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ANIMAL PRODUCTION

A typology of corporate and family dairy farms in eastern Goiás, Brazil

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ABSTRACT: *This study aimed to identify a typology of corporate and family dairy farms in eastern Goiás, Brazil. A semi-structured questionnaire was administered to 170 farm operators in the municipalities of Cristalina, Luziânia, and Silvânia. Dairy farms were categorized into two groups, corporate and family farms. Data were analyzed by exploratory factor analysis using principal component analysis extraction. Four factors were identified: Milking management (F1), Production scale (F2), Productivity (F3), and Sociodemographic characteristics (F4). Corporate and family farms were then compared in terms of factor scores. Corporate farms scored higher on F1 and F2 and were characterized by larger production scale, greater adoption of milking management and hygiene practices; and consequently, greater alignment with institutional and market demands. These results indicated that corporate dairy farms in eastern Goiás have higher sustainability and are more likely to remain in business than family dairy farms.*
Key words: *factor analysis, scale of production, social factor, milking management, productivity.*

Tipologia de sistemas produtivos leiteiros familiares e patronais na região leste de Goiás

RESUMO: *Buscou-se analisar a tipologia de sistemas produtivos leiteiros familiares e patronais, localizados na região leste do estado de Goiás. Foram aplicados formulários semiestruturados em 170 sistemas produtivos leiteiros nas cidades de Cristalina, Luziânia e Silvânia. Os sistemas leiteiros foram segregados em dois grupos G1: produtores familiares e G2 produtores patronais. Para as demais variáveis foi aplicada a técnica de Análise Fatorial Exploratória - AFE com método de extração de Componentes Principais – ACP. Quatro Fatores foram obtidos: F1- manejo de ordenha, F2 - escala de produção, F3 - produtividade e, F4 - social. Os grupos G1 e G2 foram comparados frente aos Fatores. Produtores de leite patronais (G2) apresentaram maiores resultados para F1 e F2 quando comparados com produtores de leite familiares (G1). Desta forma, entre os sistemas produtivos leiteiros analisados, aqueles classificados como patronais (G2) apresentaram maior escala de produção de leite, maior frequência na adoção práticas de manejo e higiene de ordenha e portanto, estão mais adequados as demandas institucionais e de mercado atuais.*
Palavras-chave: *análise fatorial, escala de produção, fator social, manejo de ordenha, produtividade.*

INTRODUCTION

Brazil is the third-largest milk producer in the world, with 33.8 billion liters of milk produced in 2018 (FAO, 2018). Although, milk is produced in all Brazilian states, the activity is concentrated in Minas Gerais, Rio Grande do Sul, Paraná, and Goiás (IBGE, 2017a). Family farms are the predominant form of dairy production systems, accounting for 60% of the national milk production (SEAD, 2018c). In general, family farms are small scale, and most of their production is used for self-consumption (BÁNKUTI et al., 2018; MEDINA et al., 2015; BUAINAIN et al., 2007). Because of these characteristics, family dairy farms seem to be less competitive and,;consequently, more economically vulnerable than corporate farms (BÁNKUTI et al., 2018). This assumption becomes even more evident when considering the institutional and market changes that occurred in the 1990s in the Brazilian agroindustrial system, including

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market deregulation, trade opening, and reduction of import tariffs for milk and milk derivatives (BONDENMÜLLER FILHO et al., 2010; MARION FILHO & REICHERT, 2014).

A few years later, the Brazilian government established new standards for milk quality and transport through Normative Instructions nos. 51, 62, 31, 76, and 77 (MAPA, 2002, 2011, 2018a, 2018b, 2018c). To thrive in this new institutional and market environment, milk producers were compelled to acquire new production technologies and improve farm management (BUAINAIN et al., 2013). These changes led to an increase in productivity and milk quality for some farmers (BÁNKUTI, 2008). For many others; however, such changes resulted in activity abandonment or decreased competitiveness. As a consequence, dairy production systems in Brazil have become even more heterogeneous (BUAINAIN et al., 2013).

