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Productive characteristics in dairy buffalo (*Bubalus bubalis*) in the Eastern Amazon

[Características produtivas em búfalos leiteiros (*Bubalus bubalis*) na Amazônia]

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ABSTRACT

The objective of this study was to determine factors affecting phenotypic characteristics related to milk production and reproductive efficiency of dairy buffalo. Phenotypic records of 2,459 Murrah, Mediterranean and crossbred buffaloes from the Embrapa Eastern Amazônia herd, from 1969 to 2013 were used. Traits included: total milk production during lactation (TMP), milk production corrected for 305 days (P305); cow weight at calving (CW), fat milk percentage (F), age at first calving (AFC), calving interval (CI), calf birth weight (BW), as well as lactation (LP) and service periods (SP). Most traits were affected by genetic group as well as year and season or interaction between them. Genetic group affected F, CI, SP and CW. Very young and older cows showed poorer production traits. There was interaction between season and year for F, CI and CW. Correlations traits were generally medium to low. The principal component analysis showed that higher fat milk percentage was associated with higher percentage of Murrah breed, longer lactation period and older cows. Phenotypic characteristics in buffaloes reared in the Brazilian Amazon were significantly affected by genetic and management factors. This information can be used to help build sustainable production systems for the region and guide farmer decisions.

Keywords: breeding efficiency, Mediterranean, milk production, Murrah, genetic group

RESUMO

O objetivo deste estudo foi determinar os fatores que afetam as características fenotípicas relacionadas à produção de leite e a eficiência reprodutiva de búfalas leiteiras. Foram utilizados os registros fenotípicos de 2.459 búfalas das raças Murrah, Mediterrâneo e seus cruzamentos do rebanho da Embrapa Amazônia Oriental, de 1969 a 2013. As características incluídas foram: produção total de leite durante a lactação (PTL), produção de leite corrigida para 305 dias (P305), peso da búfala ao parto (PV), percentual de gordura do leite (G), idade ao primeiro parto (IPP), intervalo entre partos (IP), peso do bezerro ao nascimento (PN), assim como os períodos de lactação (PL) e de serviço (PS). A maioria das características foi afetada pelo grupo genético, bem como pelo ano e pela estação ou pela interação entre eles. O grupo genético afetou o G, IP, PS e PV. Búfalas muito jovens e mais velhas mostraram características de produção mais baixas. Houve interação entre estação e o ano para G, IP e PV. As correlações entre as características foram geralmente de médias a baixas. A análise de componentes principais mostrou que a maior porcentagem de gordura no leite foi associada com a maior porcentagem de sangue Murrah, com o maior período de lactação e com búfalas mais velhas. As características fenotípicas das búfalas criadas na Amazônia brasileira foram significativamente afetadas por fatores genéticos e de manejo. Essas

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informações podem ser usadas para ajudar a construir sistemas de produção sustentáveis para a região e orientar as decisões dos produtores.

Palavras-chave: eficiência reprodutiva, grupo genético, Mediterrâneo, Murrah, produção de leite ,

INTRODUCTION

Buffalo farming in Brazil is seen as a cost effective alternative, since the species easily adapt to diverse environments. The production and consumption of buffalo milk has been growing due to the demand for derivatives such as cheese and butter. The high levels of fat and total solids in buffalo milk increase the yield in the manufacture of derivatives in relation to bovine milk (Rosales and Batalha, 2017).

In Brazil, buffaloes generally produce between 1,500 and 4,500 liters of milk per lactation, and have a higher productive life than the dairy cows and can live for more than 20 years. However, there are factors limiting the commercial production of buffalo milk including late age at first calving, reproductive seasonality, prolonged calving interval and the long dry period (Tonhati et al., 2000b; Ramos et al., 2006; Malhado et al., 2007; Tonhati et al., 2008; Baldi et al., 2011). In the Amazon, the buffalo is predominantly reared in extensive ecosystems on native pastures, especially on the island of Marajó, and in a few cases, on cultivated pastures where the Murrah and Mediterrâneo breeds tend to be more expressive, and, along with smaller numbers, Carabao and Jafarabadi breeds.

Although studies have been carried out in Brazil on the productive and reproductive traits of buffaloes (Tonhati et al., 2000b; Cassiano et al., 2003), there is still lack of information on this species in a wide range of ecosystems where they are reared in Brazil. The objective of this study was to determine factors affecting phenotypic characteristics related to milk production and reproductive efficiency of dairy buffaloes from Embrapa Eastern Amazon to support genetic management strategies.

