Spatialization of climate, physical and socioeconomic factors that affect the dairy goat production in Brazil and their impact on animal breeding decisions[1]

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ABSTRACT.- Lopes F.B., Silva M.C., Miyagi E.S., Fioravanti M.C.S., Facó O., Guimarães R.F., Júnior O.A.C. & McManus C. 2012. **Spatialization of climate, physical and socioeconomic factors that affect the dairy goat production in Brazil and their impact on animal breeding decisions.** *Pesquisa Veterinária Brasileira 32(11):1073-1811.* Programa de Pós-Graduação em Ciência Animal, Escola de Veterinária de Zootecnia, Campus II Samambaia, Cx. Postal 131, Goiânia, GO 74001-970, Brazil. E-mail: camult@gmail.com

Brazil has high climate, soil and environmental diversity, as well as distinct socioeconomic and political realities, what results in differences among the political administrative regions of the country. The objective of this study was to determine spatial distribution of the physical, climatic and socioeconomic aspects that best characterize the production of dairy goats in Brazil. Production indices of milk per goat, goat production, milk production, as well as temperature range, mean temperature, precipitation, normalized difference vegetation index, relative humidity, altitude, agricultural farms; farms with native pasture, farms with good quality pasture, farms with water resources, farms that receive technical guidance, family farming properties, non-familiar farms and the human development index were evaluated. The multivariate analyses were carried out to spatialize climatic, physical and socioeconomic variables and so differenciate the Brazilian States and Regions. The highest yields of milk and goat production were observed in the Northeast. The Southeast Region had the second highest production of milk, followed by the South, Midwest and North. Multivariate analysis revealed distinctions between clusters of political-administrative regions of Brazil. The climatic variables were most important to discriminate between regions of Brazil. Therefore, it is necessary to implement animal breeding programs to meet the needs of each region.

INDEX TERM: Spatialization, animal breeding program, cluster, milk, multivariate analysis.

RESUMO.- [**Espacialização de fatores climáticos, físicos e socioeconômicos que afetam a produção de caprinos leiteiros no Brasil e seu impacto sobre as decisões em melhoramento animal.**] O Brasil possui diversidade edafoclimática e realidades socioeconômicas e políticas distintas. Isto contribui para diferenciar as regiões político administrativas do país. Objetivou-se espacializar os fatores físicos, climáticos e socioeconômicos que melhor discriminam a produção de caprinos leiteiros no Brasil. Foram analisados índice de produção de leite por cabra; índice de produção de caprinos; índice de produção de leite, amplitude da temperatura; temperatura média; precipitação; índice normalizado de diferença vegetativa; umidade relativa do ar; altitude; estabelecimentos agropecuários; estabelecimentos com pastagem nativa; estabelecimentos com pastagens de boa qualidade; estabelecimentos com recursos hídricos; estabelecimentos que recebem orientação técnica; estabelecimentos de agricultura familiar; estabelecimentos de agricultura não familiar e índice de desenvolvimento humano. Foram realizadas análises multivariadas

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para espacializar as variáveis climáticas, físicas e socioeconômicas e, assim, discriminar os Estados e Regiões brasileiras. As maiores produções de caprinos e de leite foram observadas na região Nordeste. A região Sudeste apresentou segunda maior produção de leite, seguido pelo Sul, Centro-Oeste e Norte. As médias para produtividade mostraram que as regiões Centro-Oeste e Sudeste apresentaram animais mais especializados a produção de leite. As análises multivariadas evidenciaram distinções entre clusters das regiões político-administrativas do Brasil. As variáveis climáticas foram as mais importantes para discriminar entre as regiões brasileiras. A heterogeneidade dos componentes climáticos, físicos e socioeconômicos evidenciou peculiaridades em cada região. Portanto, é preciso implementar programas de melhoramento genético animal que atendam as necessidades de cada região.

TERMOS DE INDEXAÇÃO: Especialização, análises multivariadas, cluster, leite, programa de melhoramento animal.

INTRODUCTION

In Brazil, the goat population was estimated at over 9.3 million head, of which more than 91% is in the Northeast region (IBGE 2008). Goat production is also of interest in other regions, notably in the Southeast. Goat farming in Brazil is mainly for the production of milk and most of the breeds, especially those in the Northeast, are for this purpose, with meat obtained from the culling of adult animals (Costa et al. 2008, McManus et al. 2008, Oliveira et al. 2009).

Most herds in northeastern Brazil are reared extensively. In southeastern Brazil, the animals are raised mostly in confinement (Gonçalves et al. 2001, 2008, Barros et al. 2005). Goat production is influenced by factors such as local vegetation (Skonhoft et al. 2010), average air temperature (McManus et al. 2010) and altitude (Campbell et al. 2010). These factors influence the implementation and creation of production units because of their influence on production characteristics and adaptation of animals used (Joost et al. 2010).

The successful production of small ruminants also depends on socioeconomic factors, because the higher the population, gross domestic product and the area, greater the demand for animal products and production also increases in adjacent areas (Hewitson et al. 2007, Sibbald et al. 2008).

