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Typology of dairy production systems based on the characteristics of management in the Region of West Paraná

Tipologia de sistemas de produção leiteiros baseado nas características produtivas e de manejo na Região Oeste do Paraná

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Abstract

Milk production in Brazil is complex, as it depends on a wide base of small-scale producers employing diverse strategies. In recent years, the supply chain has undergone considerable structural changes, increasing the need for knowledge and characterization of milk-production activities. Therefore, the objective proposed in this study was to characterize rural properties according to various aspects of production in order to identify the dairy cattle production systems of Western Paraná. To this end, 735 interviews were conducted through semi-structured questionnaires administered to dairy farmers using a questionnaire tab for the diversity of management practices in production systems. Data were tabulated and processed by SPSS-v.18, using multiple correspondence analysis: ACM and cluster analysis (hierarchical cluster). The first two dimensions grouped 71.9% of the total variance: DIM1 as 49.4% and DIM2 as 22.5%. Using cluster analysis, five distinct and homogeneous groups (G1, G2, G3, G4, and G5) of production systems were formed. These systems shared the common feature of small properties and were supported primarily by manual labor performed by family members. It is concluded that various milk producing groups exist in the city, with respect to the characteristics of production systems: ownership structure, squad, and how producers mobilize and act on the factors of production. The typology carried out from these characteristics demonstrates a useful tool for action and technical assistance in developing strategies for the industry.
Key words: ACM, management, property, questionnaire

Resumo

A produção de leite no Brasil é de natureza complexa, pois depende de uma base constituída de elevado número de produtores de baixa escala de produção e grande diversidade de estratégias. Nos últimos anos, essa cadeia produtiva tem sofrido consideráveis modificações estruturais, aumentando a necessidade do conhecimento e caracterização da atividade. Desta forma, o objetivo proposto neste estudo foi

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caracterizar propriedades rurais segundo aspectos produtivos a fim de identificar os diferentes sistemas de produção de bovinos leiteiros do Oeste do Paraná. Para tanto, foram realizadas 735 entrevistas através de questionários semiestruturados, com produtores de leite, utilizando um questionário guia referente às práticas de manejo da diversidade dos sistemas de produção. Os dados foram tabulados e tratados no programa estatístico *SPSS-v.18,* utilizou-se a análise de correspondências múltiplas – ACM e análise de conglomerados (*cluster hierárquico*). As duas primeiras dimensões agruparam 71,9% da inércia, sendo a DIM1 49,4% e a DIM2 22,5%. Utilizando a análise de cluster, formaram-se cinco grupos distintos e homogêneos (G1, G2, G3, G4 e G5) de sistemas de produção. Esses sistemas tinham em comum serem propriedades de pequeno porte e de apresentarem em sua maioria mão-de-obra familiar. Conclui-se que existem diferentes grupos de produtores de leite no município, com relação às características dos sistemas de produção no que diz respeito à estrutura da propriedade, plantel e maneira como os produtores mobilizam e atuam sobre os fatores de produção, a tipologia realizada a partir dessas características se mostra uma ferramenta útil na ação da assistência técnica e na definição de estratégias por parte da indústria.
Palavras-chave: ACM, manejo, propriedades, questionário

Introduction

Milk production in Brazil is complex in nature because it is based on a large number of small-scale producers who employ diverse strategies, imposing challenges to the evolution of production systems for research, extension, and industries (ALVES, 2000). In recent years, the supply chain has undergone considerable structural modifications, increasing the need for knowledge and characterization of the activities within different milk production and regional systems (MONTEIRO et al., 2007; RIBEIRO et al., 2009). The results obtained by dairy farms are based on the performance of animals, and are associated with daily or occasional practices carried out by man (CHEVEREAU, 2004).

In a systems study, the help of mathematical models is essential. These models are quick to use, easy to operate and, at the same time, reliable for the visualization of different alternatives that producers can follow and the respective costs of these alternatives (TREVISAN, 2006). However, according to Hostiou et al. (2006), dairy production systems are increasingly accepted as complex objects of study, thus requiring methods of approach that take this feature into account. To this end, multivariate statistical analysis is applied in studies of multiple measurements taken on each individual or object under investigation, and is currently being used in all areas of knowledge (DEDIEU et al., 1997; DAMASCENO et al., 2008), including multiple correspondence analysis (MCA) and cluster hierarchical analysis (CHA).

