STUDIES ON VARIATION IN SHAPE AND SIZE OF UDDER AND TEATS 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
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IN
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April 7th, 1968.

Certified that the research work embodied in the thesis entitled "Studies on the variation in shape and size of udder and teats in Ongole and Zebu-Jersey crossbred cattle in India" by Shri A.V. Narasimha Rao, 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 INDIAN COUNCIL OF AGRICULTURAL RESEARCH FOR THE AWARD OF A JUNIOR FELLOWSHIP IN GENETICS AND ANIMAL BREEDING DURING THE PERIOD 1966-1968

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INTRODUCTION

Udder in a cow may be compared to a factory where the low grade nutrients ingested by the cow are converted into one of Nature's nearest approach to perfect food namely, milk. Its shape and size give an indirect estimate of the milk producing capacity of a cow. Hence in all score cards for judging Dairy cattle special marks are reserved for mammary growth and development. Study of udder therefore is important in any planned work on cattle development.

According to Sheppard (1953), the milk yield of a cow can be predicted from the measurements of mammary glands at 3-5 months of age. Legates (1960) reported that the prediction from udder palpation measurements in Holstein heifers was about twice as accurate as prediction from dam's first lactation record. Borodin (1963) suggested that udder measurments should be used in addition to visual appraisal in selecting cows for breeding. Little work on the shape and size of udder and teats had been done on Indian cattle breeds. Recently, Sharma (1967) reported upon his observations on the udder and teats of Hariana and Tharparkar. In the present study, data are presented and discussed of an investigation carried out on the udders of Ongole and Zebu-Jersey crossbreds raised under both farm and field conditions.

REVIEW OF LITERATURE

Detailed studies on conformation in relation to milk producing capacity in cattle carried out by Gowen (1923a) established that two items of body pattern, namely weight and a wedge shaped form when viewed from the front were to a limited degree indication of amount of milk the cow would produce. The work conducted by the same author (Gowen, 1923b) on conformation and milk yield in the light of the personal equation of the dairy cattle judges showed that as a means of predicting milk yield, they were not worth as much as desired.

Arzumanjan (1938) reviewed the microscopic structure of mammary gland of the cattle. He pointed out that size of udder, apart from glandular development, was an important factor in milk production. A cow with a large udder, though a less developed glandular portion, might yield more milk than one in which the situation was reversed. The intensity of function of different alveoli, in the same gland differed and some might be entirely non-functional. He suggested that it was essential to study the qualitative character as an index of its functional capacity.

The volume of udder in non-pregnant cows as a character useful in selection had been advocated by Davydov and Fedotova (1939). They observed 37 cows, most of them

in the 5th-6th months of pregnancy, and they determined the volume of udder from its depth and circumference measured at the base and near the site of the teats. Several animals were measured twice and they admitted that the method was not very accurate and was unsuitable for large scale investigations. They found that the volume of the udder had increased throughout pregnancy. The volume was 1393 cm^3 in early pregnancy (about 18 months old) 3010 cm^3 at 6 months (about 2 years old) and 5671 cm^3 at 8½ months old. In non-pregnant cows the udder volume was 1298 cm^3 at 18 months old and 2087 cm^3 at 2 years. So they found that the mammary gland in pregnant cows developed more intensively than in non-pregnant cows. They reported that mammary gland development was a more complex phenomenon than had been believed and that it was controlled not only by hormones, but also by some other factors associated with growth. On the results of this investigation, they concluded that in judging heifers, it was necessary to take into account live weight at 1½ years and the volume of the udder at the beginning of the 2nd half of pregnancy.

Mathews _et al_. (1949) described the effect of weight and capacity of dairy cow udder in relation to producing ability, age and stage of lactation. They analysed the data from 473 _Holstein-Friesian_, grade _Holstein-Friesian_

and Jersey cows which were grouped according to age, stage of lactation and length of dry period. They found that the udder capacity increased with age; the increases were greater in the younger than in the older age groups. The weight and capacity of udder both of lactating and dry Holstein-Friesian, were greater than in those of lactating and dry Jersey respectively. Udder weight and udder capacity decreased as the lactation advanced or as the length of dry period increased. Udder weight decreased most rapidly in the first 2 months of lactation and the decrease in capacity began after 2nd month of lactation. The ratio of capacity to weight increased as lactation advanced.

Turner (1955) described the changes in capacity of the udder of dairy cows during the course of lactation. Seven cows at the Werribee Field Station were each milked at a variety of intervals between milkings at each of several stages of lactation between June 1951 and August 1952 to determine udder capacity. By allowing the udder to fill with milk, it was found that the maximum pressure attainable declined as lactation advanced. Secretion was inhibited at a lower pressure in late lactation. Besides the size or 'physical capacity' of the udder declined during advancing lactation. At any given pressure, the udder held less milk in late lactation than in early lactation. He

found that milk secretion was not affected by a milking interval of upto 16 hours.

