

Original Research Paper

# Characterization of the Sheep Farming System in the Brazilian Semiarid from the Multivariate Perspective

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**Abstract:** This study aimed to characterize the purebred Morada Nova sheep and crossbred farming systems in Ceará State, Brazil, through multivariate analysis. The study was carried out in the Morada Nova municipality in Ceará. Thirteen representative Morada Nova pure sheep Breeders (MNB) and 48 crossbreds' breeders of Morada Nova with other breeds (CMN) were interviewed. Was used a questionnaire-based including 12 variables: Breeder Age (BA); Herd Size (HS); Breeding System (BS); feed Supplementation (SUPLE); season feed supplementation (winter or summer); Age at Sexual maturity of Ram (ASR); Ram Discard Age (RDA); Age at Sexual maturity of the Ewe (ASE); Ewe Discard Age (EDA); Commercialization (COM); family participation (FAMP); Main Breeder Activity (MBA). Descriptive statistics and variance analysis were performed, followed by Tukey's test for the comparison of the farming systems of the two studied groups. Variables that characterize the farming systems were subjected to factorial analysis, cluster and discriminant analysis. Based on the factorial analysis, the variables SUPLE, SEASON, ASR, EDA, BA, HS and MBA most significantly contributed to the characterization of farming systems in both studied groups. There was obtained a high level of error classification of breeders to their origin group, due to the handling homogeneity between the studied groups. Multivariate analyses are useful for characterizing the farming system, but the results found can be influenced by the nature or characteristics of the data evaluated.

**Keywords:** Multivariate Analysis, Breeding Practices, Local Breed, Livestock System, Small Ruminants

## Introduction

Sheep were the first animals domesticated by humans and have been playing a crucial role in the beginnings of civilization (Fernandes, 1999). The domestic sheep introduced in Brazil in the colonization are mainly descendants of Portuguese and African breeds (Figueiredo, 1980; Paiva *et al.*, 2005). These animals went through a long process of natural and artificial selection, which promoted the fixation of particular characteristics necessary for the adaptation to local conditions.

Sheep, especially those of local breeds, are important for the subsistence of human populations in developing

countries. These breeds have multiple functions and significantly contribute to the income of small-scale farmers in marginal areas as well as noticed in the literature (Beneberu and Jabarin, 2006; Kosgey, 2004; Kosgey and Okeyo, 2007; Thiruvankadan *et al.*, 2009). They provide high-quality protein due to their excellent ability to transform fodder composed of grasses and legumes into foods with high protein value for human consumption (Gonzaga Neto *et al.*, 2005; Odoi *et al.*, 2000).

The sheep production is an essential component of livestock in the Brazilian semiarid. The Morada Nova breed stands out among the breeds of the Brazilian Northeastern, due to its high adaptive capacity to the

region. In 1937, it was described by Domingues (1941) during a visit to the National Department of Animal Production in Morada Nova Municipality, in Ceará State. Due to its high adaptive capacity, they are used by smallholders to meat and skin production (Fernandes, 1992). However, despite its social and cultural importance, the Morada Nova breed is in a vulnerable situation (Ribeiro *et al.*, 2014) and indiscriminate crosses with other breeds have contributed to genetic erosion; this is noticeable by the increasing number of crossbred animals over the years.

Sheep production is an economic activity present on all continents, at different climates, soils and vegetation (Silva, 2004). In general, it is performed in extensive systems with low levels of technology (Casale *et al.*, 2008), mainly in small family farms (Costa *et al.*, 2008). However, a knowledge of local farming systems is essential to define sustainable development strategies by local conditions (Castel *et al.*, 2003; Zumbach and Peters, 2000), once it is one of the main steps for breeding program implementation based on the demands and needs of the target community (Mueller *et al.*, 2015).

Studies on the characterization of the farming system generally involve many traits. The individual analysis of each trait is imprecise and provides a partial view of the farming system. On the other hand, multivariate refers to a set of statistical methods that simultaneously analyze multiple traits (Ferraudo, 2005). This statistical procedure has been widely used for the analysis of data related to breeding characterization (Yakubu *et al.*, 2011; Birteeb *et al.*, 2013; Mishra *et al.*, 2017; Arandas *et al.*, 2017). Multivariate procedures could be useful to farming systems characterization, but their use is still rather scarce in this context of the animal production mainly in studies with small ruminant (Usai *et al.*, 2006).

In this context, this study aimed to characterize the farming system of pure Morada Nova sheep and its crossbred progeny in the breed origin place, Ceará State, Brazil through multivariate analysis.

