

Reproductive efficiency and milk yield in Sindhi breed cattle

Eficiência reprodutiva e produção de leite em bovinos da raça Sindi

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Abstract

The aim of this study was to identify the average of productive and reproductive traits in Red Sindhi females and evaluate if there is an influence of the reproductive traits on milk yield in this breed. Data related to reproductive and productive traits of 638 Sindhi breed dairy cows from North, Northeast, Midwest and Southeast regions of Brazil were provided by ABCZ. Analysis of variance followed by analysis of correlation among reproductive traits and between these and milk yield traits were used. Averages for age at first calving (AFC), calving age (CA), calving interval (CI), reproductive efficiency (RE), dry period (DP), lactation period (LP), milk yield (MY), and total milk yield (TMY) were 1549.83 ± 560.47 days; 1843.53 ± 739.99 days; 533.28 ± 206.66 days; 75.46 ± 19.95%; 248.28 ± 206.66 days; 263.22 ± 63.51 days; 7.08 ± 2.78 kg of milk day⁻¹ and 1875.28 ± 893.36 kg of milk.lactation⁻¹, respectively. The traits AFC, calving order (CO), CA, CI, RE and LP were separated into categories and there was no effect on MY among different categories, while the CO showed positive correlation with LP. Therefore, it can be concluded that Red Sindhi breed dairy cows showed high averages for AFC and medium averages for MY, CI and RE.

Keywords: productive performance, lactation, milk yield, Red Sindhi breed, zebu.

Resumo

O objetivo deste estudo foi identificar as médias produtivas e reprodutivas de fêmeas da raça Red Sindi e avaliar se há influência de parâmetros reprodutivos sobre a produção leiteira desta raça. Foram coletados dados fornecidos pela ABCZ sobre o desempenho reprodutivo e produtivo de 638 matrizes da raça Sindi criadas nas regiões Norte, Nordeste, Centro-Oeste e Sudeste do Brasil. Foi utilizada a análise de variância seguida de análise de correlação entre as características reprodutivas e entre estas e a produção de leite. As médias para idade ao primeiro parto (IPP), idade ao parto (IP), intervalo de partos (IDP), período de serviço (PS), eficiência reprodutiva (ER), produção de leite (PL), duração da lactação (DL) e produção total de leite (PTL) foram 1549,83 ± 560,47 dias, 1843,53 ± 739,99 dias, 533,28 ± 206,66 dias, 248,28 ± 206,66 dias, 75,46 ± 19,95%, 7,08 ± 2,78 kg de leite.dia⁻¹, 263,22 ± 63,51 dias e 1875,28 ± 893,36 kg de leite.lactação⁻¹, respectivamente. Os parâmetros IPP, ordem de parto (OP), IP, IDP, ER e DL foram separados em classes e não mostraram diferença significativa na PL entre as diferentes classes, e a OP apresentou correlação positiva com a DL. Portanto, conclui-se que a raça Red Sindi apresentou médias elevadas para IPP e medianas para PL, IDP e ER.

Palavras-chave: desempenho produtivo, lactação, produção de leite, raça Red Sindi, zebu.

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Introduction

Red Sindhi Zebu breed (*Bos indicus*) has been standing out among other breeds to show median size, heat and ectoparasites resistance, sexual precocity, elevated conception, longevity, feed efficiency and good averages for milk and carcass yield. In addition, its excellent adaptability to adverse handling and climatic conditions in the Northeastern region of Brazil is highlighted (Pundir et al., 2007; Berman, 2011; Mello et al., 2013, 2014, 2016; Saraiva et al., 2015; Oliveira et al., 2017).

In Brazil, dairy yield systems predominantly employ Holstein breed cattle and crossbreeds, mostly of Zebu such as Gyr, Guzera and Red Sindhi. The majority of the Zebu in Brazil are applied primarily for meat or secondarily for milk. In this sense, the introduction of Sindhi breed can accentuate the importance of Brazil as a major center of Zebu selection for genetic improvements programs (Santiago, 2009; Santos, 2011; Associação Brasileira de Criadores de Zebu, 2014; Silva et al., 2014; Panetto et al., 2017; Carvalho et al., 2018).