Suchanek (1961) investigated udder capacity based on the daily milk yield of Hrbinocke cows 30-50 days after calving. The udder capacity in the 1st, 2nd and subsequent lactations was 8.71, 12.27 and 13.74 kg. He further pointed out that during lactation udder capacity decreased less than milk production.

UDDER EVALUATION

Size of udder and teats

Sheppard (1953) described the accuracy of measurements of the mammary glands by the method of palpation. He reported that the milk yield of a cow might be forecasted from measurements of the mammary gland at 3-5 months old.

Krempa and Prawdzik (1954) made biometrical investigations on morphological udder and teat characters in Black Pied Lowland cattle. They examined the udders of more than 500 cows from 10 different herds in Poland and made analysis of those of 164 cows which were in the 2nd to 6th months of lactation. Primiparous and old cows were not included in the survey. A table was given showing the arithmetic mean, the average deviation from the mean, the error of the mean,

the mean error and the C.V. in respect of udder length, distance from the ground, length of pelvis, spacing of teats, length and circumference of teat (right and left teat in the fore and rear quarters of the udder respectively). The fore teats averaged about 1 cm longer than the rear teats.

Johansson et al. (1957) found actual measurements of the teats and their placement had a high or moderately high heritabilities - length of teats 0.98 ± 0.20, diameter 0.38 ± 0.22 distance between front and rear teats 0.50 ± 0.22, index of teat placement 0.36 ± 0.22.

Dachs (1958) described the methods of conformation and size of udder as a basis for evaluation. For observing changes in udder during the course of calving interval, about 800 photographs were taken of the udder of 44 cows (50 lactations) of different breeds, and crosses and 5 udder measurements were made on 18 of these cows at 6 stages of lactation. From the photographs he concluded, that only in the period immediately after calving and at the end of lactation, or during the dry period, marked changes could be observed in the udder. Towards the end of lactation, the udder became reduced in size. He recommended the best time for evaluating an udder was after the 9th week of lactation, when the change from thrice to twice daily milking generally took place. The measurements confirmed the evidence of the photographs.

Relationship between udder measurements and 300 day yield were investigated.

Bartsch et al. (1960) in their method of udder evaluation took 29 different udder measurements before and after milking and the yield of individual quarters. Cows in the Clausberg herd were evaluated at 30-day interval until drying off and the results of 20 first and 23 second lactation animals were discussed. The productive ability of empty udder was investigated in the progeny of 3 different bulls and it was found that this could be measured by each dm^3 of empty udder. It was also found that the udder productivity and the degree of collapse of udder after milking could be used as a measure of the amount of glandular material, as there was a significant negative correlation between them.

Donald (1960) reported that the cows with short teats milk faster and had higher yields than cows with longer teats.

Krippl (1961) studied the important udder characters in German Fleckvich and German Brown cattle. He obtained the following results. (1) Between the 1st and 3rd lactation, there was a gradual increase in udder size in both breeds, whilst udder size was generally comparable in both breeds in 1st lactation. In later lactation, the percentage of cows with large udders was greater in German Brown cows than the

cows of other breed. (2) As udder size increased with age, the udder became more pendulous in both breeds. (3) Teat length increased with age in both breeds. Generally the hind teats were approximately 1 cm shorter than the fore teats. (4) Teat length and occurrence of supernumerary teats were fairly highly heritable, the genetic effect was less in udder length and circumference.

Tavildarova et al. (1961) examined 469 cows at 6 farms in Kazakhastan belonging to Estonian Black Pied, Aulie-Ata, Ala-Tau, Simmental and Red Steppe breeds. They observed that teat length and thickness did not vary during lactation. The udder circumference and depth and distance between teats decreased with declining lactation. After milking, udder circumference and depth were 85-91% of the pre-milking values.

Ahrens (1962) studied udder conformation in 174 pedigree daughters of 26 A.I. bulls in the region of Hanover. Mean values for pelvis length and 12 udder measurements were given, together with heritabilities for 8 of the most important measurements.

Fielder (1962) studied the udder conformation and characters in Yellow Hill cattle and changes in them during the course of lactations. Twenty nine udder measurements were made on the udder before and after milking on 26, 29 and

23 Yellow Hill cows in their 1st, 2nd and 3rd lactations respectively and on 10 cows from the beginning of their first to the end of their 3rd lactation. By the 240th day of lactation 85-90% of the total milk was attained in the 1st lactation Vs. 75-80% in the 2nd and 3rd lactations. He concluded that all udder measurements were greater in the 3rd lactation than in the 1st and yield were 40% higher. A dam-daughter comparison showed a relatively high heritability for all the most important udder measurements.