The high heterogeneity of Brazilian dairy production systems hinders the development of general public or private interventions. Typological studies arise as important tools to provide information for decision- and policy-makers (ANDERSEN et al., 2006; CHIKOWO et al., 2014; BONDENMÜLLER FILHO et al., 2010). This study aimed to determine the typology of family and corporate dairy farms in eastern Goiás, Brazil. Information on technical, productive, and socioeconomic characteristics of dairy farms can guide public and private interventions aimed to improve the competitiveness of dairy production systems.

MATERIALS AND METHODS

This typological investigation was conducted in the municipalities of Luziânia, Cristalina, and Silvânia, located in the eastern region of Goiás State, Brazil. In the last 10 years, milk production increased by 11.75% in Goiás and by 7.37, 8.73, and 29.91% in Luziânia, Cristalina, and Silvânia, respectively (IBGE, 2017b). During this period, Goiânia and Brasília, two capital cities located close to the study region, experienced a population growth of 12.56 and 14.23%, respectively (IBGE, 2018). These data suggested that market demands for milk and dairy products have increased in the studied municipalities.

Data were collected in January 2018 through a semi-structured questionnaire administered in person to 170 farm operators (Table 2). The analyzed farms represent 4.25% of the total number of dairy farms in Goiás (IBGE, 2017a). Rural producers were selected from contact lists provided by local dairy industries, farmers' cooperatives, and technical assistance agencies. All contacted farmers who agreed to participate were included in the study.

The questionnaire gathered information on structural, technological, and production parameters as well as on the level of institutional adequacy of dairy farms (BRITO et al., 2015a, 2015b; LANGE et al., 2016; ZIMPEL et al., 2017a). Sociodemographic characteristics of farm operators were also analyzed (Table 1). The questionnaire was approved by the Human Research Ethics Committee (COPEP, protocol no. 2,396,173) of the State University of Maringá, Paraná, Brazil.

Descriptive statistics (minimum, maximum, mean, standard deviation, and frequency) were used for general characterization of the sample. Then, dairy farms were divided into two groups (corporate and family farms) based on criteria established by Law no. 11,326 (BRASIL, 2006). The factors that best described corporate and family dairy farms were determined using exploratory factor analysis (EFA) (BÁNKUTI et al., 2014; NEUMANN et al., 2016; YABE et al., 2015). The EFA is a multivariate statistical technique of interdependence that condenses a set of correlated variables into a smaller number of factors. Factors are composed of variables with high internal correlation and low correlation with variables from other factors. This variable reduction technique can be used to create indicators for decision-making (FÁVERO et al., 2009a). Several authors have used EFA to generate indicators for dairy production systems (BRITO et al., 2015a, 2015b; LANGE et al., 2016; NEUMANN et al., 2016; ZYMPEL et al., 2016).

Initially, 35 variables were selected for EFA. However, 19 of these variables failed to satisfy Bartlett's and Kaiser–Meyer–Olkin (KMO) criteria (FÁVERO et al., 2009). Thus, only 16 variables were used in EFA (Table 1). Retained variables were either ordinal categorical or numerical. Ordinal variables are qualitative but, as they can be ranked into a preferential order, are suitable for this type of analysis (FÁVERO et al., 2009).

Factors were extracted by principal component analysis using varimax rotation, Kaiser normalization, and Bartlett's test (BARROSO & ARTES, 2003; FÁVERO et al., 2009). Variables with factor loadings lower than |0.5| were discarded (HAIR et al., 2009). The number of retained factors was defined based on the Kaiser criterion (eigenvalues greater than 1.0) (FÁVERO et al., 2009; HAIR et al., 2009).

Table 1 - Description of variables analyzed in the study.