MATERIAL AND METHODS

Birth records of 2,459 Murrah, Mediterranean, and crossbred animals from the Embrapa Eastern Amazon herd were used, in the period between 1969 to 2013, including information on the total

milk production during lactation (TMP), cow weight at calving (CW), fat milk percentage (F), age at first calving (AFC), calving interval (CI), calf birth weight (BW), as well as lactation (LP) and service periods (SP). Cumulative production up to 305 days (P305) was calculated based on the lactation period (LP) and TMP according to the following formula $P305 = (TMP / LP) \times 305$.

The herd was kept in an experimental station of Embrapa Eastern Amazon, located in the metropolitan area of the Belém city in Pará State, at 01° 27' 21" S and 48° 30' 16" W, with an altitude of 10m. The animals were raised in semi-intensive, *in situ* conservation system. This location has a rainy tropical climate, with a short dry season, according to the Koppen classification. The annual mean temperature was 27.2°C, ranging from 21.8 to 32.4°C. The relative humidity showed an annual mean of 88% and the mean annual rainfall was around 2,537mm.

The total annual insolation was 2,300 hours. The soils of the region belong to the moist yellow latosols. The main diet of the animals consisted of *Brachiaria* and *Panicum* pasture. Data included animals with AFC ranging between 549 days (18 months) and 1,830 days (60 months), animals with CI ranging between 365 days (12 months) and 450 days (14 months), and animals with TMP greater than 610kg. Six genetic group of cows and calves with genealogical record (Mediterranean (0), Murrah (1) and 0.0625, 0.125, 0.25 and 0.5% of Murrah breeds) were considered. Two calving periods were considered, with the rainy period from January to June and a dry (or less rainy) season from July to December.

Statistical analysis included analysis of variance (PROC GLM), Pearson correlations (CORR) and factor analysis (FACTOR) using the SAS package (Statistical Analysis System, v. 9.3, Cary, North Carolina). Independent variables included sex of the offspring, genetic group of cows and calves, season, year and order of birth, as well as the interaction between them. The weight of the buffalo cow at birth was used as a covariate.

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RESULTS

Genetic group (Table 1) affected fat milk percentage (F), calving interval (CI), service period (SP) and cow weight at calving (CW), with higher percentage in the Murrah breed leading to higher fat milk percentage, shorter SP and

therefore CI, as well as lighter cows (Table 2). Cows calving in the rainy season tended to produce more milk (P305) (Table 1). The variation due to year (Table 1), as seen for AFC, BW, LP, TMP and P305 was expected, while an interaction between year and season was seen for F, CI and CW (Figure 1).

Table 1. Summary for variance analysis of production traits in dairy buffaloes reared in the Brazilian Amazon

	AFC (days)	BW (kg)	LP (days)	TMP (kg)	F (%)	CI (days)	SP (days)	P305 (kg)	CW (kg)
R ²	0.09	0.16	0.14	0.33	0.31	0.23	0.23	0.42	0.45
CV	18.24	7.75	20.92	20.93	10.83	26.18	25.60	15.76	10.47
Mean	1234.13	35.85	262.11	1806.76	6.96	483.99	90.86	1896.26	556.56
GG	ns	ns	ns	ns	**	*	*	ns	**
Order	-	ns	ns	*	ns	**	*	ns	*
Cow weight	ns	**	ns	**	ns	**	ns	**	-
Sex	ns	**	ns	ns	ns	ns	**	ns	*
GG-Calf	-	ns	ns	ns	ns	ns	ns	ns	ns
Season	*	ns	ns	ns	ns	ns	ns	*	*
Year	**	**	**	**	**	**	ns	**	**
Season*year	ns	ns	ns	ns	**	*	ns	ns	**

R²: coefficient of determination, CV: coefficient of variation, GG: genetic group; P*Y: interaction between period and year, AFC: age at first calving, BW: calf birth weight, LP: lactation period, TMP: total milk production during lactation, F: fat milk percentage, CI: calving interval, SP: service period, P305: milk production corrected for 305 days, CW: cow weight at calving, ns: not significant, *: P<0.05, **:P<0.001.

