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Morphological traits and type of dairy goats registered in Brazil from 1976 to 2009

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ABSTRACT - Data from 2439 goats of the Saanen, Alpine, Anglo Nubian and Toggenburg breeds recorded from 1976 to 2009 by the Association of Goats and Sheep Breeders of Minas Gerais were used in principal component analysis. After consistency of data, six morphological variables (thorax perimeter, body length, withers height, height, width and length of the rump) and 12 variables related to breed standard score and fitness (breed characteristic, head, palette and topline, feet and legs, dairy type, body capacity, udder, rear and front ligament, udder texture, teat and final score) were analyzed. Based on the magnitude of the eigenvalue (lower than 0.7), eleven variables considered redundant were discarded, resulting in reduced costs of technician labor to evaluate the animals. Maintenance of records on height, length, rump width, breed characteristic, dairy type, front ligament and udder texture is recommended.

Key Words: correlation, discard of variable, goat, multivariate analysis

Introduction

The selection of dairy goats in the past was based primarily in morphological traits, because no records were available for productive traits of the animals. Productive traits started to be recorded only in 2005, through the Official Milk Recording Service in Goats in Brazil conducted by Embrapa Caprinos e Ovinos, in partnership with ACCOMIG/Caprileite (Facó et al., 2011).

In the past, morphological traits of animals played an important role in the identification of breeds with desirable characteristics.

In this case, the technicians usually recorded a large number of traits related to the morphology and to the type of the animal, with a significant increase in work and costs, but useless in breeding value prediction for important productive traits.

Studies involving principal component analysis using morphological traits in goats are scarce (Okpeku et al., 2011; Pires et al., 2012). Thus, the aim of this study was to evaluate several variables recorded in different goat breeds by principal component analysis, and select the most important ones accounting for total variation without loss of information.

Material and Methods

Data were obtained from Associação dos Criadores de Caprinos e Ovinos de Minas Gerais (ACCOMIG/Caprileite), related to the records of animals born between the years of 1976 and 2009, of four different breeds: 1335 Saanen, 695 Alpine, 330 Toggenburg and 79 Anglo Nubian, totaling 2439 animals.

The morphometric traits evaluated were: thorax perimeter, body length, withers height, height, width and length of the rump, and the main traits that define the breed standard and the suitability of the animal (breed characteristic, head, palette and topline, feet and legs, dairy type, body capacity, udder, rear and front ligament, udder texture, teat and final score), on a scale of 0 to 100 points (Table 1). All measures were taken after the first parturition for the female goats, for the purpose of obtaining the definitive studbook, and were taken by technicians accredited by the association. The following measures were determined with the aid of tape, with all the animals on a flat surface: thorax perimeter (TP, outer circumference of the thorax at the withers), body length (BL, distance between the cranial part of the greater tuberosity of the humerus to the ischial tuberosity), height at the withers (WH, height

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Table 1 - Summary of the breeds, number of animals (N), mean, standard deviation (SD), coefficient of variation (CV, %), minimum (Min) and maximum (Max) of the morphological traits and type of goats