	Variable	Questionnaire item	Type	Statistical analysis
V1	Teat cleaning before milking	Do you clean the cow's teats before attaching the milking cups?	Ordinal	EFA
V2	Pre-dipping	Do you perform pre-milking teat disinfection (pre-dipping)?	Ordinal	EFA
V3	Post-dipping	Do you perform post-milking teat disinfection (post-dipping)?	Ordinal	EFA
V4	Use of warm water for teat cleaning	Do you wash the cow's teats with warm water?	Ordinal	EFA
V5	Milking equipment hygiene	Do you clean the milking equipment after use?	Ordinal	EFA
V6	Frequent mastitis testing	Do you frequently test cows for mastitis?	Ordinal	EFA
V7	Type of milking system	What type of milking system do you use?	Ordinal	EFA
V8	Number of dairy cows	How many dairy cows do you have?	Numerical	EFA and descriptive analysis
V9	Number of cows in milk	How many cows in milk are there on the farm?	Numerical	EFA and descriptive analysis
V10	Daily milk production (L day^{-1})	How many liters of milk do you produce per day?	Numerical	EFA and descriptive analysis
V11	Farm size (ha)	How many hectares comprise your farm?	Numerical	EFA and descriptive analysis
V12	Milk production area (ha)	How many hectares do you use for milk production?	Numerical	EFA and descriptive analysis
V13	Milk production per area (L ha^{-1})	Calculated.	Numerical	EFA and descriptive analysis
V14	Milk production per cow (L cow^{-1} day^{-1})	Calculated.	Numerical	EFA and descriptive analysis
V15	Number of workers	How many people work on the farm?	Numerical	EFA and descriptive analysis
V16	Age of farm operator	How old are you?	Numerical	EFA and descriptive analysis
V17	Level of education of farm operator	How many years of formal education have you had?	Numerical	EFA and descriptive analysis
V18	Dairy farming experience	How long have you worked in the dairy business?	Numerical	EFA and descriptive analysis

EFA, exploratory factor analysis.

The EFA generates factor scores, which indicated the contribution of each dairy farm to the generated factors. The factor score is determined by multiplying factor coefficients by the original values of variables (FÁVERO et al., 2009). Scores were used as regression variables; in this procedure, factor loadings are adjusted from the initial correlations between variables, eliminating differences between units of measurement and normalizing variances. Factor scores of corporate and family dairy farms were compared using mean tests (FIELD, 2009). Data were tested for normality of distribution by the Kolmogorov–Smirnov and Shapiro–Wilk tests and for homogeneity of variance by Levene's test. As the data were found to be non-normally distributed, the nonparametric Mann–Whitney *U*-test was used for comparison of means ($P<0.05$) (FIELD, 2009).

RESULTS AND DISCUSSION

Dairy farms had an average size of 70.81 ± 128.49 ha, of which 32.88 ± 59.22 ha were used for milk production. Farms produced 263.89 ± 429.06 L day^{-1} and had 71.83 ± 74.85 cows, 31% of which

were lactating cows. The mean milk production per cow was 10.23 ± 4.58 L cow^{-1} day^{-1} (Table 2).

Farm operators had 45 ± 15.22 years of age, 17 ± 13.05 years of experience in dairy farming, and 6.71 ± 4.37 years of formal education. The average number of farm workers was 1.82 ± 1.39 (Table 2).

Of the 170 farms analyzed in this study, 48 (28.23%) were corporate farms and 122 (71.77%) were family farms, as classified according to criteria established by Law no. 11,326 (BRASIL, 2006). In the state of Goiás, more than 70% of food production systems are family run (IBGE, 2006).

Corporate and family farms did not differ (P<0.05) in farm operator's age, level of education, or years of experience, indicating that farm operators of both groups had similar sociodemographic characteristics. Both types of farms had a similar number of farm workers (Table 3).

There were significant differences (P<0.05) in farm size and milk production area between corporate and family farms (Table 3). Farm size is associated with the farm's capacity to produce feed and animals, influencing its dependency on external suppliers (FILHO et al., 2010; ZIMPEL et al., 2017b).

Daily milk production, number of cows and cows in milk, and milk production per cow differed (P<0.05) between corporate and family farms. These parameters were higher in corporate farms (Table 3). Corporate farms produced 50.17% more milk per day than family farms. This high productivity was likely influenced by the high number of cows in milk (35.73 versus 17.10 in family farms). The recommendation is to have 83% of cows in milk for increased profits (EMBRAPA, 2007). Other factors, such as nutritional management, adoption of technologies, and investment in facilities, can also influence cow productivity and farm production scale.

