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EFFECTS OF AGE AT FIRST CALVING, GESTATION LENGTH AND DRY PERIOD ON MILK YIELD IN A GYR HERD

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ABSTRACT

Relationships of several reproductive traits and milk yield were studied in 716 Gyr cows at Sant'Ana da Serra farm, Mococa, State of São Paulo, a humid tropical climate region. Mean age at first calving was 49.8 ± 0.4 months, with a coefficient of variation (C.V.) of 20.8%. Only year of parturition significantly affected age at first calving ($P < 0.01$). Heritability, estimated from paternal half-sib correlations, was 0.91 ± 0.20, a value considered unrealistically high. Overall mean gestation length was 287.7 ± 0.5 days (C.V. = 3.3%) for 419 observations, with month and year of parturition having significant effects. Heritability estimate was 0.30 ± 0.14. Overall mean dry period for 1.276 observations was 238 ± 3 days (C.V. = 48%); repeatability estimate was 0.19 ± 0.06. Estimated annual genetic trend for dry period was -0.6 days, phenotypic trend was 11.5 days, and environmental trend, 12.1 days. Month and year of parturition and cow age had no significant effect on dry period. Highest milk yield was obtained at fourth

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lactation. The gross correlation between milk yield and gestation period was 0.11, and between previous dry period and subsequent milk yield, 0.16. Normal gestations of 285 to 290 days were associated with higher milk yields. Milk yield increased as dry period advanced from 30 to 390 days, and declined as dry period continued beyond 390 days. Delays in first mating and a more extensive dry period decreased reproductive efficiency in the herd studied.

INTRODUCTION

Events occurring in the reproductive life of cattle have economic consequences both in terms of milk and meat production by effectively conditioning the amount of product available for the market and the frequency with which it can be obtained. Thus, the larger the number of parturitions in a cow's life and the earlier the animal starts its reproductive life, the greater the amounts of milk and meat produced. The physiological limits of maximum yields and frequent parturitions have been the subject of several studies. Objectives of the present study were to estimate the correlation between age at first calving, gestation length and dry period and milk yield in a Gyr herd, selected for milk yield for about 30 years at the Sant'Ana da Serra farm, Mococa, State of São Paulo, Brazil.

LITERATURE REVIEW

Tropical cattle usually start their reproductive life at a later age than temperate cattle. Joshi and Phillips (1953) reported that most Zebu breeds were more than 40 months old at first parturition. Mahadevan (1966) suggested that late age at first calving in native breeds was due to delayed first heat (a trait peculiar to these breeds), and was the main factor accounting for lack of economic success of the dairy industry in tropical countries. Lôbo (1980) attributed this delayed puberty, also observed in Pitangueiras cattle, to a consequence of management practices, i.e. selection of a minimum age or weight for mating, as well as to lack of adequate feeding and management of heifers after weaning. Reddy and Bhatnagar (1971), in a study of Tharparkar cows in India, concluded that earlier parturitions would improve reproductive efficiency, although they considered that better feeding and management would be more important in decreasing age at first calving than selection in itself.

Results reported concerning age at first calving permit one to estimate age at sexual maturity (when gestation length is subtracted) since data on the manifestation of the first fertile heat are scarce. Ages at first calving reported for Gyrs go from 41.60 months (Teixeira *et al.*, 1973) to 57.24 months (Solanki *et al.*, 1973), with similar values both in Brazil and in India.

Gestation length usually varies within narrow limits. However, since it is a breed trait, its estimation is justified from the point of view of both descriptive context and interaction with other traits. The Gyr gestation length has been reported to vary from 284 days (Kerur, 1969) to 290 days (Teixeira *et al.*, 1973) with a coefficient of variation (C.V.) of 4.2% reported by the latter investigators.

The rest period for the mammary gland between two lactations, denoted dry period, seems to be longer than in taurines. Mahadevan (1958), in a study of Zebu performance in the tropics, reported that improved feeding and management techniques reduced the dry period and observed no evidence of appreciable genetic influence on this trait. Subsequent milk production is affected by dry period. Singh and Desai (1962), in a study of Hariana in India, observed that a dry period of 60 to 90 days provided maximum yield in the next lactation, with no further increases after exceeding 90 days. In Brazil, Correa (1956) reported an average dry period of 195 days for Gyrs; in India, Mahadevan (1958) reported 133 days, and Malik and Ghei (1977), 270 days.