Farmers, in general, try to minimize the impact of external factors that negatively affect animal production. These include various environmental (soil and climate, vegetation and geomorphology), socioeconomic (gross domestic product and population) and technological (ownership of knowledge about information such as feeding, handling, reproduction, health and sanitation) factors (Herrero et al. 2010). Factors affecting production and productivity of goats in the Northeast may not be the same characteristics that influence these in the South and Southeast. Brazil has a land area of continental dimensions, as well as wide variety of climate and soil and vegetative diversity. Agricultural systems in different regions of the country have peculiarities that differentiate them from each other. Thus, the aim of this study was to analyze the spatial distribution of the production of dairy goats in Brazil in relation to physical, climate and socioeconomic factors.

MATERIALS AND METHODS

Analyses were performed using individual climate, physical and socioeconomic data from 5,564 Brazilian municipalities (Fig.1). Study variables were obtained by the Brazilian Institute of Geography and Statistics, National Institute of Meteorology, National Institute for Space Research, United States Geological Survey and the United Nations Program for Development.

All analyses were performed using the computer program Statistical Analysis System (SAS ®). Multivariate regression analysis (PROCREG -stepwise) were performed to create three indices (IGP, IMP and PIM) that best describe the municipalities based on the variables related to the actual goats, the volume of milk productivity and gross domestic product (GDP), the area and population.

$$IGP = \beta_1 \times CA + \beta_2 \times CA^2 + \beta_3 \times CP + \beta_4 \times CP^2 + \beta_5 \times CH + \beta_6 \times CH^2$$
$$IMP = \beta_1 \times LA + \beta_2 \times LA^2 + \beta_3 \times LP + \beta_4 \times LP^2 + \beta_5 \times LH + \beta_6 \times LH^2$$
$$PIM = \beta_1 \times PA + \beta_2 \times PA^2 + \beta_3 \times PP + \beta_4 \times PP^2 + \beta_5 \times PH + \beta_6 \times PH^2$$

where the IGP is index of goat production, IMP is the rate of milk production; PIM is the productivity index of milk/doe; β is the estimator of the parameters analyzed, CA is the ratio of goats per area, CP is goats by the ratio of GDP (Gross Domestic Product), CH is the ratio of goats per inhabitant, LA is the ratio of milk production per area, LP is the ratio of milk production per GDP, LH is the ratio of milk production per capita, PA is the ratio of milk productivity per area; PP is the ratio of milk productivity per GDP, and PH is the ratio of dairy products per head of population.

Variables used in the analysis on a municipality basis were: index of goat production (IGP), index of milk production (IMP), productivity index of milk/goat (PIM), temperature range (TR),

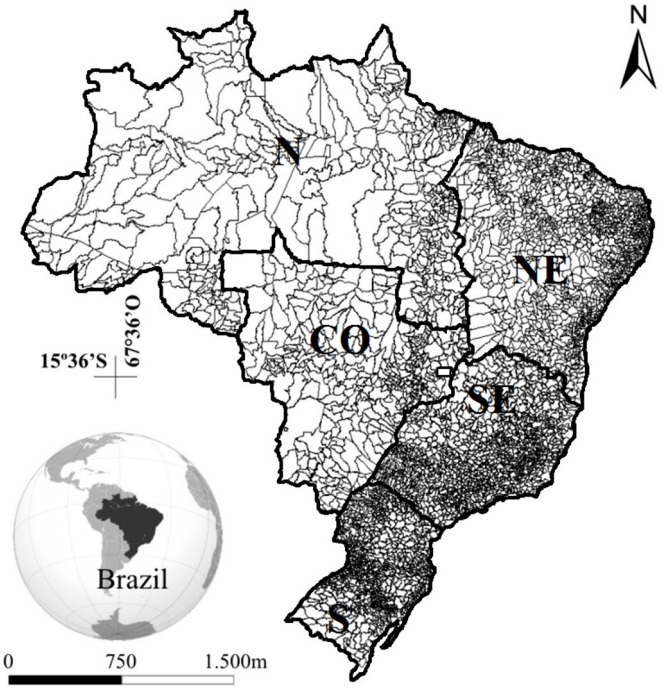

Fig.1. **Physiographic division of the 5564 Brazilian municipalities and regions (CO, N, NE, S and SE).** CO = Midwest, N = North, NE = Northeast, S = South, SE = Southeast.

average temperature (AT), precipitation (PR), normalized difference vegetation index (NDVI), relative humidity (RH), altitude (AL), farms per area (FA), farms with native pasture (FNP), farms with good pastures (FGP); farms with water resources (FWR), farms that receive technical advice (FTA), family farms (FF), non-family farms (NFF) and human development index (HDI). The variables were standardized by the STANDARD procedure of SAS®, assuming a mean of zero (0) and variance one (1).

Analyses of variance were performed using the GLM procedure. The sources of variation were the Brazilian States and Regions. The means were adjusted by least squares method (LSMEANS) and compared using the Tukey test ($p<0.05$).

To better understand the correlation structure and try to understand the sources of variation in the data analysis a factor analysis (PROC FACTOR) was performed. In this analysis, the assumption of orthogonality criterion was tested by Kaiser-Meyer-Olkin statistic (Kaiser, 1970). To best explain the variance of each factor, we used the option SMC (Squared Multiple Correlations), i.e., the square of the multiple correlations of each variable with the other variables was used as a prior estimate of the commonalities. We used a screen test to establish the minimum number of factors to be considered.