EFA extracted 4 factors from the 16 structural, productive, and socioeconomic variables. Together, the factors explained 76.46% of the variance in the dataset (Table 4), meeting the criteria for EFA (FÁVERO et al., 2009a; HAIR et al., 2009). Bartlett's test was significant (0.00) and the KMO value was 0.819, indicating that the dataset was suitable for EFA (FÁVERO et al., 2009).

The first factor (F1) was denominated Milking management (Table 5). Milking management practices are strongly associated with milk quality (SURANINDYAH et al., 2015; de SILVA et al., 2016) and the price of milk in transactions with the dairy industry (BOZO et al., 2013).

The second factor (F2) was termed Production scale, because it was formed by the variables number of dairy cows, number of cows in milk, daily milk production, and farm size (Table 5). Farm area is an important variable, as it influences production scale and income, (ANDERSEN et al., 2006) and indicates the capacity to produce and stock feed as well as to expand facilities (MARCONDES et al., 2017; DEFANTE et al., 2019). On-farm feed production implies a lower dependency on external feed suppliers (BONDENMÜLLER FILHO & BÁNKUTI, 2016). Daily milk production, number of lactating cows, and type of milking and cooling system are frequently investigated in typological studies of dairy farms, which have shown than daily milk production is positively correlated with number

Table 2 - Descriptive statistics of dairy farms in eastern Goiás, Brazil.

Variable	n	Min	Max	Mean	SD
Age of farm operator (years)	170	14	86	45.76	15.22
Level of education of farm operator (years)	170	0	21	6.71	4.38
Dairy farming experience (years)	170	1	60	17.27	13.05
Farm size (ha)	170	2	1003	70.81	128.49
Milk production area (ha)	170	1.5	500	32.88	59.22
Number of workers	170	1	15	1.83	1.39
Daily milk production (L day^{-1})	170	25	4200	263.98	429.06
Number of cows in milk	170	3	210	22.36	21.44
Number of dairy cows	170	6	550	71.83	74.85
Milk production per cow (L cow^{-1} day^{-1})	170	3.33	30	10.23	4.58
Milk production per area (L ha^{-1})	170	0.7	84	13.03	13.45

SD, standard deviation.

Table 3 - Comparison of corporate and family dairy farms in eastern Goiás, Brazil.

Variable	Farm type	n	Mean	SD
Age of farm operator (years)	Corporate	48	45.29[a]	16.35
	Family-run	122	45.94[a]	14.83
Level of education of farm operator (years)	Corporate	48	7.33[a]	4.94
	Family-run	122	6.46[a]	4.13
Dairy farming experience (years)	Corporate	48	17.69[a]	14.91
	Family-run	122	17.11[a]	12.31
Farm size (ha)	Corporate	48	164.75[a]	211.88
	Family-run	122	33.85[b]	27.32
Milk production area (ha)	Corporate	48	63.81[a]	102.86
	Family-run	122	20.71[b]	16.17
Number of workers	Corporate	48	1.85[a]	0.90
	Family-run	122	1.82[a]	1.55
Daily milk production (L day^{-1})	Corporate	48	505.63[a]	691.88
	Family-run	122	168.92[b]	197.27
Number of cows in milk	Corporate	48	35.75[a]	32.69
	Family-run	122	17.10[b]	11.31
Number of dairy cows	Corporate	48	117.50[a]	105.20
	Family-run	122	53.87[b]	48.73
Milk production per cow (L cow^{-1} day^{-1})	Corporate	48	12.04[a]	5.48
	Family-run	122	9.52[b]	3.98
Milk production per area (L ha^{-1})	Corporate	48	15.05[a]	14.29
	Family-run	122	12.24[a]	13.09

[a,b]Within variables, means followed by different letters differ significantly by the Mann–Whitney *U*-test (P<0.05).

of lactating cows and technological sophistication in milking and cooling (CHIKOWO et al., 2014; CORTEZ-ARRIOLA et al., 2015; DEFANTE et al., 2019; CASALI et al., 2020).