Variable	Anglo Nubian (N = 79)					Alpine (N = 695)					Saanen (N = 1335)					Toggenburg (N = 330)				
	Mean	SD	CV	Min	Max	Mean	SD	CV	Min	Max	Mean	SD	CV	Min	Max	Mean	SD	CV	Min	Max
TP	83.51	7.29	8.73	72	104	83.31	7.47	8.97	47	108	87.57	8.15	9.31	61	120	84.62	7.53	8.90	65	106
BL	80.63	7.79	9.66	67	99	78.89	7.18	9.10	60	102	78.65	7.63	9.70	58	121	76.72	7.19	9.37	56	99
WH	78.00	5.76	7.38	69	94	73.76	5.65	7.65	57	99	73.61	5.88	7.99	58	104	72.18	5.08	7.03	34	94
RH	77.99	4.98	6.39	69	96	73.34	5.04	6.87	57	99	73.30	5.52	7.53	51	108	71.74	4.89	6.81	34	90
RW	17.77	3.78	21.28	8	26	13.63	3.94	28.95	7	26	14.61	4.26	29.14	7	30	14.60	4.48	30.68	6	24
RL	21.35	2.33	10.92	17	28	22.86	2.80	12.24	8	31	23.18	2.60	11.21	10	32	23.30	2.44	10.48	11	30
FE	79.49	5.34	6.72	65	93	80.04	7.07	8.83	56	97	81.44	6.89	8.46	60	99	78.39	8.14	10.39	57	98
BC	4.76	0.49	10.21	2.5	5	4.67	0.54	11.45	2	5	4.78	0.48	9.95	1.5	5	4.76	0.52	10.97	2.5	5
HE	4.84	0.37	7.72	4	5	4.58	0.59	12.85	2	5	4.70	0.55	11.61	2	5	4.63	0.57	12.22	3	5
PTL	6.17	0.70	11.42	4.8	7.2	6.34	0.84	13.31	3	8	6.47	0.87	13.42	3	8	6.40	0.91	14.29	3	8
FL	9.22	0.99	10.71	6	11.2	9.06	1.34	14.76	4	12	9.28	1.32	14.23	1.6	12	9.12	1.31	14.40	4	12
DT	11.70	1.55	13.26	8	19	16.40	1.75	10.65	9.33	20	16.61	1.73	10.44	9.3	20	15.82	2.09	13.22	10.0	20
BC	14.99	2.06	13.73	8.8	18	16.31	1.97	12.07	7	20	16.56	1.93	11.64	9	20	15.92	2.07	12.97	10.4	20
UD	5.90	1.22	20.72	4	8.5	7.21	1.17	16.16	2	10	7.20	1.21	16.76	1	10	6.83	1.25	18.32	2	10
RL	2.28	0.65	28.66	1	3	3.80	0.79	20.88	2	5	4.11	0.83	20.20	1	5	3.73	0.96	25.86	1	5
FL	1.80	0.44	24.65	1	3	4.12	1.01	24.53	1	6	4.23	0.92	21.78	1	6	3.59	1.31	36.54	1	6
UT	2.65	0.55	20.91	1	3	3.99	0.78	19.45	1	5	4.12	0.85	20.62	2	5	3.74	0.90	24.00	1	5
TE	2.69	0.56	20.97	2	4	3.06	0.67	22.04	1	4	3.05	0.78	25.49	1	4	2.95	0.74	25.17	1	4

TP - thorax perimeter; BL - body length; WH - withers height; RH - rump height; RW - rump width; RL - rump length; FE - final score; BC - breed characteristics; HE - head; PTL - palette and top line; FL - feet and limbs; DT - dairy type; BC - body capacity; UD - udder ; RL - rear ligament; FL - front ligament; UT - udder texture; TE - teat.

at the highest point of interscapular region), height rump (RH, measured from ground level to the sacral tuberosity of the ilium, with the animals on a flat surface), rump width (RW, distances between iliac bumps) and length rump (RL, distance between the tuberosity coxae of the ilium and the ischial tuberosity) (Table 1).

Since the variables linked to the score involved different units, it was necessary to standardize these variables.

$X_j (j=1,2,\ldots,p)$; in this case, the structure of dependence X_j was given by the correlation matrix.

Data were previously adjusted for fixed effects of seasons (dry: April to September, rainy: October to March), year of birth, breed and the interaction between these effects. This adjustment was made by analysis of variance using procedure PROC GLM from SAS (Statistical Analysis System, version 9.0), considering the following statistical model:

$$y_{ijkl} = \mu + s_i + a_j + b_k + (sab)_{ijk} + e_{ijkl}$$

in which, y_{ijkl} is the value measured for the characteristic; μ is a constant associated with each observation; s_i is the effect of season of birth i, a_j is the effect of year of birth j; b_k is the effect of breed k; $(sab)_{ijk}$ is the interaction effect between the station i, year of birth j and breed k; and e_{ijkl} is the random error associated with each observation, supposed to be independent and normally distributed with zero mean and variance σ^2.

After adjustments, they were subjected to principal components analysis, in which the starting point is the correlation matrix, the variables are standardized to zero mean and variance equal to one. The authors chose for the use of a correlation matrix instead of a covariance matrix to minimize possible discrepancies between the marked variances and to allow comparisons between the eigenvectors in a component. The solution, using the correlation matrix, is recommended when the variables are measured on very different scales, since this is equivalent to a matrix array of standardized variables (Johnson & Wichern, 1998), and since the morphometric traits analyzed contained assessments and metrics of fitness by subjective scoring table.

