CAPRIGRAN Linear Appraisal Evidences Dairy Selection Signs in Murciano-Granadina Goats and Bucks: Presentation of the New Linear Appraisal Scale

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SUMMARY

Selection for zoometrics defines individuals' productive longevity, endurance, enhanced productive abilities and consequently, its long-term profitability. When zoometrics analysis is aimed at in large selected or in terms of selection populations, linear appraisal systems (LAS) provide a timely re-sponse. The particular analysis of each variable permits determining specific strategies for each trait and serve as a model for other breeds. Among the strategies proposed the reduction/readjustment of the levels in the scale as it happens for limb related traits, the extension of the scale as it occurs in the stature of males, or the subdivision of the scale used in males into two categories, bucks younger than two years and bucks of two years old and older. Murciano-Granadina has drifted towards better dairy linked conformation traits but without losing the grounds of the zoometric basis which confers it with an enhanced adaptability to the environment. Hence, such strategies can help to achieve a better understanding of the momentum of selection for dairy-linked zoometric traits in Murciano-Granadina population and their future evolution to enhance the profitability and effi-ciency of breeding plans.

El Sistema de Calificación Lineal de CAPRIGRAN Evidencia los Signos de Selección para la Aptitud Lechera en Cabras y Machos Cabríos de Raza Murciano-Granadina

RESUMEN

La selección para la zoometría define la longevidad productiva, la resistencia, las capacidades productivas mejoradas de los individuos y, en consecuencia, su rentabilidad a largo plazo. Cuando el análisis zoométrico está dirigido a grandes poblaciones seleccionadas o en vías de selección, los sistemas de calificación lineal (LAS) brindan una respuesta oportuna. El análisis particular de cada variable permite determinar estrategias específicas para cada rasgo y servir de modelo para otras razas. Entre las estrategias propuestas la reducción/reajuste de los niveles en la escala como ocurre con los rasgos relacionados con las extremidades, la ampliación de la escala como ocurre en la estatura de los machos, o la subdivisión de la escala utilizada en los machos en dos categorías, machos menores de dos años y machos de dos años en adelante. Murciano-Granadina ha derivado hacia mejores rasgos morfológicos ligados a la aptitud lechera pero sin perder el fundamento de la base zoométrica que le confiere una mayor adaptabilidad al medio. Por lo tanto, tales estrategias pueden ayudar a lograr una mejor comprensión del impulso de selección de caracteres zoométricos ligados a la aptitud lechera en la población murciano-granadina y su evolución futura para mejorar la rentabilidad y eficiencia de los planes de mejora.

INTRODUCTION

The overall visual evaluation of animals has been used since specialization in animal production began, but this assessment has the disadvantage that it is subjective and scarcely predictive of the productive capacity of an animal (Kouri et al., 2019). In the search for more predictive and objective methods, in 1993 the American Dairy Goat Association published the Linear Appraisal System for dairy goats. In French goats, the combined Goat Index (BCI) 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).

The application of linear morphological qualification in dairy goats breeding programs is to take into account morphology as a criterion when selecting animals., in addition to selecting for productive characteristics, we will also select for type. However, caution must be taken since some type characters

may be negatively correlated with milk production (Mellado et al., 2008).

The challenge starts as if a metric character is determined by an effectively infinite number of loci, selection cannot cause any permanent change in the genetic variance but will cause a temporary change which is rapidly reversed when selection ceases. This is due entirely to the correlation between pairs of loci induced by selection. When the correlation is negative it may lead to a reduction in the genetic variance under stabilizing or directional selection. However, when it is positive, it may lead to an increase in the variance under disruptive selection (Bulmer, 1971). Such term is also a synonim of diversifying selection, which describes changes in population genetics in which extreme values for a trait are favoured over intermediate values. Hence, the variance of the trait increases and the population is divided into two distinct groups where more individuals acquire peripheral character value at both ends of the distribution curve (West-Eberhard, 2005).

When selection ceases, the correlation rapidly disappears as joint equilibrium at pairs of loci is re-established, and the variance returns to its original value. An expression is derived for the predicted amount of change in the genetic variance due to disequilibrium in the absence of linkage. The change is likely to be small under selection intensities found under natural conditions, but it may be appreciable under intense artificial selection. This limiting result shows that the magnitude of any permanent change in the variance due to selection must decrease as the number of loci involved increases and that, when the number of loci is large, it is likely to be much less than the temporary change due to disequilibrium.

In these regards, the ideal morphotype would be equivalent to that structure on which the greatest dairy potential of a breed would be based. What we do is compare the morphology of a specific animal with the ideal dairy morphotype (Assan, 2020).