## Materials and Methods

### Study Area

The study was carried out in the municipality of Morada Nova, which is part of the 10<sup>th</sup> Ceará State Administrative Region. It covers an area of 2,779 km<sup>2</sup> and is the 6<sup>th</sup> municipality of the state, located 152 km from the capital (Fortaleza city). The headquarters of the municipality is located at 5°6'24"S and 38° 22'21"W, at an elevation of 89 m (IBGE, 2014).

Morada Nova is an agricultural and agro-industrial development center with a population of 61,903 inhabitants, according to the IBGE census 2014. The climate is semiarid, with an average annual rainfall of 742.5 mm. The dry period lasts for more than eight months and a drought

period is characterized by a dry season longer than one year (IBGE, 2014). The rainy season is short and irregular and occurs from February to April.

Goat and sheep farming occur in 10 and 16%, respectively, of the rural establishments in Ceará State (Farias *et al.*, 2014). In Morada Nova, sheep and goats predominate, followed by cattle and pigs (Campos, 2003). According to local livestock research (IBGE, 2014), the Morada Nova sheep herd is among the ten most abundant in the state, with 43,011 heads, mainly containing Morada Nova animals crossbred with other breeds, commonly used in the regions Dorper and Santa Inês.

### Sampling and Data Collection

Data were obtained through semi-structured interviews with the 13 remaining breeders of Morada Nova sheep (MNB) and 48 breeders of crossbred herds, resulting from the crossing of Morada Nova animals with other breeds commonly used in the region, with the predominance of Santa Inês breed (CMN). For semi-structured interviews (Albuquerque *et al.*, 2010), a questionnaire was used; the questions addressed the social and demographic profiles of the breeders and the breeding system in terms of food, sanitary conditions and reproductive management to obtain the information (traits): Breeder Age (BA); Herd Size (HS); Breed System (BS); Feed supplementation (SUPPLE ); feed supplementation Season - winter or summer (SEASON); Age at Sexual maturity of Ram (ASR ); Ram Discard Age (RDA); Age at Sexual maturity of the Ewe (ASE); Ewe Discard Age (EDA); Commercialization (COM); Family Participation (FAMP); Main Breeder Activity (MBA). The interviews were conducted locally with questionnaires completed at the 'respondent's place of residence, by a single the interviewer, to avoid misinterpretation. All interviewed breeders signed informed consent. Privacy rights were ensured.

### Statistical Analyses

Social and demographic aspects and the breeding system mentioned in item 2.2. were submitted to frequency distribution analyses. The age of introduction and discard of ram and ewe to the breeding season were submitted to variance analysis and the mean ages taken from both groups were compared by Tukey's test (5% significance).

Data were submitted to factorial analysis, based on principal components, to summarise the original variable set (breeder social profile; food, health and reproductive management), in some independent factors and identify variables that most contributed to the farming system characterization. We used varimax orthogonal rotation, which has a more significant potential to interpret factors. The Jolliffe criterion was used to choose factors (Jolliffe, 1972; 1973), whose sum of eigenvalues should explain, at least, 70% of the total variation.

Cluster analysis was used to identify homogenous breeder's groups, using the Ward method. Also, discriminant analysis was performed to identify traits with higher factor load and classify individuals into their origin groups. Multivariate analyses were performed with the support of FACTOR, CLUSTER and DISCRIM procedures of the software package *Statistical Analysis System* (SAS, 1999).

## Results and discussion

### *Social and Demographic Profiles of the Studied Groups*

The general characteristics of the social and demographic profiles of the two studied groups are shown in Table 1. The reduced number of breeders interviewed in each group denotes the current breed demography. The number of purebred breeders is decreasing with a consequent increase of crossbred herds. Most of breeders interviewed in groups were of male gender, with culture inherited from interaction of Portuguese settler culture with that of the Indians. This population has its own culture (*sertaneja*), marked by its dedication to their land and by specific characteristics of their way of life, family organization and power structuring (Andrade, 1963; Folch, 2011).

**Table 1:** General characteristics of the surveyed groups

Variables	Groups of breeders			
	MNB		CMN	
	N	%	N	%
Sex				
Male	13	100	43	89.58
Female	-	-	5	10.42
Age (years)				
20-40	-	-	8	16.67
41-50	4	30.77	13	27.08
51-70	7	53.85	25	52.08
> 70	2	15.38	2	4.17
Defined as				
Farmer	4	30.76	26	54.17
Breeder	2	15.39	8	16.67
Farmer and breeder	5	38.46	14	29.16
Other functions	2	15.39	-	-
Main income source				
Agriculture	1	7.69	8	16.67
Bovine farming	5	38.47	20	41.67
Sheep	1	7.69	5	10.41
Poultry farming	1	7.69	-	-
Goat breeding	-	-	1	2.08
* Mixed system	4	30.77	12	25.00
Others	1	7.69	2	4.17

\*Mixed system = Livestock (goats, sheep, cattle, pigs) and agriculture. \* MNB = Morada Nova breeders. \* CMN = Crossbred Morada Nova breeders

The predominance of breeders of the male gender is typical in animal husbandry in the northeastern Brazilian. In general, rural women are essential economic agents who contribute to household incomes and the development of their community in several ways. They occupy a subordinate position and their work generally appears as "help", even though they work as hard as men or perform the same activities (Brumer, 2004). Studies also indicate that the "head of the family" is not always the primary decision-maker and that gender determines in part how resource allocation decisions are made on a farm (Handa, 1994; Doss, 1996; 2001; McPeak and Doss, 2006).