Klossner (1962) studied 485 Black Pied Lowland cows in 40 herd book herds in the district of Hanover for udder conformation. These cows were the daughters of 28 A.I. bulls and were in their 1st-6th lactation. Thirteen udder measurements together with their heritabilities were given. In general the principal udder and teat characteristics were relatively strongly inherited.

Andreae (1963) observed the changes with age in udder and teat measurements of cows. Twelve udder measurements were made during the 6th week of lactation on 60 Black Pied Lowland cows in their 1st-5th lactation and 25 cows in their 5th-8th lactation. The cows were sired by 15 and 17 bulls respectively. The changes in udder and teat conformation took place between the 1st and 3rd lactations. He discussed in detail the other changes and gave 6 criteria for udder

evaluation.

Borodin (1963) ascertained the importance of measurements in evaluation of cow's udder. At the state farm, Balagon, teat length and circumference, the distance between the teats, and udder length, depth, size (length x depth) and index (length relative to depth) were ascertained in adult Simmental grades in the second month of lactation. Measurements were taken 1 hour before milking. Cows in which milk yield was highest had cup-shaped udders with a length not exceeding 50 cm and depth 90-100% of this. He suggested that in selection udder measurements should be used in addition to visual appraisal.

Freter (1963) studied udder conformation in 167 Black Pied Lowland cows which were the daughters of 23 bulls on 40 farms in the district around Hanover. Data on 20 udder measurements, pelvis length and milk yield were recorded. Intra-class correlations were used to calculate heritabilities. The 9 highest included 0.77 and 0.60 for average width of fore and rear teats respectively, 0.50 and 0.11 for length of fore and rear teats, 0.06 for depth of udder at the front.

Arzumanjan (1964) found out a coefficient of udder volume (circumference x depth) for 201 cows, at the collection farm Putik Kommunism in Moscow Province. He observed that lactation yield, daily milk yield and milk production per

100 kg body weight all increased with increasing udder coefficients.

Naito *et al.* (1964) estimated udder and rump size photometrically on 35 lactating cows. They found that parents significantly influenced the phenotype of their daughters in respect of several rump and udder measurements.

Brantov (1965) analysed the data obtained from 3 farms by the Kuban Agricultural Institute. Thirteen udder measurements were made on Red Steppe cows half an hour before milking, which were in 35th-55th day of lactation. Udder measurements increased to 4th calving and gradually decreased after the 6th-7th lactation.

Garkavijs *et al.* (1965) made investigations on udder measurements in Latvian Red cows and heifers. They reported that the average udder circumference was 90-100 cm and average udder depth 22.27 cm, these measurements were 10% less for heifers than for cows. The majority of cows have bowl-shaped udders with an average width of 25-29 cm and an average length of 30-33 cm. The average teat length and diameter is 6.9 and 2.3-3.0 cm respectively in 75% of the females; these measurements are 1.0 and 0.2-0.5 cm less for heifers than for cows.

Krempa (1965) gave a simplified method of udder evaluation. On the basis of four measurements, he formulated

2 indices; the index of udder capacity (V.P.) and the index of udder efficiency (V.S.). V.P. $= \frac{Pd}{100}$, where P is the area of the trapezium circumscribed by the line of the teats and d = the length of the udder. VS $= \frac{Mi}{VP}$, where Mi is the milk yield in a 300 day lactation.

Piotrowska *et al.* (1965) made preliminary investigations on the udder appraisal in 217 *Black Pied Lowland* cows and presented the following udder measurements.

		cm
Average length of base of udder	...	41.0
Width of udder	...	32.2
Depth of fore quarters	...	31.6
Depth of rear quarters	...	32.2
Length of front right and left teat	...	7.4 7.5
Length of rear teats	...	6.6 6.7

They concluded that during the course of 5 consecutive lactations, the depth and width of the udder increased. The front teats yielded 42.88% of the milk and the rear teats 57.12%.

Pandza (1965) discussed the udder characters of *Black Pied* and *Simmental* cows at the farms Nladen, Stojanovic in Nova Topla. Data were obtained on the udder and teat

measurements and conformation during the 1st four lactations. He reported that the udder measurements were greater for the Black Pied than for the Simmentals, although, they were not appreciably different from those of a selected herd of Simmentals. In the two breeds, the amount of udder contracted after milking decreased from the 1st to 4th lactation.

Richardson et al. (1965) made teat measurements on 277 Holstein heifers in 3 herds at 3, 6, 12 and 3 months after 1st calf. The measurements included :

1) Length of front and rear teats
2) Distance between front and rear teats on both sides
3) Width between rear teats
4) Distance between front teats

Estimates of repeatability of each were made by deriving correlations for all age groups. In general, the repeatability of measurements in the 3 younger ages were high (0.38 to 0.73). All measurements except length of teats, were repeatable between each of the 3 younger ages and after 1st calf.