In this sense, MCA is a multivariate approach to the exploitation of categorical data, analogous to factor analysis, used mainly to verify graphical relationships between variable categories (GREENACRE, 2007). MCA is more effective when the amount of data to be analyzed is great, and visual inspection or simple statistical analysis cannot reveal its structure. As a complementary tool, CHA, the intent of which is to organize a series of cases in homogeneous groups, is used so that individuals within a group are as close as possible to each other and different from those in other groups (REIS, 2000). Thus, the objective proposed in this study was to characterize farms according to aspects of production in order to identify the various dairy cattle production systems of Western Paraná.

Material and Methods

This study was conducted in the Western region of Paraná State. Data collection on milk production systems (MPS) was performed in the Secretariat of Agriculture and Supply - SEAB office of the municipality of Marechal Cândido Rondon via the

Participatory Fast Assessment (PFA) (VERDEJO, 2006; VALLADARES, 2007), using a semi-structured questionnaire guide, taking advantage producers' visits to the SEAB for proof of aftosa vaccination.

The questionnaire consisted of questions on general information regarding the producer and property, milk production and herd, feed management, milking management, reproductive management, sanitary control, and finally, milk marketing. The information collected in the questionnaire was used for the subsequent construction of explanatory variables (LEBART et al., 2000). At the end of the interview, each of the producers' responses was considered a variable. Subsequently, the selection of variables was performed using MCA. The variables having the greatest contribution to scores described in terms of explained variance were kept (KUBRUSLY, 2001) as well as those that gave an acceptable level of internal consistency for the instrument (Cronbach's α>0.75): 23 variables in all. A total of 735 producers were interviewed, approximately 80% of the county's dairy farmers.

Following selection and construction of the questionnaire variables, the selected variables were tabulated to generate a matrix in which lines corresponded to milk production systems and columns corresponded to variables. The categories for each variable, when necessary, were transformed and coded so that multiple correlation analysis could be performed (MINGOTI, 2005; CRIVISQUI, 1995; PEREIRA, 1999).

The determination of the explanatory variables of production systems was made using MCA, a multivariate statistical technique for qualitative data (LEBART et al., 2000; SMITH et al., 2002). The software, Statistical Package for Social Sciences (SPSS-v.18) was used for the analysis. As a complementary tool, CHA was performed by means of SPSS-v.18.