The predominance of breeders of the male gender responsible for animal care is also a feature found in other parts of the world, especially in developing countries. For example, on the African continent, Urgessa *et al.* (2012), characterizing sheep and goat farming systems in Ethiopia also found a predominance of breeders of males' gender in livestock production as well as Umunna *et al.* (2014) in Nigeria.

The highest proportion of breeders in both investigated groups was 51 to 70 years old. The rural exodus can explain the small number of young breeders in this area, which is common in Brazil and other developing countries (Ayantunde *et al.*, 2007; Nascimento, 2013). This action seriously threatens the future of livestock breeding (Vinholi and Martins, 2012).

Although agriculture was not the main activity of most interviewees, 38.46% of the MNB group defined themselves as farmers and breeders. In the crossbred breeders (CMN) group, over half (54.17%) defined themselves as farmers. This self-denomination makes them feel socially included and be recognized by their farmer's condition, their ways of working as well as for possession and control of necessary production means (Wanderley, 2015).

In the study area, goat and sheep farming predominated (Campos, 2003). However, both studied groups reported bovine farming as their primary activity and source of income, with emphasis on milk cattle. Cattle farming has been performed in the Morada Nova municipality since the 18th century, mainly on family farms; according to some breeder reports, the gains from cattle farming are used for the payment of general expenses. Sheep is regarded as a way of "savings," which can be used sporadically.

The state of Ceará covers the most significant part of the semiarid territory and 89% of the rural establishments are family-based, with diversified farming activities (Campos, 2004; Farias *et al.*, 2014).

Mixed systems, that is, farming systems based on livestock (goat, sheep, cattle and pig production) and agriculture, were most often used by breeders and are considered the primary source of income for 30.77% of

Morada Nova breeders. According to the interviewed breeders, this diversification in the farming system allows the use of resources in a balanced way, mainly in terms of resource availability (animals and agriculture), access to the market, or the capacity to generate income. Farias *et al.* (2014) verified the adoption of a diversified system (animal and grain yield) when evaluating family breeders in the Ceará semiarid region, considering as essential component for farming system resilience as a way of maintaining family autonomy in the studied territory.

In many tropical developing countries, animal farming systems are very diversified, mainly due to agroecological development (Wurzinger *et al.*, 2006; Gizaw *et al.*, 2010). In this context, small ruminants are also crucial as a diversification strategy aimed at reducing market and climatic risks and optimizing the use of available resources (Valdivia and Nolan, 1996). The diversification of the farming systems has been a trend in the South America region, as verified by Salamanca *et al.* (2015) in southern Peru south and by Yáñez and Marchan (2012) in Chile. The diversification is also prevalent in countries of the African continent and includes small plots with mixed farming systems (agriculture and livestock) (Kosgey *et al.*, 2006).

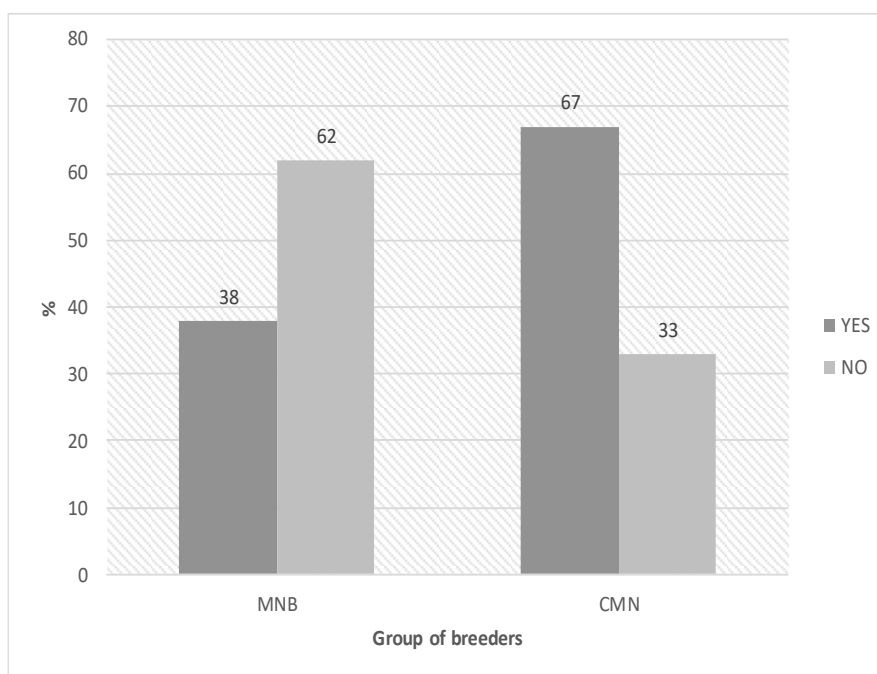
However, only 38% of Morada Nova breeders can count on family member participation to take care of their herds. The small portion of family members involved in breeding is worrisome for the conservation

