STUDIES ON BREEDING EFFICIENCY IN ONGOLE AND ZEBU-JERSEY CROSSBRED CATTLE IN INDIA.

By

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IZATNAGAR. (U. P.)

THESIS
Submitted to the Agra University, Agra,
in partial fulfilment of the requirements for the degree of
MASTER OF VETERINARY SCIENCE (A. H.)
IN
ANIMAL GENETICS & BREEDING

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Dr. S.S. Prabhu, Ph.D., D.Sc.,
Head, Division of Animal Genetics

Indian Veterinary Research Institute,
Izatnagar, U.P.

April 15, 1968.

Certified that the research work embodied in the thesis "Studies on breeding efficiency in Ongole and Zebu-Jersey crossbred cattle in India" by Shri P.L. Narayana Sarma is an original piece of work carried out by him in this Division under my guidance and supervision.

Prabhu S.S.
(S.S. PRABHU)

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THE AUTHOR WISHES TO PLACE ON RECORD HIS DEEP SENSE OF GRATITUDE TO THE ANDHRA PRADESH AGRICULTURAL UNIVERSITY FOR DEPUTING HIM WHILE CONTINUING IN SERVICE TO UNDERTAKE THESE STUDIES AT THE POST GRADUATE COLLEGE OF ANIMAL SCIENCES, INDIAN VETERINARY RESEARCH INSTITUTE, IZATNAGAR, U.P. DURING THE PERIOD

1966-1968

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INTRODUCTION

Agriculture is the backbone of Indian economy as more than 80% of the population depends directly or indirectly on agriculture. It was no wonder therefore that most of the cattle breeds developed in the country had draught as the major objective. This is clear from an assessment of 31 cattle breeds recognised as existing in the country (Phillips, 1944). The majority of these are for draught purposes, with attempts made here and there to introduce milk into them through breeding.

Today, with the rapid growth of motor and electric power, bullock power is on its way out. On the other hand, the emphasis has shifted from breeding for draught to breeding for milk. To bring about radical changes in the situation within the shortest possible time crossbreeding with bulls of exotic dairy breeds is being actively advocated and it is fast becoming the new plan of animal breeding. Unfortunately, information about our own cattle is scanty and diffuse. Though records were maintained at all well run cattle breeding farms, no efforts were made till recently to analyse those records and draw conclusions. Some information is now available on the production capacity of our animals from the published papers based on analysis of farm data. On the other hand, we have a big gap existing in the

field of various physical and physiological characters of our cattle breeds, the extent of their variation and their nature. These lacunae are being filled by a series of studies undertaken by the Division of Animal Genetics, Indian Veterinary Research Institute, Izatnagar, U.P. under the guidance of Dr. S.S. Prabhu. Physical traits like horn pattern, head size, skin thickness, udder size and shape, extra teats etc. were dealt by others (Singh, 1965; Sharma, 1967; Mohan, 1967; Narayan, 1967; Choudhury, 1967; Chatterjee, 1967; Bhatia, 1967).

In the present study are presented our findings concerning the breeding efficiency in Ongole and Zebu-Jersey crossbreds found in the Ongole tract, kept under farm and field conditions.

REVIEW OF LITERATURE

Various workers had used different measures to measure breeding efficiency in cows. They were :

1. Regularity of occurrence of oestrous cycle (Pou *et al*, 1953).

2. Conception rate and number of services per conception (Erb *et al*, 1940; Bowling *et al*, 1940; Seath and Staples, 1941; Hilder *et al*, 1944; Trimberger and Davis, 1945; VanDemark and Salisbury, 1950; Tabler *et al*, 1951; Davis and Benjamin, 1953; Pou *et al*, 1953; Boyd *et al*, 1954; Legates, 1954; Bhattacharya and Prabhu, 1955; Carman, 1955; Kohli and Suri, 1960; Singh, 1961; Sharma and Prabhu, 1966; Tomar, 1966).

3. Non-returns to service (Tanabe and Salisbury, 1946; Dunbar and Henderson, 1953).

4. Number of days from calving to first oestrus (Olds and Seath, 1953; Carman, 1955; Kohli and Suri, 1957).

5. Number of days from first service to conception (Tabler *et al*, 1951; Pou *et al*, 1953; Carman, 1955).

6. Service period (Prasad, 1958; Kohli and Suri, 1960; Singh *et al*, 1965).

7. Calving interval (Dunbar and Henderson, 1953; Inchiosa and Pfau, 1954; Legates, 1954; Singh, 1958).

8. Number of calves produced per unit of time expressed as a percentage of a theoretical ideal (Williams, 1919; Spielman and Jones, 1939; Tabler et al, 1951; Wilcox et al, 1957; Dutt and Desai, 1965; Tomar, 1965; Gautam et al, 1966).

9. Age at first calving (Verley and Touchberry, 1961).

In this investigation the measures of breeding efficiency used were (1) No. of calves produced per unit of time expressed as a percentage of a theoretical ideal. (2) Calving interval. (3) Age at first calving and such only references to these items had been reviewed in detail.

No. of calves produced per unit of time expressed as a percentage of a theoretical ideal

Williams (1919) considered 12 months as an ideal calving interval and two years as the ideal age at which a heifer should calve. Every calendar month after the 15 months of age of the heifer was designated as a breeding month. He determined the average number of breeding months required to produce a calf by dividing the total number of breeding months by the number of calves born. The percentage reproductive

efficiency was obtained by dividing 12 the ideal number of breeding months for the production of a calf by the determined average number of breeding months per calf.

He used this method to analyse the reproductive efficiency of a Guernsey herd which produced a calf for each 28.7 months and found the reproductive efficiency to be 41.8% of the ideal efficiency.

Spielman and Jones (1939) proposed the term 'reproductive efficiency' for the net biological accomplishment of all reproductive activity. It represented the integrated effect of all factors concerned i.e. oestrus, ovulation, fertilisation, implantation, gestation and parturition. They used a numerical expression based on the assumption that to be 100% efficient a heifer should be bred at a certain age depending upon the breed and that she should drop a calf every 12 months thereafter. The total number of reproductive months represented the number of months that an animal remained in the breeding herd.

As the desired calving interval was 12 months, each cow was credited with 12 months per pregnancy (which were called 100% months). That portion of the calving interval in excess of 12 months was considered as possessing zero per cent reproductive efficiency. Cows removed from the herd

before calving and known to be pregnant were allowed one 100 per cent month for each month of pregnancy. The number of 100 per cent months divided by the total number of reproductive months furnished the reproductive efficiency.

Analysing the records of 368 cows of four major dairy breeds; the authors reported the mean reproductive efficiency amongst the four breeds to be from 67.55% to 81.27%. Marked differences in the reproductive efficiency were found to exist between breeds as well as cow groups.

Tabler et al (1951) used a method similar to that of Spielman and Jones (1939) and reported the average reproductive efficiency in 19 Ayrshire cow families to be ranging from 77 to 89%.

Herman et al. (1953) reported the breeding efficiency of Jersey, Holstein and Guernsey cows to be 77.51%, 83.04% and 85.05% respectively as measured by the percentage of cows calving in 12 months.

Wilcox et al. (1957) estimated the reproductive efficiency of a Holstein-Friesian herd using the formula

$$\text{Breeding efficiency} = \frac{365 \times (N-1) \times 100}{D}$$

Where N equals to the total number of parturitions

and D equals to the number of days from 1st parturition to the last parturition. In this formula, the first reproductive cycle of each cow was excluded because of the excessive influence of environment. In addition, the reproductive cycles after the 6th parturition were excluded because of the suspected bias caused by special managemental practices in favour of the older cows. They used this method to analyse the reproductive efficiency of a Holstein-Friesian herd and reported the average breeding efficiency to be 87.2%.

Rigor and Nelmida (1959) reported the breeding efficiency of Red Sindhi and crossbred Jersey cows to be 71.4% and 71.3% respectively as determined by dividing 365 days by the actual calving interval.

Rigor et al (1959) reported the breeding efficiency of two herds of Sahiwal cows to be 84.29% and 83.18% respectively as determined by dividing 365 days by the actual calving interval.

Maoli et al (1964) used the formula reported by Wilcox et al (1957) and observed the average breeding efficiency of Brown Alpines, Dutch Friesians and crossbreds between the two breeds to be 93.0%, 106.0% and 90.0% respectively.

Dutt and Desai (1965) observed the average breeding efficiency of Gangatiri cows graded to Hariana as 63.5% using the formula reported by Wilcox et al (1957). Animals which completed 2, 3, 4, 5, 6 and 7 lactations were found to have 49.6%, 50.8%, 58.7%, 68.2%, 71.7% and 66.9% breeding efficiency respectively.

Tomar (1965) evolved a formula for working out the breeding efficiency in Zebu cows. The breeding efficiency of a female expressed as a percentage is given by the formula

$$\frac{[n\ (365) + 1020]\ 100}{AC + Ci}$$

where n was the number of calving intervals, AC was age at first calving and Ci was the sum of the calving intervals in days.

Heritability estimates of breeding efficiency

Spielman and Jones (1939) reported a significant correlation ($r = 0.546 \pm 0.118$) between the reproductive efficiency of the foundation cows and the mean reproductive efficiency of their female descendants.

Tabler et al (1951) observed no significant variation in breeding efficiency in 19 Ayrshire cow families studied by them.

Wilcox *et al* (1957) obtained a heritability estimate of 0.32 for breeding efficiency by intra-sire regression of offspring on dam in a *Holstein-Friesian* herd.

Inter-relationship of breeding efficiency with longevity of fertility

Spielman and Jones (1939) reported a significant correlation ($r = 0.804 \pm 0.026$) between breeding efficiency and the probable number of successful gestations of a cow.

Wilcox *et al* (1957) reported that the correlation between breeding efficiency and longevity as measured by the successful parturitions of a cow was close to zero.

Inter-relationship of breeding efficiency with age at first calving

Dutt and Desai (1965) observed the breeding efficiency to be high in early calvers than in late calvers.

Gautam *et al* (1966) observed that age at first calving and breeding efficiency were not related to each other in *Hariana* cows but were influenced by individuality. However, it was significantly superior in cows calving at an age of 33-36 months.

Inter-relationship of breeding efficiency with milk production

Gaines (1927) studied 4671 records from the *Guernsey*

herd register and found a low correlation (r = 0.039) between the level of milk yield and length of service period. He found that maximum level of milk secretion was not antogonistic to the recurrence of conception.

Eckles (1929) observed the herd at the University of Minnesota over a period of 29 years and found no relationship between the level of production of the cow and conception rate or development of sterility.

Clapp (1937) believed that high milk production might inhibit the oestrous cycle rather than prevent conception following mating and that cows milked twice daily came into heat after calving 23 days earlier on an average than did cows milked four times daily.

Espe (1946) reported that lactation tended to supress the normal functioning of the bovine ovary.

Boyd et al (1954) in an analysis of 29 herds serviced by the Kentucky artificial breeding association found low correlation (r = 0.04) between the level of milk production and services to conception. The intra-herd correlation coefficient between the two variables indicated an erratic relationship.

Carman (1955) found a significant correlation between

the level of milk production in the previous lactation and the onset of oestrus during the following lactation. Current lactation production level significantly influenced days to conception, but not days to first oestrus. He concluded that demands of high milk production on the blood circulatory system affected the breeding performance of the individual.

Singh (1961) reported positive significant correlation between services per conception and 150 day milk yield of the current lactation. But the genetic correlation between the two was insignificant (rg = -0.116) indicating thereby that services to conception and 150 days milk yield were not genetically correlated to a considerable degree.

Dutt and Desai (1965) reported that the milk producing ability of an animal was found to have no significant effect on its breeding efficiency.

Calving interval

Sanders (1927) reported the average calving interval for *Bos taurus* cows to be about 365 days. He stated that the average weekly milk yields were markedly depressed either by a too short, or a too long calving interval and suggested that for attaining maximum milk yields cows should not be allowed to calve at intervals of less than a year.