Linear Appraisal enables to evaluate each characteristic of the animal independently of the rest. The rater translates biological variability on a point scale, ranging from 1 to 9. However, the adaptation of a highly selected breed linear appraisal system may not appropriately fit the reality found for zoometrics in local populations which account with a strong rusticity, thus adaptability potential (Fernández Álvarez et al., 2020) (Figure 1).

In this regard, the analysis of the symmetry on the distribution curve of linear appraisal traits revealed the international scales which have traditionally been used do not fit the distribution of data found in the population of Murciano-Granadina does and bucks as a result of the progress of selection practices. This has also been reported for similar traits

Figure 1. Zoometric evaluation of a Murciano-Granadina buck (Evaluación zoométrica de un macho cabrío de raza Murciano-Granadina).

in other species (Lomillos Pérez and Alonso de la Varga, 2020).

Indeed, it is the early signs of selection for these traits, in the context of a locally adapted breed to harsh conditions and orography which defines the zoometric profile of a breed. Murciano-Granadina has drifted towards better dairy linked conformation traits but without losing the grounds of the zoometric basis which confers it with an enhanced adaptability to the environment (Delgado et al., 2017; Luigi-Sierra et al., 2020; Guan et al., 2021).

The aim of this paper is to present the new linear appraisal scale to be applied in Murciano Granadina goats and bucks basing on previous research progresses in regards the application of statistical tools for scale optimization and validation and the analysis of the biological representativity of the scale for zoometric traits observed in the current population.

OPTIMIZATION AND VALIDATION OF PREVIOUS SCALE

The first attempt to validate the linear appraisal scale being applied were implemented in 2005 (Sánchez et al., 2005). The combination of principal component analysis and categorical regression (CATREG) resulted successful for the optimization and validation of the reduction of zoometric evaluation procedures and linear appraisal scoring systems such that they are not only able to describe the status of a certain population but can also be used to predict the future evolution of parameters based on their linear correlations.

FICHA DE CALIFICACIÓN POR TIPO

GANADERÍA					NIF	
ID. ANIMAL		FECHA NACIMIENTO	/ /	Nº PARTOS	FECHA ÚLTIMO PARTO	/ /

ESTRUCTURA Y CAPACIDAD

	MUY BAJA	1 2 3 4 5 6 7 8 **9**	MUY ALTA	
ESTATURA	MUY BAJA	1 2 3 4 5 6 7 8 9	MUY ALTA	
ANCHURA DE PECHO	MUY ESTRECHA	1 2 3 4 5 6 **7** 8 9	MUY ANCHA	CALIFICACIÓN
PROFUNDIDAD CORPORAL	POCO PROFUNDA	1 2 3 **4** 5 6 **7** 8 9	MUY PROFUNDA	
ANCHURA DE GRUPA	MUY ESTRECHA	1 2 3 4 5 6 7 8 **9**	MUY ANCHA	
ÁNGULO DE GRUPA	MUY DERRIBADA	1 2 3 4 5 6 7 8 **9**	MUY CORREGIDA	

ESTR. LECHERA

ANGULOSIDAD	REDONDEADA	1 2 3 4 5 6 7 8 9	MUY ANGULOSA	CALIFICACIÓN
CALIDAD HUESO	BASTO Y REDONDEADO	1 2 3 4 5 6 7 8 **9**	PLANO Y NÍTIDO	

SISTEMA MAMARIO

INSERCIÓN ANTERIOR	INEXISTENTE	1 2 3 4 5 6 7 8 **9**	MUY FUERTE	
ALTURA INSERCIÓN POSTERIOR	MUY BAJA	1 2 3 4 5 6 7 8 **9**	MUY ALTA	
LIGAMENTO SUSPENSOR MEDIO	MUY DÉBIL	1 2 3 4 **5** 6 7 8 9	MUY PROFUNDO	CALIFICACIÓN
ANCHURA POSTERIOR DE UBRE	MUY ESTRECHA	1 2 3 4 5 6 7 8 **9**	MUY ANCHA	
PROFUNDIDAD DE UBRE	MUY ALTA	1 2 **3** 4 5 6 7 8 9	MUY DESCENDIDA	
COLOCACIÓN DE PEZONES	MUY LATERALES	1 2 3 4 5 6 7 8 **9**	VERTICALES	
DIAMETRO DE PEZONES	MUY ESTRECHOS	1 2 3 **4** 5 6 7 8 9	MUY ANCHOS	

PATAS Y PIES

PATAS TRASERAS (VISTA POSTERIOR)	MUY JUNTAS	1 2 3 4 5 6 7 8 **9**	PARALELAS	
PATAS TRASERAS (VISTA LATERAL)	RECTAS	1 2 3 4 **5** 6 7 8 9	MUY CURVADAS	CALIFICACIÓN
MOVILIDAD	MUY DEFICIENTE	1 2 3 4 5 6 7 8 **9**	MUY EFICIENTE	

REGIONES	%
Estructura y capacidad	25
Estructura lechera	15
Sistema mamario	40
Patas y pies	20

DEFECTOS	
CALIFICACIÓN FINAL	

FECHA	/ /
CALIFICADOR	GANADERO
Fdo.	Fdo.