MATERIALS AND METHODS

Data for 716 cows sired by 34 bulls were used to study the influence of several genetic and non-genetic effects on age at first calving, gestation length and dry period in a herd maintained at "Sant'Ana da Serra" farm and selected for milk production. The farm is located at an altitude that varies from 640 to 690 m, 21°28' latitude South, and 47°01' longitude West of Greenwhich. The climate is tropical humid, of the Cwa type in the Köeppen classification, with dry winters. Mean atmospheric temperature was 21.5°C (18.3 to 23.3°C) with an average relative humidity of 71.1% (58.3 to 79.5%). Mean annual precipitation was 1,435.5 mm, distributed over two seasons, 237 mm from April to September and 1,198.5 mm from October to March.

The farm soil is classified as type A (Classes III and IV), i.e. land that can be worked mechanically, of medium to high fertility and fit for annual cultures. Pasture consists of "gordura" grass (*Melinis minutiflora*, P. Beauv,),

"jaraguá" grass (*Hyparrhenia rufa*), Napier grass (*Pennisetum purpureum*, Schum), and "colonião" grass (*Panicum maximum*), all of them in association with perennial soy (*Glycine wightii*, verde). The herd is maintained on pasture the year around and at milking time cows receive a daily supplementation consisting of corn silage and barley chaff, at the rate of 1 kg per 3 kg milk produced. Milk control is performed monthly on every milking cow in the herd.

Statistical analysis

The data were analyzed by method of least squares analysis of variance, using Harvey (1977) model:

$$Y_{ijk} = \mu + a_i + F_j + E_{ijk}$$

where Y_{ijk} = trait studied (age at first calving, gestation length, dry period), μ = overall mean, a_i = effect of sire ($i = 1,2, \ldots, 34$), F_j = set of fixed effects (month and year of calving), and E_{ijk} = residual (error) variance. Variance components and heritability of age at first calving and gestation length were estimated by conventional methods. Phenotypic, genetic and environmental trends for dry period were obtained by the method of Henderson *et al.* (1959). Not all data were complete for all responses; hence numbers of observations differed in the various studies.

RESULTS AND DISCUSSION

Age at first calving

Mean age at first calving was 49.8 ± 0.4 months, with a C.V. of 20.8%, for 599 observations. Values obtained here were similar to those reported by other investigators, and confirm the statement by Joshi and Phillips (1953) that, in Zebu cattle, first calving occurs at about 40 months of age. Analysis of variance is given in Table I.

Although month of calving was not significantly related to age at first parturition, the highly significant year effects represented a gradual increase in age at first calving for the period studied. This trend may be related to increase in herd size during the last years of the study and to a management decision to require increased weight (and therefore an advanced age) at first service. This may represent an opportunity for management to decrease age at first calving by supplying more feed to heifers during critical growth phases.

Heritability of age at first calving, estimated by correlation among paternal half-sibs, was 0.91 ± 0.20, a value considered to be unrealistically

Table I - Least squares analysis of variance of age at first calving.

Sources of variation	d.f.	Mean squares	F
Month of calving	11	43,946	0.87
Year of calving	20	612,422	12.07**
Sire	33	264,460	5.21**
Residual	534	50,725	
Total	598		

**P < 0.01.

high, since values of near to or less than 0.40 are most frequently reported in the literature. This estimate may be due to small sample size (sampling error), or to an imperfect mathematical model. At the least, appreciable heritability is suggested, and additional study of the Gyr is warranted.

Gestation length

Overall mean gestation length was 287.7 ± 0.5 days, standard deviation of 9.6 days and C.V. of 3.3% for 419 observations. These data agreed with those reported in other studies, i.e. gestation lengths averaging less than 290 days and with a low C.V. Analysis of variance shows the effects of the variables studied (Table II). Month effects were significant; the shortest mean gestation length occurred in March, whereas the longest occurred in July. Gestations whose final third occurred during warm and rainy months, October to March, were shorter, whereas they were longer when the final third occurred during the cool and dry months from April to September. Calvings that occurred during June, July and August were after the longest periods of gestation (Table III). A probable explanation for this may be the higher percentage of water in fetal tissue. Since water is a very good heat conductor, one might assume that the high environmental temperatures of the tropical summer, by causing heat stress in the pregnant dams, may have a more marked effect on the fetus, which might absorb the environmental heat with higher intensity and thus suffer a shorter gestation because of the deleterious effect of heat.

A decreasing trend in gestation length was observed over the years studied (1973 to 1977). Estimated heritability was 0.30 ± 0.14, i.e. a value

Table II - Least squares analysis of variance of gestation length.

Sources of variation	d.f.	Mean squares	F
Month of calving	11	145.6	1.96*
Year of calving	4	884.3	11.88**
Sire	29	147.4	1.98**
Age of cow			
Linear	1	124.4	1.67
Quadratic	1	15.2	0.20
Residual	372	74.5	
Total	418		

*P <0.05; **P <0.01.

comparable to those reported by other investigators for paternal half-sib estimates.