Table 2. Main environmental effects of production traits in dairy buffaloes reared in the Brazilian Amazon

Genetic Group	AFC (days)	BW(kg)	LP(days)	TMP(kg)	F(%)	CI(days)	SP(days)	P305 (kg)	CW(kg)
0	1238.78	36.44	269.25	1958.28	6.50 ^c	543.98 ^a	103.81 ^a	2098.05	565.89 ^a
0.0625	1273.23	36.18	264.78	2051.64	5.53 ^d	487.38 ^{bc}	93.03 ^{ab}	2046.74	563.04 ^{ab}
0.125	1234.67	35.85	248.43	1711.25	6.97 ^{bc}	459.17 ^{cd}	90.16 ^b	1954.96	558.57 ^{ab}
0.25	1226.90	35.56	260.34	1766.17	6.81 ^{bc}	450.35 ^d	85.54 ^b	1954.76	552.86 ^b
0.5	1173.00	37.00	271.49	1385.36	7.03 ^{ab}	460.19 ^{cd}	91.40 ^b	1947.22	515.18 ^c
1	1197.31	35.55	285.95	1740.52	7.52 ^a	512.09 ^{ab}	95.63 ^b	1754.47	550.90 ^b
Order									
1		35.59	274.01	1671.78 ^b	6.87	471.80 ^b	95.64 ^a	1747.61	505.25 ^d
2		35.99	262.44	1819.02 ^a	6.89	540.33 ^a	97.85 ^a	1961.84	559.51 ^c
3		35.79	251.50	1834.22 ^a	6.93	459.26 ^b	91.39 ^{ab}	2016.27	584.97 ^b
4		36.16	247.09	1736.34 ^{ab}	7.01	449.49 ^b	91.31 ^{ab}	1938.90	580.31 ^b
5		36.29	269.00	1795.64 ^{ab}	7.26	448.48 ^b	83.06 ^b	1895.37	595.86 ^a
6+		35.74	257.32	1699.69 ^{ab}	7.14	452.61 ^b	83.36 ^b	1870.27	602.65 ^a
Sex									
F	1232.84	35.56 ^b	265.54	1798.76	6.99	489.07	94.45 ^a	1893.72	562.25 ^a
M	1254.43	36.13 ^a	259.78	1790.80	6.94	484.33	89.04 ^b	1883.35	556.08 ^b
Season									
Dry	1255.01	35.88	264.98	1802.62	7.03	518.13	97.29	1873.86 ^b	557.74
Rainy	1239.87	35.83	261.39	1789.51	6.94	472.65	87.74	1948.8920 ^a	559.72
Year ¹									
1970	1236.90 ^{abcdef}	33.76 ^{cdef}	293.75 ^{abc}	1728.10 ^{bcdefg}	7.50	-	-	1781.90 ^{ab}	503.58
1975	1194.29 ^{bcdef}	34.45 ^{cdef}	310.13 ^{abc}	1872.74 ^{cdefg}	6.57	478.44	93.86	1866.35 ^{ab}	505.76
1980	1252.65 ^{bcdef}	34.83 ^{abcdef}	282.94 ^{bc}	1548.19 ^{cdefg}	7.21	477.25	89.43	1812.91 ^{ab}	504.22
1985	1195.06 ^{abcdef}	34.99 ^{abcdef}	243.81 ^{bc}	1811.90 ^{abcd}	6.71	436.17	86.97	2059.24 ^a	533.03
1990	1156.07 ^{cdef}	36.20 ^{abcdef}	-	-	-	442.33	89.85	-	574.21
1995	1277.41 ^{abcdef}	37.19 ^{abc}	-	-	-	532.94	95.75	-	579.69
2000	1299.86 ^{abcdef}	37.18 ^{abcdef}	-	-	-	479.12	91.95	-	597.99
2005	1193.81 ^{def}	36.36 ^{abcdef}	-	2214.66 ^a	-	606.29	97.64	-	580.85
2010	1305.14 ^{abcdef}	36.24 ^{abcdef}	-	1854.64 ^{cdefg}	-	551.32	109.39	-	588.03
2013	1205.53 ^{bcdef}	35.22 ^{abcdef}	-	1498.13 ^{fg}	-	651.69	75.00	-	550.18

AFC: age at first calving, BW: calf birth weight, LP: lactation period, TMP: total milk production during lactation, F: fat milk percentage, CI: calving interval, SP: service period, P305: milk production corrected for 305 days, CW: cow weight at calving,¹data presented every five years. Different letters in the column differ statistically (P<0.05) by Tukey's test.