and maintenance of the Morada Nova breed, due to most breeders are already relatively old (Fig. 1) and rural exodus as yet discussed.

### Breeding of the Studied Herds

Table 2 shows the general characteristics of the two studied groups. Most pure herds contained between 31 and 200 animals, whereas crossbred herds were generally lower (30 to 100 animals) but with several crossbred herds significantly higher than that of pure herds, indicating breed replacement and, consequently, genetic erosion. This situation was confirmed by Ribeiro *et al.* (2014) when evaluating the status of Morada Nova sheep breed. These authors observed genetic material loss, with an effective number ( $N_e$ ) less than 50, the minimum value recommended by the FAO (1998). This situation is common and ultimately leads to a loss of genetic material and the disappearance of the resilient local breeds.

In this present survey, it was observed a prevalence of animals raised free in the native grasslands (> 80%) in both groups of evaluated breeders. In northeastern Brazil, the rearing of small ruminants has historically been practiced extensively, with little or no technical assistance (Nunes, 2008; Santos, 2014; Souza, 2004). Feeding was based on native grassland, without the use of technologies; mating was uncontrolled and there was no record keeping. This management system has been practiced for several years, as reported by Muniz *et al.* (2011).



**Fig. 1:** Family participation in the farming system (%) according to the studied groups. MNB = Morada Nova breeders. CMN = Crossbred Morada Nova breeders

**Table 2:** General characteristics of Morada Nova and crossbreed production systems

Variables	Groups of breeders			
	MNB*		CMN*	
	N	%	N	%
Herd size (animals)				
< 30	1	7.69	15	31.25
31 to 60	4	30.77	16	33.33
61 to 100	3	23.08	11	22.92
101-200	3	23.08	4	8.33
201-300	1	7.69	1	2.08
> 300	1	7.69	1	2.08
Management system				
Extensive	11	84.62	44	91.67
Semi-extensive	2	15.38	4	8.33
Nutritional management				
Food supplementation	12	92.30	44	91.67
Without supplementation	1	7.69	4	8.33
Supplementation period				
Drought	12	100.00	44	100.00
Sanitary management				
Vermifugation	13	100.00	48	100.00
Purpose of production				
Live animals for the meat market	6	46.15	31	64.58
Reproduction	1	7.69	1	2.08
Meat market and reproduction	3	23.08	7	14.58
Meat market and breeding animals	3	23.09	2	4.17
Self-consumption	-	-	7	14.58

\* MNB = Morada Nova breeders. \* CMN = Crossbred Morada Nova breeders

Local breeds, such as the Morada Nova breed, are often characterized by multiple functionalities, making them perfectly suited to the prevailing rearing system in the region. Nowadays, crossbreeding of Morada Nova sheep are common in the region. Generally, crossbred animals have less adaptive attributes, which are required to fulfill multiple roles (Drucker *et al.*, 2001). In local farming systems with limited resources, local breeds may be more promising than crossed and pure exotic breeds (Ayalew *et al.*, 2003; Tibbo *et al.*, 2008). Besides, crosses represent a severe threat to the local genetic heritage.

#### Nutritional Management of the Herds

Although the extensive breeding system was prevalent, 92.30% of the Morada Nova breeders and 91.67% of the crossbreed breeders offered supplementation during the dry season, when food resources are dramatically reduced (Table 2). Generally, sorghum and corn silage were offered; this approach is typical for goats and sheep and prevents malnutrition (Costa *et al.*, 2008). In dry areas in developing countries, feed supplementation is commonly practiced (Silva, 2002; Urgessa *et al.*, 2012).

The primary feed source in the studied area is the *Caatinga* vegetation, which is an essential and major food source in the dry northeastern regions during the dry season. During the rainy season, feed is abundant,

while in the dry season, forage availability and quality are reduced (Silva *et al.*, 2010). Campos (2003), studying sheep and goat rearing systems in Ceará state, also found that native pasture grass was the primary feed source throughout the year. This approach is common in most poor regions in the world, as reported by Gebretsadik and Anal (2013) for northern Ethiopian sheep farms.