Figure 2. Zoometric evaluation sheet for Murciano-Granadina does and bucks (Ficha para evaluación zoométrica para machos y hembras de raza Murciano-Granadina).

Table 1. Zoometric traits, former LAS scale and new LAS scale proposal in Murciano-Granadina primipara/multipara does (Caracteres zoométricos, escala tradicional de calificación lineal y nueva propuesta de escala de calificación lineal en cabras primiparas/multiparas de la raza Murciano-Granadina).

Gender/Status	Major area	Linear trait	Zoometric Scale/Categorical Scale	Zoometric Optimum Scoring	Reference/Middle point	LAS Extrapolation	LAS Optimum scoring	New LAS Proposal
Primipara/Multipara does	Structure and capacity	Stature (Height to withers)	62-78 cm	72 cm (primipara) and 74 cm (multipara)	5 (70 cm)	1-9 points	6 (primipara) and 7 (multipara)	1-9 points
		Chest Width	15-23 cm	20 cm (primipara) and 21 cm (multipara)	5 (19 cm)	1-9 points	6 (primipara) and 7 (multipara)	1-9 points
		Body Depth	Shallow-Extremely deep	Intermediate	5 (elbow end matches rib depth)	1-9 points	7 (primipara and multipara)	1-8 points
		Rump Width	13-21 cm	18 cm (primipara) and 19 (multipara)	5 (17 cm)	1-9 points	6 (primipara) and 7 (multipara)	1-7 points
		Rump Angle	55º-31º	31º	5 (43º)	1-9 points	9	1-7 points (Not relevant)
	Dairy structure	Angulosity	Angulous extremity-Rough extremity	Angulous extremity	5 (Intermediate)	1-9 points	9	1-10 points
		Bone Quality	Round and rough bones-flat and neat bones	Flat and neat bones	5 (Intermediate)	1-9 points	9	1-5 points
	Mammary system	Anterior insertion	Weak-Strong	120º	5 (90º)	1-9 points	9	1-5 points
		Rear Insertion Height	11-3 cm	3 cm	5 (7 cm)	1-9 points	9	1-5 points
		Median Suspensor Ligament	1-9 cm	5 cm	5 (5 cm)	1-9 points	5	1-6 points
		Udder width	3-11 cm	11 cm	5 (7 cm)	1-9 points	9	1-5 points
		Udder Depth	-10-10 cm	-5 cm (5 cm over hock level) and 0 cm (udder bottom at hock level)	5 (0 cm/at hock level)	1-9 points	3 (primipara) and 5 (multipara)	1-9 points
		Nipple placement	90º-0º	0º	5 (45º)	1-9 points	9	1-6 points
		Nipple Diameter	0.5 cm to 4.5cm	2 cm	5 (2.5 cm)	1-9 points	4	1-9 points
	Legs aplomb	Rear Legs Rear View	Very close-Parallel and separated	Parallel and separated	5 (slightly close)	1-9 points	9	1-7 points
		Rear Legs Side View	Straight-Very curved	Desirable curvature. A short distance from an imaginary line to anterior curvature of hock	5 (desirable curvature)	1-9 points	5	1-7 points
		Mobility	Very bad mobility due to skeleton structure-long and strong, straight and uniform stride	Good mobility. Easy and harmonic movement	5 (moderate mobility)	1-9 points	9	1-5 points

Principal component analyses determined that CAPRIGAN linear appraisal system (Figure 2) was solid and internally consistent for the measurement and capture of the variability of zoometric parameters related to dairy performance. However, the resulting models were quite conservative, as only one variable from the whole zoometric panel was discarded for bucks and does. The outputs of linear regression demonstrate that an optimal fit, variability explanatory power and predictive potential can be achieved by modeling a reduced number of variables from the entire linear appraisal scoring system and traditional zoometric evaluation for Murciano-

Granadina does (Figure 1) and bucks. Conclusively, our results suggest that the combination of PCA and categorical regression (CATREG) may be successful for the optimization and validation of the reduction of zoometric evaluation procedures and linear appraisal scoring systems such that they are not only able to describe the status of a certain population but can also be used to predict the future evolution of parameters based on their linear correlations.