Canonical correlation analysis was performed to summarize the variation between classes (CANCORR). Discriminatory power of variables in differentiating regions and units of the federation was defined by a discriminant analysis (DISCRIM) (Lachenbruch1997). To determine the subsets of variables used in the quantitative discrimination of the Brazilian regions, the procedure STEPDISC ($p<0.10$) was used.

To organize the information about the regions and states, so that similar groups were formed, we used the procedures CLUSTER and CANDISC. The method adopted for the definition of clusters was the minimum variance method (Ward's method). In this method, the intra-group variance is calculated for all possible clusters, choosing the arrangement that provides the smallest variance. The graphics were created using the procedures GPLOT, GMAP and TREE.

RESULTS

Brazil is a country of continental proportions. It has specific climate, physical, and socioeconomic differences by region. This is clear when looking at the ranges for the variables under study, especially area, GDP and population (Table 1). Thus, multivariate regression analyses were necessary to adjust the total goat milk produced and goat milk productivity (l/doe/year) by GDP, area and number of inhabitants. All data is on a municipality basis. The indices for production of goat milk and yield (IGP, IMP and PIM) were respectively:

$$IGP = -130.007 + CA\mathbf{x}468.673 + CP\mathbf{x}154 - CP^2\mathbf{x}1143.806 + CH\mathbf{x}2153.789 - CH^2\mathbf{x}7.437;$$

$$IMP = -903.785 + LA\mathbf{x}379.677 - LA^2\mathbf{x}0.378 + LP\mathbf{x}473 - LP^2\mathbf{x}246.487 - LH\mathbf{x}966.266;$$

$$PIM = 2.36029 + PA\mathbf{x}70.50967 + PP\mathbf{x}17113 + PP^2\mathbf{x}1.43355 + PH\mathbf{x}1062.44162.$$

Production spatialization

The Northeast region had a higher average effective number of animals and milk productions ($p<0.05$) than the other regions (Fig.2). Although large differences were seen for the North, Midwest, South and Southeast regions, there were no statistically significant differences ($p>0.05$), probably due to large variations. For productivity, the Southeast Region had higher mean estimate to the other regions (Table 2). Breeding programs are usually based on improvements in productivity (Blackburn et al. 1998). Thus, it assumes that in regions such as South and Southeast would be a better base to start a breeding program for goats in Brazil.

About 91% of Brazil's goats are raised in the Northeast. However, these animals have low production levels, with around 66% of all milk produced. On the other hand, in the Southeast, which has about 3% of the goat, the herd milk production is around 25% of the national total. This demonstrates both the use of more specialized animals for milk production, as well as higher input farming systems (intensive). In the Northeast, there was predominance of

Table 1. Municipal statistical data for the climate, physical and socioeconomic variables related to goat production in Brazil

Variable	Mean	Standard deviation	Minimum	Maximum
Area (km^2)	1,544.31	5,717.00	2.85	160,755.00
GDP (R$/year)	545,001.50	5,817,536.67	6,492.19	357,116,681.00
Population	34,083.15	200,479.18	834.00	10,990,249.00
Number of goats	1,272.86	6,441.27	0.00	188,854.00
Milk volume per year (l)	5,458.70	50,895.71	0.00	2,381,685.00
Productivity (l/doe/year)	9.79	85.55	0.00	5,475.00
Temperature amplitude (°C)	9.38	1.48	4.36	13.41
Temperature Mean (°C)	27.71	3.45	22.00	36.00
Precipitation (mm/year)	1,437.84	371.02	353.17	3370.26
Relative humidity (%)	60.19	11.56	20.37	98.91
Altitude (m above sea level)	568.40	315.46	1.36	2091.10
NDVI	0.24	0.30	-0.47	0.96
Farms per area	0.04	0.07	0.00	3.06
Farms with native pasture	0.09	0.13	0.00	3.23
Farms with good pastures	0.09	0.22	0.00	9.23
Farms with water resources	0.79	1.16	0.00	33.33
Farms that receive technical advice	13.57	39.88	0.00	1587.00
Family Farms	0.09	0.13	0.00	4.48
Non-family farms	0.01	0.02	0.00	1.21
Human development index	0.70	0.08	0.47	0.92

GDP = Gross Domestic Product; INDV = normalized difference vegetation index.