Gaines and Palfrey (1931) reported the average calving interval in Red Danish cows (Bos taurus) to be 401 days, but with a mode of 350-370 days.

Joseph and Dave (1931) reported the average calving interval in Sahiwal cows to be 448 days and this period was found to be enhanced by about 25% when the calves were allowed to suckle their dams. The interval between calvings was not affected by the season of calving.

Sikka (1931) reported the average calving interval in Sahiwal (Zebu) cows to be 13½ months.

Kartha (1934) reported the average calving interval of the ordinary village cow (Zebu) as 700 days, whereas, at the Government farms it was reported to be between 450-501 days.

Sayer (1934) demonstrated that with special feeding and handling the service period in the Pusa Pedigree Sahiwal herd could be reduced from 172 to 90 days.

Maule (1953) while reviewing the crossbreeding experiments in the tropics observed an increase in calving interval when Friesian blood increased above 50%.

Stonaker et al (1953) reported an increase of calving interval with increase in Sindhi inheritance in crossbred

Jersey x Sindhi cows, but the differences were not significant. Calving interval of various percentages of Jersey inheritance were reported as follows :

	Calving interval (months)	Check group Red Sindhi
3/4 Jersey	12.4	18.2*
1/2 Jersey	13.8	14.2 NS
1/4 Jersey	16.0	17.0 NS
1/8 Jersey	17.1	17.4 NS
1/16 Jersey	17.9	16.9 NS

* Significant at 5% level
NS - Not significant

Khishin and El-Issawi (1954) reported the average calving interval for Jersey, 1/2, 3/4 and 1/8 Jerseys grades to be 384, 363, 359 and 383 days respectively.

Amble et al (1958) reported the average calving interval between the first two calvings for 5 different Indian breeds of cattle under farm conditions as follows :

Breed	Average inter-calving period (months)
Red Sindhi (Hosur)	18.0
Red Sindhi (Bangalore)	14.7
Kangayam	16.7

Breed	Average inter-calving period (months)
Gir	15.7
Kankrej	16.2
Tharparkar	14.8

Singh (1958) reported the 1st, 2nd and 3rd calving intervals in Tharparkar cattle to be on an average 457.9, 441.1 and 411.1 days. Significant influence of the calving sequence on the length of the calving interval was observed by him.

Singh et al (1958) reported the average calving interval for the Hariana cows to be 484 ± 4.8 days. These authors observed a significant influence of the season as well as of the sequence of calving on the length of the intercalving period. Animals which calved in the months of May and June had the highest calving interval of 514 ± 10.67 days, while those calving from July to November had the lowest intercalving period of 464 ± 6.67 days. The differences in the intercalving period in different seasons and months were stated to be due to environmental factors like climate and nutrition.

Dhandapani (1962) in crosses of Jersey cows x Red Sindhi bulls and subsequent backcrosses to Red Sindhi reported the average calving interval to be almost constant at 13.05-13.5

months in over 5 generations of backcrossing.

Mahadevan and Hutchinson (1964) reported the average calving interval of 1/4, 1/2 and 3/4 Bos taurus to be 420, 428 and 486 days respectively. They found that increasing the exotic blood tended to lower the reproductive efficiency.

Mahadevan (1966) summarised the calving intervals of 12 breeds of cattle in the tropics as follows.

Calving intervals in twelve herds of cattle in the tropics

Breed	Location	Calving interval (days)	Reference
Red Sindhi	Karnal (India)	437	India NDRI 1961
Sahiwal	Karnal (India)	460	India NDRI 1961
Tharparkar	Karnal (India)	441	India NDRI 1961
Kenana	Wad Medani (Sudan)	395	Alim, 1960
Butana	Atbara (Sudan)	416	Alim, 1962
Native Egyptian	El-Sirw and Gemizah (Egypt)	419	Asker et al, 1958
White Fulani	Accra (Ghana)	408	Turtur, 1962
Nganda	Entebbe (Uganda)	420	Mahadevan and Marples, 1961
Boran and Jiddu	Tanga (Tanganyika)	382	Mahadevan and Hutchinson, 1964

Breed	Location	Calving interval (days)	Reference
Sahiwal Grade	Western Kenya	388	Mahadevan et al, 1962
European and African Crossbred	Tanga (Tanganyika)	432	Mahadevan and Hutchinson, 1964
European	Bopatalawa and Ambawela (Ceylon)	466	Mahadevan, 1956

The author is of the opinion that there is considerable room for improvement in reproductive efficiency in the top dairy herds in the tropics and that this improvement could be achieved by the use of high energy concentrate feeds and mineral supplements to improve the fertility and yield of the dairy animals during the grazing period.

Rao (1966) reported the average length of the calving interval in Ongole cows to be 531.25 days.

Bhashin and Desai (1967) reported the calving interval of Friesian x Sahiwal and 3/4 Friesian x Hariana cows to be 404 and 428 days respectively.

Age at first calving

Eckles (1920) cited by Hammond (1927) reported the

average age at first calving for Bos taurus breeds of cattle based on the information obtained from the breeders to be 23, 26, 27 and 29 months for Jerseys, Guernsey, Friesian and Ayrshire respectively.

Hammond (1927) observed the average age at puberty of Bos taurus cows to be about 9 months. This age varied considerably with the breed and nutrition given. Well fed animals came into heat earlier than poorly fed ones. Both breed and feed were stated to affect the rate of maturing of the animal.

Littlewood (1933) found that average age at first calving of 23 F_1, 27 F_2, 12 F_3 and 2 F_4 Ayrshire x Red Sindhi crosses was 32, 36, 38 and 36 months respectively.

Sayer (1936) based on his experiments for early maturity in Sahiwal (Bos indicus) cows reported that the age at first calving in these animals could be reduced by good feeding and management.

Fohrman et al (1951) observed the age at first calving in crossbred Jersey-Sindhi heifers as one year eleven months to two years two months.

Tandon (1951) analysed the data relating to Red Sindhi and Sahiwal cows and their crosses with Holstein-Friesian

bulls from selected military dairy farms in India for differences in age at first calving. Sindhi crosses were reported to calve earlier than Sahiwal crosses. Early maturity of Friesians (Bos taurus) was considered to be dominant over late maturity of Red Sindhi and Sahiwal cows (Bos indicus). He postulated that age at first calving has threshold expression and the genes for early maturity are dominant over late maturity.

Joshi and Phillips (1953) stated that in most Zebu breeds of cattle heifers usually calve when they are over 40 months of age.

Mahadevan (1953) stated that it should be possible to lower the age at first calving in Zebu cows by good feeding and management.

Maule (1953) while reviewing the crossbreeding experiments in the tropics observed an increase in age at maturity when Friesian blood increases above 50%.

Stonaker et al (1953) observed that the age at first calving in Sindhi cows appeared to be greatly decreased by the introduction of Jersey genes. The greater the relationship to Jersey, the younger was the comparative age at first calving. The average age at first calving for various concentrations of Jersey blood as compared with pure Red Sindhi was as follows.

	Months	Check group Red Sindhi (months)	Significance
3/4 Jersey	31	47	1%
1/2 Jersey	29	49	1%
1/4 Jersey	36	40	1%
1/8 Jersey	39	43	1%
1/16 Jersey	41	36	Not significant

Khishin and El-Issawi (1954) observed the average age at first calving as 28.4, 32.4, 28.9 and 26.7 months respectively for Jersey, 1/2, 3/4 and 7/8 Jersey grades in Egypt.

Sundaresan et al (1954) were of the opinion that the European breeds of cattle came into heat early, and generally a few heat periods elapsed before they reach the age at 1st breeding while the Indian cattle were usually more than 36 months of age at first heat and were bred during first heat. According to these authors, the age at first calving in European cattle was a matter of managemental practice, whereas in Indian cattle the age at first calving was a consequence of age at first heat period, a physiological and probably a hereditary trait.

Sundaresan (1955) reported the average age at first calving for Red Sindhis at Allahabad Agricultural Institute to be 3.24 years Vs. 2.73 years for Jersey x Red Sindhi.

Mahadevan (1956) reported the average age at first calving in European breeds of cattle comprising of Ayrshires, Friesians, Short Horns and Red Polls to be 40-41 months and 30 months in Jerseys under the conditions in Ceylon.

Amble et al (1958) reported the average age at first calving for 5 Indian breeds of cattle as follows.

Breeds	Average age at first calving (months)
Red Sindhi	41.7
Kangayam	44.1
Gir	47.0
Kankrej	47.4
Tharparkar	49.4

Mahadevan and Hutchinson (1964) reported superiority of crossbreds (Bos taurus x Bos indicus) over Zebu by 2.5 months on an average in age at first calving.

Naidu and Desai (1965) observed that the average age at first calving in Holstein-Friesian x Sahiwal crosses denoted a decreasing trend of age at first calving as the Holstein-Friesian level reached to 16-19/32 and then showed an increasing trend along with the increase in the Friesian blood level. The overall average age at first calving of

the grades of different levels of Holstein-Friesian inheritance was reported by them to be 36.5 and 36.3 months in northern and southern regions of India respectively.

Mahadevan (1966) summarised the available information on age at first calving in Indian, African, ~~and~~ European and crossbred cattle in the tropics as follows.

Age at first calving in Indian, African, European and crossbred cattle in the tropics

Breed	Location	First calving age (months)	Reference
Red Sindhi	Kuala Lumpur (Malaya)	38.0	Malaya Min. Agric. Coop., 1962
"	Karnal (India)	42.9	India NDRI, 1961
"	Hosur and Bangalore (India)	41.7	Amble et al, 1958
Sahiwal	Karnal (India)	42.8	India NDRI, 1961
"	Kanke (India)	41.1	Singh and Choudary, 1961
Tharparkar	Karnal (India)	43.8	India NDRI 1961
"	Kanke (India)	43.2	Singh and Choudary, 1961
Hariana	Mathura (India)	46.7	Singh and Desai, 1961

Breed	Location	First calving age (months)	Reference
Hariana	Hissar (India)	59.3	Kohli et al, 1961
Kenana	Wad Medani (Sudan)	38.4	Alim, 1960
Butana	Athara (Sudan)	44.0	Alim, 1962
Native Egyptian	El-Sirw and Gemizah (Egypt)	44.3	Asker et al, 1958
Nganda	Enteloebe (Uganda)	42.0	Mahadevan and Marples, 1961
Small East African Zebu	Western Kenya	42.7	Galukande et al, 1962
Boran and Jiddu	Tanga (Tanganyika)	39.9	Mahadevan and Hutchinson, 1964
Indian x African	Western Kenya	42.3	Mahadevan et al, 1962
European x African	Tanga (Tanganyika)	37.4	Mahadevan and Hutchinson, 1964
European	Bopatalawa and Ambawela (Ceylon)	40.0	Mahadevan, 1956

According to Mahadevan (1966) irrespective of the fact whether the cattle were Indian, African, European or crossbreds, the mean age at first calving of cattle in the tropics varied from about 3-4 years. Bos taurus and crossbred

cattle had an age at first calving in the tropics not significantly different from that of Bos indicus cattle. The attainment of an early age at first calving in the tropics demanded an improvement in the level of husbandry which appeared to be difficult to maintain over long periods of time with a large number of animals.

Rao (1966) reported that the average age at first calving in Ongole breed of cattle on a Government farm to be 42.3 months.

Heritability of age at first calving

Stonaker (1953) reported that the heritability of age at first calving in a population of crossbred, backcross and Red Sindhi cattle at Allahabad to be 0.39.

Amble et al (1958) reported the estimates of heritability of age at first calving for 5 Indian breeds of cattle under farm conditions as follows :

Breed	Heritability coefficient
Red Sindhi (Hosur)	-0.09
Red Sindhi (Bangalore)	0.16
Kangayam	-0.08
Gir	-1.24
Kankrej	0.66
Tharparkar	0.48

Singh and Desai (1961) reported the heritability of age at first calving in Hariana cattle in U.P. State farms to be ranging from 0.34 to 0.40.