Red Sindhi breed exhibits hardiness and adaptability to the adverse climatic conditions, showing, during the dry periods of the year, good body condition score and the ability to convert low quality food in meat and milk. Therefore, the breed is recommended to be raised on the Northeast region of Brazil, because of the poor conditions of management and climate. In addition to the hardiness and adaptability to the Northeast region, Sindhi breed also shows good averages for milk yield traits (Moura et al., 2009; Cardoso et al., 2015; Mello et al., 2016).

Therefore, the aim of this study was to identify the averages for productive and reproductive traits in Red Sindhi dairy cows and heifers and evaluate the influence of reproductive parameters on milk yield in this breed.

Materials and methods

Red Sindhi breed reproductive and productive performance data were collected from Zebu Breeders Association (ABCZ) database, including females belonging to 28 herds located in the states of Paraíba, Rio Grande do Norte, Minas Gerais, Ceara, Distrito Federal, São Paulo, Espírito Santo and Para. For all variables, 638 Sindhi females, non-pregnant and lactating, with age from 2 to 13 years old, were used.

Database used for this study included four breeding seasons from 1986 to 2013. As the herds are located in different regions in Brazil, there was no possibility to measure the eminence of rainfall precipitation seasonality, and consequently, forage seasonality. However, in the Northeast region, there is a well-established dry period during the year, leading the females do not express their maximum potential of performance, as all the females in this study had forage as their basic feed system.

The reproductive and productive traits age at first calving (AFC), calving order (CO), calving age (CA), calving interval (CI), reproductive efficiency (RE), dry period (DP), lactation period (LP), milk yield (MY) and total milk yield (TMY) were evaluated. For the purpose of the analysis, some parameters were divided into classes, such as AFC (1 to 6), CA (1 to 5), CI (1 to 4), RE (1 to 5) and LP (1 to 8), with the milk yield (MY) used as the variable.

According to Duarte & Bastos (2005), the calving interval, alone, constitutes the most important trait in the evaluation of the livestock reproductive performance, not only for its direct impact in profitability of the farm, but also for the limitations that requires the breeding programs. Cavalcante et al. (2000) show the calving interval as a fundamental trait, since it interferes in the livestock profitability, shortening the animal breeding magnitude, the selection intensity, since the extension of the calving interval decreases the number of calves weaned and increases the interval between generations. Therefore, the reproductive efficiency (ER) can be calculated using the calving interval (CI), when the ER does not exceed 100%: $ER = (365 \text{ days} * 100) / CI$ (in days).

To calculate AFC, 36.4% of the total data were excluded, as this related to pluriparous females, and the remaining 63.6% of the total data were used to calculate CI, DP and RE, corresponding to primiparous females. Moreover, the effects of LP, CA, CI, DP, RE, CO and AFC on the milk yield (MY) were evaluated. For some of these traits, classes were established and defined according to the tables.

Regarding to the analysis of the data, the effect of all factors on the total milk yield was tested, and the following statistical model was used:

$$Yijklmn = \mu + Ai + Ej + Fk + Gl + Hm + In + eijklmn \quad (1)$$

where: $Yijklmn$ = observation related to the MY (daily); μ = constant common to all observations; Ai = 88 effect of LL among classes ($i=1=149-179$ days; $2=180-210$ days; $3=211-241$ days; $4=242-272$ days; $5=273-303$ days; $6=304-334$ days; $7=335-365$ days and $8=366-396$ days); Ej = effect of CA among classes ($j=1=730-1460$ days; $2=1461-2191$ days; $3=2192-2922$ days; $4=2923-3653$ days and $5= >3653$ days); Fk = effect of CI among classes ($k=1=346-554$ days; $2=555-764$ days; $3=765-974$ days and $4= >974$ days); Gl = effect of RE among classes ($l=1=100-85\%$; $2=84-69\%$; $3=68-53\%$; $4=52-37\%$ and $5= <37\%$); Hm = effect of CO among classes ($m=1, 2, 3, 4, 5$ and 6); In = effect of AFC among classes ($n=1=730-1095$ days; $2=1096-1461$ days; $3=1462-1827$ days; $4=1828-2193$ days; $5=2194-2559$ days and $6=2560-2923$ days); and $eijklmn$ = random error associated with each observation.