Suchanek (1965) pointed out the differences in measurements of the udder of Bohemian Red Spotted cows during lactation. Data on 15 udder measurements were obtained from 38 cows during the 30th—60th day of lactation. He reported

that when the milking interval was increased from 12-18 hours udder measurements decreased during lactation, and vertical measurements increased by 2.9-13.4%. He concluded that measurements decreased during lactation and vertical measurements increased more than horizontal measurements in succeeding lactations. Optimum teat length and diameter were 5.8 cm and 2.5-3.2 cm respectively.

Makaveev (1966) made 13 udder measurements on the udder of each of 144 cows and 100 heifers between the 60th and 120th days of lactation. He reported that the vertical measurements increased more with age than did the horizontal measurements. Udder conformation and milking characters were also compared in daughter groups of 6 bulls. Variation in all the characters studied was considerable.

Maskovskaja (1967) studied Bestuzhev cows in the 2nd-4th month of lactation and recorded 8 udder measurements on adult females. Udder size was calculated from circumference x depth. The udder was evaluated on a point system with maximum and minimum values for each of the 8 measurements. All the udder measurements differed between farms and between sire lines.

Witt et al. (1967) conducted biometrical udder investigations on 539 Black Pied Lowland cows during the 6th and 38th weeks of lactation. They reported that the length and

width of udder were primarily affected by stage of lactation, whereas depth and distance from ground depended more on lactation number. Stage and number of lactation had an almost equal influence on udder volume and space between fore and rear teats. They also pointed out that cows should be compared within stage and number of lactation. Heritabilities of udder characters were higher for measurements taken during the 6th than during 38th week of lactation. The best characters to select for were distance from the ground (minimum about 45 cm) and this could be made more effective by also considering udder length and distance between fore and rear teats. However, as all heritabilities were fairly low, selection intensities would have to be high for improvement.

Sharma (1967) studied the udder conformation in 193 Hariana cows and 148 Tharparkar cows located at 4 and 2 farms respectively. Three udder measurements and 2 and 4 teat placement and teat measurements were made. He reported that most of these measurements varied due to order of lactations in both the breeds.

Shape of udder and teats

Ipsen (1954) examined the entries in 1941-1951 Red Danish herd books for 3083 cows in Fyn and 1968 in Sjaelland and compared with those of 2522 cows in the Danish, Jersey herd books of 1952-53 with regard udder conformation and

evaluation. The incidence of most common udder and teat defects was tabulated. Slope of rump was found to be related to a pendulous udder. These defects were more common in Jersey than in Red Danish cows. Pendulous udders were found to be inherited. He observed no significant difference in the average production of all the Jersey cows and the Jerseys with defective udders, the butter fat percentage and yield tended to be slightly less for the latter.

Suvenvuo (1955) studied the structure of the udder and teats and described 4 types of udders and 4 types of teats. He suggested that Finnish cows with teats less than 5 cm and over 10 cm in length should not be entered in the herd book.

Bjorck and Johansson (1956) described the types of udder and teat and their significance in milking. A classification with the use of symbols of udder and teat types, as found in Sweden had been devised and agreed upon by representatives from various Swedish Agricultural organisations. They described the udders as either trough shaped, spherical or pendulous; teats as pear shaped, cylindrical or cone shaped. Other characteristics such as those of symmetry and spacing of teats were also included in the classification.

Pohl (1956) reported that the heritability of udder type appeared to be fairly high (about 60% udder size) and suggested that the rudimentary teats of bulls should be one

of the factors considered in selection.

Nesterenko (1957) analysed the data on the production and biological characters of Black Pied cattle in the Ryazan Province and reported that of the 659 cows, 54.1% had bowl-shaped udders and these cows yielded 22.4% more milk those with rounded udders and 41.2 more than those with narrow goat shaped udders. The percentage of cows with bowl shaped udders increased with age.

Cerkascenko (1958) described the udder shape and gave its consideration in evaluating cows. Udder shape was examined in 39 cows and 46 of their daughters. Dams with bowl shaped udders had daughters of which the greater percentage had bowl shaped or rounded udders. About 1/3 of the daughters of the dams with rounded udders had goat like udders. Over 50% of the daughters of dams with goat like udders also had goat like udders. Some cows had the same shape of udder as had their paternal grand-dam. Cows with bowl-shaped udders yielded 905.7 kg more milk in a 300 day lactation than did those with rounded and 1600.3 kg more than those with goat like udders.