#### Sanitary and Reproductive Profiles of the Herds

Sanitary management in extensive systems is generally confined to herd deworming. All investigated breeders vermifuge their animals up to four times throughout the year (Table 2). The deworming is the most used sanitary practice in the region, albeit with questionable results (Alencar *et al.*, 2008).

Table 3 shows the averages standard deviation (months) of the age of introduction and discard of ram and ewe for breeding in the herds of the two studied groups. We found no significant differences in ram and ewe introduction and discard ages among the studied groups; however, the ewes remained in the herds for longer (Table 3).

In general, rams entered breeding at 10 or 11 months and were replaced at about 24 months. The less time the animal is kept in the herd, the higher the genetic gain. However, this limited time of stay contributes to a loss

of origin genes and represents a severe threat to the breed genetic diversity. Therefore, in conservation programs, the generation intervals should be increased, and more considerable attention should be given to mating management to control consanguinity and its unfavorable effects.

The breeders try to prevent inbreeding mates, but it is difficult once, another usually replaces breeding animals from the same herd. The use of animals from outside the herd would facilitate the genic flow and contribute to increased intra-breed diversity. The rams are mainly responsible for the genetic improvement of the herd and are, therefore, of great importance for the efficiency of the farming system (Azevêdo *et al.*, 2008).

In our research, only 30.77% of Morada Nova breeders participate or have already participated in the genetic improvement program (Fig. 2) (Facó *et al.*, 2008). The low participation can be explained by the fact that breeding programs for goats and sheep have often failed because of obstacles such as the lack of zootechnical records and breeder participation (Shiotsuki and Facó, 2013).

All breeders of crossbred animals did not participate in the breeding program (Fig. 2) since the animals are mostly produced for slaughtering. In general, only purebred breeders participated in the breeding program, because their main objective is the genetic selection.

Purebred Morada Nova ewes (MNB) are introduced in the herds for reproduction at the age of 9 months and

are discarded at about 72 months of age, which is much earlier than in the crossbred group (CMN). This practice may contribute to lower generation interval and loss of genetic material. In conservation programs, breeding animals should be kept for longer to favor the maintenance of the genes of origin (Bodó, 1992).

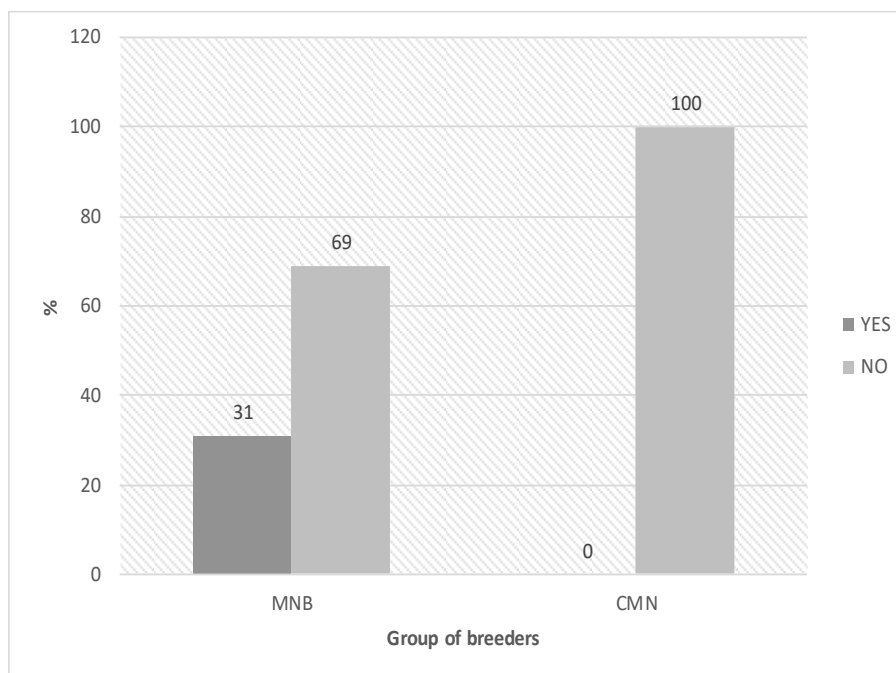
### *Productive Profiles and Commercialization of Herds*

Although the Morada Nova breed is highly appreciated for both reproduction and sold as live animals for the meat market, only about 23.09% of the breeders sold their animals for breeding (Table 2). Most of the breeders send their animals for slaughter, (46.15%) for MNB and (64.58%) for CMN.