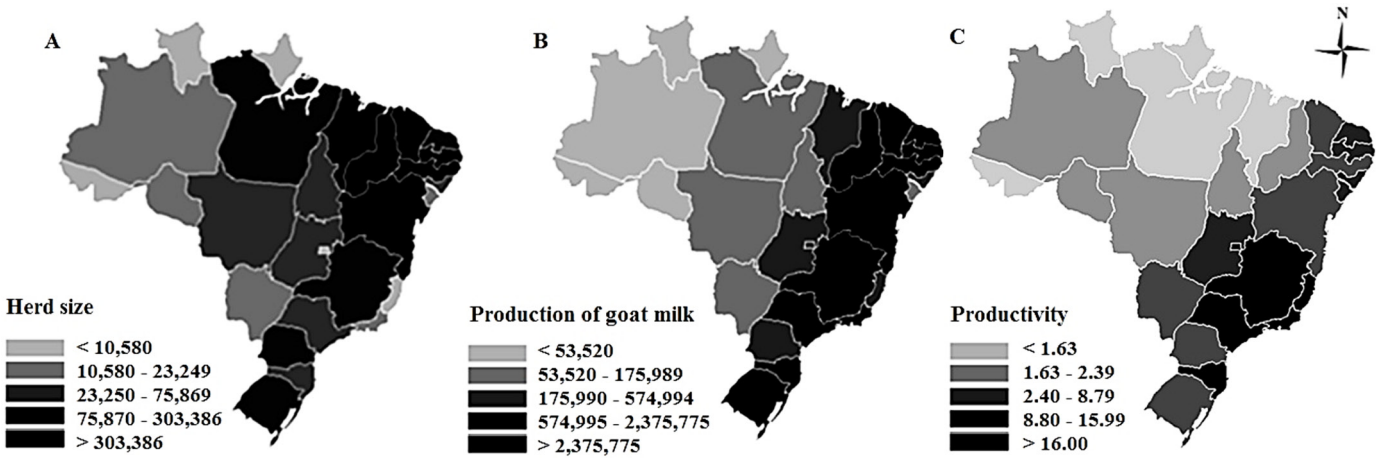

Fig.2. (**A**) Herd size (number of goats). (**B**)Total milk production. (**C**) Production of milk per doe (l/doe) by States.

Table 2. Average for the production of goat milk and municipal productivity adjusted by the method of least squares between the states (UF) within each region and between the Midwest (CO), North (N), Northeast (NE), South (S) and Southeast (SE)

Region	UF	Number of goats	Means between states	Milk production (l)	Means between states	Productivity (milk/doe/year)	Means between states
CO	GO	88.23^{B}	188.43^{B}	2,701.56^{A}	1,168.56^{B}	4.45^{A}	1.98^{BC}
	MS	261.99^{A}		706.85^{A}		1.03^{A}	
	MT	204.85^{A}		97.45^{A}		0.43^{A}	
N	AC	331.73^{ABC}	274.55^{B}	[illegible]	80.57^{B}	[illegible]	0.31^{C}
	AM	239.19^{BC}		[illegible]		[illegible]	
	AP	78.19^{C}		[illegible]		[illegible]	
	PA	526.62^{A}		290.36^{A}		0.31^{A}	
	RO	207.98^{BC}		233.37^{A}		1.73^{A}	
	RR	380.80^{AB}		[illegible]		[illegible]	
	TO	157.33^{BC}		40.29^{A}		0.09^{A}	
NE	AL	332.44^{C}	2,997.10^{A}	3676.99^{B}	11,373.62^{A}	15.99^{AB}	9.18^{ABC}
	BA	5,129.46^{A}		27,890.71^{A}		5.51^{CD}	
	CE	4,069.92^{AB}		9717.11^{AB}		10.35^{BC}	
	MA	1,396.87^{C}		647.64^{B}		1.42^{D}	
	PB	2,067.85^{BC}		19,507.55^{AB}		11.81^{ABC}	
	PE	5,605.44^{A}		15,444.67^{AB}		17.98^{A}	
	PI	6,535.09^{A}		10,251.09^{AB}		1.24^{D}	
	RN	1,636.47^{BC}		13,700.72^{AB}		11.59^{ABC}	
	SE	200.37^{C}		1526.07^{B}		6.70^{CD}	
S	PR	310.24^{A}	212.64^{B}	521.31^{A}	816.52^{B}	3.04^{B}	12.05^{AB}
	RS	191.72^{B}		654.84^{A}		5.00^{AB}	
	SC	135.98^{B}		1,273.42^{A}		28.10^{A}	
SE	ES	131.49^{AB}	114.20^{B}	1,653.53^{B}	3,429.90^{B}	12.19^{B}	21.39^{A}
	MG	87.07^{BC}		1,648.17^{B}		18.61^{B}	
	RJ	167.59^{A}		8,875.57^{A}		46.73^{A}	
	SP	70.68^{C}		1,542.34^{B}		8.01^{B}	

^{ABC} Different upper case superscripts in the column indicate statistically significant difference ($p<0.05$) between the states within each region and between regions of Brazil, by Tukey test.

semi-intensive and, in most cases, with less specialized animals for milk production.

For the Midwest, the states of Goiás and Mato Grosso do Sul were more specialized in milk production, while Mato Grosso has dual purpose animals (dairy and meat). In the North, the states of Acre, Amazonas, Roraima and Amapá had no effective production of goat milk. Possibly, these animals are raised for meat production. In the states of Para, Rondônia and Tocantins the animals are dual purpose. The low productivity of these states may be related to the lack of specific technical information, with a low number of animals in commercial production, among others.

Productive and environmental descriptors

Three factors were needed to explain 97% of the variance (Table 3). The Adequacy of the database for this analysis

Table 3. Common factors, percentage of variance explained by each factor and cumulative variance

Factor	Eigenvalue	Explained variance (%)	Accumulated variance (%)
1	2.61	0.45	0.45
2	2.03	0.35	0.81
3	0.96	0.16	0.97

was represented by the value of Kaiser-Meyer-Olkin (KMO) (0.72). This confirms the assumption of orthogonality, i.e., all factors help in understanding the variance because they are independent of each other. The correlation matrix presented nonsingular estimates.

The first two eigenvectors (Fig.3) showed clear groupings of the relationships between the variables measured, and it was possible to group into three fairly distinct groups, the variables that had a closer relationship: i) Human Development Index, precipitation, relative humidity, altitude and normalized difference vegetative index; ii) farms per area, farms with native pasture, farms with good pastures, productivity index of milk/goat, farms with water resources, family farms and non-family farms; iii) farms that receive technical advice, temperature range, index of goat production, index of milk production, average temperature.