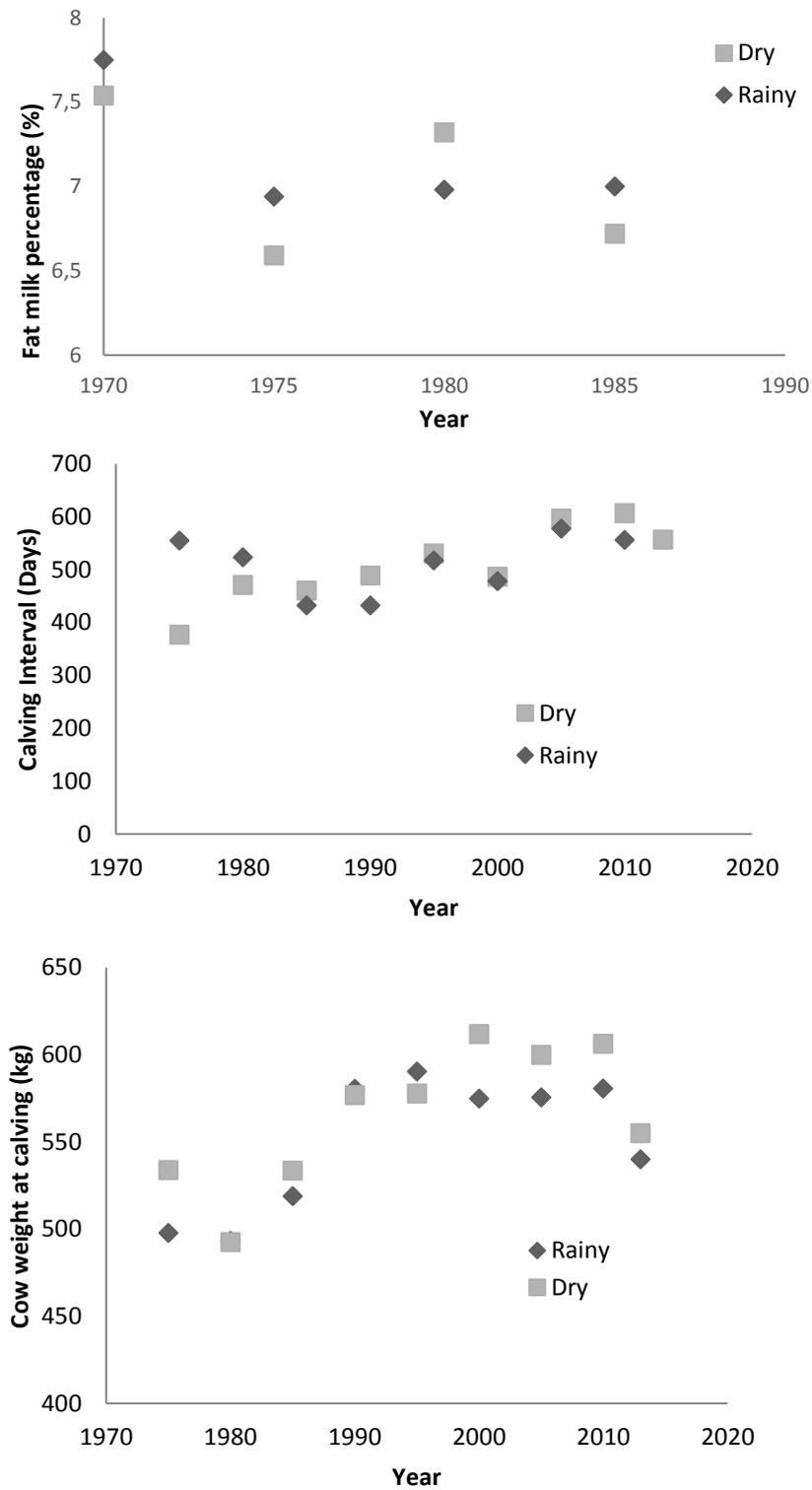


Figure 1. Interaction effect between year and season for fat milk percentage (A), calving interval (B) and cow weight at calving (C) in dairy buffaloes reared in the Brazilian Amazon.