Byckov (1959) evaluated udder shapes in 173 Black Pied cows at the State Farm Gorki II in Moscow, with additional data on their dams. He reported that 53.2% had cup-shaped udders with equally well developed quarters and good forward

attachment. 30.1% had rounded udders which were less well developed than the cup shaped udders. 16.7% had goat like udders with unequally developed quarters. Milk yield, butter fat content and body weight were least in the group with goat like udders. Dam-daughter comparison showed that 30.9%, 10.8% and 9.4% respectively of the daughters of dams with cup shaped, rounded and goat like udders also had these udder shapes. Level of production was related to udder shape in both dams and daughters. He also found that the udder shape was similar, in a high percentage of the daughters sired by individual bull.

Tavildarova et al. (1961) classified the udder shape and size of cows of various breeds in Kazakhstan. They classified the udders of 469 cows at 6 farms in 1956-1958, as cup shaped, rounded of goat like. Those of 60% of the Eastonian Black Pied and Aulie-Ata were cup shaped of 66-71% of the Ala-Tau and Simmental crossbreds rounded, and of 43.9% of the Red Steppes (Ukranian Red) cup shaped. Only 2-3% of the total were goat like within breeds. The milk yield of females with cup shaped udders exceeded that of females with rounded udders by 6.0-18.1% and average daily yield was 15.6-26.4% higher. The rounded udders had small circumference and relatively greater depth and teats were close together as compared to cup shaped udders. Although, there was no appreciable difference in teat length, the fore teats tended to be longer than the

rear teats, and rounded udders had longer teats than cup shaped udders.

Brodauf (1963) reported that the milk hernia, the so called 'bottle teats' was a fairly common inherited defect in German Simmental cattle. He observed 25 out of 297 cows with this condition in one district in Oberbaden. In 7 small herds totalling 40 cows, it was found in 6 cows of which 5 were sired by one bull which had 12 daughters in the herd. He concluded therefore, that the defect was a simple autosomal recessive mode of inheritance.

Barysnikov (1964) reported that majority of the cows in Kurgan breed had cylindrical teats. The fore teats were longer than rear teats. He studied udder conformation in 234 cows in 1st and 2nd lactation. 78.3 and 79.6% respectively of the females had bowl shaped udders and the remainder had rounded udders. Only 43.5% of the older cows had bowl shaped udders. The milk yield of cows with bowl shaped udders was higher than that of females with rounded udders.

Gimatidinov et al. (1964) discussed the shape and size of udder of Red Steppe cows of various productive types. They reported the occurrence of bowl and rounded udders, whereas, goat like udders were rare, of dairy type cows 42% had bowl shaped udders Vs. 31% of milk meat females.

Brantov (1965) analysed the data from 3 farms obtained by the Kuban Agricultural Institute. The udders of Red Steppe cows were evaluated visually during 35th-55th day of lactation. 116 females had cup shaped udders, 143 rounded udders and 13 had goat shape udders. He reported that the average lactation yield of the 1st group was 12% greater than that of the last group and that of females with rounded udders were intermediate.

Garkavijs et al. (1965) evaluated the udders of Latvian Red cows and found that majority of them have bowl shaped udders with an average width 25-29 cm and an average length of 30-33 cm. The teats were conical or cylindrical for 80% of the females.

Starkov (1966) analysed the data of 99 purebred daughters of 6 Black Pied males of the stud farm Krasnaja Zvezda in Minsk Province. The udders of females were bath-shaped, bowl shaped, rounded, pendulous or resembled those of goats. The bath shaped udders had the greatest circumference, length, width, length relative to depth and the least depth and shortest teats; they were related to the highest milk yields and obtained greater number of points in evaluation for udder conformation. Cows with udders like those of goats (elongated with well developed rear quarters and depth greater than width) had the lowest milk yield and were awarded fewer points for udder conformation.

Maskovskaja (1967) evaluated udders of Bestuzhev cows on a point system in their 2nd-4th month of lactation. He presented average milk yields of cows with udders that were bowl shaped rounded and resembled those of goats as 3883, 3193 and 2803 kg respectively. The first was evaluated highest and the last lowest.

Sharma (1967) studied the variation of udder shape and size in 193 and 148 cows of Hariana and Tharparkar breeds located at 4 and 2 farms respectively. He reported the incidence of 93.3%, 2.6% and 4.1% in Hariana and 80.9%, 2.0% and 8.1% in Tharparkar of bowl shaped, rounded and goat type udders respectively. Goat shaped udders were twice as frequent in Tharparkar than in Hariana. He also reported three types of teats viz. cylindrical, funnel and bottle shaped with the incidence of 76.2%, 22.8% and 1.0% respectively for the front quarters in Hariana Vs. 77.0%, 14.9% and 8.1% respectively in Tharparkar. The figures for rear quarters were 63.7%, 35.8% and 0.5% respectively in Hariana Vs. 61.5%, 29.1% and 9.5% respectively in Tharparkar. In both Hariana and Tharparkar highest incidence was that of cylindrical type followed by funnel and bottle types. He also reported significant variation among farms in respect of both cylindrical and funnel types in both the breeds.