Batra and Desai (1964) reported the heritability of age at first calving in Sahiwal cows to be 0.504 ± 0.194.

Naidu and Desai (1965) observed the heritability estimate of age at first calving in 4-15/32 Friesian x Sahiwal cows to be 0.113 ± 0.02 in farms situated in the Northern region of India while in the farms in the Southern region it ranged from -0.13 to 0.13.

Doss and Bhatnagar (1967) reported the heritability of age at first calving in Tharparkar cows maintained at Karnal to be 0.213 ± 0.088.

MATERIALS AND METHODS

The data used in the present study were obtained from the records of the Government Livestock Farm, Chinthaladeevi in respect of Ongole cows and from Jersey Crossbreeding Station, Vishakapatnam in respect of Zebu-Jersey crossbred cows. Both these places are situated in Andhra Pradesh.

The Government Livestock Farm, Chinthaladeevi was originally started in the year 1918 as an Agricultural-cum-Livestock Research Station and was maintaining a foundation stock of Ongole cows. New animals were purchased periodically from the Ongole tract and added to the herd during the course of the years. This farm is now under the control of the Animal Husbandry Department and the main aim of this farm at present is to provide male stock for improvement of rural cattle. Natural service is practiced as the breeding method in this farm.

The Jersey crossbreeding station was established in the year 1955 as a part of planned research-cum-development programme sponsored by the Indian Council of Agricultural Research for improvement of milk potentialities in the local non-descript Zebu cows by the introduction of Taurus blood. Upto 1963, Jersey semen required for artificial insemination at this centre was flown from Bangalore, but subsequently, it

was being supplied by a semen collection centre established locally.

Information on the following points on Ongole cows was obtained :

1. Date of birth
2. Sire and dam of the animal
3. Date of first and subsequent calvings
4. Milk yield
5. Lactation period
6. Dry period

With respect to crossbred animals information was available only on the following points.

1. Date of birth
2. Sire and dam
3. Date of first and subsequent calvings.

The particulars regarding milk production, lactation and dry periods were not available systematically as the livestock owners were selling away the animals to areas outside the scheme.

In all 306 Ongole and 117 crossbred cows were available for the study. The records for the Ongole cows extended over the period from 1923-1965 for 42 years whereas those of

crossbreds extended from 1957-1963. Only normal calvings and lactation records were used in this study. All calvings or lactation records that were affected by disease or otherwise abnormal were excluded from the analysis.

Managerial practices

As the Ongole cows utilised in this study belonged to the Government Livestock Farm, the feeding and management practices for these animals were based on approved methods. Heifers were mated at the first heat-period. The cows were allowed to suckle their calves and were milked twice daily. Cows were rebred at first heat after 60 days after parturition.

The crossbred cows used in this study belonged to an average stock owner who had little knowledge about the scientific methods of feeding. The managerial practices for these animals were in accordance with what an average stock owner could provide and was in accordance with the traditionally accepted methods of feeding and management of livestock. Roughages formed the main ingredient of the cattle feed. The nutritional status of these animals was generally substandard as adjudged from the established scientific standards.

METHODS

The breeding efficiency of the individual animals was calculated according to the formula described by Wilcox et al (1957).

$$\text{Breeding efficiency} = \frac{365 \times (n-1) \times 100}{D}$$

where n = total number of calvings

D = number of days from first to last calving

The breeding efficiency was calculated for those animals which had completed at least 3 calvings, i.e. having at least 2 calving intervals, so as to reduce the bias coming due to 2 calvings alone.

The heritability of breeding efficiency was determined by two methods i.e. paternal half-sib correlation and intra-sire regression of offspring on dam in Ongole cows but in crossbred animals it was estimated by one method only i.e. the paternal half-sib correlation.

The inter-relationship of breeding efficiency with (1) age at 1st calving, (2) first lactation total milk yield, (3) average milk yield per lactation, (4) average daily milk yield during the 1st calving interval, (5) overall average yield per day, (6) number of lactations completed, was estimated in Ongole cows. In crossbred cows, however, the inter-relationship of breeding efficiency with (1) age at first calving, (2) number of lactations completed could be studied.

The influence of the season on the breeding efficiency was determined in Ongole cows only as the data available for

the crossbreds was small. The month of calving and subsequent intercalving period was calculated for each animal and the influence of the season on this measure of breeding efficiency was ascertained.

The calving sequence and its influence on the length of the calving interval was determined both in Ongole and in Zebu-Jersey crossbreds.

The age at first calving and its heritability was estimated in Ongole and in crossbred animals.

For statistical treatment of data, the standard methods given in Snedecor (1956) and Kempthorne (1957) were followed.

RESULTS

Breeding efficiency

Statistics

The averages of breeding efficiency of Ongole and Zebu-Jersey crossbred cows are presented in Table 1 with their ranges, standard deviations, standard errors, coefficients of variation and standard error percentages.

Table 1

Average mean breeding efficiency (%) in Ongole and crossbreds

Breed	No. of animals	Range	Average	S.D.	S.E.	C.V. %	S.E. %
Ongole	306	42.7-109.2	74.9	13.6	0.7	18.1	1.2
Crossbreds	62	41.1-92.9	70.0	11.6	1.4	16.5	2.0

The average breeding efficiency of Ongole cows was found to be 74.9%, while that of crossbred cows to be 70.0%, and was higher in Ongole cows than in the crossbreds. The maximum level of breeding efficiency attainable in Ongole

was 109.2%, whereas in the crossbreds it was 92.9%. The coefficients of variation were found to be almost of the same order both in Ongole and crossbred cows, the values being 13.6% and 11.6% respectively.

Influence of the sire

To study the influence of the sires on the breeding efficiency of their daughters, the data were divided into 33 sire groups in Ongole and 5 sire groups in crossbred animals. The results are presented in Tables 2 and 3.

Table 2

Sirewise means of breeding efficiency (%) in Ongole

Sire No. or name	No. of half-sibs	Range	Mean	Deviation from farm mean
G	11	55.5-89.7	73.7	-1.2
O_1	12	63.3-84.3	76.5	+1.6
O_4	14	62.2-98.4	80.5	+5.6
9	4	67.2-93.5	80.7	+5.8
12	4	72.0-100.1	88.7	+13.8
26	3	61.4-87.4	74.0	-0.9
31	4	76.5-87.6	81.5	+6.6

Table 2 (contd)

Sire No. or name	No. of half-sibs	Range	Mean	Deviation from farm mean
125	8	52.9-83.2	71.8	-3.1
148	4	57.8-74.1	67.0	-7.9
164	6	51.3-80.7	59.6	-15.3
174	3	45.5-74.5	60.3	-14.6
182	9	52.9-74.0	62.7	-12.2
213	3	72.0-89.0	79.0	+4.1
224	4	66.0-85.7	75.7	+0.8
225	7	51.0-88.3	67.7	-7.2
226	3	51.1-64.8	58.6	-16.3
249	4	60.5-87.5	73.0	-1.9
298	7	49.2-94.6	69.4	-5.5
315	10	52.0-89.9	67.6	-7.6
324	7	61.9-86.5	74.4	-0.5
336	4	45.8-77.6	63.0	-11.9
362	3	69.7-87.9	76.6	+1.7
399	3	78.7-82.0	80.0	+5.1
417	6	59.3-78.2	70.1	-4.8
428	13	55.7-90.6	75.9	+1.0
444	3	42.7-95.4	75.6	+0.7
449	3	65.2-89.6	76.3	+1.4

Table 2 (contd)

Sire No. or name	No. of half-sibs	Range	Mean	Deviation from farm mean
502	5	42.9-94.9	69.4	-5.5
511	5	62.2-109.2	86.4	+11.5
524	19	56.8-96.8	83.0	+8.1
574	12	58.2-93.7	76.5	+1.6
583	7	56.2-104.8	79.2	+4.3
625	13	63.1-100.4	86.4	+11.5
Total	223	42.7-109.2	75.0	+0.1
Overall	306	42.7-109.2	74.9	-

Table 3

Sirewise means of breeding efficiency (%) in crossbreds

Sire No. or name	No. of half-sibs	Range	Mean	Deviation from the overall mean
BA	27	41.1-89.4	67.4	-2.6
RT	15	42.9-87.5	70.4	+0.4
PH	3	68.0-74.2	70.3	+0.3
SR	8	59.9-85.2	73.1	+3.1
AN	9	57.2-92.9	74.0	+4.0
Overall	62	41.1-92.9	70.0	-

The number of offspring under various sire groups in Ongole breed ranged from 3 to 19 half-sibs while in crossbreds it ranged from 3 to 27. The variation in the average breeding efficiency among the different sire groups ranged from 60.3% to 88.7% in Ongole and from 67.4% to 74.0% in crossbred animals.

The results of analysis of variance to test the differences in the averages of breeding efficiency between the various sire groups are presented in Table 4.

Table 4

Analysis of variance (breeding efficiency)

Breed	Source of variation	D.F.	S.S.	M.S.
	Between sires	32	11984.0	374.5**
Ongole	Within sires	190	26239.5	138.1
	Total	222	38223.5	
	** $P < 0.01$			
	$\bar{K}$ (Average No. of progeny per sire) = 6.68			
	Between sires	4	396.0	99.0 NS
Crossbreds	Within sires	57	7838.0	137.5
	Total	61	8234.0	
	NS - Not significant			
	$\bar{K}$ (Average No. of progeny per sire) = 11.00			

The differences in the averages of breeding efficiency between the different sire groups were found to be highly significant in Ongole, but not in crossbred animals.

The heritability estimates of breeding efficiency estimated by the method of paternal half-sib correlation are presented in Table 5.

Table 5

Heritability estimates of breeding efficiency

Breed	No. of half-sibs	No. of sires	Heritability estimate	Standard error of the heritability estimate
Ongole	223	33	0.81	0.34
Crossbreds	62	5	-0.10	0.16

The heritability estimate of breeding efficiency in Ongole breed was found to be 0.81 ± 0.34 whereas, in crossbreds, it was found to be negative and was -0.10 ± 0.16.

The data on Ongole cows yielded 87 dam-daughter comparisons of breeding efficiency. The mean breeding

efficiency for dams was found to be 72.2%, while that of daughters to be 73.5%.

The results of analysis of covariance of breeding efficiency for dam-daughter pairs are presented in Table 6.

Table 6

Covariance analysis of breeding efficiency for dams (X) and daughters (Y) in Ongole

Source of variation	D.F.	$M.S._X$	$M.P._{XY}$	$M.S._Y$	Coefficient of regression of Y on X
Between sires	17	312.7	7.2	371.4	
					b = 0.259±0.120
Within sires	69	133.2	35.6	152.2	

$h^2 = 0.518 \pm 0.240$

It will be observed from Table 6 that the intra-sire regression coefficient of offspring on dam for breeding efficiency was found to be 0.259 ± 0.120. The heritability estimate of breeding efficiency estimated by doubling the intra-sire regression coefficient of offspring on dam was found to be 0.518 ± 0.240.

Influence of age at first calving on breeding efficiency

To study the influence of age of cows at first calving on their breeding efficiency the data were divided into 8 age groups on the basis of their age at first calving with a class interval of 100 days. The youngest age group included all the animals calving upto 900 days whereas, the oldest group included all those calving above 1501 days.

The averages of breeding efficiency of the various age groups with their standard deviations, standard errors, coefficients of variation and standard error percentages separately for Ongole and crossbred animals are presented in Tables 7 and 8 and it is graphically represented in Fig. 1.