Statistical analysis of the data was performed using the SAS® computer program (Statistical Analysis System, 2004). Primarily, analysis of variance was performed (proc GLM) followed by analysis of correlation (proc CORR) among the reproductive traits and among these and milk yield traits, with a level of significance at 5%.

Results and discussion

From 777 calvings observed during the period of this study, 152 corresponded to calving orders from first to ninth order, and it were dismissed due to lack of information. Therefore, 593 calvings remained, with 377 related to primiparous females, and 216 from second to sixth calving orders. Therefore, only calvings from first to sixth calving orders were included in this study.

Table 1 shows the average values for the traits. It was 1549.83 ± 560.47 days; 1843.53 ± 739.99 days; 533.28 ± 206.66 days; 248.28 ± 206.66 days; $68.44 \pm 21.20\%$; 263 ± 63.51 days and 1875.28 ± 893.36 kg for age at first calving (AFC), calving age (CA), calving interval (CI), dry period (DP), reproductive efficiency (RE), lactation period (LP) and total milk yield (TMY), respectively.

Table 1. General average of age at first calving (AFC), calving age (CA), calving interval (CI), dry period (DP), reproductive efficiency (RE), milk yield (MY), lactation period (LP) and total milk yield (TMY) of Red Sindhi cows and their respective standard deviations (SD), minimum and maximum (max) values.

Parameters	N	Average	SD	Min	Max
AFC (days)	377	1549.83	560.47	742	2909
CA (days)	593	1843.53	739.99	742	4765
CI (days)	216	533.28	206.66	346	1749
DP (days)	216	248.28	206.66	61	1464
RE (%)	216	68.44	21.20	21	100
MY (kg.day-1)	593	7.08	2.78	2.4	20.15
LP (days)	593	263	63.51	149	442
TMY (kg)	593	1875.28	893.36	444	6548.76

N: amount of animals.

Pundir et al. (2007) evaluated 809 lactation records of 160 Red Sindhi cows, daughters of 24 sires, from 1 to 11th parity and spread over a period of 48 years from 1958 to 2005. These authors saw that age at first calving, lactation milk yield, lactation length, gestation period, dry period and service period at Kalsi farm were 1577 ± 56 days, 1532 ± 88 kg, 291 ± 25 days, 291 ± 3 days, 195 ± 14 days and 192 ± 14 days, respectively.

Patro & Rao (1983) in Cuttack, Teodoro et al. (2002) on the Northeastern region of Brazil, and Khatri et al. (2004) in Tando Mohammad Khan, performed studies about Red Sindhi females and observed 1338.7, 1160.4 and 2154.6 days of average for AFC, respectively.

Duarte & Bastos (2005), in a study with Guzera females in the state of Mato Grosso do Sul, Brazil, observed 1380.6 days of average for AFC. Likewise, Schwengber et al. (2001) concluded that this trait was strongly influenced by environmental factors, and that breeding season coincided with the months of good forage availability, leading the cows shows lower AFC when compared to those of the same breed managed during the dry seasons of the year. Therefore, it could be observed that AFC was also influenced by nutrition, whereas females showed slow AFC in tropical climates, probably due to the fact that Zebu were fed basically by forage and underwent lack of supplementation.

The average for CI was 533.28 days, with standard deviation by 206.66 days. Duarte & Bastos (2005) evaluated reproductive parameters for Guzera breed in the state of Mato Grosso do Sul, Brazil, fed by forage, and observed an average of 407.18 ± 46.13 days, with coefficient of variation by 11.32%. However, Teodoro et al. (2002) observed 456.92 ± 108.78 days of average for CI in Red Sindhi females, evidencing that Sindhi Brazilian herds could be improved to obtain a CI within of 365 days.

Reproductive efficiency (RE) is a variable dependent upon CI, as when CI is higher, as RE is lower. In our study, the average for RE was 68.44%, with standard deviation by 21.20%. Duarte & Bastos (2005) observed average for RE by 89.64% in Guzera breed. This value was lower than others reported in the literature for *Bos indicus*, such as 81.52% (Rangel et al., 2009).

