemented. In cases in which there was no genealogical information checked with DNA, the data of the parent, father or mother, was indicated as not controlled. DNA certification of kinship matrix ensured the genealogical basis integrity. All of the zoometric analyses were performed by the same rater. Zoometric records belonged to 39,823 animals. Eighty-five genetically connected herds were included in the analysis.

Traits

Seventeen linear characters have been experimentally scored; Height at withers (EST), Chest Width (AP), Body Depth (PC), Rump Width (AG), Rump Angle (ANG), Angularity (ANGUL), Bone Quality (HUESO), Anterior Attachment (IA), Posterior Insertion Height

(ALTIP), Median Superior Ligament (LSM), Udder Width (AU), Udder Depth (PU), Teat Placement (CP), Teat Diameter (DP), Rear legs rear view (VPPT), Rear legs side view (VLPT) and Mobility (MOV).

Model

The BLUP (Best Linear Unbiased Predictors) methodology was used, applying a Simple Animal Model, using the genetic evaluation software MTDFREML (Boldman et al., 1995). The animal model used was the following:

$$y_{ijklmnop} = \mu + ST_i + R_j + PM_k + IRA_l + A_m + (bE + b2E)_n + DEL_o + e_{ijklmno}$$

where: $y_{ijklmno}$ = dependent variable; μ = population mean; ST_i = status fixed effect (2 levels); R_j= herd fixed effect (85 levels); PM_k = fixed effect of the parturition month (12 levels); IRA_l = interaction between the herd and parturition year; A_m = random additive effect of the animal; $(bE + b2E)_n$ = linear and quadratic components of the age of the goat as a covariate; DEL_o = linear component of the days in milk as a covariate and $e_{ijklmno}$ = effect of random residuals.

RESULTS

Table I presents heritabilities for the seventeen linear appraisal zoometic traits derived from the evaluations perfomed in 2011, published by Gómez-Carpio et al. (2012) and 2021.

DISCUSSION

The Murciano-Granadina goat is a very widespread autochthonous Spanish breed which is linked to those regions with dry and warm climates. Due to its rusticity, it is very suitable for dairy production in especially arid and hot countries of America and Africa, which is the basis for its international competitiveness within the dairy goat panorama (Delgado et al., 2017).

This remarkable rusticity, strongly conditions productive performance in the Murciano-Granadina breed as suggested by Sanchez et al. (2005). Indeed, Delgado et al., (2017), would inquire that to determine and obtain a good productive capacity in this breed, zoometric traits must be evaluated, since the productive quality or excellence of animals will strongly be linked to the adscription of goats to the dairy morphotype, but without losing the grounds of adaptability that the breed inherently has. In these regards, angular animals, with wide chests, lightly fat covered, with a strong bone structure, and a lively expression are sought after.

The outcomes of the first genetic evaluations for linear morphological traits in the Murciano-Granadina goat breed were described as very satisfactory, due to the high frequency of males and females with from average to high breeding values (Gómez-Carpio et al., 2012). However, the lack of convergence attained for some of these traits such as body depth, rump angle, bone quality, udder width and rear legs side view, rendered the evaluation inefficient.

Table I. Heritability and standard error progress from 2011 to 2021 for linear appraisal traits in Murciano-Granadina goats (Progreso desde 2012 a 2021 de las heredabilidades y errores estándar para los caracteres relacionados con la calificación lineal en cabras Murciano-Granadina).

	$h^2_{2011\ (1)}$	$SE_{2011\ (1)}$	h^2_{2021}	SE_{2021}
Stature (Height to withers)	0.220	0.110	0.430	0.000
Chest Width	0.280	0.110	0.291	0.001
Body Depth	NC	NC	0.100	0.000
Rump Width	0.260	0.110	0.310	0.000
Rump Angle	NC	NC	0.171	0.001
Angulosity	0.180	0.090	0.251	0.001
Bone Quality	NC	NC	0.310	0.000
Anterior insertion	0.120	0.080	0.211	0.001
Rear Insertion Height	0.160	0.090	0.259	0.001
Median Suspensor Ligament	0.120	0.090	0.330	0.000
Udder width	NC	NC	0.100	0.000
Udder Depth	0.170	0.100	0.290	0.000
Nipple placement	0.200	0.120	0.270	0.000
Nipple Diameter	0.270	0.110	0.410	0.000
Rear Legs Rear View	0.170	0.090	0.221	0.001
Rear Legs Side View	NC	NC	0.091	0.001
Mobility	0.160	0.100	0.110	0.000

NC: Non-convergent variables; h^2: Heritabilities; SE: Standard error.
(1) Gómez-Carpio, et al. (2012).

In line with these results, Gómez-Carpio et al. (2012) would suggest the need for readjustments of the analysis model, as well as an increase in the volume of the database, both genealogical and zoometric records. The variety of traits, the differences in the scales used to score them and their mere biological nature compelled the implementation of rather complex models than those that had traditionally been implemented. For example, apart from the effect of the herd, the strong adaptability of the breed suggested adding terms to control the effect of seasonality in the breed (through the inclusion of parturition month) but also on the particular handling of herds along time, through the inclusion of the interaction between parturition year and herd. Additionally, rather than the number of parturitions that each goat had had up to the moment when it was zoometrically evaluated, as considered in 2011, the marked dairy aptitude of the breed suggested approaching alternative methods to control for the productive status of each goat.

In these regards, apart from determining whether goats were either primipara or multipara, the effect od days in milk was included in the model as a covariate. Days in milk (DEL) is related closely to dry period length and is a good indicator of reproductive efficiency and herd management. Drying period was suggested to be an important factor to account for in the productive evaluation in Murciano-Granadina seeking the improvement of both milk quantity and nutritional quality (Pizarro et al., 2019a,b; 2020a,b,c,d,e,f). The rest of the model remained the same.

The modifications together with the vast increase in the number of animals comprising the kinship matrix and those for which actual zoometric records were present, translated into the drastic reduction of standard errors of prediction as reported in Table I, but also evidence the increased quality of information with which 2021 genetic evaluation has been carried out.

Heritabilities were in the range of those found in literature for Alpines, LaManchas, Nubians, Oberhaslis, Saanens, and Toggenburgs (Luo et al., 1997). All variables converged at the genetic evaluation performed in 2021. Heritability estimates increased 1.52 times on average with higher increase values being reported for height at withers with 1.95 higher heritabilities in 2021than in 2011 and mobility, which was the only trait for which a reduction in the value of heritability of 0.69 was reported. Such a reduction may be ascribed to the drastic reduction occurring in the standard error of prediction which was 10 times higher on average.

These results encourage us to continue working and improving these methods for their general integration in the breeding program of the Murciano-Granadina breed. Getting deeper in the study of the connections between linear appraisal derived traits and productive traits such as milk yield or protein, fat, lactose, dry matter, somatic cells contents may mark a significant step towards a rather efficient and accurate dairy goat selection and thus ensure that in the future the information offered to breeders accounts with quality enough as for the breed to consolidate its prominent position in the international dairy goat panorama.

CONCLUSIONS

In conclusion, the progress reported for the heritabilities of the seventeen traits studied in this paper enable breeders to select animals that either improve or correct certain undesirable conditions or which adscribe to a desirable zoometric standard. Even if linear appraisal derived morphofunctional traits are often not considered by breeders, our results suggest selection is feasible and may in turn make the animals more suitable for the productive demands, since selection for linear appraisal may indirectly improve the performance of the animals of the breed in question; for instance, aplombs, bone structure, muscle development or mammary conformation.

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