Results and Discussion

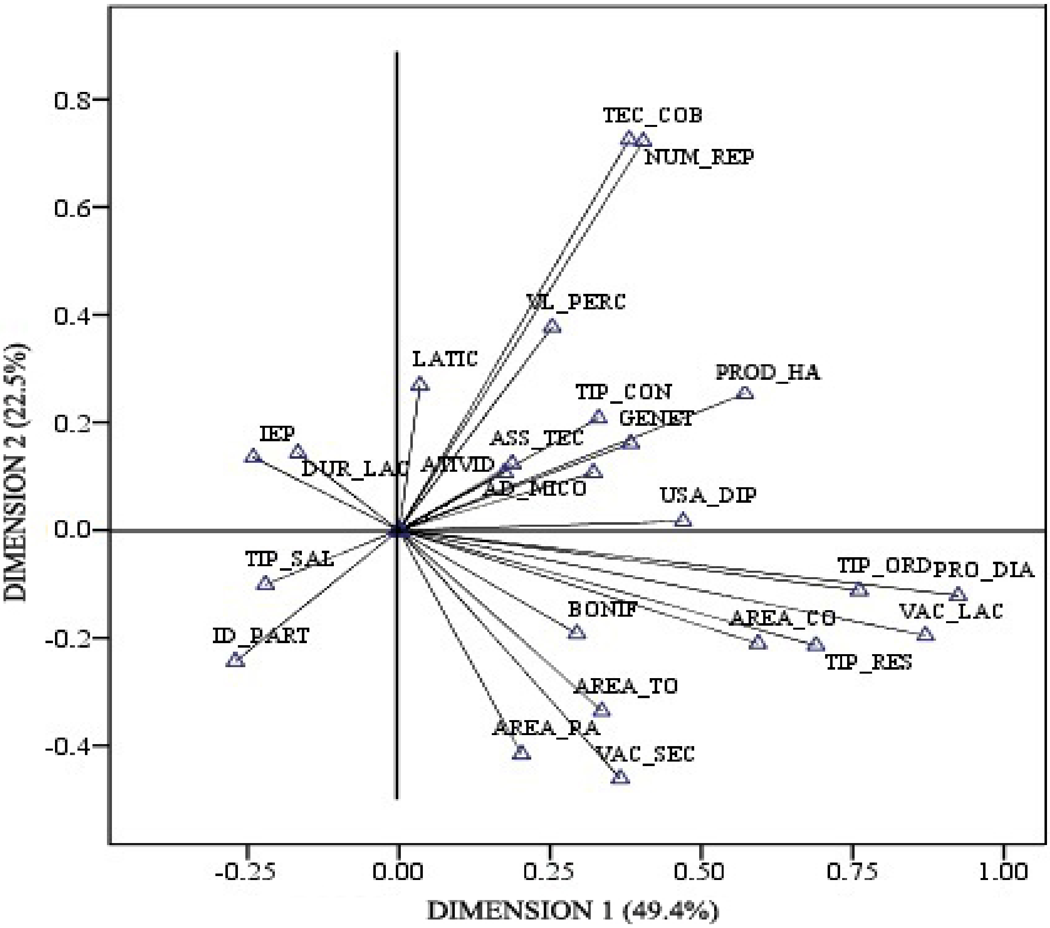
The variables we studied can be summarized in two dimensions, as uncovered by MCA and presented in Table 1. Dimension 1 (DIM1) explains 49.4% of the variance and dimension 2 (DIM2) explains 22.5% to 71.9% of the total pooled variance (Table 1), satisfying the criterion of at least 60% of the explained variance (BARROSO; ARTES, 2003). We can say that the higher the percentage of cumulative variance, the higher the number of variables that were used to explain the work. The results of this study are similar to those obtained by Carrillo et al. (2011), who observed 71% of variance explained when studying dairy production systems in the metropolitan region of Maule, Chile. Bodenmüller Filho et al. (2010) reached 56.51% of the accumulated variance to study the diversity of milk production systems in Londrina, PR. Even so, Aleixo et al. (2007) reached 52.76% of the accumulated variance when they analyzed the top three factors to determine homogeneous groups of dairy farmers in the State of São Paulo. Thus, the total explained variance in this study reached a level considered acceptable for a study of its kind, according to Fávero et al. (2009). The relationship between the variables of MPS and the two dimensions formed by the set of their contributions in terms of eigenvalues explains the characterization of the properties in the municipality of Marechal Cândido Rondon (Figure 1).

Table 1. MCA statistics and contributions of components of the Factor Analysis to eigenvalues and percentage of variance explained.

N	Eigenvalues	% Variance	Accumulated Variance
DIM1	8.32	49.4	49.4
DIM2	5.76	22.5	71.9
TOTAL	14.08	-	-

N = Dimensions (DIM1 e DIM2).

Figure 1. Representation of the variables and their contribution to formation of the first two dimensions of the MCA



Legend: AREA_CO: cutting area; AREA_PA: pasture area; AREA_TO: total area; ASS_TEC: technical assistance; ATIVID: activity; BONIF: bonus; DUR_LAC: lactation length; GENET: genetics; ID_PART: age at first calving; IEP: calving interval; LATIC: main dairy products; NUM_REP: number of transfers; PRO_DIA: production per day; PROD_HA: production per hectare; TEC_COB: coverage technique; TIP_CON: type of concentrate; TIP_ORD: type of milking; TIP_RES: type cooler; TIP_SAL: type of salt; USA_DIP: use of dipping; VAC_LAC: number of dairy cows; VAC_SEC: number of dry cows; VL_PERC: Percentage of lactating cows.