Khatri et al. (2004), in study with Red Sindhi cattle carried out in Tando Mohammad Khan, observed that TMY production was 1060.3 ± 67.26 liters in 226.98 ± 10.82 days of lactation, and the average value for DP was 455.1 ± 41.65 days.

Table 2 shows the averages for milk yield (MY), lactation period (LP) and total milk yield (TMY) according to age at first calving (AFC), calving age (CA) and calving order (CO) among classes. There was no difference ($P \geq 0.05$) for MY among different classes for ACF (AFC1 - AFC6),

Table 2. Averages for milk yield (MY), lactation period (LP) and total milk yield (TMY) according to classes for age at first calving (AFC), calving order (CO) and calving age (CA).

	Interval (days)	N	MY (kg)	LP (days)	TMY (Kg)
AFC1	730-1095	95	6.88	251.76	1761.50 ^c
AFC2	1096-1461	106	6.89	251.77	1742.05 ^c
AFC3	1462-1827	58	6.79	262.55	1760.67 ^c
AFC4	1828-2193	66	6.80	259.07	1737.76 ^c
AFC5	2194-2559	29	6.67	250.85	1672.69 ^c
AFC6	2560-2923	23	6.53	269.61	1759.00 ^c
Average			6.76	257.60	1738.95
CO1		377	6.81	255.48	1742.87
CO2		130	7.59	262.15	2016.17
CO3		48	7.39	280.10	2055.30
CO4		20	7.48	316.35	2424.23
CO5		13	7.76	329.23	2550.27
CO6		5	7.65	328.80	2516.84
Average			7.45	295.35	2217.61
CA1	730-1460	219	6.93	254.62	1787.08
CA2	1461-2191	204	7.15	264.10	1886.83
CA3	2192-2922	122	7.17	266.16	1918.74
CA4	2923-3653	33	7.14	289.82	2094.05
CA5	>3653	15	7.45	294.53	2171.01
Average			7.17	273.85	1971.54

CO (CO1 - CO6) and CA (CA1 - CA6). The average values for each class of AFC, CO and CA were 6.76 kg of milk per day and 257.60 days of lactation, 7.45 kg of milk per day and 295.35 days of lactation and 7.17 kg of milk per day and 273.85 days of lactation, respectively.

Balieiro et al. (2003), in a study with primiparous cows from Gyr breed with age of 45.52 ± 0.09 months, observed 2653.58 ± 6.28 kg of average for MY, in 305 days of lactation, while Herrera et al. (2008) evaluated the same breed and observed that AFC classes between 24 and 61 months (class 1 - 24 to 36 months; class 2 - 36 to 48 months; class 3 - 48 to 61 months) yield 2170.24 kg in 305 days of lactation, whereas it can be concluded that AFC can influence the MY. Thus, lower AFC resulted in lower MY.

In this study, although Sindhi females from several states of Brazil were used, the milk yield (MY) generated was similar, independent of AFC classes, which highlights the adaptability of Sindhi breed to climatic and management conditions.

Soares et al. (2009) evaluated the influence of CO on milk yield (MY) in Gyr, Guzera and Red Sindhi breed females, concluding that milk yield (MY) was influenced by CO, whereas the milk yield became elevated until the sixth calving (CO1= 13.376 kg; CO2= 11.092 kg; CO3= 16.077 kg; CO4= 17.907 kg; CO5= 14.183 kg; CO6= 17.211 kg). It was observed from the seventh birth onwards, milk production was lower (CO7=13.058 kg. Therefore, considering the results of this study, it can be said that starting with CO7, the higher the parity, the lower the MY, probably due to the aging of the female and consequent reduction in the number of milk secretory cells.

Khatri et al. (2004) evaluated five lactations in Red Sindhi cows in Tanto Mohammad Khan and observed the effect of CO on TMY and LP. In this study, the average of CO1, CO2, CO3, CO4 and CO5 were respectively, 956.2 ± 90.3 liters and 219.5 ± 11.2 days, 1113.4 ± 85.7 liters and 249.9 ± 12.0 days, 1220.5 ± 65.0 liters and 225.1 ± 11.4 days, 912.1 ± 55.4 liters and 209.6 ± 11.3 days and 1099.3 ± 39.9 liters and 230.8 ± 8.2 days. Therefore, in the light of these results, the authors observed that there was a higher milk production in OP3, however without significant difference and there was a significant difference when comparing the number of days of lactation from LP2 to LP4.