Udder evaluation in crossbreds

Gercikov (1959) reviewed the prospects of using Jersey on Black Pied-East Friesian type cows of varying origin. He reported that the 1st generation crossbreds had udder shape which is similar to that of Jersey.

Horn et al. (1960) reported that Jersey x Hungarian Spotted crossbreds had better persistency of milk yield and better udder development than those in the controls.

Lebedev et al. (1960) while studying the method of increasing butter fat content of milk, reported that Jersey x Black Pied crossbreds had better udder development than in those of Black Pied cows. Butter fat percentage was higher in crossbreds.

Lenschow et al. (1963) made udder measurements and tests of ease of milking in 127 Black Pied Lowland, 14 Jersey and 51 crossbred cows. They reported that Jersey and crossbred cows had better udder conformation than Black Pied Lowland cows.

CORRELATION STUDIES

Davydov (1938) studied the correlation between the rate of milk collection in the udder, and milk yield and between the latter and udder qualities. He analysed the data

and found the correlation between yield and udder volume and udder capacity equalled 0.66-0.77. Multiple correlation of yield with rate of milk collection and udder qualities equalled 0.85-0.87. A certain relationship was found between rate of milk collection and udder qualities on the one hand and the live weight on the other (r = 0.47 - 0.68).

Davydov and Fedotova (1939b) reported a positive correlation between body weight and udder volume, while studying the volume of the udder in non-pregnant cows as a character useful in selection. The range of 'r' was from 0.08 ± 0.17 at birth to 0.22 ± 0.16 at 9 months to 0.39 ± 0.6 at 1½ years. They also established correlation between udder and milk yield for the 1st four months of the 1st lactation (r = 0.21 ± 0.14), for the most productive months 0.35 ± 0.14 and for the highest daily yield 0.41 ± 0.14.

Mathews _et al_. (1949) reported a highly significant correlation between age and either udder weight or udder capacity for all lactating and for all dry cows. The correlations between age and capacity were higher for lactating than for dry cows, and those between age and udder weight were higher for dry than for lactating cows. There was also highly significant correlations between producing ability and udder weight and capacity in both lactating and dry cows.

Witt (1951) reported a definite positive correlation between teat circumference and teat length.

Falkenhausen (1952) found a significant correlation between udder type and average milk yield of the control years in Gray Brown Mountain cattle. Maximum yield was correlated with well formed, large well attached udders.

Krempa and Prawdzik (1954) found a significant correlation of 0.61 between length of udder and milk yield and between length of udder and spacing of teats (r = 0.69).

Liebenberg and Jannermann (1957) ascertained the influence of breeding on udder shape and size. 85 cows of different ages and breeds were measured 6 weeks after calving and 1-2 hours before milking. Analysis of data showed a striking association between udder size and daily milk yield and also between the latter and annual milk yield for the year in which the measurements was taken. Cows with the smallest udders averaged 10.3 kg daily and 2976 kg annually Vs. 22.7 kg and 4520 kg for cows with largest udders.

Dachs (1958) obtained correlation of 0.84 ± 0.15 and 0.75 ± 0.1 between 300 day yield and udder length as measured by the Reinecke Duerst methods respectively.

Bartsch et al. (1960) collected data on 29 different udder measurements of cows in Clausberg herd. Highly significant

positive correlations were obtained between udder volume and average daily milk yield in 94 lactations (r = 0.6611 ± 0.0581) and between udder volume and lactation yield in 64 cattle (r = 0.6059 ± 0.073).

Legates et al. (1960) studied the value of mammary gland palpation in selecting dairy heifers. A high correlation between udder measurements at 3, 4 and 5 months and production was reported. The multiple correlation of all udder measurements with production was 0.22 Vs. 0.21 using only the 5 month measurement.

Tomar and Tomar (1960) studied body type and milk production in Hariana cows and found a significant positive correlation between the volume of the teats and milk production in the dry cows, while in the case of cows in milk, it was not found significant. In the case of combined herd a highly significant correlation was reported. They gave the possible interpretation for the findings which might be that the size of the teats of the cows in milk become larger on account of the milking practice and that their present milk yield also was not considered.

Fuhrer (1961) reported significant correlation between milk yield and horizontal udder circumference (r = 0.599 ± 0.096) and udder volume (r = 0.661 ± 0.084).

Suchanek (1961) studied the relation between udder capacity and milk production in 92 cows and presented the following correlations between udder capacity and

a) Maximum daily milk yield (r = 0.721)

b) Milk yield in a normal lactation (r = 0.646)

c) Udder depth (r = 0.834)

d) Udder length measured by tape (r = 0.807)

e) Diagonal measurement of udder (r = 0.704)

f) Width at tips (r = 0.434)

g) Length of pelvis (r = 0.309)

Ahrens (1962) studied udder conformation in 174 pedigree daughters of 26 A.I. bulls in the region of Hanover. He reported seven highly significant correlations (over 0.80) between udder characteristics.