Table III - Mean gestation length (days) according to month of calving estimated by method of least squares analysis of variance.

Month	Number of observations	Mean	Standard error
January	28	280.03	1.98
February	35	281.70	1.97
March	21	274.36	2.27
April	23	278.16	2.27
May	61	277.60	1.79
June	36	282.10	1.97
July	19	282.57	2.45
August	32	281.96	2.07
September	29	279.99	2.16
October	48	278.23	1.93
November	46	279.77	1.91
December	41	281.02	1.97
Total	419	279.79	1.34

Dry period

Overall mean dry period was 238 ± 3 days, with a standard deviation of 116 days days and a C.V. of 48% for 1276 observations from 1963 to 1976. Dry period was longer than reported by Correa (1956) in Brazil and Mahadevan (1958) in India, but shorter than the 271 days reported by Malik and Ghei (1977) for a different Gyr herd in India. In any case, it was longer than observed for European dairy cattle. Environment, month and year of parturition and cow age had no detectable effect on dry period (Table IV).

Table IV - Least squares analysis of variance of factors affecting dry period.

Sources of variation	d.f.	Mean squares	F
Month of calving	11	12,310	1.32
Year of calving	13	10,772	1.15
Linear[a]	1	4,110	0.44
Quadratic	1	425	0.05
Cubic	1	43,065	4.62
Quartic	1	12,733	1.37
Quintic	1	3,883	0.42
Residual	8	9,315	
Age of cow			
Linear[b]	1	7,145	0.76
Quadratic	1	433	0.05
Cubic	1	41,191	1.53
Cow	441	15,570	1.67**
Remainder	821	9,340	
Total	1,289		

[a] Estimates of year effects sums of squares were sequential.

[b] Estimates of age effects sums of squares were non-sequential.

**P $<$ 0.01.

A marked though not significant increase in dry period (162 to 297 days) occurred over the years studied, which may be explained by manage-

Table V - Gestation length, dry period and milk yield according to order of parturition.

Order	Gestation length (days)			Dry period (days)			Milk yield (kg)		
	N	Mean ± S.E.	C.V. (%)	N	Mean ± S.E.	C.V. (%)	N	Mean ± S.E.	C.V. (%)
1st	24	281.7 ± 2.3	4.0	—	—	—	441	2346 ± 35	31
2nd	66	289.9 ± 0.9	2.4	295	259.5 ± 7.2	48.7	369	2884 ± 50	33
3rd	60	289.1 ± 0.8	2.0	262	232.1 ± 6.8	47.8	323	2993 ± 60	36
4th	56	287.6 ± 0.9	2.4	230	235.2 ± 7.3	47.3	267	3042 ± 64	35
5th	45	288.0 ± 1.0	2.3	176	234.3 ± 8.4	47.6	199	2999 ± 77	36
6th	35	288.7 ± 0.9	1.8	126	223.6 ± 9.3	46.7	150	2793 ± 81	36
7th	29	288.5 ± 1.7	3.2	86	234.3 ± 14.1	55.9	105	2782 ± 89	33
8th - 12th	15	286.9 ± 1.7	2.3	101	227.2 ± 11.0	48.5	117	2648 ± 77	32
Total	330	288.1 ± 0.4	2.6	1276	238.2 ± 3.0	48.3	1971	2788 ± 22	35

ment's desire to obtain greater yields per lactation after a more extended dry period. Estimated annual genetic trend for dry period was -0.6 days; phenotypic trend was 11.5 days and environmental trend, 12.1 days. Repeatability of dry period, estimated by intraclass correlation, was 0.19 ± 0.06.

Effect of dry period and gestation length on milk yield

Order of parturition, although not included in the analysis of variance, showed some peculiar aspects in terms of gestation length, dry period and milk production, as can be observed in Table V. The shortest gestations were the first and those from the eighth on, whereas the first dry period immediately before the second parturition was the longest, with subsequent periods stabilized up to the 12th calving. The highest milk yield was obtained at fourth lactation, with lower amounts of milk produced at the beginning and towards the end of productive life, as observed also in European cattle.

Gross correlations between gestation length, dry period and milk yield were -0.04, 0.11 and 0.16. The low correlations obtained indicate little association between the traits studied and milk yield. However, the effect of gestation length on milk yield and fat percentage can be seen in Table VI. In general, very short or very long gestations were associated with lower milk

Table VI - Effect of gestation length on milk yield and fat percentage.