Table 7

Age at first calving and breeding efficiency (%) in Ongole

Age at first calving in days (Groups)	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
Upto 900	10	74.8	19.7	6.2	26.3	8.2
901-1000	25	79.6	16.2	3.2	20.3	4.0
1001-1100	50	76.3	12.1	1.7	15.8	2.2
1101-1200	75	73.8	11.6	1.3	15.7	1.7
1201-1300	56	69.8	14.3	1.9	20.4	2.7

Table 7 (contd)

Age at first calving in days (Groups)	No. of obser-vations	Average	S.D.	S.E.	C.V. %	S.E. %
1301-1400	44	76.3	13.4	2.0	17.5	2.6
1401-1500	23	76.1	14.3	2.9	18.7	3.8
1501 & above	23	78.5	11.6	2.7	14.7	3.4
Overall	306	74.9	13.6	0.7	18.1	0.9

Table 8

Age at first calving and breeding efficiency (%) in crossbreds

Age at first calving in days (Groups)	No. of obser-vations	Average	S.D.	S.E.	C.V. %	S.E. %
Upto 900	11	75.2	12.4	3.2	16.4	4.2
901-1000	2	72.5	3.6	2.5	4.9	3.4
1001-1100	10	70.4	9.3	2.9	13.2	4.1
1101-1200	8	67.0	13.6	4.8	20.2	7.1
1201-1300	5	61.8	7.6	3.4	12.2	5.5
1301-1400	9	68.1	14.3	4.7	20.9	6.9
1401-1500	7	66.5	11.4	4.3	17.1	6.4
1501 & above	10	73.7	10.1	3.3	13.7	4.4
Overall	62	70.0	11.6	1.4	16.5	2.0

It will be observed from Tables 7 and 8 that in Ongole cows the maximum breeding efficiency of 79.6% was found to be associated with cows calving in the age group of 901-1000 days whereas in crossbred cows the maximum breeding efficiency was noticeable in the cows calving below 901 days of age.

The results of analysis of variance to test for the differences in the averages of breeding efficiency in the various age groups are presented in Table 9.

Table 9

Analysis of variance (breeding efficiency)

Breed	Source of variation	D.F.	S.S.	M.S.
Ongole	Between age groups	7	2609.0	372.7*
	Within age groups	298	53591.0	179.8
	Total	305	56200.0	
Crossbreds	Between age groups	7	988.0	141.1 NS
	Within age groups	54	7246.0	134.1
	Total	61	8234.0	

*P < 0.05

NS - Not significant

It will be observed from Table 9 that the differences in the averages of breeding efficiency among the various age groups were significant at 5% level of significance in Ongole cows, whereas, it was not found to be significant in crossbred cows.

Since the differences in the average breeding efficiency between the different age groups were significant in Ongole cows, critical differences were calculated to find out which age group was significantly superior to the other in breeding efficiency. The results are presented in Table 10.

It will be observed from the table of critical differences that cows calving in the age group of 1201-1300 days were having the lowest breeding efficiency of 69.8% and the breeding efficiency of this group was significantly different from the breeding efficiency of the animals calving either at a lower or higher age than this group.

The graph presented in Fig. 1 will reveal that the influence of age at first calving on breeding efficiency was not regular in as much as those calving at an earlier age showed a higher breeding efficiency while those calving at later ages also showed a higher breeding efficiency, the intermediary age groups being found to have comparatively low breeding efficiency.

Table 10

Critical difference test in Ongole using bar notation
(breeding efficiency)

	Age at first calving (days) groups							
	901-1000	1501 & above	1001-1100	1301-1400	1401-1500	Upto 900	1101-1200	1201-1300
Mean (%)	79.6	78.5	76.3	76.3	76.1	74.8	73.8	69.8

The trend of the influence of age at first calving on breeding efficiency both in Ongole and crossbred cows was, however, the same in that the animals calving in the age group around 900 days had a higher breeding efficiency which gradually declined as the age at first calving increased to a level of 1201-1300 days. In later age groups, the breeding efficiency again showed an upward trend.

Early age at first calving around 900 days in Ongole as well as in crossbred animals was not found to be detrimental to the future breeding efficiency of the animals.

The phenotypic (intra-sire) genetic and environmental correlations between age at first calving and breeding efficiency in Ongole and only the phenotypic correlation between the two traits in crossbred cows are presented in Table 11. It was not possible to obtain estimates of genetic and environmental correlations between these two traits in crossbred cows, since the sire component was negative.

It will be observed from Table 11 that the phenotypic correlation coefficients between the age at first calving and breeding efficiency in Ongole and crossbred cows were +0.039 and -0.060 respectively. These values could be taken to be nearly zero.

Table 11

Phenotypic, genetic and environmental correlations between age at first calving and breeding efficiency in Ongole and crossbreds

Breed	Type of correlation	D.F.	Value
	Phenotypic (intra-sire)	190	+0.039
Ongole	Genetic	32	-0.258 ±0.271
	Environmental	190	+1.100
Crossbreds	Phenotypic	60	-0.060

The genetic correlation coefficient between the two traits in Ongole cows was -0.258 ± 0.271 and the environmental correlation was found to be 1.1. Though there was an indication that the breeding efficiency was negatively associated with the age at first calving, not much reliance could be placed on this as the estimate of standard error of the correlation was high.

Influence of milk yield on breeding efficiency

As the data on milk production was not available in crossbred animals, the studies of the influence of milk

production on breeding efficiency was limited to the Ongole breed.

Total milk yield in first lactation

To study the influence of the total milk yield in the first lactation on the breeding efficiency of cows, the data were classified into 5 groups, on the basis of total milk yield in the first lactation with a class interval of 500 kg. The averages of breeding efficiency of the different milk yield groups are presented in Table 12 with their standard deviations, standard errors, coefficients of variations and S.E. percentages.

Table 12

First lactation total milk yield and breeding efficiency (%) in Ongole

First lactation milk yield groups (kg)	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
Upto 500	15	77.2	14.7	3.8	19.0	4.9
501-1000	64	71.7	14.0	1.7	19.5	2.3
1001-1500	103	76.1	11.8	1.1	15.5	1.4
1501-2000	33	75.9	12.0	2.0	15.8	2.6
2001& above	8	79.3	14.7	5.2	18.5	6.5

It will be observed from Table 12 that high milk yields in first lactation were not antogonistic to the attainment of high breeding efficiency in the future life of the animal.

The results of analysis of variance to test the differences in the averages of breeding efficiency among the various milk yield groups are presented in Table 13.

Table 13

Analysis of variance (breeding efficiency in Ongole)

Source of variation	D.F.	S.S.	M.S.
Between milk yield groups	4	1095.0	273.5 NS
Within groups	218	36129.0	165.7
Total	222	46224.0	

NS - Not significant

It will be observed from Table 13 that the differences in the average breeding efficiency of the various milk yield groups were not significant.

Influence of average milk yield per lactation on the breeding efficiency

To study the influence of average milk yield per lactation on breeding efficiency the data was arranged into 4 groups on the basis of average milk yield per lactation with a class interval of 500 kg. The results are presented in Table 14.

Table 14

Breeding efficiency (%) in Ongole classified into milk yield groups

Average milk yield per lactation in kg (groups)	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
501-1000	69	72.7	13.2	1.6	18.1	2.0
1001-1500	72	76.0	13.0	1.5	17.1	1.9
1501-2000	29	70.4	12.4	2.3	17.4	3.2
2001 & above	4	81.5	5.8	2.9	7.1	3.5

It will be once again seen from the table that a high average milk yield per lactation was not detrimental to the high breeding efficiency of an animal. Cows yielding low quantities of milk were not found to be superior in breeding

efficiency in comparison to the cows yielding high quantities of milk.

The results of analysis of variance to test the differences in the averages of breeding efficiency in the various milk yield groups are presented in Table 15.

Table 15

Analysis of variance (breeding efficiency) in Ongole

Source of variation	D.F.	S.S.	M.S.
Between milk yield groups	2	772.0	386.0 NS
Within groups	167	29253.0	175.1

NS - Not significant

It will be observed from the table that the differences between the various groups were not found to be significant.

The phenotypic correlation coefficients between breeding efficiency and total milk yield in the first lactation and average milk yield per lactation are presented in Table 16.

Table 16

Phenotypic correlations between breeding efficiency and milk production in Ongole

Trait	D.F.	Value
Breeding efficiency and 1st lactation total milk yield	190	+0.01
Breeding efficiency and average milk yield per lactation	172	+0.08

The correlation coefficients between breeding efficiency and first lactation total milk yield and average milk yield per lactation were found to be 0.01 and 0.08 respectively. These results indicated that the level of first lactation total milk or the average yield per lactation were not having any influence on the breeding efficiency of the animal.

The graph showing the relationship between the breeding efficiency and first lactation total milk yield and average milk yield per lactation is presented in Fig. 2.

It will be seen from Fig. 2 that the association between

the level of milk production taken either as the total milk yield in first lactation or as an average yield per lactation and breeding efficiency was not steady.

Relationship between the average milk yield per day during the first calving interval and breeding efficiency

To study the relationship between the average milk yield per day during the first calving interval and the breeding efficiency, the daily average production during the first calving interval was correlated with the breeding efficiency of the animal. The results are presented in Table 17.

Table 17

Phenotypic, genetic and environmental correlations between breeding efficiency and average milk yield per day during the 1st calving interval in Ongole

Type of correlation	D.F.	Value
Phenotypic (intra-sire)	190	+0.340
Genetic	32	+0.530±0.239
Environmental	190	+0.440

It will be observed from Table 17 that the milk yield per day during the first calving interval was fairly highly positively correlated with the breeding efficiency. The genetic and environmental correlations were positive and fairly high.

Relationship between overall daily milk production and breeding efficiency

To study the relationship between the overall daily average milk production and breeding efficiency correlation coefficients were calculated between average daily milk production and the breeding efficiency. This was done lactation-wise. The results are presented in Table 18.

Table 18

Phenotypic correlations between breeding efficiency and overall daily average milk production in Ongole

No. of lactations	No. of animals	Daily average milk production	Average breeding efficiency (%)	Correlation coefficient
2	72	2.07	76.20	0.43**
3	50	2.21	73.50	0.41**
4	35	2.40	73.00	0.32 NS
5	26	2.30	76.30	0.34 NS
6	11	2.21	76.20	0.23 NS

** $P < 0.01$; NS - Not significant

It will be observed from Table 18 that the daily average milk production was significantly correlated with the breeding efficiency upto 2nd and 3rd lactations but over the 4th, 5th and 6th lactations the daily average milk production was not significantly correlated.

The general indication was that the average daily milk production increased upto 6th lactation as the breeding efficiency increased.

To study further the inter-relationship between the daily average milk production and breeding efficiency the data were grouped into classes with a class interval of 10% breeding efficiency and the average daily milk production for the different groups was estimated. The results are presented in Table 19.

Table 19

Breeding efficiency in percentage and overall daily average milk production in Ongole

Breeding efficiency (%)	No. of observations	Overall daily average milk production (kg)
41-50	4	1.47
51-60	28	1.65
61-70	42	1.95

Table 19 (contd)

Breeding efficiency (%)	No. of observations	Overall daily average milk production (kg)
71-80	47	2.19
81-90	52	2.67
91-100	19	2.36
101 & above	2	3.20

It will be observed from Table 19 that the daily average milk production was low in animals with low breeding efficiency. High daily averages of milk production were found to occur in animals having a high breeding efficiency of 81-90% which implies that a calving interval of 405-456 days was optimum for the attainment of high daily average milk production.

Animals in the group having over 101% breeding efficiency and above which signified a calving interval of less than one year, were found to have the highest daily average milk production, but the number of observations in this group were small to draw any valid conclusion.

The graph showing the relationship between the daily average milk production and breeding efficiency is presented in Fig. 3.

It will be observed from Fig. 3 that the daily average milk production increased as the breeding efficiency increased to a level of 81-90%; but thereafter, in the level of 91-100% breeding efficiency the daily average milk production declined. It rose up again in animals having a breeding efficiency of over 101%.

Influence of the number of lactations completed on breeding efficiency

To study the influence of the number of lactations completed on breeding efficiency the data were arranged into 9 groups according to the number of lactations completed by the animals. The results are presented in Tables 20 and 21.