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The correlations between traits were in general medium to low (Table 3), with higher fat milk percentage associated with higher percentage of Murrah breed, longer lactation period and older cows, explaining 24.96% of the total variation

(Figure 2). Also, calf birth weight was positively related with the cow weight at calving. Total milk production was positively related with lactation period and cow weight at calving.

Table 3. Correlations between production traits in dairy buffaloes reared in the Brazilian Amazon

	BW (kg)	LP (days)	TMP (kg)	F (%)	CI (days)	SP (days)	P305 (kg)	CW (kg)	% Murrah	O
LP	-0.06									
TMP	0.07	0.59**								
F	0.01	0.27*	-0.04							
CI	0.06	0.14	0.16	-0.02						
SP	-0.04	0.14	0.05	-0.02	0.45**					
P305	0.10	-	0.58**	-0.26*	-0.05	-0.05				
CW	0.29*	-	0.31*	0.00	0.15	0.01	0.44**			
% Murrah	-0.08	0.23*	-0.12	0.42**	0.06	0.04	-0.27*	-0.08		
O	0.02	-0.08	0.00	-0.01	-0.16	-0.11	0.13	0.36**	0.05	
AFC	0.03	-0.07	0.05	-0.02	0.03	-0.04	0.13	0.45**	0.13	0.92**

BW: calf birth weight, LP: lactation period, TMP: total milk production during lactation, F: fat milk percentage, CI: calving interval, SP: service period, P305: milk production corrected for 305 days, CW: cow weight at calving, O: order of birth, AC: age at first calving, *: P<0.05, **:P<0.001.

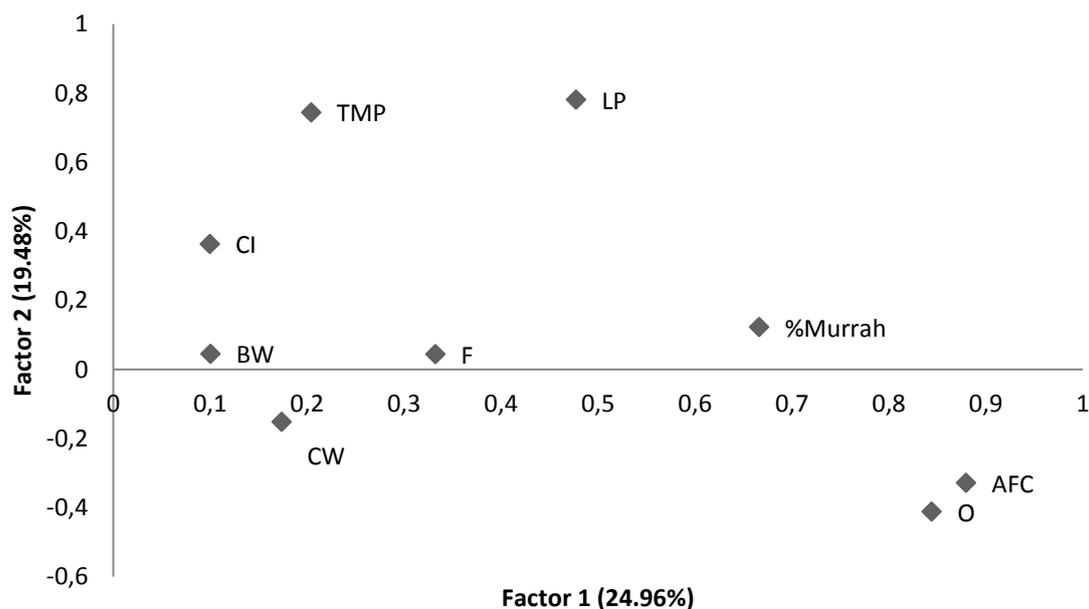


Figure 2. Principal component analysis for production traits in dairy buffaloes reared in the Brazilian Amazon. BW: calf birth weight, LP: lactation period, TMP: total milk production during lactation, F: fat milk percentage, CI: calving interval, CW: cow weight at calving, O: order of birth, AFC: age at first calving.