Classes (days)	N	Milk (kg)		% Fat	
		Mean	C.V. (%)	Mean	C.V. (%)
– 265	5	2,472	44	5.30	6.3
265 ⊢ 270	6	1,828	59	4.84	5.9
270 ⊢ 275	7	1,953	59	4.82	4.8
275 ⊢ 280	21	2,493	57	5.08	6.9
280 ⊢ 285	50	2,654	52	5.01	9.4
285 ⊢ 290	92	3,179	35	4.95	7.3
290 ⊢ 295	127	2,939	39	4.95	8.4
295 ⊢ 300	41	2,663	49	4.88	7.5
300 ⊢ 305	13	3,006	43	5.03	9.9
305 ⊢	2	2,083	35	4.31	3.6
Total	364	2,858	43	4.96	8.1

yields, the highest milk production being located in the class where gestation length was about average. Fat percentage followed an inverse trend, i.e., the higher the milk yield, the lower the fat percentage, with the highest percentages occurring after shorter or longer than average gestations.

The effect of dry period on milk yield and fat percentage can be seen in Table VII. These results confirm the fact that there is an optimum resting period for the mammary gland, after which yield starts falling again, even though in the present study the dry period followed by highest milk production was of much longer duration than that reported by Singh and Desai (1962), who observed a dry period of 60 to 70 days to lead to higher milk yields. The longer gestation and dry period, by being linked with better milk yield, cause a drop in productivity by leading to longer calving intervals and to a more extended idle period of the mammary glands.

Table VII - Effect of dry period on milk yield and fat percentage.

Classes (days)	N	Milk		% Fat	
		Mean	C.V. (%)	Mean	C.V. (%)
– 30	13	2,354	40.7	4.90	10.4
30 ⊢ 90	55	2,513	37.3	4.90	9.2
90 ⊢ 150	266	2,661	34.6	4.83	9.9
150 ⊢ 210	328	2,810	35.0	4.84	9.1
210 ⊢ 270	211	2,886	36.5	4.90	8.8
270 ⊢ 330	193	3,215	37.7	4.89	10.1
330 ⊢ 390	157	3,261	38.3	4.85	9.1
390 ⊢ 450	57	3,022	43.7	4.82	9.2
450 ⊢	80	2,738	46.5	4.91	8.0
Total	1360	2,890	38.2	4.86	9.3

CONCLUSIONS

Age at first parturition was 49.8 months in the Gyr herd studied, despite thirty years of selection for milk yield. Gestation lengths were longer than for European breeds as were dry periods between lactations. Highest production was obtained after long gestations and extended dry periods,

but only up to a certain limit. Correlation between milk yield, gestation length and dry period was low. Genetic trend for dry period was negative but low, whereas the phenotypic and environmental trends were positive. Delaying of first mating and extending the dry period to increase production impaired overall herd productivity. Genetic parameters (heritabilities) for gestation length and dry period, medium and low, respectively, do not permit one to expect marked gains by selection. Further studies in Gyr of age at first calving, with more data, are needed.

RESUMO

Visando detectar a influência de alguns caracteres reprodutivos sobre a produção leiteira de vacas Gir, foram estudadas 716 vacas da Fazenda Sant'Ana da Serra, localizada em Mococa, SP, em região de clima tropical úmido. A média da idade ao primeiro parto foi de 49,8 ± 0,4 meses, com um coeficiente de variação (C.V.) de 20,8%. Apenas o efeito de ano da parição influenciou significativamente ($P < 0,01$) a idade ao primeiro parto. A estimativa de herdabilidade foi de 0,91 ± 0,20, considerada irrealista. A média para o período de gestação foi de 287,7 ± 0,5 dias (C.V. = 3,3%), para 419 observações havendo influência significativa de mês e ano do parto. A estimativa de herdabilidade foi 0,30 ± 0,14. A média geral do período seco, para 1.276 observações foi de 238 ± 3 dias (C.V. = 48%). O coeficiente de repetibilidade foi 0,19 ± 0,06. A tendência genética anual estimada para o período seco foi de -0,6 dias; a fenotípica foi de 11,5 dias e a ambiente, de 12,1 dias. Não houve significância dos efeitos de mês e ano do parto, e idade da vaca sobre o período seco. A maior produção de leite foi obtida na quarta lactação. A correlação entre produção de leite e período de gestação foi de 0,11 enquanto que entre o período seco anterior e a subsequente produção de leite foi de 0,16. Observou-se que as gestações normais, entre 285 e 290 dias, estavam associadas às melhores produções de leite. A produção leiteira aumentou à medida que se alongava o período seco de 30 até 390 dias, decaindo novamente com o seu alongamento. O atraso nas primeiras cobrições e o período seco mais extenso diminuem a eficiência reprodutiva no rebanho estudado.

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