Table 20

No. of lactations completed and their average breeding efficiency (%) in Ongole

No. of lactations completed	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
2	91	75.7	15.4	1.6	20.3	2.1
3	75	72.8	13.3	1.5	18.2	2.0

Table 20 (contd)

No. of lactations completed	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
4	54	73.9	13.3	1.8	17.9	2.4
5	36	74.4	11.7	1.9	15.7	2.5
6	21	75.9	11.4	2.5	15.0	3.2
7	16	77.1	9.3	2.3	12.0	2.9
8	9	83.1	11.8	3.9	14.1	4.6
9	1	82.0	-	-	-	-
10	3	85.3	11.2	6.4	13.1	7.5
Overall	306	74.9	13.6	0.7	18.1	0.9

Table 21

No. of lactations completed and their average breeding efficiency (%) in crossbreds

No. of lactations completed	No. of observations	Average	S.D.	S.E.	C.V. %	S.E. %
2	38	67.7	12.6	2.0	18.6	2.9
3	17	71.2	7.1	1.7	9.9	2.3
4	5	76.2	10.1	4.4	13.2	5.8
5	1	80.0	-	-	-	-
6	1	93.0	-	-	-	-
Overall	62	70.0	11.9	1.4	17.0	2.0

It will be observed from Tables 20 and 21 that in Ongole cows the breeding efficiency was found to increase steadily starting from the group of animals that had completed 3 lactations upto the group of animals that had completed 10 lactations. This result indicated that the breeding efficiency and the number of successful lactations an animal would complete were dependent upon one another. Highest breeding efficiency of 85.3% was found to occur in animals which had completed 10 lactations. A similar trend was noticeable in the crossbred animals.

The results of analysis of variance to test the differences in the averages of breeding efficiency among the various groups are presented in Tables 22 and 23.

Table 22

Analysis of variance (breeding efficiency in Ongole)

Source of variation	D.F.	S.S.	M.S.
Between lactation groups	7	1484.0	212.0 NS
Within groups	297	54316.0	182.8
Total	304	55800.0	

NS - Not significant

Table 23

Analysis of variance (breeding efficiency in crossbreds)

Source of variation	D.F.	S.S.	M.S.
Between lactation groups	2	390.0	195.0 NS
Within groups	58	7197.0	124.0
Total	60	7587.0	

NS - Not significant

In Ongole cows, animals that had completed 8 lactations and in crossbreds that had completed 4 lactations were used for the analysis of variance test owing to the fewer number of animals in the higher groups.

It would be seen from the tables that the differences in the average breeding efficiency among the various groups were not significant.

The influence of the number of lactations completed on the breeding efficiency ~~in~~ of the animal is graphically represented in Fig. 4.

It will be observed from Fig. 4 that both in crossbreds and Ongole cows, the trend was that animals that would evince more number of lactations were also superior in their breeding efficiency.

Calving interval

The overall average length of calving interval and the average inter-calving period in relation to sequence of calving with the standard deviations, standard errors, coefficients of variation and standard error percentages separately for Ongole and crossbred cows are presented in Tables 24 and 25.

It will be seen from the tables that the average length of calving interval in Ongole cows was found to be 498.3 ± 4.3 days and 526.7 ± 11.6 days in crossbreds. The coefficient of variation was 29.5% in Ongole, while it was 27.7% in crossbred cows and found to be high in both cases. The first inter-calving periods in Ongole and crossbred cows were found to be 528.8 ± 8.5 and 565.9 ± 19.9 days in Ongole and crossbred cows respectively.

Table 24

Means of calving interval (days) in Ongole in relation to sequence of calving

Calving sequence	No. of observations	Mean	S.D.	S.E.	C.V. %	S.E. %
First	306	528.8	149.5	8.5	28.2	1.6
Second	306	492.2	139.6	7.9	28.3	1.6
Third	224	494.3	140.2	9.4	28.3	1.9
Fourth	140	476.7	150.2	12.7	31.5	2.6
Fifth	84	473.9	146.5	15.9	30.9	3.3
Sixth	49	504.3	142.3	20.3	28.2	4.0
Seventh	22	452.0	126.4	26.8	27.9	5.9
Eighth	13	448.6	100.5	27.9	22.4	6.2
Ninth	4	475.2	220.3	110.1	46.3	23.1
Tenth	3	500.0	146.0	84.3	29.2	16.8
Overall	1151	498.3	147.2	4.3	29.5	0.8

Table 25

Means of calving interval (days) in crossbreds in relation to sequence of calving

Calving sequence	No. of observations	Mean	S.D.	S.E.	C.V. %	S.E. %
1	62	565.9	156.6	19.9	27.6	3.5
2	62	516.1	142.2	18.0	27.5	3.4
3	24	476.0	95.1	19.4	19.9	4.0
4	7	505.8	93.2	35.2	18.4	6.9
5	2	410.5	26.1	18.4	6.3	4.4
6	1	357.0	-	-	-	-
Overall	158	526.7	146.2	11.6	27.7	2.2

The results of analysis of variance to test the differences in the average length of the calving interval between the different sequences of calving are presented in Tables 26 and 27.

Only calving intervals upto 8th sequence in Ongole and 4th sequence in crossbreds were considered for the analysis of variance test, owing to the limited number of observations in the higher sequences of calving.

Table 26

Analysis of variance (calving interval in Ongole)

Source of variation	D.F.	S.S.	M.S.
Between sequences	7	497080.0	71011.4**
Within sequences	1136	24210430.0	21311.9
Total	1143	24707510.0	

** $P < 0.01$

Table 27

Analysis of variance (calving interval in crossbreds)

Source of variation	D.F.	S.S.	M.S.
Between sequences	3	27797.0	9265.6 NS
Within intervals	151	2990771.0	19601.0
Total	154	3018568.0	

NS - Not significant

It will be seen from Tables 26 and 27 that the differences in the averages of calving intervals between the different calving sequences were highly significant in Ongole cows but not in crossbred cows.

As the differences in the average inter-calving period between the various sequences of calving were significant in the Ongole cows, critical differences were calculated to find out which of the sequences were significantly different from the other and the results are presented in Table 28.

It will be observed from Table 28 that the first, sixth, seventh and eighth calving intervals were significantly different from 2nd, 3rd, 4th and 5th calving intervals, while there were no differences between the other sequences.

Influence of the season on the inter-calving period

To study the influence of the season on the inter-calving period the month of calving and subsequent inter-calving period was calculated in Ongole cows in respect of 1151 calvings occurring in different months of the year and were grouped into 4 classes seasonwise and the results are presented in Tables 29, 30 and 31.

Table 28

Critical difference test in Ongole using bar notation
(calving interval)

	Sequence of calving interval							
	1	6	7	8	3	2	4	5
Mean (days)	528.8	504.3	452.0	448.6	494.3	492.2	476.7	473.9

Table 29

Means of calving interval (days) in Ongole in relation to month of calving

Month	No. of observations	Mean	S.D.	S.E.	C.V. %	S.E. %
January	107	484.8	151.6	14.6	31.2	3.0
February	110	517.7	182.1	17.3	35.1	3.3
March	98	499.8	155.2	15.6	31.0	3.1
April	88	483.3	124.7	13.3	25.8	2.7
May	101	493.0	150.7	15.0	30.5	3.0
June	74	486.9	110.0	12.7	22.5	2.6
July	87	495.7	146.5	15.7	29.5	3.1
August	84	500.7	153.3	16.7	30.6	3.3
September	101	499.9	115.1	11.4	23.0	2.2
October	98	512.5	160.1	16.1	31.2	3.1
November	95	490.7	127.2	13.0	25.9	2.6
December	108	508.5	159.7	15.3	31.4	3.0
Overall	1151	498.3	147.2	4.3	29.5	0.8

Table 30

Mean inter-calving period (days) of Ongole in relation to month of calving

	MONTHS											
	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Between 1st and 2nd calving	515.2 ±27.7 (38)	558.5 ±28.8 (31)	497.9 ±25.1 (29)	532.8 ±31.4 (25)	542.5 ±36.7 (22)	521.5 ±25.5 (18)	556.1 ±47.6 (18)	512.6 ±29.0 (21)	524.6 ±18.6 (25)	589.0 ±39.4 (23)	511.6 ±25.4 (25)	504.3 ±20.7 (31)
Between 2nd and 3rd calving	475.6 ±41.7 (20)	483.6 ±25.5 (29)	471.8 ±20.0 (31)	510.1 ±23.9 (26)	487.5 ±17.5 (29)	475.8 ±24.8 (16)	537.6 ±30.2 (24)	489.1 ±29.6 (24)	491.2 ±26.7 (17)	479.5 ±24.0 (33)	479.0 ±25.2 (30)	527.6 ±40.1 (27)
Between 3rd and 4th calving	473.6 ±25.9 (22)	508.7 ±30.6 (25)	497.4 ±59.2 (12)	428.0 ±25.4 (13)	520.3 ±51.7 (16)	496.0 ±25.0 (20)	450.1 ±22.3 (21)	510.6 ±37.7 (14)	495.7 ±21.7 (27)	511.8 ±31.1 (17)	480.1 ±31.9 (16)	545.1 ±36.4 (21)
Between 4th and 5th calving	466.4 ±40.5 (11)	521.3 ±81.3 (11)	536.0 ±50.0 (11)	429.1 ±16.5 (12)	459.7 ±42.2 (14)	429.6 ±16.6 (5)	480.5 ±29.0 (14)	443.3 ±18.6 (12)	495.0 ±42.6 (15)	561.8 ±72.6 (10)	465.0 ±33.7 (14)	422.4 ±25.9 (11)
Between 5th and 6th calving	454.4 ±20.0 (5)	608.5 ±135.8 (4)	568.4 ±99.0 (7)	432.2 ±40.7 (5)	471.8 ±57.3 (9)	408.5 ±50.6 (8)	412.2 ±34.8 (6)	424.0 ±38.2 (6)	468.6 ±25.8 (11)	459.5 ±39.8 (6)	454.2 ±32.3 (4)	515.6 ±42.1 (13)
Between 6th and 7th calving	525.2 ±81.7 (4)	596.0 ±185.3 (4)	443.0 ±51.8 (3)	433.8 ±33.0 (6)	440.8 ±31.6 (8)	422.5 ±28.5 (4)	374.0 - (1)	783.2 ±169.7 (4)	537.0 ±88.0 (4)	433.2 ±18.1 (5)	572.0 ±52.9 (3)	514.0 ±130.6 (3)

Table 30 (contd)

	MONTHS											
	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Between 7th and 8th calving	405.2 ±25.9 (4)	388.3 ±14.6 (3)	682.0 ±207.0 (2)	- -	398.5 ±43.5 (2)	- -	398.5 ±39.5 (2)	347.0 - (1)	459.0 ±42.0 (2)	426.0 ± 8.4 (3)	637.5 ±51.4 (2)	383.0 - (1)
Between 8th and 9th calving	415.6 ±44.9 (3)	393.5 ±30.5 (2)	381.5 ±48.5 (2)	474.0 - (1)	391.0 - (1)	603.0 ±124.0 (2)	-	504.0 - (1)	- -	- -	460.0 - (1)	- -
Between 9th and 10th calving	- -	394.0 - (1)	- -	- -	- -	801.0 - (1)	392.0 - (1)	- -	- -	- -	- -	314.0 - (1)
Between 10th and 11th calving	- -	- -	616.0 - (1)	- -	- -	- -	- -	548.0 - (1)	- -	336.0 - (1)	- -	- -

Figures in parenthesis denote No. of observations

Table 31

Means of calving interval (days) in relation to season of calving in Ongole

Season	No. of observations	Mean	S.D.	S.E.	C.V. %	S.E. %
Spring (February, March, April)	296	501.6	158.0	9.1	31.4	1.8
Summer (May, June, July)	262	492.2	138.2	8.5	28.0	1.7
Autumn (August, September, October)	283	504.5	143.1	8.5	28.3	1.6
Winter (November, December, January)	310	494.9	147.3	8.3	29.7	1.6
Total	1151	498.3	147.2	4.3	29.5	0.8

Such a study of the influence of season on the inter-calving period could not be made in the crossbred cows owing to the limited data. It will be seen from the tables that there were no wide fluctuations in the length of the inter-calving period depending on the month or season in which the

animals had calved. Even the distribution of the calvings was uniformly spread over all through the year ($X^2_{df\ 11}$= 13.46NS).