Rangel et al. (2009) evaluated a Guzera herd from the state of Paraiba, Brazil, and observed the effect of CO on MY and LP. In this study, the averages for MY and LP were 8.60 ± 2.82 kg per day and 290.64 ± 34.17 days, respectively, whereas CO generated an influence on the parameters evaluated. In fact, females with CO1 showed the lowest milk yield (8.11 ± 2.35 kg) per day and the longest LP (302.38 ± 35.87 days), while females with CO5 showed the highest daily milk yield (9.14 ± 3.08 kg) and the shortest LP (282.96 ± 30.42 days), with lower MY and higher LP at the sixth calving (8.19 ± 2.98 kg and 291.98 ± 32.72 days).

According to Teodoro et al. (2000), the MY increases until physiological maturity, which occurs at around 8.4 years, gradually reducing with aging of the animal. Thereby, the same authors analyzed a Guzera herd data from Embrapa Gado de Leite, Minas Gerais, Brazil, and observed 2242.67 ± 846.48 kg of average for MY, with averages varying from 331.00 to 6270.00 kg of milk per lactation.

The average for MY observed in our study was found to be next to the value observed by Cobuci et al. (2000), who observed 2359.00 kg of average for MY. In addition to decrease in MY in Guzera cows, the increase in the incidence of reproductive disorders has been observed, which generally imply the maintenance of these females inviable as when maintaining good productive and reproductive performances. It has been observed the retention of aging animals on the herds, as a function of necessity to maintain a minimum number of females for breeding season, with the responsibility of the farmers to replace when possible or as soon possible (Teodoro et al., 2000; Tozer & Heinrichs, 2001; Hossein-Zadeh, 2013; Wondossen et al., 2018).

In females with first and second calvings, part of the energy is directed towards body growth and development, with maximum performance obtained when they complete their growth phase, which generally occurs from 4 to 5 years of age. When they reach at older age, the organic capacity of the productive tract is fully developed, and nutrients are primarily directed to the maintenance and milk yield processes. As aging the animal, it has been observed a reduction in the number of secretory cells available for MY, leading to decreased function and a consequent reduction in MY (Capuco & Akers, 1999; Teodoro et al., 2000; Dobson et al., 2007; McManus et al., 2011; Baratta et al., 2017).

Table 3 shows the averages for MY, LP and TMY according to CI, RE and LP among classes. There was no difference ($P \geq 0.05$) for MY among classes for CI (CI1 - CI4), RE (RE1 - RE5) and LP (LP1 - LP8). The average values of MY and LP for the class were: 7.41 kg of milk per day and 266.62 days of lactation for CI (CI1 - CI4), 7.54 kg of milk per day and 273.43 days of lactation for RE (RE1 - RE5) and 7.16 kg of milk per day and 272.51 days of lactation for class LP (LP1 - LP8).

Table 3. Averages for milk yield (MY), lactation period (LP) and total milk yield (TMY) according to classes for calving interval (CI), reproductive efficiency (RE) and lactation period (LP).

	Interval (days)	N	MY (Kg)	LP (days)	TMY (Kg)
CI1	346-554	148	7.62	281.20	2147.12
CI2	555-764	46	7.56	275.41	2130.36
CI3	765-974	14	6.47	234.86	1563.59
CI4	>974	8	7.98	275	2164.74
Average			7.41	266.62	2001.55
RE1	100-85	81	7.52	280.20	2119.42
RE2	84-69	59	7.72	277.36	2122.58
RE3	68-53	42	7.80	288.48	2299.13
RE4	52-37	26	6.70	246.12	1699.71
RE5	<37	8	7.98	275	2164.74
Average			7.54	273.43	2081.12
LL1	149-179	63	7.26	164.92	1193.5
LL2	180-210	68	6.66	195.29	1302.4
LL3	211-241	109	7.17	227.86	1633.2
LL4	242-272	102	6.71	257.30	1726.0
LL5	273-303	97	7.02	287.09	2012.9
LL6	304-334	61	6.93	316.54	2195.8
LL7	335-365	53	7.49	351.40	2636.6
LL8	366-396	28	8.07	379.68	3064.3
Average			7.16	272.51	1970.59