**Table 3:** Mean age and standard deviation (months) of introduction and discard of ram and ewe to breeding in the two studied groups

Ages (months)	Breeder group	
	MNB*	CMN*
Age of ram introduction	11±2.93 <sup>a</sup>	10±2.51 <sup>a</sup>
Age of ram discard	24±0.52 <sup>a</sup>	24±0.87 <sup>a</sup>
Age of ewe introduction	9±1.91 <sup>a</sup>	9±2.55 <sup>a</sup>
Age of ewe discard	72±1.70 <sup>a</sup>	60±1.09 <sup>b</sup>

Values with similar lowercase letters within row do not differ significantly from each other by Tukey's test at 5% probability level. \* MNB = Morada Nova breeders. \* CMN = Crossbred Morada Nova breeders



**Fig. 2:** Percentages of breeders participating in genetic breeding programs. MNB = Breeders of Morada Nova breed. CMN = Breeders of Crossbred Morada Nova breed

The skin of Morada Nova sheep, although of high quality, is not efficiently used (Jacinto *et al.*, 2004) due to an insufficient infrastructure for commercialization. In general, according to Santos *et al.* (2008), the sheep slaughtering in Brazil considers the carcass as the primary marketing unit. However, various by-products, such as the skin, represent a potential source of income.

In the group that raises crossbreed animals (CMN), the activity was solely performed for slaughtering and sale (64.58%). The current world consumption of sheep meat stands at about 2.5 kg per person annually out of annual meat consumption of 41.6 kg per person (Morris, 2017). In Brazil, there has been a considerable increase in the sheepmeat market in recent years, mainly because of the increased demand for sheep meat in urban areas (Ziguer *et al.*, 2011). However, the productive chain of the sheep industry in Brazil is high informality, due to precarious control. This situation favors illegal slaughter and the consequent sale of informal carcasses, which represents a barrier that must be overcome to determine the real value of sheepmeat consumption (Sorio and Rasi, 2010). According to Bankuti and Souza Filho (2006), the informal production of sheep meat can be reduced by joint actions of the health surveillance system and the

inspection system. In Brazil, the health surveillance system is limited to the survey of the general hygienic conditions of retail establishments and of the quality of the product offered for sale but neglecting the origin of the product (Sorio and Rasi, 2010).

### Multivariate Analyses

Table 4 shows a summary of the factorial analysis for the 12 variables used to characterize the farming system. Out of the 12 linear combinations generated, the first six explained 75% of the variation (Table 4), allowing a 50% reduction of the sample space. Ibidhi *et al.* (2018), characterizing the sheep farming system in Tunisia through a multivariate approach, also found six components that together explained 82% of the total variation. Differences may occur due to local conditions, quantity and type of traits used to explain the phenomena and variation retained by each one.

The commonality obtained in the present study ranged from 0.443 to 0.921 (Table 5). This parameter indicates the extent to which variables explain the cumulative variation of the factor (Morrison, 1976). Variables with commonality less than 50% have little explanatory power.

**Table 4:** Factors, eigenvalues, Percentage of Explained Variance (%PEV) and Percentage of the Cumulative Variance explained (%PCV) of the studied traits of farming system

Factor	Eigenvalues	% PEV	% FCV
1	2.45076253	0.2042	0.2042
2	1.77618391	0.1480	0.3522
3	1.40247008	0.1169	0.4691
4	1.23938355	0.1033	0.5724
5	1.17433094	0.0979	0.6703
6	1.00230293	0.0835	0.7538

**Table 5:** Factor loads for the variables used to characterize the purebred Morada Nova sheep and crossbreed farming system

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	C
BA	-0.26831	-0.02882	<b>0.63622</b>	0.13446	-0.34742	0.29595	0.70397227
HS	-0.30130	0.44833	0.29916	-0.22030	<b>0.50574</b>	0.20671	0.72831495
BS	-0.20678	0.55603	0.08079	-0.56429	0.02159	0.22783	0.72924721
SUPPLE	<b>0.94722</b>	0.03767	0.01808	-0.08347	0.12281	0.01312	<b>0.92119882</b>
SEASON	<b>0.94722</b>	0.03767	0.01808	-0.08347	0.12281	0.01312	<b>0.92119882</b>
ASR	0.04834	<b>0.81174</b>	-0.06427	0.19617	-0.00961	-0.15934	0.72934663
RDA	-0.08662	0.24207	-0.57422	0.34081	0.43822	0.09513	0.71307142
ASE	0.39045	0.43400	0.03349	0.40369	<b>-0.53768</b>	0.13488	0.81219440
EDA	-0.23870	-0.05551	0.29339	<b>0.70690</b>	0.36001	0.00980	0.77555275
COM	0.34946	-0.30821	0.56365	-0.02229	0.38378	-0.11110	0.69489485
FAMP	0.25128	0.47157	0.36717	0.11877	0.06177	-0.07080	0.44326653
MBA	0.21504	-0.18981	0.16562	0.09241	0.07268	<b>0.86583</b>	0.87317530
%PEV *	20.42	14.80	11.69	10.33	9.79	8.35	