The results of analysis of variance to test the differences in the averages of inter-calving period between different seasons are presented in Table 32.

Table 32

Analysis of variance (calving interval in Ongole)

Source of variation	D.F.	S.S.	M.S.
Between seasons	3	27593.0	9197.6 NS
Within seasons	1147	24860407.0	21674.2
Total	1150	24888000.0	-

NS - Not significant

It will be observed from Table 32 that the differences in the inter-calving period between the four seasons were insignificant.

Age at first calving

The averages of age at first calving for Ongole and Zebu-Jersey crossbred cows are presented in Table 33 with their standard deviations, standard errors, coefficients of variation and standard error percentages.

Table 33

Averages of age at first calving (days) in Ongole and crossbreds

Breed	No. of animals	Range	Mean	S.D.	S.E.	C.V. %	S.E. %
Ongole	306	731-1719	1207.7	158.9	9.0	13.1	0.74
Crossbreds	117	694-1850	1253.3	270.6	25.0	21.6	1.90

The average age at first calving in Ongole cows was found to be 1207.7 ± 9.0 days and 1253.3 ± 25.0 days in crossbred cows. The coefficients of variation were 13.1% and 21.6% in Ongole and crossbred cows respectively and indicated further scope for improvement in age at first calving.

To study the frequency distribution of animals calving at different ages the data is classified into different age groups with a class interval of 100 days both in Ongole and crossbred animals and the results are presented in Tables 34 and 35.

Table 34

Frequency and cumulative percentage of age at first calving in Ongole

Age at first calving (days) (Groups)	Frequency	Cumulative frequency	Cumulative %
Upto 900	10	10	3.2
901-1000	25	35	11.4
1001-1100	50	85	27.7
1101-1200	75	160	52.2
1201-1300	56	216	70.5
1301-1400	44	260	84.9
1401-1500	23	283	92.4
1501 & above	23	306	100.0

Table 35

Frequency and cumulative percentage of age at first calving in crossbreds

Age at first calving (days) (Groups)	Frequency	Cumulative frequency	Cumulative %
Upto 900	15	15	12.8
901-1000	4	19	16.2
1001-1100	19	38	32.4
1101-1200	13	51	43.5
1201-1300	15	66	56.4
1301-1400	14	80	68.3
1401-1500	14	94	80.2
1501 & above	23	117	100.0

It will be seen from Tables 34 and 35 that the modal group of age at first calving in Ongole cows was 1101-1200 days while in crossbred animals it was above 1500 days. Thus a large proportion of crossbred animals were found to calve at comparatively higher age than Ongole cows.

In both Ongole and crossbred animals the average age at first calving fell in the class 1201-1300 days of age,

while 70.5% of the Ongole cows calved below this age group, only 56.4% of the animals in crossbreds calved below this group. The percentage of cows calving at higher ages was found to be more in crossbreds than in Ongole cows.

The heritability estimates of age at first calving cows obtained by paternal half-sib correlation for Ongole and crossbred cows are presented in Table 36.

Table 36

Heritability estimates of age at first calving in Ongole and crossbreds

Breed	No. of half-sibs	No. of sires	Heritability estimate	Standard error of the heritability estimate
Ongole	223	33	0.83	0.35
Crossbreds	117	5	0.22	0.25

It will be observed from Table 36 that the heritability of the age at first calving in Ongole cows was 0.83 ± 0.35 and high while in crossbreds it was 0.22 ± 0.25 and low. The standard error of the estimate in both the cases was found to be fairly high.

Fig. 1

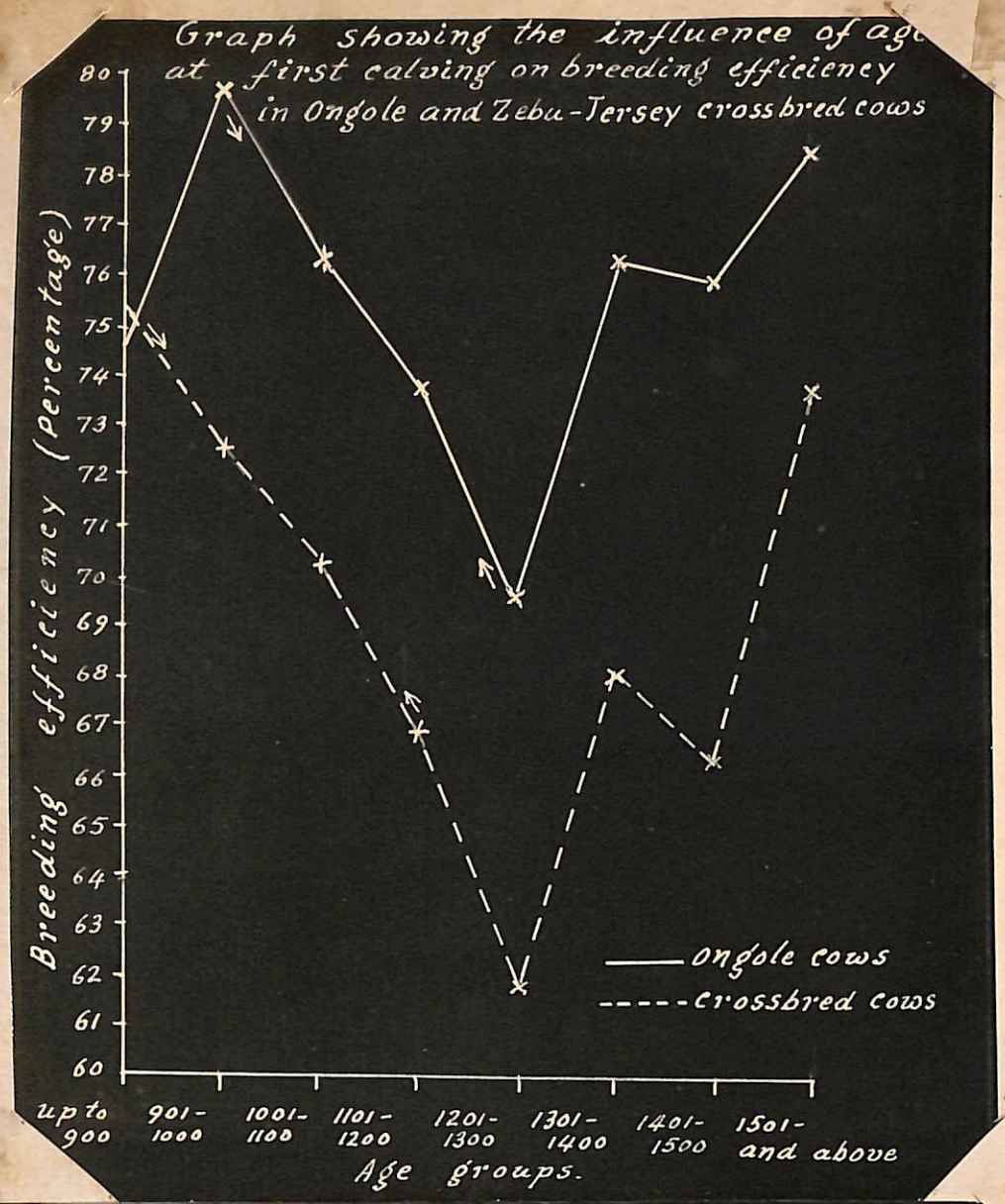

Graph showing the influence of age at first calving on breeding efficiency in Ongole and Zebu-Jersey crossbred cows
Breeding efficiency (percentage)
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
Ongole cows
crossbred cows
upto 900
901-1000
1001-1100
1101-1200
1201-1300
1301-1400
1401-1500
1501- and above
Age groups.

Fig. 2

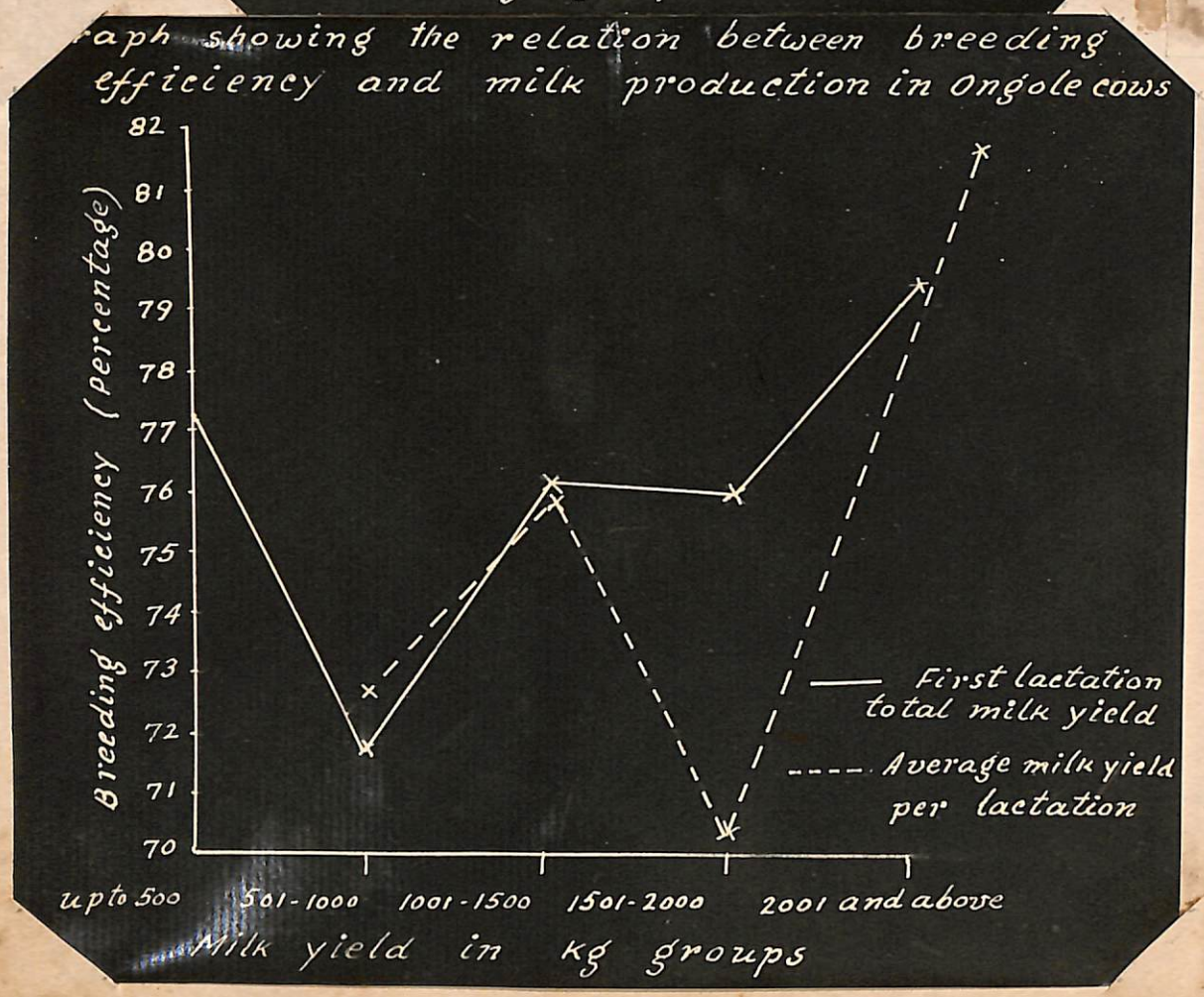

Graph showing the relation between breeding efficiency and milk production in Ongole cows
Breeding efficiency (percentage)
82
81
80
79
78
77
76
75
74
73
72
71
70
First lactation total milk yield
Average milk yield per lactation
upto 500
501-1000
1001-1500
1501-2000
2001 and above
Milk yield in kg groups