Fielder (1962) found positive correlation between milk yield and udder length, width and volume. Small positive correlations between udder measurements and pelvic measurements in particular in cows less than 5 years were also reported by him.

Sirbulescu et al. (1962) studied relationship between characters indicating milk production and their actual milk yield in Romanian Spotted cows and Dobrogee Red cows. Out of 10 characters studied in 314 Romanian Spotted and 82 Red cows

they found association for only 4 characters. They reported that cows with a well defined milk vein, well developed udder, a large amount of ear wax or a long thin tail had a yield average. Skin thickness had no practical relation to milk production.

Burnside et al. (1963) studied relationships among udder height, age and milk production in 319 Holstein cows. Data included 657 measurements of udder height and udder height less height of hock. Repeatability of these two measurements were 0.71 and 0.70 respectively. They reported highly significant correlation between udder height and age, 90 day milk yield and 305 day yield. They indicated that higher producing cows tended to have lower udders. Milk production and age were found to be phenotypically associated with variation in udder height and udder height less hock height.

Suzuki et al. (1963) reported following correlations between 305 day milk and

a) Length of udder surface ($r = 0.659 \pm 0.06$)
b) Width of udder surface ($r = 0.682 \pm 0.049$)
c) Width of fore udder ($r = 0.634 \pm 0.063$)
d) Udder volume index (calculated from the above three measurements) ($r = 0.823 \pm 0.030$)

They also reported that the correlation between yield

and distance between the teats varied from 0.30 to 0.55. The average error in milk yield estimated from udder measurements was approximately 565 kg and therefore yields were not accurately estimated from such measurements.

Borodin (1964) studied evaluation of cow's udder by measurements and showed correlation between milk yield and

a) Udder length (r = 0.177)

b) Udder depth (r = 0.357)

c) Udder size (r = 0.392)

Hladky (1964) while studying association between udder and teat measurements and milk production in 61 adult Czechoslovak Red Pied cows reported correlations between lactation yield and length of the right and left half of the udder, width of the fore-quarters and udder circumference. He also correlated these characters with milk yield in the first 100 and first 180 days. Daily milk yield was correlated with lactation butter fat yield.

Arzumanjan (1964) while studying udder type and production in cows reported a correlation of r = 0.498 between udder coefficient (circumference x depth) and milk production. He found no relation between udder coefficient and body weight.

While studying teat-shape and size in relation to

production characteristics and mastitis in 220 Holstein and Ayrshire cows which were grouped according to the shape, diameter, length and cross sectional area of their teats, Hickman (1964) found no significant differences in production traits attributed to variation in teat shape or measurements. He calculated partial linear regressions of milk yield, fat percentage and persistency in teat measurements after removal of the effects of farm, year and age. He also reported negative and highly significant regression of 180 days milk yield on length of front teats in Holsteins.

Avizov (1965) while studying the inheritance of some characters in 102 dairy cows, reported that milk yield was found to be related to the size of their udders. Females with the highest yields also had largest udders.

Brantov (1965) reported correlation between lactation yield, yield on the day on which the udder was measured with udder circumference, length and width in Red Steppe cows.

Ruzevskii et al. (1965) while studying the conformation of udder in 150 Black Pied Lowland cows reported correlations between daily milk yield and udder width (r = 0.552), udder depth (r = 0.344) and circumference (r = 0.724).

Makaveev (1966) studied udder conformation and milking characters in 144 cows and 100 Bulgarian Red heifers. He

found that daily milk yield in heifers was correlated with udder circumference (r = 0.664), udder width (r = 0.557) and udder length (r = 0.216). Udder conformation and milking characters were also compared in daughter groups of 6 bulls. Variation in all the characters studied was considerable.

Maskovskaja (1967) made 8 udder measurements in Bestuzhev cows in their 2nd-4th month of lactation. He reported correlation between milk yield and udder size (r = 0.575).

Sharma (1967) while studying variation in shape and size of udder in Hariana and Tharparkar breeds reported significantly positive correlations between the yield during the day of measurement, lactation yield and udder length, udder width and depth. He concluded that udder measurements provide a useful guide in selection of dairy cows of these breeds.

MATERIALS AND METHODS

Personal visits were made to four different places situated in Andhra Pradesh for the collection of data used in the present study. One important dual-purpose breed of cattle Ongole located in two farms and non-descript Jersey crosses located both in farm and field conditions were included in the study. At one of the places a co-ordinated research-cum-development scheme of Jersey cross-breeding with non-descript hilly cattle is being carried out with the financial backing of Indian Council of Agricultural Research since 1955. The total number of cows studied for variation in shape and size of udder and teats were 238 under various production levels. Details of places visited, breeds examined are given in Table 1.