(%PEV\* = Percentage of Explained Variance; C = Commonality; Breeder Age (BA); Herd Size (HS); Breed System (BS); Feed Supplementation (SUPPLE); feed supplementation Season - winter or Summer (SEASON); Age at Sexual maturity of Ram (ASR); Ram Discard Age (RDA); Age at Sexual maturity of the Ewe (ASE); Ewe Discard Age (EDA); Commercialization (COM); Family Participation (FAMP); Main Breeder Activity (MBA).

**Table 6:** Percentage of breeders classified in each group according to the evaluated traits

Breeder group	CMN (%)	MNB (%)
MNB	89.58	10.42
CMN	69.23	30.77
Total (N)	52.00	9.00

\* MNB = Morada Nova Breeders. \* CMN = Crossbred Morada Nova breeders

The Supplementation (SUPPLE) and SEASON traits showed the most significant commonality, mainly because they were variables of higher load in the first factor. In general, the most variables showed commonalities above the 0.5, suggested by Hair Júnior *et al.* (2009), a good fit of the model. The high commonality of a variable group is an indication that they are linearly correlated and, therefore, should be included in factorial analysis. So, we named the first factor of the "nutritional factor." Food supplementation is a strategy used to reach the nutritional requirements of the animals and to maintain a proper animal development; supplements can be given at any time of the year, a variable commonly inserted in studies on the characterization of animal production systems (Silva *et al.*, 2009; Batista, 2015). In the Brazilian semiarid region, supplementation is generally performed in the dry season due to lower food availability.

The feed is one of the most critical parts of the animal production systems. Hence, the feeding strategies adopted influences several features, among them, the composition of the lamb meat and, consequently, its sensorial characteristics. The quality and quantity of food resources available to animals depend mainly on climatic and seasonal aspects (Priolo *et al.*, 2001; Schreurs *et al.*, 2008; Montossi *et al.*, 2013).

The age of ram for breeding in the herd was the most loaded variable in the second factor, justifying its inclusion in characterization studies. The ram can reach sexual maturity as early as at six months of age (Nunes *et al.*, 1997), the importance of the trait in the second factor, reflects the reproductive management system that varies from herd to herd.

The breeder age had the highest load in the third factor. Social variables are essential to be included in this kind of study once the age of breeder can indicate current trends and prospects for animal breeding. Studies indicate that as older as of the head of the family, higher the probability to the family to keep small ruminants. The younger is more likely to volunteer and work part-time in the neighbouring periurban area while the older one remains on the farm. The age of the breeder is a variable that

influences the farming systems once the number of young breeders has been decreasing over time due to lack of incentives and to public policies to attract young people to rural areas (Dossa *et al.*, 2008).

However, public policies to keep young people involved in livestock is essential to ensure the continuity of family farms, which are responsible for a significant percentage of food produced in Brazil and other developing countries (FAO, 2007).

The age of the breeder was also an essential variable in studies on dairy farms (Lopes Junior *et al.*, 2012), indicating that this variable is of fundamental importance within any family production chain.