Production of goats showed a higher correlation with average temperature and farms that receive technical advice, and negatively correlated with relative humidity, precipitation, normalized difference vegetation index, altitude and Human Development Index. Milk production was positively related to temperature range, farms with good pastures and farms per area. Productivity index of milk per goat showed a higher correlation with Human Development Index (Fig.4).

Regional discriminants

All political administrative regions of Brazil were well discriminated through analyzing the production, climate,

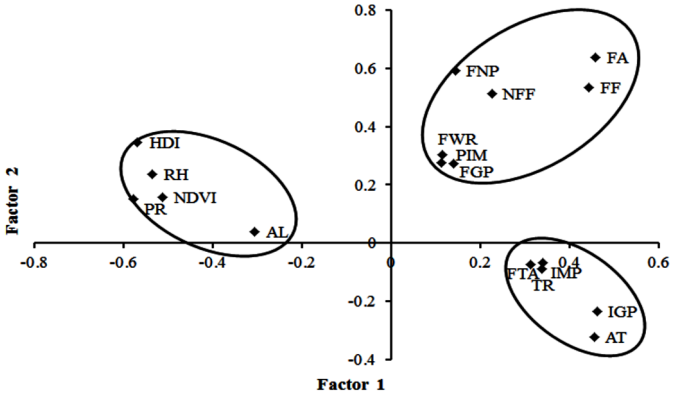

Fig.3. **Graphical representation of the first two factors.** IGP = Index of goat production; IMP = Index of milk production; PIM = Productivity index of milk/goat; TR = Temperature range; AT = Average temperature; PR = Precipitation; NDVI = Normalized difference vegetative index; RH = relative humidity; AL = altitude; FA = Farms per area; FNP = Farms with native pasture; FGP = Farms with good pastures; FWR = Farms with water resources; FTA = Farms that receive technical advice; FF = Family farms; NFF = Non-family farms; HDI = Human Development Index.

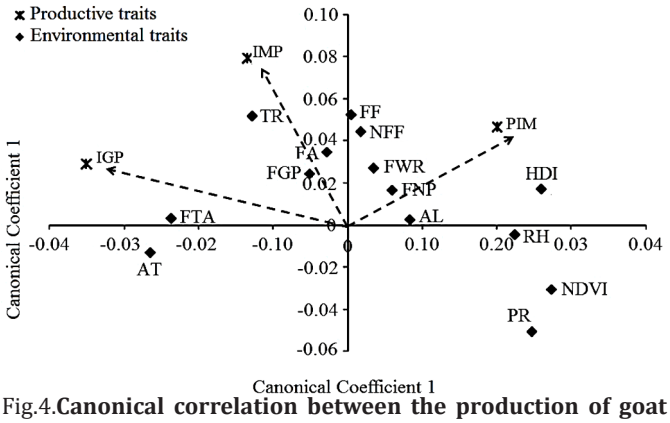

Fig.4.**Canonical correlation between the production of goat meat and milk and the physical, environmental and socioeconomic variables.** IGP = Index of goat production; IMP = Index of milk production; PIM = Productivity index of milk/goat; TR = Temperature range; AT = Average temperature; PR = Precipitation; NDVI = Normalized difference vegetative index; RH = relative humidity; AL = altitude; FA = Farms per area; FNP = Farms with native pasture; FGP = Farms with good pastures; FWR = Farms with water resources; FTA = Farms that receive technical advice; FF = Family farms; NFF = Non-family farms; HDI = Human Development Index.

Table 4. Success of discriminate analysis for political administrative regions of Brazil

Region	CO	N	NE	S	SE	Total of cities
CO	**97.97**	0	0	2.03	0	443
N	0	**100**	0	0	0	448
NE	0	0	**100**	0	0	1784
S	0.26	0	0	**80.40**	19.34	1157
SE	1.56	0	0	1.86	**96.58**	1665
Error	0.0203	0	0	0.196	0.0342	0.0501

CO = Midwest, N =North, NE =Northeast; S =South, SE =Southeast.

physical and socioeconomic variables (Table 4). For the North and Northeast, the factors studied discriminated well these regions, i.e., no confounding with other regions. Only 2.03% of the municipalities in the Midwest were incorrectly allocated to the South. The Southern region showed discriminatory power of 80.40%, with almost 20 percent of confounding with the Southeast Region. The latter presented was well discriminated (96.58%), with low confounding with the Midwest and South, with percentages of 1.56 and 1.86%, respectively.

The results of discriminant analysis (*stepdisc*) showed that the sources of climate variability (range of temperature, average temperature, precipitation, humidity, altitude and normalized difference vegetation index) were more important in explaining the causes variation between regions ($p<0.05$). The human development index was essential to discriminate both the Northeast region from the Midwest, South and Southeast, the South and the North and South ($p<0.8$). Other factors discriminate the regions below 10% significance (Table 5).