The criterion of minimum explained variance equal to or less than 70% to retain the main components was adopted. The technique of principal component from the matrix of correlation consists of transforming a set of variables p $X_1, X_2, \ldots, X_p$ in a new set: $Y_1, Y_2, \ldots, Y_p$.

The criteria used to dispose of variables was based on recommendations from Jolliffe (1972), who suggests that the number of discarded variables be equal to the number of principal components whose variance (eigenvalue) is less than 0.7, and the suggestion of Khattree & Dayanand (2000),

that the variable that had the highest coefficient in absolute value of the principal component smallest eigenvalue (lowest variance) should be less important in explaining the total variance and therefore susceptible to discard. Thus, the disposal process consists of considering the component corresponding to the smallest eigenvalue and rejecting the variable associated with the highest weighting coefficient (in absolute value). So, the next smallest component will be evaluated. This process continues until the last component associated with the eigenvalue below 0.7 is considered. The reason for this is that the variables highly correlated with principal components of smaller variance represent a practically insignificant variation. All analyses were performed using the PRINCOMP procedure of SAS (Statistical Analysis System, version 9.0).

Results and Discussion

Of the 18 principal components, 11 showed variance lower than 0.7 (eigenvalue lower than 0.7) (Table 2) according to the criteria of Jolliffe (1972), so they can then be discarded.

Only the first seven components that framed within the selection criteria adopted were kept, because they presented eigenvalue greater than 0.7 and could explain 76.93% of the total variation. The eleven variables with higher weightings, in terms of absolute value, from the last major component, were liable to be discarded (Table 3).

The suggested variables for disposal (Table 3), in order of least importance to explain the total variation in this study were: final score, withers height, rear ligament, body capacity, head, thorax perimeter, udder, feet and legs, body length, teat, palettes and topline. Because of the smaller eigenvalue of the main component and higher weighting coefficient, its importance will be lower and its important variable will represent little significance in the data block. Dossa et al. (2007), working with goats, showed that the best discriminate model used only five morphological measures from 12 pre-selected, thereby indicating that only a few measurements are needed to separate breeds.

Table 2 - Principal components, eigenvalues (λ_i) and percentage of variance explained by components (% VCP)

Principal components[1]	λ_i	%VCP	%VCP (accumulated)
1	5.0743	0.2819	0.2819
2	2.9620	0.1646	0.4465
3	1.7218	0.0957	0.5421
4	1.5315	0.0851	0.6272
5	0.9540	0.0530	0.6802
6	0.8657	0.0481	0.7283
7	0.7390	0.0411	0.7693
8	0.6171	0.0343	0.8036
9	0.5930	0.0329	0.8366
10	0.5535	0.0307	0.8673
11	0.5336	0.0296	0.8970
12	0.4442	0.0247	0.9216
13	0.4075	0.0226	0.9443
14	0.3608	0.0200	0.9643
15	0.3422	0.0190	0.9833
16	0.1820	0.0101	0.9935
17	0.0813	0.0045	0.9980
18	0.0365	0.0020	1.0000

[1] Each principal component (Y_i) is a linear combination of the eighteen standardized variables (X_j).

The results were similar to those of Leite et al. (2009), when the first four principal components of 11 studied explained 75% of the total variation in meat quails and suggested seven variables for disposal. Of the seven principal components evaluated in goats by Pires et al. (2012), four (57.14%) yielded variances no greater than 0.7 (eigenvalues no greater than 0.7). The first three principal components were selected and explained 99.5% of the total variation. Barbosa et al. (2005) found that, after analysis of 11 variables of performance of pigs, six were subjected to elimination, and recommended the evaluation of only five variables, with no significant loss of information. The results of this study suggest the following variables to be maintained: height, length and width of the rump, breed characteristic, dairy type, front ligament and udder texture. Those can be used in studies that will aim to define the classification system of linear goats, assisting in the selection process and reducing costs to the producer (and the technician team) to make that assessment.