The variables those that contributed the most to the formation of DIM1 were the following: productivity per day, number of milking cows, milking type, kind of cooler, higher cutting area for the production of bulky, and higher production per hectare. For DIM2 the most important variables were covering technique, the number of transfers, and the number of dairy cows compared with the total number of cows. Thus, DIM1 features higher productivity per day and per area, with a greater contribution to production technology, and properties with more capitalized structure with respect to equipment. In contrast, DIM2 consists of smaller properties, but with better control of reproductive performance, which can be connected to the low diversification of agricultural activities of the smaller properties, spending more time on animal control. That can also be related to the greatest operational capability present in these properties, which predominantly use family labor to work in the dairy business. The best obtained performance indices are due to the greater involvement of family labor in production activities compared to hired labor, particularly when based on a family tradition of dairy farming.

It is also observed that, as the shaft of DIM1 moves in the negative sense, it comes across production systems with lower efficiency with respect to the following indices: age at first calving, calving interval (IEP), and lactation length. Advanced age at first calving and long intervals between births reduce the lifetime production of the animals and thus reduce the profitability of dairy farming (RIBAS et al., 1997). On the properties studied, the occurrence of lower production rates was due to operational problems ranging from lack of technical knowledge to problems with planning the forage and feed capacity of the property. Lopes Junior et al. (2012) report that the lack of specific actions of TARE (Technical Assistance and Rural Extension), according to the nature of each system, and the lack of permanence prospects (employment and income in rural property for the permanence of the security of the youngest) contribute to low production rates of the MPS. About the axis of DIM2 as it moves downward, one finds properties with less total area and grazing, and with a higher proportion dry cows out of the total cow herd.

The correlation matrix (Table 2) may highlight some variables in the study, such as production per day (PRO_DIA), that had a strong correlation with dairy cows (VAC/LAC), type of milking (TIP_ORD), cooler type (TIP_RES) and production per hectare (PROD_HA), showing correlations of 91%, 67% , 63%, and 62%, respectively. These results indicate that daily production is directly linked to the number of dairy cows and better structure in relation to equipment. Additionally, the PROD_HA has a connection with the PRO_DIA and a high correlation with DC. This result can be explained, since the amount of milk produced per hectare is determined, *inter alia*, by the number of dairy cows and daily production. As in this study, Smith et al. (2002), studying dairy production systems in Chile, identified higher production per hectare with a higher stocking rate and more productive cows.

Table 2. Correlation between the main variables transformed to the MCA.

	L/DAY	L/HA	VAC/ LAC	DUR/ LAC	IEP	TEC/ COB	NUM/ REP	TIP/ ORD	TIP/ RES
PRO/DAY	1.000								
PROD/HA	0.621	1.000							
DC/LAC	0.915	0.540	1.000						
DUR/LAC	-0.077	-0.051	-0.052	1.000					
IEP	-0.128	-0.081	-0.103	0.834	1.000				
CI/COB	0.203	0.206	0.110	-0.028	-0.058	1.000			
NUM/REP	0.229	0.229	0.134	-0.027	-0.058	0.985	1.000		
TIP/MIL	0.671	0.378	0.637	-0.088	-0.165	0.205	0.231	1.000	
TIP/COOL	0.616	0.329	0.603	-0.118	-0.184	0.205	0.088	0.502	1.000

Legend: PRO/DIA: production per day, PROD/HA: production per hectare, VAC/LAC: number of dairy cows, DUR/LAC: lactation length, IEP: calving interval, TEC/COB: technical cover, NUM/REP: number of transfers, TIP/ORD: type of milking, TIP/RES: type cooler.