Regional groupings

The distances between clusters (Ward's Minimum-Variance Method) for the Federative Units (FU) were effective

Table 5.Variablesdiscriminate between the Brazilian regions

Region	N	NE	S	SE
CO	PIM IGP IMP TR AT PR AL INDV FF NFF	PIM IMP TR AT PR FWR AL INDV FNP FWR HDI	PIM IGP TR AT PR FWR AL INDV FA FGP FWR FTA NFF HDI	PIM IGP TR AT PR FWR INDV FNP FGP FWR FF
N		IGP TR AT FWR AL FWR AG	PIM IGP TR AT PR AL INDV FF HDI	PIM IGP TR AT PR FWR AL INDV FGP
NE			PIM IMP TR AT PR FWR AL INDV FF HDI	PIM IMP TR AT PR AL INDV FWR FF HDI
S				PIM IGP IMP TR AT PR INDV FNP FGP FTA NFF HDI

CO = Midwest, N = North, NE = Northeast; S = South, SE = Southeast; IGP = Index of goat production; IMP = Index of milk production; PIM = Productivity index of milk/goat; TR = Temperature range; AT = Average temperature; PR = Precipitation; NDVI = Normalized difference vegetative index; RH = relative humidity; AL = altitude; FA = Farms per area; FNP = Farms with native pasture; FGP = Farms with good pastures; FWR = Farms with water resources; FTA = Farms that receive technical advice; FF = Family farms; NFF = Non-family farms; HDI = Human Development Index.

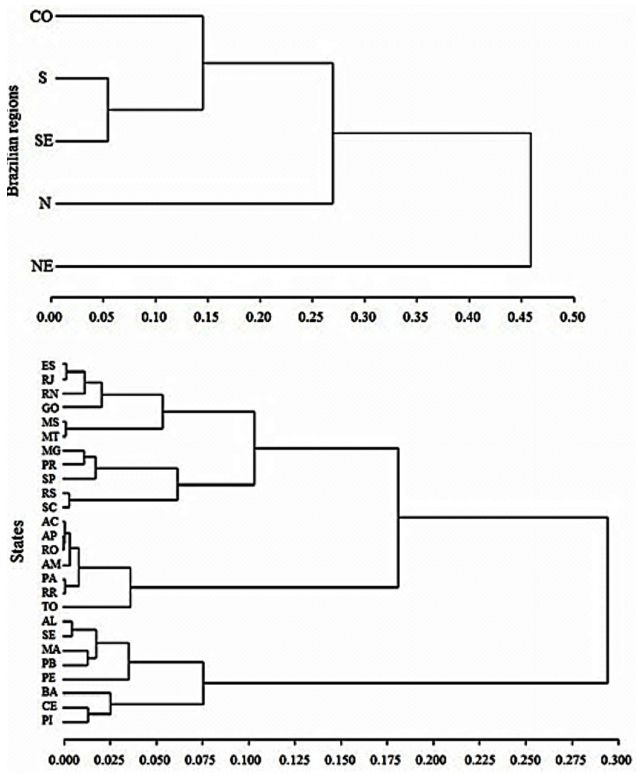

Fig.5. **Dendogram of the distances between states (UF) and Brazilian regions.** CO =Midwest, N = North, NE =Northeast, S = South, SE =Southeast; ES = Espirito Santo; RJ = Rio de Janeiro; RN = Rio Grande do Norte; GO = Goiás; MT = Mato Grosso; MS = Mato Grosso do Sul; MG = Minas Gerais: SP =São Paulo; PR =Paraná; RS = Rio Grande do Sul; SC = Santa Catarina; AC = Acre; AP =Amapá; RO =Rondônia; RR = Roraima; AM = Amazonas; PA = Para; TO = Tocantins. AL = Alagoas; SE = Sergipe; MA =Maranhão; BA = Bahia; CE = Ceara; PI =Piauí; EGP =Paraíba; PE = Pernambuco.

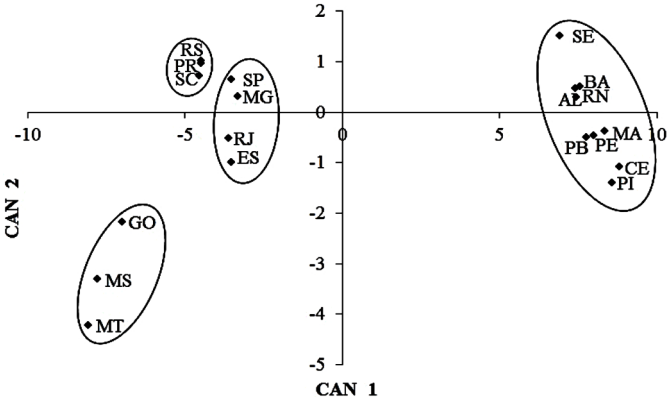

Fig.6. **Graphical representation of the canonical discriminant analysis of the states within the regions of Brazil.** ES = Espirito Santo; RJ = Rio de Janeiro; RN = Rio Grande do Norte; GO =Goiás; MT = Mato Grosso; MS = Mato Grosso do Sul; MG = Minas Gerais; SP =São Paulo; PR =Paraná; RS = Rio Grande do Sul; SC = Santa Catarina; AL = Alagoas; SE = Sergipe; MA =Maranhão; BA = Bahia; CE = Ceara; PI =Piauí; PB =Paraíba; PE = Pernambuco.