After the disposal of redundant variables, the recommended features are sufficient to explain the form and the fitness of the animals. Height rump is a very variable trait that used to determine the proper size of the animal, and if it is consistent with the breed standards, it presents high genetic correlations between growth traits (Pereira et. al., 2010). Traits rump width and length were maintained; the rump of dairy goats should preferably be large and broad, since it will allow for larger space to accommodate the udder, besides serving as a parameter to avoid problems with dystocic parturitions, since multiple births is a common feature of this species. Variations in the characteristics of a breed enables the identification of the animal within the breed standards. Dairy type is a variable that contains all the information regarding goats evaluated on their fitness to milk production, as well as the goat of dairy breed is able to transmit this characteristic to their female cubs. This feature also allows the body condition score to be rated.

Front ligament and udder texture are variables used to evaluate the quality of the mammary apparatus of the goat, which, for a system of milk production, is one of the most important and valued traits in females goats.

The traits suggested for disposal in this work have shown significant simple linear correlation with the others, in other words, they are redundant; on the other hand, the selected variables showed lower correlation with each other (Table 4).

In general, the correlations showed to be moderate; the variables "height rump" with "height at the withers" stood out for showing a highly positive correlation. Hence, the assessment of growth traits by height rump is already sufficient, and so, the indication of height at the withers could be discarded. Width rump and udder traits showed an average negative correlation, indicating that the smaller the limbs aperture is, the greater is the difficulty of the animal to contain in it the mammary system. Variables body capacity and dairy type expressed a high and positive correlation with each other, and also with variable final score, which represents an important result, because as the grade of the animal is increased, its performance regarding its productive function improves. Udder shows an average positive correlation with dairy type and rear ligament. Okpeku et al. (2011) found high correlations for some traits in goats in southern Nigeria.

The strong link between body capacity and the set that is part of dairy type is an indication that an animal that has a good score performance will therefore be satisfactory.

In cows, Zavadilová et al. (2011) used survival analysis methodology to describe relationships between type traits

Table 3 - Weighting coefficients of morphological measurements and type of goats with the principal components discarded in order of least importance

Variables	Principal components										
	8	9	10	11	12	13	14	15	16	17	18
TP	–0.1303	–0.0314	–0.0429	–0.0855	0.4399	–0.7042	0.0625	–0.0178	–0.1350	–0.0399	–0.0140
BL	0.1510	–0.0809	0.4737	0.2919	0.4686	0.2209	0.0027	–0.0651	–0.0073	–0.0378	0.0020
WH	0.0597	–0.0528	–0.2320	–0.0747	–0.2998	0.0174	–0.0107	–0.0537	0.0117	–0.7091	–0.0127
RH	0.0303	–0.0749	–0.2596	–0.1042	–0.3350	–0.0607	0.0180	–0.0378	0.0322	0.6965	0.0120
RW	0.1406	0.4371	–0.1505	0.2979	0.0933	0.1853	0.1963	0.2530	0.0792	0.0471	0.0063
RL	–0.4562	0.0243	0.2799	–0.1246	–0.0838	0.4487	–0.2024	0.1369	–0.0635	0.0049	–0.0008
FE	0.0209	0.0149	–0.0261	0.0264	–0.0307	0.0379	–0.0369	–0.0122	0.0313	0.0140	–0.8790
BC	0.0277	0.0663	0.0201	–0.0074	–0.0607	–0.1775	–0.5158	0.4321	0.0081	0.0094	0.0427
HE	–0.0980	0.0869	0.0278	–0.1271	–0.0208	0.0971	0.5521	–0.3939	–0.0213	0.0028	0.0748
PTL	0.5260	–0.2689	0.2932	–0.3246	–0.0047	0.0675	0.0125	0.0111	–0.0479	0.0400	0.1229
FL	–0.2282	–0.3403	–0.2441	0.6811	0.0105	0.0279	–0.0043	–0.0589	0.0112	0.0159	0.1651
DT	0.0256	0.1621	–0.1202	–0.0194	–0.1144	0.1004	–0.0274	–0.0752	–0.6817	–0.0095	0.2279
BC	–0.0384	0.1145	0.0661	–0.0584	–0.1204	–0.0716	0.0552	–0.0283	0.6899	–0.0456	0.2440
UD	–0.1459	0.1829	–0.4096	–0.3635	0.5199	0.2606	–0.0546	0.0940	0.1040	0.0192	0.1446
RL	–0.0212	–0.1207	0.0210	0.0295	0.0017	–0.0028	–0.4514	–0.5621	0.1014	0.0193	0.0914
FL	–0.4135	–0.0884	0.3872	–0.0569	–0.1994	–0.2073	0.2811	0.2899	0.0568	–0.0080	0.1171
UT	0.3582	–0.3587	–0.1653	0.0801	0.0038	0.0909	0.2273	0.3763	0.0193	–0.0409	0.1123
TE	0.2551	0.6068	0.1995	0.2328	–0.1617	–0.1832	–0.0500	–0.0752	0.0272	0.0018	0.0998