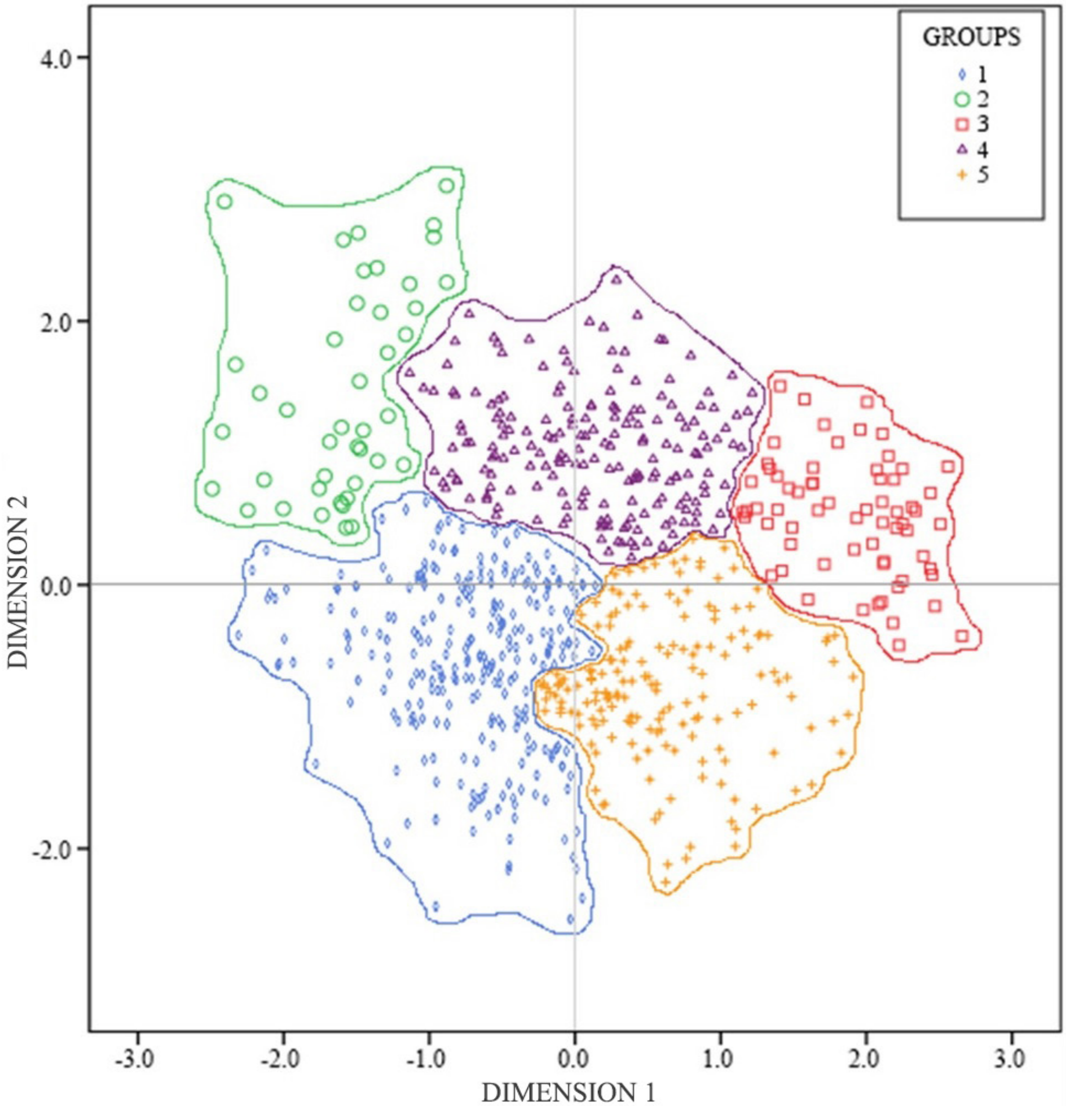
The variable duration of lactation (DUR_LAC) is also prominent when correlated with the calving interval (IEP), featuring a correlation of 83%. It is evident with these data that a longer time-to-weaning is directly linked to greater CI and consequently, lower reproductive rates. According to Ribas et al. (1997), the duration of lactation is directly related to the management criteria adopted in each property and the influence of pregnancy, lactation, and the persistence of individual milk production. Another variable that stands out is the number of repetitions (NUM_REP), which is highly correlated with the used coverage technique (TEC_COB), reaching 98%. Thus, the use of artificial insemination may be important for controlling the reproductive performance of the herd. Respondents who were producers were mostly using the technique of natural mating, but the data show that this technique had low efficiency when data regarding livestock control was considered. The profitability of livestock farming is directly linked to the indices obtained, since they all have a direct influence on production, and consequently, in producer profits. Thus, producers and technicians should be vigilant in the identification of indices that present major negative influences on activity performance so as to identify bottlenecks, therefore maximizing production and minimizing costs (LOPES et al., 2007).