The third factor (F3), termed Productivity, was composed of the variables milk production per cow and per area (Table 5). Dairy farms with high productivity generally seek to optimize their production by adopting novel technologies and efficient production strategies, thereby obtaining greater financial returns (NEUMANN et al., 2016; VOGES et al., 2015; ZIMPEL et al., 2017).

The fourth factor (F4) was named Sociodemographic characteristics and comprised the variables age, level of education, and dairy farming experience of the farm operator (Table 5). Farm operator's age is associated with the adoption of new technologies and work techniques as well as the effort directed toward certain management factors (BYRNE et al., 2015; ASANTE et al., 2011). In general, older farm managers are resistant to technological and productive changes for fear of losing decision-making authority and capacity. Another factor that contributes to the resistance of older farm operators is

Table 4 - Total variance explained.

Factor	----------Initial eigenvalues----------		
	Total	% of Variance	Cumulative %
1	6.84	42.80	42.80
2	2.45	15.31	58.12
3	1.67	10.45	68.57
4	1.26	7.88	76.46

Table 5 - Factor loadings from exploratory factor analysis of sociodemographic, structural, and production characteristics of dairy farms in eastern Goiás, Brazil.

Variable	----------Factor loading----------			
	F1	F2	F3	F4
Teat cleaning before milking	0.928	0.088	0.124	0.068
Pre-dipping	0.895	0.154	0.095	0.068
Post-dipping	0.914	0.167	0.104	0.059
Use of warm water for teat cleaning	0.887	0.183	0.115	0.035
Milking equipment hygiene	0.834	0.078	0.124	0.172
Frequent mastitis testing	0.792	0.069	0.094	0.112
Type of milking system	0.674	0.449	0.266	−0.005
Number of dairy cows	0.149	0.878	0.141	0.009
Number of cows in milk	0.223	0.865	0.232	0.053
Daily milk production (L day^{-1})	0.231	0.818	0.413	0.034
Milk production area (ha)	0.089	0.806	−0.346	−0.024
Milk production per area (L ha^{-1})	0.157	0.043	0.883	0.129
Milk production per cow (L cow^{-1} day^{-1})	0.338	0.301	0.680	0.036
Age of farm operator	−0.062	−0.048	−0.147	−0.849
Level of education of farm operator	0.091	0.215	−0.073	0.744
Dairy farming experience	−0.116	0.223	−0.087	−0.636

F1, Milking management; F2, Production scale; F3, Productivity; F4, Sociodemographic characteristics.

the fear of retiring and losing the professional identity and respect earned throughout their lives (CONWAY et al., 2017; MARTÍNEZ-GARCÍA et al., 2013).

Young farm operators are more likely to adopt novel nutritional, management, and milking hygiene techniques because they believe the techniques produce positive results. In addition, such actions are performed more efficiently by younger farmers than by older farmers. Adoption of more efficient strategies generates positive and profitable results, enhancing production, hygiene, and management practices (ECKSTEIN et al., 2016; ZYMPEL et al., 2017).

Dairy farming experience and education level are other important factors influencing decision-making in dairy production systems (BUAINAIN et al., 2007; ECKSTEIN et al., 2016; ZIMPEL et al., 2016). Short time in the activity can affect the decisions and actions taken by the farm operator; however, more experienced farmers are more resistant to changes (CONWAY et al., 2017). Level of education is associated with workforce qualification and interpretation and understanding of production techniques. Education has a positive correlation with variables that determine dairy farming success, including income (MEDINA et al., 2015). Thus, more educated farm operators tend to adopt milking hygiene practices, as they understand that hygiene influences milk quality and, consequently, financial returns (ECKSTEIN et al., 2016; LANGE et al., 2016).

Corporate and family farms differed (P<0.05) in F1 and F2 scores (Table 6). Corporate farms had a higher factor score (0.465) on F1 than family farms (−0.183) (P<0.05) (Table 6), indicating that the former carried out milking management practices more frequently. Milking management practices include mastitis testing (e.g., strip cup test), teat disinfection, and equipment sanitation. By adopting these practices, corporate farms tend to produce higher-quality milk and, consequently, may obtain higher net returns per liter of milk. In addition, milking management practices can reduce the costs of disease treatment (ECKSTEIN et al., 2014, 2016).