RE is a variable dependent on CI. In our study, there was no effect on MY among classes. However, when it compared numerically, the highest production was observed in females which the longest CI and the lowest RE. This fact could be due to stimulation of udder in suppressing the release of GnRH (gonadotrophin releasing hormone) by the hypothalamus and, thus, suppressing ovulation and estrus cycle. In addition, it should be taken into consideration that in zebu females is used the traditional beef cattle weaning management, whereas the females are weaned at around seven months (Yavas & Walton, 2000).

Herrera et al. (2008) evaluated females from Gyr breed raised in several regions of Brazil and observed 9.80 kg of milk per day of average for MY, whereas there was only a slight increase in the peak of the lactation (10.32 kg of milk). Therefore, it could be concluded from this study that Gyr breed with values for MY at the start of lactation next to the peak of lactation, followed by a decreased in MY, as lactation advanced (9.77 kg; 9.55 kg; 9.23 kg; 8.49 kg; 7.92 kg; 7.43 kg; 6.82 kg; 6.42 kg), respectively.

Regarding to Red Sindhi breed females, Pires (1971) observed 1304.00 kg of average for MY in 240 days of lactation. However, Moura et al. (2009) evaluated Guzera and Red Sindhi breed females raised in the Northeastern region of Brazil and observed 1996.86 kg of average for MY in 304 days of lactation (6.57 kg milk per day) for Guzera females, and 2019.41 kg in 298 days

(6.78 kg milk per day) for Red Sindhi females. This results found by these authors were greater than those found by Guimarães et al. (2002) for Gyr breed females. Therefore, according to Moura et al. (2009), Guzera and Red Sindhi breeds could be explored for dairy yield systems in the Northeastern of Brazil.

Table 4 shows the significant correlation between CI and DP with RE, with a value of -0.91 ($P < 0.05$), showing that as the DP increase, as CI increase and RE decrease. This finding was in accordance to the study of Guimarães et al. (2002), which verified that the RE was influenced by CI, showing negative correlation ($r = -0.54$), as both of them are interdependent variables. In addition, the increase in the DP ($r = -0.32$) generated the increase in CI, also compromising the RE.

Table 4. Statistical significance and relationship between the following parameters: age at first calving (AFC), calving order (CO), calving age (CA), calving interval (CI), dry period (DP), reproductive efficiency (RE), milk yield (MY) and lactation period (LP).

Parameters	AFC	CO	CA	CI	DP	RE	MY
CO	----						

	377						
CA	1	0.66					
	<0.0001	<0.0001					
	377	593					
CI	----	-0.11	0.22				
	0	0.1032	0.001				
		216	216				
DP	----	-0.11	0.22	1			
	----	0.1032	0.001	<0.0001			
		216	216	216			
RE	----	0.1	-0.18	-0.91	-0.91		
	0	0.1409	0.0067	<0.0001	<0.0001		
		216	216	216	216		
MY	-0.03	0.1	0.05	-0.02	-0.02	0.03	
	0.6292	0.0136	0.2687	0.7596	0.7596	0.6865	
	377	593	593	216	216	216	
LP	0.06	0.26	0.14	-0.08	-0.08	0.08	0.07
	0.2833	<0.0001	0.0006	0.2415	0.2415	0.2185	0.1082
	377	593	593	216	216	216	593

By correlating the reproductive and productive parameters, a correlation between CO and LP was observed ($r = 0.26$), showing that LP decreased when CO was lower, due to the fact that primiparous females are physiologically limited in lactation because of their energy requirement for growth at the consumption of body maintenance, reproduction and lactation.

Conclusions

Regarding to the reproductive traits, it can be concluded that Red Sindhi breed females showed high averages for AFC and medium averages for CI and RE when compared to averages for reproductive traits in zebu breeds. Regarding to CA, it was observed that the females have longevity, and as they continue to calve at older ages, milk yield generally increases until the fifth calving and lactation.

Regarding to milk yield, Red Sindhi breed females showed viable averages, although this value could not be compared to others found in zebu breeds.

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