DISCUSSION

Although there was no increase in production over the last years, the average total milk production during lactation (TMP) observed in this study was higher than the average of the national herd which ranges from 1,482 to 1,650kg of milk (Tonhati *et al.*, 2000a; Ramos *et al.*, 2006; Rodrigues *et al.*, 2010) and similar to the average of 1,830.81 and 1,844.08kg found in Brazilian summaries of Buffalo breeding programs – PROMEBUL (Ramos *et al.*, 2004) and ABCB, (Programa..., 2007), respectively. These differences may be due to breed, production environment and feeding regime which vary widely over the country. The fat milk percentage (F) results (6.96%) confirmed the high fat content in the buffalo milk, a desirable factor for cheese production. This value was similar to those found by Fundora *et al.* (2001), Tonhati *et al.* (2000a) and Aspilcueta-Borquis *et al.* (2007) with average values of 6.98, 6.87 and of 6.85%, respectively.

Age at first calving (AFC) averaged 41.14 months, similar to the average described by Rolim Filho *et al.* (2009) of 39.52 months. Despite this characteristic suffering intense environmental influence, the later age at first calving led the cow being more likely to be culled one year after the start of reproductive life, while early calving buffaloes were less likely to be culled and stayed longer in herds (Galeazzi *et al.*, 2010). The higher AFC observed in this study may reflect management decisions, as well as nutritional and health limitations of the environment in which these animals were reared.

Gestation of the buffalo is around 310 days, so service periods (SP) close to 60 days are ideal for the production of one calf per year, reducing the calving interval (CI) closer to 12 months and obtaining a good reproductive management efficiency ratio. The higher SP observed in this study of 90.86 days may be due to longer lactation period or management factors reflecting in longer CI (483.99 days or 15.91 months). According to Cassiano *et al.* (2003) CI closer to 12 months is physiologically possible in buffaloes and economically advantageous.

Genetic group influenced fat milk percentage (F), cow weight at calving (CW) and reproductive characteristics such as calving interval (CI) and

service period (SP), but had no effect on total milk production during lactation (TMP) and age at first calving (AFC). Murrah had the highest fat milk percentage between the genetic groups, with 7.52 %. Most traits did not differ according to sex, except calf and cow weights as well as service period. Male calves were heavier and cows with male calves were lighter and had a shorter service period.

Season of calving is affected by climatic aspects which also affect vegetation and animal comfort. In some climatic types in the Amazon, there is rain almost all year round, with a season with heavy rain (January to June) and another where it rains less (July to December). Most traits were not influenced by season, except milk production corrected for 305 days which was higher in the rainy season. This may reflect greater pasture availability and therefore improved nutrition. According to Cassiano *et al.* (2003) reproductive characteristics were mainly determined by management, nutrition, climate and health in a given year, or certain periods, as well as management techniques and climate variations.

The largest influence ($P < 0.05$) of order of birth was generally with primiparous females and older cows. This may reflect physiological immaturity at first calving and the use of cows beyond reproductive efficiency. In this case, cows can be kept up to the 13th calving, with ages up to 20 years, reflecting problems with teeth and udder quality (Peeva and Ilieva, 2007).

Milk production increased in order of birth 2, and CI and SP were better from order of birth 3 and 5, respectively. Tonhati *et al.* (2000a) observed a milk production increase in order of birth 4 and F from the 3rd order of birth. Sampaio Neto *et al.* (2001) also found differences ($P < 0.01$) in milk production and CI from order of birth 5. Cassiano *et al.* (2003) also found effects of order of birth on CI and PS, buffaloes reaching their optimum productivity from 5th to 7th calving, later than what was found in this study.

Marques *et al.* (1991) found a high correlation between TMP and F (0.894) different from that found in this study which was negative and not significant (-0.04). As milk production increases there tends to be a decrease in fat milk percentage due to an increase in water content of the milk

(Aspilcueta-Borquis *et al.*, 2010). Both TMP and F showed low correlation with the reproductive efficiency, AFC and CI. Ramos *et al.* (2006) also found low correlation between milk production and CI (0.01), as well as Malhado *et al.* (2009) found negative correlations between TMP and AFC as well as TMP and CI (-0.15 and -0.02, respectively). Positive correlations were found between cow and calf weights, as well as CI and SP. The negative correlation between LP and CW meant that cows that were longer in milk tended to be lighter.

CONCLUSIONS

Production characteristics in dairy buffaloes reared in the Brazilian Eastern Amazon were significantly affected by management factors. This information can be used to help build sustainable production systems for the region and guide farmer decisions, because the dairy buffaloes can be raised for profit in the Brazilian Amazon.

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