The factor score on F2 was higher (P<0.05) for corporate farms (0.590) than for family farms (−0.232) (Table 6). Family farms are in general small scale and have low product diversification, with higher dedication to the dairy activity (LANGE et al., 2016). Corporate farms are larger, allowing them to meet the market requirements for high volumes of milk. A low milk production area implies reduced animal capacity and inability to produce feed. Such characteristics, added to a low income, means that

Table 6 - Comparison of factor scores of corporate and family dairy farms in eastern Goiás, Brazil.

Factor	Farm type	n	Mean	Standard deviation
Milking management	Corporate	48	0.465[a]	0.983
	Family-run	122	−0.183[b]	0.950
Production scale	Corporate	48	0.590[a]	1.592
	Family-run	122	−0.232[b]	0.469
Productivity	Corporate	48	0.067[a]	1.280
	Family-run	122	−0.026[a]	0.871
Sociodemographic characteristics	Corporate	48	−0.010[a]	1.085
	Family-run	122	0.004[a]	0.969

[a,b]Within factors, means followed by different letters differ significantly by the Mann–Whitney *U*-test ($P<0.05$).

farm operators are not able to purchase other inputs for milk production (QUDDUS, 2012). The financial resources of family farms are usually directed toward family expenses, with little investment in animals, farm size, inputs, and new equipment, influencing production scale (NEUMANN et al., 2016).

The differences in milking management and production scale between corporate and family farms might have been associated with the farm operator's decision-making. According to MARTÍNEZ-GARCÍA et al. (2013), decision-making is generally influenced by three main factors: lack of financial resources, resistance to the adoption of novel techniques, and third-party information. Farm size also affects decision-making, as it must be considered when determining the technological level adopted. Corporate farms are capable of investing in high-level technologies and can easily adapt to current institutional and market norms, contributing to profitability and reducing susceptibility (BÁNKUTI & CALDAS, 2018). These characteristics explain why corporate farms had better results than family farms in the present study.

Dairy farms did not differ in F3 score (G1, −0.026, and G2, 0.067; P>0.05) (Table 6). Thus; although, differences were reported between groups in production scale, the use of internal resources (animals and production area) was similar between corporate and family farms. In other words, regardless of the farm's capacity to produce animal feed, the mean milk production per cow was similar between groups. Family farmers' access to credit has boosted investment in feed and infrastructure. The small farm size (and consequently low feed production capacity) is compensated by supplementation with concentrate and silage. Investments in infrastructure, feed, and technologies can increase the productivity of family farms (CORTEZ-ARRIOLA et al., 2015; SOUZA & BUAINAIN, 2013).

No differences in F4 scores were reported between family (0.010) and corporate (0.004) farms ($P<0.05$, Table 6). In previous studies, the sociodemographic characteristics of farm operators did not influence the adoption of management tools or participation in farmers' cooperatives (BRITO et al., 2015b; SCHEBELESKI & BÁNKUTI, 2016; ZIMPEL et al., 2016). Thus, other aspects must be considered to explain the differences between corporate and family farms.

Overall, our findings showed that family farms are smaller scale and adopt milking and hygiene practices less frequently than corporate farms. As a result, family farms have difficulty meeting market and institutional requirements for production volume and milk quality, which decreases their competitiveness compared to corporate farms.

CONCLUSION

This typological study showed that corporate dairy farms differ from family-run enterprises mainly in their greater adoption of production technologies, access to information, feed production capacity, and production area. These characteristics indicated that corporate dairy farms are better equipped to meet institutional and market demands for bulk milk, which implies reduced vulnerability and greater chances to stay in business in the medium and long term.

Public and private strategies are necessary to facilitate the adaptation of family dairy farms to the current institutional and market environment, particularly

in terms of production scale. Increased participation in collective arrangements, such as efficiently managed dairy cooperatives, may help decrease the vulnerability of the analyzed family farms.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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