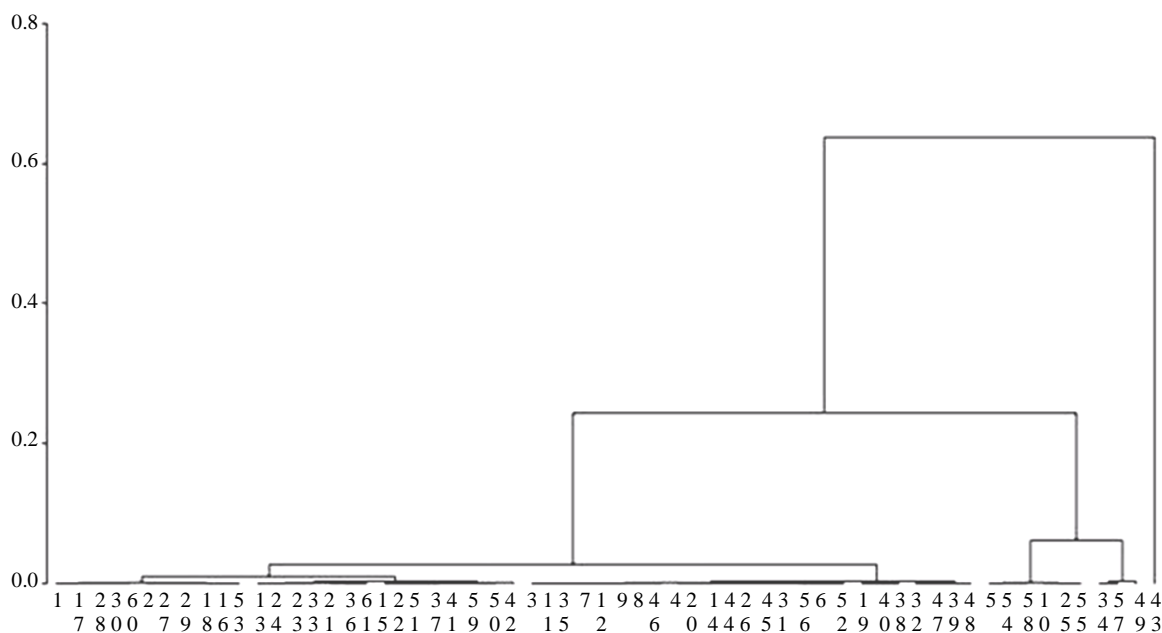
The age of ewe discard was of minor importance when compared to that of rams. However, it should not be neglected and in this study, it showed the most significant load in the fourth factor that contributed 10% of the total variation. Other variables of minor importance, although they should also receive considerable attention, were herd size and the breeding ewe age. These are variables with more weight on the fifth factor. The ewe produces offspring and, consequently, increase the number of animals in the herd; they are, therefore, essential variables in the same factor. The ewe is fertile before it has completed its body development. Therefore, early mating should be avoided because they can compromise future ewe development (Derivaux, 1980; Hafez, 1988; Dukes, 1996).

In this study, the leading breeder activity was in the sixth-factor group, which allows verifying the context and level of importance of sheep on the whole sheep production chain. Although the breeder activity is associated with a factor that adds less variability (8%), its importance should not be disregarded, since it is a determining characteristic of future animal production.

Figure 3 shows the dendrogram obtained by the Ward method with two clusters formed. The first cluster was subdivided into subgroups with distances near zero, indicating homogeneity of characteristics in the two studied groups.

The second cluster was formed by only one isolated breeder that was influenced by the herd size, which is outside the observed general reality, representing an *outlier*. Most crossbred animal breeders (CMN) were tightly grouped, indicating the social and demographic profiles as well as similar sanitary conditions, food supply and reproductive management. On the contrary, Morada Nova breeders were spread among various subgroups, indicating that this group presents a homogeneity concerning the social and demographic aspects and the feeding of the animals, in the sanitary conditions and the reproductive management with the group of crossbreeds of the breed.





**Fig. 3:** Dendrogram obtained by the Ward method to characterize the farming system (1-48 CMN breeders, 49-61 = MNB breeders)

The discriminant analysis not allowed to discriminate the two groups of breeders studied due to the homogeneity between the groups of breeders. It was observed that 69.23% of MNB group breeders were classified to origin group and only 10.42% of the CMN were classified in their origin group (Table 6). These results are in agreement with the cluster analysis, in which some of the CMN group breeders were scattered among the formed subgroups (Fig. 3). Arandas *et al.* (2017) evaluating selection criteria and the selection objective adopted by these two groups observed the same trend.

Morada Nova sheep can easily be managed and are highly adapted to semiarid areas, with low feed requirements. They play essential historical and social roles in semiarid areas of Brazil.

### Conclusion

Multivariate analyses are useful for characterizing the farming system, but the results found can be influenced by the nature or characteristics of the data evaluated.

The supplementation (SUPPLE) and Season of Supplementation (SEASON) are crucial in studies of the farming system since these traits have a higher commonality and highest factor load in the first factor. These traits together with 'Breeder's Age (BA), the Ewe Discard Age (EDA), Herd Size (HS), Age at Sexual maturity of the Ewe (ASE) and Main Breeder Activity (MBA) were the most important to characterize the farming system in the two studied groups.

The factor analysis was useful to identify a set of six latent constructs to characterize the farming system and

the discriminant analysis does not allow to discriminate the two groups of breeders studied, due to the handling homogeneity between the studied groups.

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The breeders of Morada Nova sheep

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### Author's Contributions

**Janaina Kelli Gomes Arandas:** Responsible for the development of research and preparation of the scientific article that is derived from the doctoral thesis of the first author.

**Ângelo Giuseppe Chaves Alves:** Contribution to the development of research and scientific review of the content of the article.

**Olivardo Facó:** Contribution to the development of research and scientific review of the content of the article.

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**Luciana Shiotsuki:** Contribution to the development of research.

**Maria Norma Ribeiro:** Project coordinator, contribution to the development of research and scientific review of the content of the article

## Ethics

The research was carried out following the ethical norms established for research with humans, as a signature of the Free and Informed Consent Form, which is an essential and fundamental document of the protocol and the research with ethics.

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