THE ANALYSIS OF DISTRIBUTION AND SKEWNESS

After symmetry analysis was performed, scale readjustment proposal suggested specific strategies should be implemented such as scale reduction of lower or upper levels, determination of a set up

moment to evaluate and collect information from young (up to 2 years) and adult bucks (over 2 years), addition of upper categories in males due to upper values in the scale being incorrectly clustered together. The new scale proposal shows Murciano-Granadina goats' zoometric traits and by extension LAS, may not particularly fit the scales used for other standardized highly selected breeds (Tables 1 and 2).

The particular analysis of each variable permits determining specific strategies for each trait and serve as a model for other breeds, either selected or in terms of selection. Among the strategies proposed the reduction/readjustment of the levels in the scale as it happens for limb related traits, the extension of the scale as it occurs in the stature of

Table 1. Zoometric traits, former LAS scale and new LAS scale proposal in Murciano-Granadina bucks (Caracteres zoométricos, escala tradicional de calificación lineal y nueva propuesta de escala de calificación lineal en machos cabríos de la raza Murciano-Granadina).

Gender/Status	Major area	Linear trait	Zoometric Scale/ Categorical Scale	Zoometric Optimum Scoring	Reference/Middle point	LAS Extrapolation	LAS Optimum scoring	New LAS Proposal
Bucks	Structure and capacity	Stature (Height to withers)	68-92 cm	83 cm (young) and 86 cm (adult)	5 (80 cm)	1-9 points	6 (young) and 7 (adult)	1-10 points
		Chest Width	15-31 cm	25 cm (young) and 27 cm (adult)	5 (23 cm)	1-9 points	6 (young) and 7 (adult)	1-11 points
		Body Depth[a]	Shallow-Extremely deep	Intermediate	5 (elbow end matches rib depth)	1-9 points	7 (young and adult)	1-7 points
		Rump Width	14-22 cm	19 cm (young) and 20 cm (adult)	5 (18 cm)	1-9 points	6 (young) and 7 (adult)	1-5 points
		Rump Angle	55-31º	31º	5 (43º)	1-9 points	9	1-6 points
	Dairy structure	Angulosity[a]	Angulous extremity-Rough extremity	Angulous extremity	5 (Intermediate)	1-9 points	9	1-9 points
		Bone Quality[a]	Round and rough bones-flat and neat bones	Flat and neat bones	5 (Intermediate)	1-9 points	9	1-5 points
		Rear Legs Rear View[a]	Very close-Parallel and separated	Parallel and separated	5 (slightly close)	1-9 points	9	1-6 points
	Legs aplomb	Rear Legs Side View[a]	Straight-Very curved	Desirable curvature. Short distance from an imaginary line to anterior curvature of hock	5 (desirable curvature)	1-9 points	5	1-7 points
		Mobility[a]	Very bad mobility due to skeleton structure-long and strong, straight and uniform stride	Good mobility. Easy and harmonic movement	5 (moderate mobility)	1-9 points	9	1-5 points

[a]Same criteria for males and females.

males, or the subdivision of the scale used in males into two categories, bucks younger than two years and bucks of two years old and older, respectively can help to achieve a better understanding of the momentum of selection for dairy-linked zoometric traits in Murciano-Granadina population and their future evolution to enhance the profitability and efficiency of breeding plans.

PRELIMINARY REPORTS ON THE GENETIC EVALUATION FOR LINEAR APPRAISAL

The first attempt to perform an estimation of genetic parameters was carried out in 2012. Six hundred and fifty-four goats belonging to six herd of the top breeding nucleus were evaluated using a kinship matrix of 890 animals. A total of 17 traits were considered: Stature, chest width, body depth, rump width, rump angle, angularity, bone quality, anterior and posterior attachment height, half superior ligament, udder width, udder depth, nipple placement, nipple diameter, rear legs view, lateral legs view and movements. The genetic evaluation was carried out using a Animal Model through MTDFRML package (Gómez et al., 2012). Heritabilities ranged bwtween 0.12 for anterior insertion and 0.28 for median suspensor ligament (Gómez-Carpio et al., 2012).

CONCLUSSIONS

After the validation of CAPRIGAN LAS system was confirmed, the analysis of optimization suggests the removal of rump angle from the panel of zoometric traits implemented. The evaluation of measurement distribution in the population suggested the adaptation of former LAS scales and the separation of bucks (currently evaluated with independence of their age) into two groups with 2 years old being the turn point. The new LAS scale appears in the context of Murciano-Granadina breed being a highly selected breed for milk production and quality attributes, which still maintains its proficient adaptability to harsh environments which is the basis for its international competitiveness.

ACKNOWLEDGMENTS

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