Average clusters of production values can assist in the discussion of the characterization of production systems, aiming at specific advice (Table 3). Ascending hierarchical classification analysis reduced the initial data set of 735 production systems to five heterogeneous groups of systems (G1, G2, G3, G4 and G5). The quadrants obtained from the intersection of the DIM1 and DIM2 axes allow us to interpret the system groups according to characteristics linked to milk production (Figure 2). MPS of group 1 (G1) have the greatest number of producers of all the systems formed. These are characterized by being producers with an average area of about 5 hectares allocated to milk production. They have the worst reproductive rates and lowest production per day, reaching a daily average of only 82 liters of milk (Table 3). Producers own a small number of animals and have little capital raised for milk production, but this group contains a large number of producers that survive only on milk production. Group 2 (G2) differs from G1 by having even smaller areas, with an average area of about 2 hectares allocated to milk production. G2 also contains systems with low daily production, low numbers of animals in production, and less technological support for dairies. In addition, another feature differentiates the G1: the greatest number of systems exist that diversify the income-generating activities in the property, particularly the raising of swine and poultry. These data show that the development of dairy farming conditions as a result of this activity should be considered a secondary activity within the property. The modernization of agriculture has hindered the permanence of small producers in the field, generating social exclusion and unemployment, as intense competition in both domestic and global markets leads to a large majority of small producers being edged out of the industry (CÂNDIDO et al., 2010). As a result, other forms of work and production within the same property become necessary economic strategies adopted by producers, representing opportunities for the national agricultural system.

Table 3. Characteristics of dairy production systems.

Groups	Systems amount per group	Average daily production (liters/day)	Average production per hectare (liters/ha)	Average dairy cows	Average production per cow (liters/day)	Production in 305 days in milk (liters)
1	266	82	6513	8	10	3052
2	42	24	6677	3	8	2523
3	66	681	28524	34	20	6136
4	191	143	12947	11	13	4016
5	170	282	13926	19	15	4544
Mean	-	242	13717	15	13	4054
Total	735	-	-	-	-	-

Figure 2. Factorial representation of MCA and clusters of systems.



It can be seen that the positioning of group 3 (G3) is on the positive side of the axes of DIM1 and DIM2 (Figure 2). In G3, systems with the highest yield potential of all groups are highlighted. Producers are looking to maximize the production potential and reproduction of the herd. In this group, which has 66 MPS and a mean of 34 lactating cows, the average production per day per cow is 20 liters and the average total output is 681 liters per system. Also, the high average production per hectare is worth mentioning, reaching 28524 liters per year. To achieve positive results, systems need to make use of a set of sanitary practices, manage livestock and pastures, and provide a minimum set of improvements and equipment for the development of the activity (IPARDES, 2009). It is this reality, transmitted by G3 production systems, and the adoption of these technologies that is enabling the maintenance of producers in the activity and higher production rates. Group 4 (G4) and Group 5 (G5) are similar, but they have a small difference in daily production in the average production per cow per day, and the number of animals in lactation. G4 has mostly producers of dairy cattle on which their livelihoods depend. Due to groups of production systems that are similar in size to the areas of the properties, what further differentiates them from each other are the difficulties encountered in the organization of work and the control of the herd; enlarging this difference is the variation in physical structures at the properties. On farms where dairy farming is the only source of income, producers face difficulties in the return of capital generated for the activity itself. Under these conditions, the income generated on the property every month is practically all committed to family expenses, allowing only a small percentage of the revenue to be returned to dairy farming in the form of investments in technology that can contribute to increased production rates.

Conclusion

The two dimensions found amounted to 71.9% of the explained variance. With this study, we found five distinct homogeneous groups that belonged to the 735 farmers studied, those characterized by having mostly small farms and family farms. Using the correlation matrix in the present study, we concluded that the data we found were useful because there was a strong theoretical relationship that could be confirmed, such as strong correlations between production per hectare per day and the number of cows lactating, or high correlation intervals between the number of births and the duration of lactation.

It is noteworthy that the differentiation of action strategies to improve the milk quality for different groups of producers should be based on the most important variables for the construction of the first major components. This paper provides information on the characteristics of production systems with regard to the structure of the property, the squad, and how producers mobilize and act on the factors of production. The type made from these characteristics is presented as a useful tool for the provision of technical assistance and the development of strategies for the industry.

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