Fig. 3

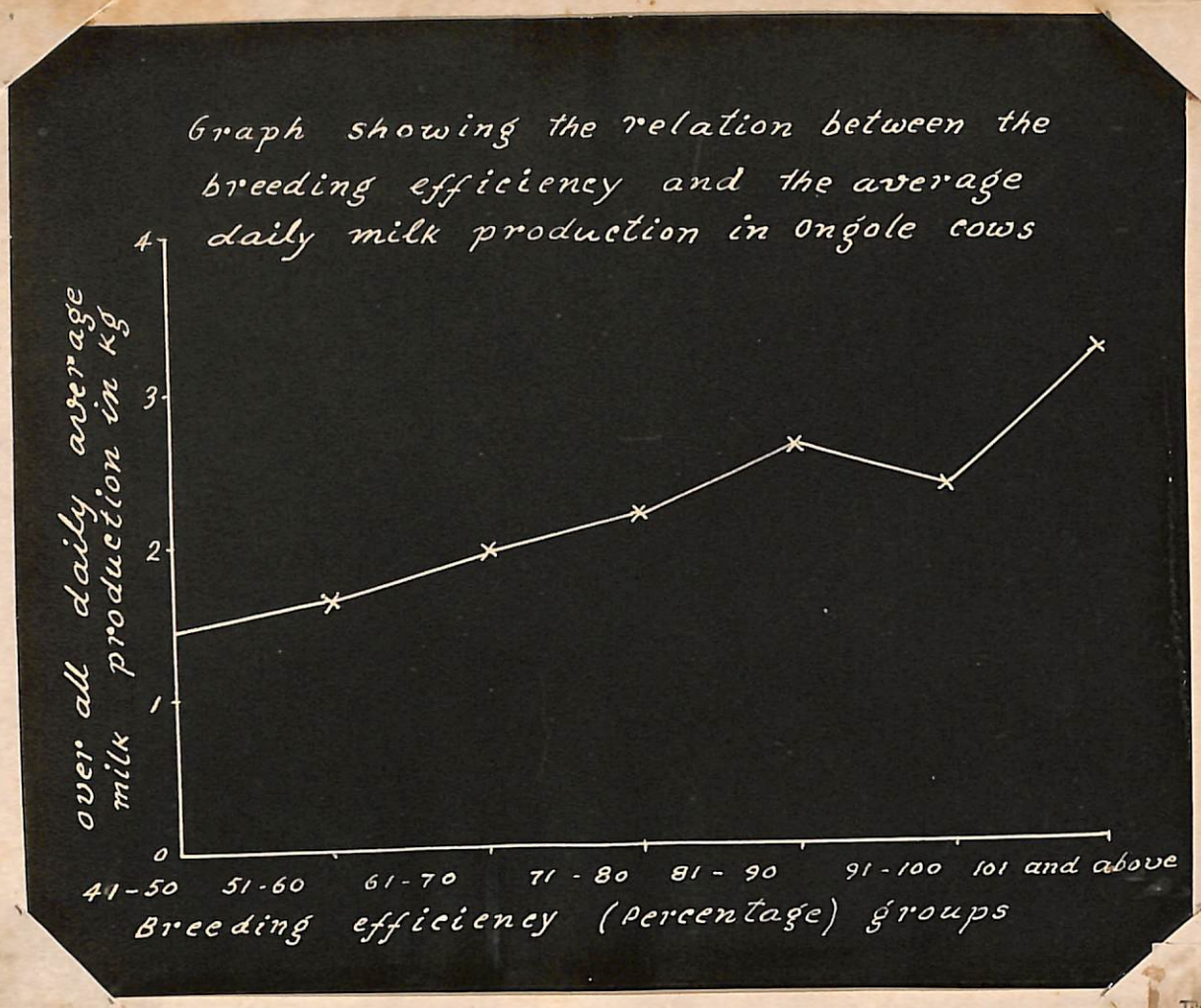
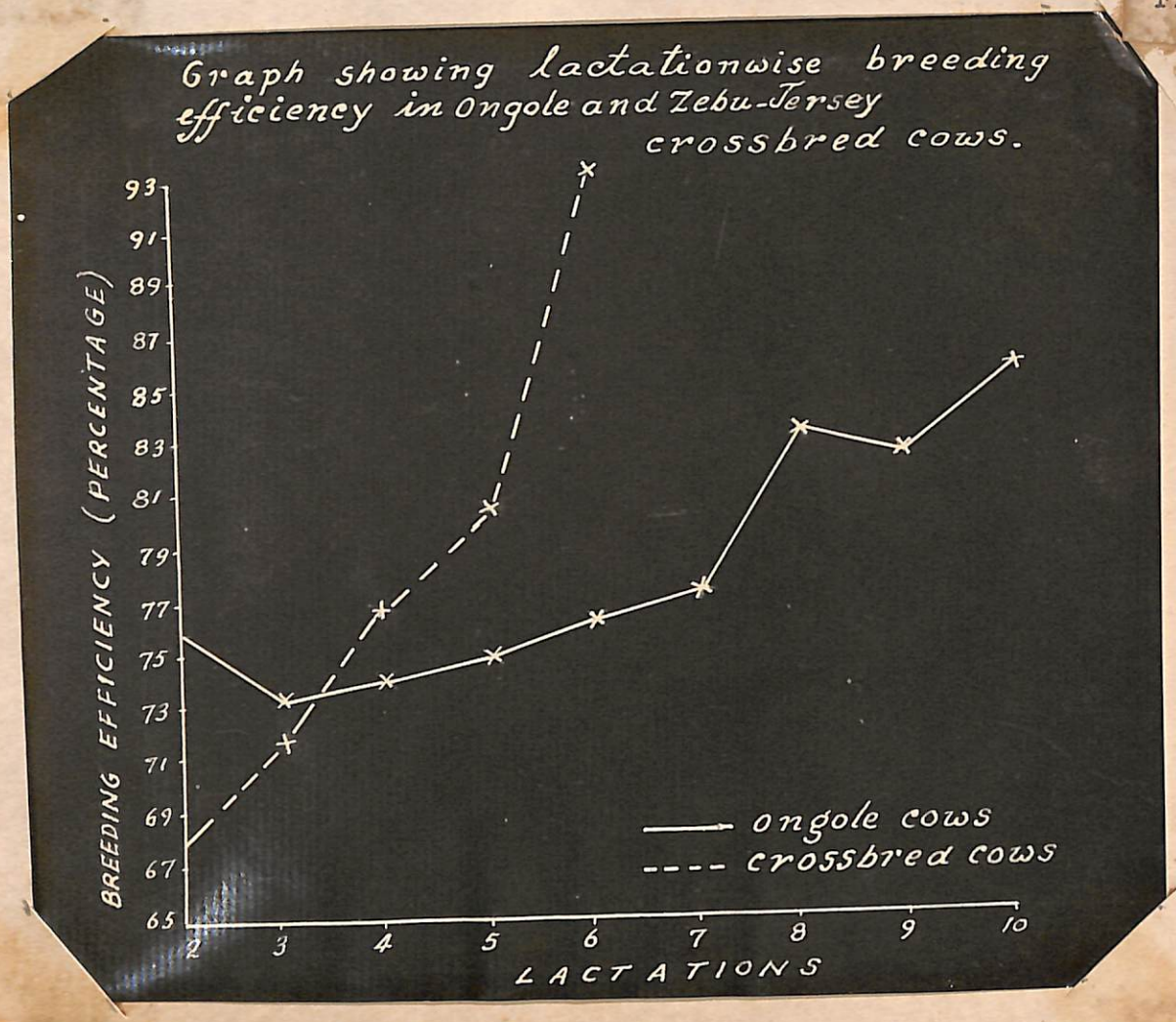

Graph showing the relation between the breeding efficiency and the average daily milk production in Ongole cows
over all daily average milk production in kg
4
3
2
1
0
41-50
51-60
61-70
71-80
81-90
91-100
101 and above
Breeding efficiency (percentage) groups

Fig. 4


Graph showing lactationwise breeding efficiency in Ongole and Zebu-Jersey crossbred cows.
BREEDING EFFICIENCY (PERCENTAGE)
93
91
89
87
85
83
81
79
77
75
73
71
69
67
65
2
3
4
5
6
7
8
9
10
LACTATIONS
Ongole cows
crossbred cows

DISCUSSION

In this investigation an attempt was made to study the breeding efficiency in Zebu-Jersey crossbred animals under field conditions. Breeding efficiency of one Indian Zebu breed of cattle viz. Ongole was also studied simultaneously to find out how the breeding efficiency in this breed compared with that of Jersey crosses.

Most of the earlier work on breeding efficiency in Zebu and Jersey crosses in our country concerned with the study of some physiological aspect of this trait such as number of services per conception, service period or calving interval. An attempt was made in this study to estimate breeding efficiency in Ongole and Jersey crosses on the basis of efficiency of production of calves in a given unit of time. For this purpose the formula reported by Wilcox et al (1957) was used as a measure of breeding efficiency. In addition, age at first calving and calving interval and inter-relationship of breeding efficiency with other productive traits were also studied.

Rigor and Nelmida (1959) reported the breeding efficiency of Red Sindhi and crossbred Jersey cows to be 71.4% and 71.3% respectively. In our study, we found that the breeding efficiency in Ongole cows was 74.9% (C.V. 13.6%),

in crossbred cows 70.0% (C.V. 11.6%). These results were in near agreement with the findings of the above workers, except that the breeding efficiency of Ongoles differed from that of crossbred cows, the crossbreds having comparatively low breeding efficiency than Ongole cows. Higher estimates of breeding efficiency were reported in Sahiwal cows (83.18-84.29%) by Rigor et al. (1959), Wilcox et al. (1957) in Holstein-Friesians (87.2%), Maoli et al. (1964) in Brown Alpines (93.0%), Dutch Friesians (106.0%) and crossbreds (90.0%), and lower estimates by Dutt and Desai (1965) in Gangatiri cows graded to Hariana.

The low breeding efficiency of crossbred cows in the present study might be due to poor managerial practices which were too inadequate to compensate for the extra stress on the constitution of the animals due to their increased milk production.

Spielman and Jones (1939) observed a high correlation (0.546 ± 0.118) between the breeding efficiency of the foundation cows and the mean reproductive efficiency of their female descendants. Wilcox et al. (1957) reported the heritability estimate of breeding efficiency in Holstein-Friesian cows to be 0.32. In our study the heritability estimates of breeding efficiency in Ongole cows was 0.81 ± 0.34 by

paternal half-sib correlation and it was 0.518 ± 0.240 by intra-sire regression of offspring on dam. These results were in agreement with the high values reported by the other workers. The heritability estimate in Jersey crosses by paternal half-sib correlation was low (-0.10 ± 0.16) and negative. The negative value was due to high within sire variations due to environmental causes.

Majority of reports on heritability of breeding efficiency indicated that the expressed hereditary influence on the breeding efficiency was small. Legates (1954), Singh (1958) using calving interval as the measure of breeding efficiency, Legates (1954), Singh (1961) using services per conception as the measure, Pou et al. (1953) using regularity of occurrence of oestrus and number of days from 1st service to conception as the measures, Prasad (1958) using service period as the measure reported very low heritability estimates of breeding efficiency.

The higher values of heritability estimates obtained in our present study in respect of Ongole cows might be due in part to absence of intra-herd variation and uniform managerial practices followed in this herd, which decreased the environmental variation to a minimum and the method used to obtain the breeding efficiency of the individual animals.