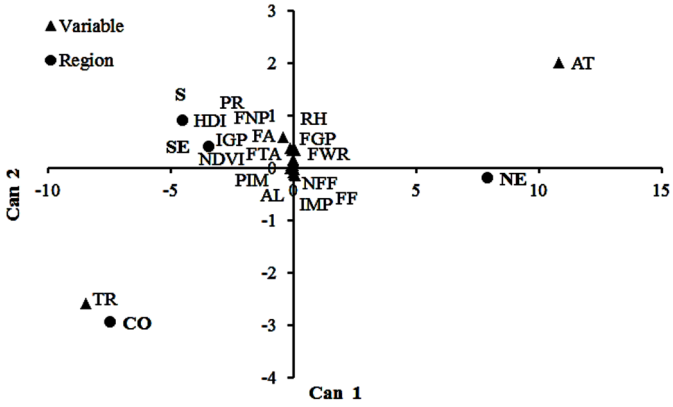

Fig.7. **Graphical representation of means of canonical variables and regions.**CO = Midwest, N = North, NE = Northeast, S: =South, SE = Southeast; IGP = Index of goat production; IMP = Index of milk production; PIM = Productivity index of milk/goat; TR = Temperature range; AT = Average temperature; PR = Precipitation; NDVI = Normalized difference vegetative index; RH = relative humidity; AL = altitude; FA = Farms per area; FNP = Farms with native pasture; FGP = Farms with good pastures; FWR = Farms with water resources; FTA = Farms that receive technical advice; FF = Family farms; NFF = Non-family farms; HDI = Human Development Index.

in grouping the States within their respective regions. Thus, it was possible to group the states in four distinct groups: I) Espirito Santo, Rio de Janeiro, Rio Grande do Norte, Goiás, Mato Grosso and Mato Grosso do Sul; II) Minas Gerais, São Paulo, Paraná, Rio Grande do Sul and Santa Catarina; III) Acre, Amapá, Rondônia, Roraima, Amazonas, Pará and Tocantins, and IV) Alagoas, Sergipe, Maranhão, Bahia, Ceará, Piauí, Paraíba and Pernambuco. Group IV is the group more differentiated, compared to other groups, as is represented by the federal units in the Northeast, which produced more goats (Fig.5).

Due to the low production of milk and goats in the Northern region, this was removed from the canonical analy-

sis. These discrepancies for the North are also justified by the small number of municipalities and population per unit area, and present the largest municipal territorial extensions. Canonical components showed that the Midwest region showed the greatest variation among the federating units, followed by the Northeast and Southeast and South (Fig.6).

The canonical average for both regions and for the study variables showed distinction between all regions. For the Northeast region factors related to average high temperature were more important, while in the Midwest there was a higher temperature range, which indicates greater temperature changes throughout the year. The South and Southeast were more similar, being more related to human development index, precipitation and the normalized difference vegetation index (Fig.7).

DISCUSSION

Univariate approach

All components of climate, physical and socio-economic estimates were highly variable. Therefore, the indices (PIG, IMP and IGP) determined by means of multivariate regression were important, especially in economic terms, as regions with higher GDP and a larger number of people tend to demand more products of animal origin (Sibbald al et al. 2008).

As most dairy goats were in the Northeast of the country, this also has the largest goat milk production (Fig.2). However, higher productivity per doe was seen in the Southeast, probably due to the use of specialized dairy herds, reared in intensive systems while the Northeast has dual purpose animals, raised in extensive and semi-intensive systems (Gonçalves et al. 2008, McManus et al. 2008, Oliveira et al. 2009).

All regions showed distinct productions. These are related to both the genetic component and climate, physical and socioeconomic variables, intrinsic to each region. These differences are attributed not only to the breeds used, but also the use of biotechnologies, the technical advisory services, the level of information farmers receive, and market demand.

Although the Northeast region shows high yields of milk in some states, most animals are dual purpose. It must be remembered that each municipality has a different area that may affect the figures. To the South, the state of Paraná had the highest effective number of goats (dual purpose), but the state of Santa Catarina is more specialized in animals for milk production.

The highly variable productions of goat milk and productivity also arise from the distinctions between the objectives of selection, and shape important aspects to be considered. When the animal breeding programs are designed without the selection objectives are in line with the characteristics of each region and also to the needs of the farmers in each region, these programs tend to have limited results (Kosgey et al. 2006).

These results are an indication that the selection objective for the Southeast should be milk productivity, confirming results obtained by Blackburn et al. (1998) and McManus et al. (2011), who showed that breeding programs are usually created by taking into account the levels of production, breeding systems and profitability.

Multivariate approach

Three distinct groups were formed in the factor analysis: i) variables related to the physical components (FNP, FA, NFF, FF, FWT, FGP and PIM), ii) climatic variables (AT and TR), milk production and technical guidance, and, iii) other climate variables (RH, AL, PR and NDVI) and a socioeconomic component, represented by the municipal human development index (HDI).

A positive relationship was found between number of animals, milk production, technical guidance, range of temperature and average temperature. Areas with native pastures are more related to farms with water, which in turn are more related to production of goat milk. The production of goat milk is more related to variable temperatures and average temperature range, respectively. The productivity of goat´s milk was found to be more closely related to relative humidity, precipitation, NDVI, altitude and human development index (Fig.3).