TP - thorax perimeter; BL - body length; WH - withers height; RH - rump height; RW - rump width; RL - rump length; FE - final score; BC - breed characteristics; HE - head; PTL - palette and top line; FL - feet and limbs; DT - dairy type; BC - body capacity; UD - udder ; RL - rear ligament; FL - front ligament; UT - udder texture; TE - teat.

Table 4 - Simple correlation coefficients between traits evaluated

	TP	BL	WH	RH	RW	RL	FE	BC	HE	PTL	FL	DT	BC	UD	LR	LF	UT	TE
TP	1.00																	
BL	0.44	1.00																
WH	0.57	0.58	1.00															
RH	0.59	0.56	0.91	1.00														
RW	0.29	0.18	0.32	0.27	1.00													
RL	0.55	0.36	0.50	0.50	0.20	1.00												
FE	0.29	0.21	0.20	0.21	–0.11	0.23	1.00											
BC	0.10	0.07	0.04	0.02	0.09	0.06	0.31	1.00										
HE	0.11	0.03	0.03	0.01	0.10	0.13	0.27	0.63	1.00									
PTL	0.25	0.12	0.21	0.17	0.00	0.20	0.51	0.16	0.13	1.00								
FL	0.16	0.06	0.09	0.08	–0.17	0.16	0.59	0.20	0.16	0.41	1.00							
DT	0.27	0.24	0.20	0.22	–0.04	0.20	0.80	0.17	0.09	0.32	0.37	1.00						
BC	0.39	0.30	0.25	0.29	–0.07	0.32	0.75	0.15	0.09	0.38	0.38	0.78	1.00					
UD	0.08	0.03	0.07	0.07	–0.23	0.04	0.64	0.09	0.09	0.27	0.37	0.42	0.33	1.00				
LR	0.11	0.06	0.07	0.05	0.22	0.06	0.40	0.18	0.19	0.03	0.01	0.23	0.09	0.24	1.00			
LF	–0.01	0.05	0.00	0.00	–0.07	–0.01	0.51	0.06	0.04	0.12	0.19	0.30	0.22	0.42	0.48	1.00		
UT	0.13	0.12	0.07	0.11	–0.05	0.10	0.47	0.13	0.16	0.03	0.09	0.29	0.21	0.28	0.50	0.31	1.00	
TE	0.07	0.08	0.07	0.07	–0.23	0.11	0.51	0.02	0.03	0.23	0.30	0.29	0.28	0.45	0.12	0.28	0.28	1.00

TP - thoracic perimeter; BL - body length; WH - withers height; RH - rump height; RW - rump width; RL - rump length; FE - final score; BC - breed characteristic; HE - head; PTL - palette and topline; FL - feet and limbs; DT - dairy type; BC - body capacity; UD - udder ; LR - rear ligament; LF - front ligament; UT - udder texture; TE - Teat.

and functional longevity in the Czech Holstein population, confirming the important influence of udder traits, final score, and feet and legs on the functional longevity of cows. Concluding the selection index for functional longevity, information could be used on the longevity of daughters.

The principal components obtained in this study can be used to combine with other economic parameters in assessing animals.

Conclusions

Among the 18 evaluated variables using principal component analysis, eleven are redundant and can be discarded, resulting in reduced technician labor costs for animal evaluation. Keeping records on rump height, rump length, rump width, breed trait, dairy type, front ligament and udder texture is recommended.

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