Dutt and Desai (1965) reported higher breeding efficiency in early calvers than in late calvers. Gautam *et al*. (1966) reported that age at first calving and breeding efficiency were not related to each other; but were influenced by individuality. These findings were in agreement with our findings here. The breeding efficiency in *Ongole* cows in our study was found to be maximum (79.6%) in cows calving between 901-1000 days, while in *Jersey* crosses it was maximum (75.2%) in cows calving below 901 days. In the later age groups, upto 1201-1300 days of age breeding efficiency decreased but increased again in the age groups above 1301 days. These results indicated, therefore, that selection for early calvers could be practiced in the *Ongole* and *Jersey* crosses without any loss of their breeding efficiency.

Clap (1937), Espe (1946), Singh (1961) reported a negative relationship between breeding efficiency and milk production which was contrary to our findings.

Gaines (1927), Eckles (1929), Boyd *et al*. (1954), Dutt and Desai (1965) reported that the milk producing ability of a cow had no influence on its breeding efficiency. These findings were in agreement with our findings also. In our study, *Ongole* cows yielding over 2000 kg of milk per

lactation were found to have a high breeding efficiency which was around 80%. This indicated the possibility of increasing the milk production in this breed at least to a level of 2000 kg per lactation without undesirable effects on breeding efficiency.

In our study, the overall average daily production was found to be positively associated with breeding efficiency upto 6th lactation in Ongole cows. The overall daily average production was 2.67 kg in animals with 81-90% breeding efficiency Vs. 1.47 kg in animals with 41 to 50% breeding efficiency. This result indicated that improvement in both overall daily average production and breeding efficiency could be brought about simultaneously and attention paid to one characteristic would automatically improve the other trait.

The genetic correlation coefficient between breeding efficiency and average milk per day during the first calving interval was found to be fairly high (0.530 ± 0.239). Therefore selection of animals on the basis of their milk production during the first calving interval would also result in simultaneous improvement of breeding efficiency.

Spielman and Jones (1939) reported a significant correlation (r = 0.804 ± 0.026) between breeding efficiency

and the probable number of successful gestations of a cow. Dutt and Desai (1965) noticed the breeding efficiency to increase as the number of lactations completed by the animal increased in Gangatiri cows graded to Hariana. Our results also revealed a similar trend both in Ongole and crossbreds, although, the differences in the averages of breeding efficiency between the different lactation groups were not significant.

Sikka (1931) reported the average calving interval in Sahiwal to be 13½ months, Kartha (1934) in Zebu cows maintained at Government Livestock Farms to be 450-501 days, Amble et al. (1958) in Red Sindhi, Kangayam, Gir, Kankrej and Tharparkar to be 14.7, 16.7, 15.7, 16.2 and 14.8 months respectively. The average calving interval of 498.3 days (C.V. 29.5%) obtained in Ongole cows in our study was generally in the range of values reported by the above workers for the other Indian breeds of cattle. A slightly higher value 531.25 days was reported for Ongole by Rao (1966).

Stonaker et al. (1953) at Allahabad reported the average calving interval in Jersey-Red Sindhi crosses to be 13.8 months and found it to increase with increase in Sindhi inheritance. Khishin and El-Issawi (1954) in Egypt found it to be 384 days, Dhandapani (1962) in crosses of Jersey cows

with Red Sindhi observed it to be 13.05 to 13.50 months. The average calving interval of 526.7 days (C.V. 27.7%) in Jersey crosses in our present study was very much higher than the values reported by the above workers. The longer calving intervals observed in our study might be due to the greater susceptibility of crossbred cows to the average managerial practices, under field conditions. It appeared that short calving intervals for the Jersey crosses obtained under farm conditions of management would not be obtained under average field conditions of care of these animals.

Sayer (1934) reported that with special feeding and handling, the service period in pedigree Sahiwal herd cows could be reduced from 172 to 90 days. Mahadevan (1966) observed it to be possible to reduce the long calving intervals in Zebu breeds of cattle by the use of high energy concentrate feeds and mineral supplements to improve the fertility in animals. These observations coupled with the findings in the present study indicated that long intervals were met with not only in Zebu, but also in crossbreds when the managerial conditions were poor and that attainment of short calving intervals in Zebu and crossbreds would require an improvement in the level of animal husbandry practices.

Singh (1958) in Tharparkar and Singh et al. (1958)

in Hariana reported significant influence of the sequence of calving on the calving interval. Our results were in agreement with the findings of the above workers in respect of Ongole cows, but not in respect of crossbred cows. The 1st, 6th, 7th and 8th calving intervals in Ongole cows were found to be significantly longer than 2nd, 3rd, 4th and 5th calving intervals. The insignificant effect of the sequence of calving on the length of calving interval in crossbred animals might be due to different environmental conditions to which the crossbreds were exposed under field conditions.

Joseph and Dave (1931) reported no significant effect of the season of calving on the length of calving interval. Singh et al. (1958) observed a significant influence of the season of calving on the inter-calving period in Hariana cows. Cows calving in the month of May and June were found by them to have significantly longer calving intervals (514.0 ± 10.67 days), while those calving from July to November had the shortest calving interval (464.0 ± 6.67 days). Our results revealed that the season of calving in Ongole cows had no influence on the inter-calving period. This might be due to the fact that the climatic factors in the Southern region of India are comparatively less diverse throughout the year.

Amble et al. (1958) reported the average age at first

calving in Red Sindhi, Kangayam, Gir, Kankrej and Tharparkar to be 41.7, 44.1, 47.0, 47.4 and 49.4 months respectively. The average age at first calving (1207.7 ± 9.0 days) in Ongole cows obtained in our study was within the range of values reported for the other Indian breeds of cattle. A slightly higher value (42.3 months) was reported for Ongole by Rao (1966).

Littlewood (1933), Kartha (1934) reported reduction in the age at first calving of Indian Zebu breeds of cattle when crossed with foreign breeds of cattle (Bos taurus). Fohrman et al. (1951) reported the average age at first calving in Jersey-Sindhi crosses to be ranging from 1 year 11 months to 2 years 2 months, Stonaker et al. (1953) observed it to be 29 months and Sundaresan (1955) reported it to be 2.73 years. The average age at first calving in Jersey crosses in our study was 1253.3 days which was higher than the estimates of the above workers. It almost approached the estimates reported for the other Indian breeds of cattle.

Mahadevan (1966) stated that irrespective of the fact whether the cattle were Indian, African, or crossbred, the mean age at first calving of cattle in the tropics varied from 3-4 years and the attainment of an early age at first calving in the tropics would demand an improvement in the level of animal husbandry practices which would appear to be

difficult to maintain over long periods of time and with a large number of animals. These findings were in agreement with the findings in our study that the Jersey crossbred cows under field conditions were found to have an age at first calving not significantly different from that of the native Zebu cows.

Amble et al. (1958) reported the heritability of age at first calving in Red Sindhi, Kangayam, Gir, Kankrej and Tharparkar breeds to be 0.16, -0.08, -1.24, 0.66 and 0.48 respectively, Singh and Desai (1961) in Hariana cattle found it to be 0.34 to 0.4 and Batra and Desai (1964) in Sahiwal stated it to be 0.504 ± 0.194. The heritability estimate of age at first calving obtained in our study for Ongole was 0.83 ± 0.35 which was nearer to the heritability estimates reported for Kankrej and Sahiwal.

Stonaker (1953) reported the heritability estimate of age at first calving in a population of crossbred, backcross and Red Sindhi cattle to be 0.39, Naidu and Desai (1965) in 4-15/32 Friesian x Sahiwal cows to be 0.113 ± 0.02. The estimates of heritability of age at first calving obtained in the present study was found to be 0.22 ± 0.25 and was within the range of values reported by the above workers for the crossbred populations.

SUMMARY

1. The phenotypic and genetic parameters of breeding efficiency were estimated in Ongole and Zebu-Jersey crossbred cows.

2. The average breeding efficiency in Ongole cows was found to be 74.9% ± 0.7%. In crossbred cows, it was 70.0% ± 1.4% under field conditions which was lower than in Ongole cows.

3. The heritability estimate of breeding efficiency in Ongole cows was high and found to be 0.81 ± 0.34 by paternal half-sib correlation and 0.518 ± 0.240 by intra-sire regression of offspring on dam. Therefore selection of animals for high breeding efficiency was suggested.

4. The heritability estimate of breeding efficiency in Zebu-Jersey crossbred cows was found to be -0.10 ± 0.16. The negative estimate was attributed to the small size of the sample$ and high environmental variations.

5. Age was not found to have any influence on breeding efficiency. However breeding efficiency was found to be superior in early calvers than in late calvers and the trend was the same in both Ongole and crossbred cows.

Ongole cows calving between 901-1000 days of age were found to have the highest breeding efficiency of 79.6% while in crossbreds highest breeding efficiency was noticeable in animals calving below 900 days of age. Selection for early calvers could be practiced in Ongole and crossbred cows without loss of their breeding efficiency.

The phenotypic correlation coefficients between age at first calving and breeding efficiency were found to be +0.039, and -0.060 in Ongole and crossbred cows respectively which were not significantly different from zero. The genetic correlation coefficient between these two traits in Ongole cows was found to be -0.258 ± 0.271.

6. The total milk yield in first lactation or average milk per yield per lactation was not found to have influence on breeding efficiency in Ongole cows. However, cows yielding over 2000 kg in their first lactation or per lactation on an average, were found to have the highest breeding efficiency. Therefore selection of cows yielding to a level near about 2000 kg in their first lactation or per lactation on an average can be practiced without loss of their efficiency.

The phenotypic correlation coefficients between

breeding efficiency and first lactation total milk yield and average milk yield per lactation were 0.01 and 0.08 respectively which were not significantly different from zero.

7. Breeding efficiency and average daily yield during first calving interval were found to be significantly correlated, the phenotypic correlation coefficient being 0.340. The genetic correlation coefficient was 0.530 ± 0.239.

   Therefore it is suggested that simultaneous selection for both the traits could be practiced to bring about rapid improvement in both.

8. Breeding efficiency and overall daily average yield were positively correlated upto 6th lactation. It was suggested that attention paid to one characteristic would automatically take care of the other trait.

   Overall daily average yield was found to be maximum in cows with a breeding efficiency of 81-90% or a calving interval of 405-456. It was suggested that for maximum overall daily average production the calving interval should be less than 456 days.

9. No significant differences were observed in breeding efficiency of animals completing different number of

lactations. However, a general tendency was observed that animals that would complete more number of lactations to have high breeding efficiency.

10. The average calving interval in Ongole cows was found to be 498.3 ± 4.3 days with coefficient of variation of 29.5%. The 1st, 6th, 7th and 8th calving intervals were significantly higher than the 2nd, 3rd, 4th and 5th calving intervals. Season of calving was not found to have significant influence on the calving interval. The distribution of calvings was spread uniformly over the year. Feeding of high energy concentrate feeds was suggested to reduce the inter-calving period.

11. The average calving interval in Zebu-Jersey crossbred cows under field conditions was found to be 526.7 ± 11.6 with a coefficient of variation of 27.7%. Sequence of calving was not found to have significant influence on the inter-calving period which was attributed to high environmental influence. Improved animal husbandry practices would help in reducing the length of the calving interval.

12. The average age at first calving in Ongole cows was found to be 1207.7 ± 9.0 with a coefficient of variation of 13.1%. The modal group was found to be between 1101-1200 days.

13. The average age at first calving in Zebu-Jersey crossbred cows under field conditions was found to be 1253.3 ± 25.0 with C.V. of 21.6%. The modal group was found to be above 1500 days. Good management and breeding would effect reduction in the age at first calving.

14. The heritability of age at first calving in Ongole cows was found to be 0.83 ± 0.35. Therefore selection for early calvers was suggested.

15. The heritability of age at first calving in Zebu-Jersey crossbred cows was found to be 0.22 ± 0.25 under field conditions.

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