The productivity of goat milk (PIM) showed a positive correlation with RH, NDVI and PR. This variable also showed high correlation with HDI (Human Development Index), whose values were 0.74, 0.66, 0.61, 0.77 and 0.74 for the Mid-West, North, Northeast, South and Southeast, respectively. This is an indication that regions with higher indicators of longevity, education and income were more specialized in animals for milk production (Fig.4). The municipalities with the highest HDI, concentrated in South and Southeast regions showed to be inversely related to the production of goats, as the highest milk production per municipality is located in northeastern Brazil, which presents HDI below the national average (0.71).

All Brazilian regions showed specific peculiarities, revealed by discriminant analysis. In general, the climate variables, physical and socioeconomic had, on average, discriminatory power exceeding 94% (Table 4). Climate variables explain the variation between these regions (AT, TR, RH, PR and NDVI).

The reduction of areas for livestock production, due to population growth has created new opportunities to promote the dairy goat rearing through government initiatives (Devendra 2010, Bett et al. 2011). Bett et al. (2009a) have shown that the largest goat dairy producing areas are located in environments of medium to high rainfall. In this study, the largest goats production were in the Northeast, in areas with medium to high temperature, low to medium precipitation and low Human Development Index, with averages of 30.35°C, 1156.19 mm/year and 0.61, respectively. Thus, because there are poorer communities in this region, with greater governmental incentive for goat rearing, which serve as a source of food protein, both meat or milk (Lobo et al. 2011).This is an indication that physical, socioeconomic and climate are important sources of variation that should be considered for that animal breeding programs can be successful (McManus et al. 2011).

The four regions, broken down by means of canonical

analysis (Northeast, Midwest, Southeast and South) were well defined and differentiated. Of these, two have distinct peculiarities, for the production of milk and goats: i) the Northeast region (SE, BA, RN, AL, MA, PE, PB, EC, PI), markedly different, due to a high number of goats with low individual milk production in extensive production systems; ii) Southeast (SP, MG, RJ and ES), using animals specialized for milk production, in intensive systems (Gonçalves et al. 2001, 2008).

These tests also revealed which climate and socioeconomic variables were most important for production in the different regions. It is therefore possible to create programs of genetic improvement of goats rooted not only in production levels (Blackburn et al. 1998), but also in all the factors that may influence the production of goats in different regions of Brazil (McManus et al. 2011).

Animal breeding program

As we intensify production systems, with increasing demand for efficiency, there are greater the need for structured breeding programs. This is only possible through systematic data collection with efficient and well-defined selection objectives. These goals should be oriented according to the expectations and demands of market, and with different environmental conditions, specific to each region. Thus, as one of the main prerequisites for achieving success, animal breeding programs must be based on clearly defined goals and objectives, consistent with the market structure and conditions consistent with the general environment. Blackburn et al. (1998) showed that depending on the environment and the level of production, different breeds should be used. Thus, when creating a breeding program, one should take into account these two factors.

The development of a breeding program should include the implications for agricultural policies, infrastructure, and involvement of both the government and private initiatives as the producer, weather, market and choice of breed best suited to the region. A breeding program should be integrated and its success is determined by participation of the producer (Kosgey et al. 2006).

The success of animal breeding programs is limited by knowledge of the interactions between genotype and climate, social, political, economic and cultural variables. For example, the Southeast region of Brazil has higher GDP, HDI and population, and lower average temperature. For this region, the use of specialized and purebred goats for milk production should be the basis for the success of a breeding program, since HDI indicates high educational and economic levels. This sets a positive relationship between consumption and demand. The Northeast region has large areas, is less populated, has average high temperature, low relative humidity, and its HDI is below the national average. These factors, combined with marketing and parameters desired by farmers reflect selection for distinct characteristics of goats. These animals must have dual purpose, as well as contribute to improving the income of disadvantaged families through the sale of milk, can also add economic returns through the sale of animals for slaughter (Lobo et al. 2011).

The valuation of components such as technical guidance, water resources, marketing services, productivity, monitoring and evaluation activities for the rearing of dairy goats are of great importance to the sustainability of breeding programs for dairy goats (Bett et al. 2009b). This is because the production of dairy goats in tropical systems is influenced by soil and climate conditions, biological and socioeconomic. The implementation of breeding programs should be grounded by taking into consideration this set of factors, because they are often difficult or impossible to change (Wollny 2003).

Sustainable systems of livestock production must be adjusted to local conditions, natural and social. The recognition of differences in social, economic, cultural and edaphoclimatic between regions increase the distinction between the objectives of selection. The differentiation of these objectives is important for the maintenance of genetic variability of domestic animals. Not only is the heterogeneity of the circumstances of production between regions, countries or individual farms, but also uncertainty and risk associated with future circumstances that promote the differentiation between the goals of creating and maintaining breeders (males and females) are better adapted to regions specific (Olesen et al. 2011).

Thus, the implementation of animal breeding programs, specific to similar regions, especially in terms of climate, it is essential to obtain higher production levels, consistent and appropriate to the local environment. The heterogeneity of the Brazilian reality requires the design of breeding programs that meet the specificities of each region in order to minimize the impact of different factors that influence them.

CONCLUSIONS

Brazil, a country of continental proportions, presents heterogeneity of climate, physical and socio-economic components specific in each region. This becomes more evident, for example, when we compare the goats raised in the South region of Brazil with goats raised in the Northeast, which don't presents the same performance, what can be due to the great environmental and socio-economic distinctions that exist between these regions. Therefore, it is necessary to implement programs of animal breeding that meet the needs and characteristics of each region.

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