A. The following biometrical investigations on morphological udder characters on lactating cows were made.

Udder measurements

(1) Length of udder surface

(2) Width of udder surface

(3) Depth of udder surface

(4) Circumference of udder surface

Table 1

Details of cows examined

Sl. No.	Farms and locations	Breeds	Lactations I	II	III	IV	V	VI	VII	Total
1.	Government Livestock Farm, Chinthaladeevi (Andhra Pradesh)	Ongole	25	19	24	18	14	8	7	115
2.	Government Livestock Farm, Mahanandi (Andhra Pradesh)	"	5	3	8	5	2	2	5	30
3.	Jersey Crossbreeding Scheme, Visakhapatnam (Andhra Pradesh)	Crossbreds (Field)	20	19	17	12	7	-	-	75
4.	Government Livestock Farm, Visakhapatnam (Andhra Pradesh)	Crossbreds (Farm)	18	-	-	-	-	-	-	18
		Total	68	41	49	35	23	10	12	238

Teat placement and teat measurements

(1) Distance between fore teats

(2) Distance between fore and hind teats

(3) Distance between hind teats

(4) Length of teats

(5) Diameter of teats

B. A visual appraisal was made at each place to evaluate the udder and teat shape. The evaluation of udder shape was done on the basis of description given by Cerkascenko (1963) and Tavildarova et al. (1961). Three types of udders viz. (1) bowl shaped (Fig. 2), (2) rounded (Fig. 2) and (3) goat type (Fig. 2) were classified. With respect to teat types also three types viz. (1) cylindrical, (2) funnel and (3) bottle type (Fig. 2) were classified. All these types were evaluated three times at each place for accuracy.

C. Besides the following information was obtained from the pedigree and history sheets and other relevant records maintained at different farms and places.

1) Brand number of cows in milk

2) Date of birth

3) Sire number and dam number of cows

4) First lactation yield

5) Order of lactation

6) Milk yield in the previous lactation

7) Date of calving in the current lactation

8) Total milk yield of current lactation and days in milk, one day before on which the udder was measured

9) Stage of lactation (for this each lactation was divided into 3 stages as - Stage I - 1-100 days, Stage II - 101-200 days and Stage III - 201-300 days)

10) First 90 day milk yield in the current lactation for those who passed this period

11) One day yield

For the purpose of accuracy in connection with the current one day yield, the cows were stripped completely one day prior to the measurement and the yields were recorded. At all the places weaning was not practiced. The milking was done twice a day at all places. The interval between two milkings at each place was approximately between 10-12 hours.

Procedure

Cows at different production levels were taken for the present study. Cows within a week of freshening who will have distended udders due to odematous swelling associated with parturition and cows in the last stage of lactation whose udders become reduced in size were omitted from the study (Dachs, 1958).

All measurements were taken 1-2 hours before milking. For this purpose, the milking cows at each place were secured properly on a level ground for the accuracy of measurements.

Though the time of day for taking measurements was different between places, the period from milking was fixed within a given place. The procedure for taking each measurement was standardised on Institute animals prior to taking the actual work.

I. UDDER MEASUREMENTS

(1) Length of udder surface

The udder length was measured with a cloth tape from the rear attachment of udder (more 'cut up' in the thigh) to the front of the udder along the sole of the udder where fore udder blends smoothly with the body. For all the animals the udder lengths were measured on both left and right sides separately which were averaged (Fig. 1).

(2) Width of udder surface

The udder width was measured as a distance between two lateral line of attachments of the udder to abdominal wall, beneath the flank. The cloth tape was kept in position on one side of the cow, under the flank, near the stifle joint and the tape was passed over, in between fore and hind teats to

other side (Fig. 1).

(3) Depth of udder surface

Udder depth was obtained by taking difference of two under mentioned measurements.

a) Distance from the barn floor to the base of the udder

It was measured as a vertical distance perpendicular to the body axis, from the lateral line of attachment of the udder to abdominal wall from where the udder width was measured, to the ground floor.

b) Distance from the barn floor to the lowest point of udder floor at the place of attachment of teats

Deduction of second measurement from the first one gives the udder depth (Fig. 1). Weighted steel tape was used for taking both these measurements.

(4) Circumference of udder surface

Udder circumference was measured by means of a cloth tape, one end of which was placed on the near side of the udder at the base and was passed round the udder between the hind legs close to body attachment and was brought to the site on the near side and the measurement was recorded (Fig. 1).

II. Teat placement and teat measurements

(1) Distance between fore teats

This was measured as a distance between two fore teats at their mid-width at the place of attachment to the quarters.

(2) Distance between fore and hind teats

This measurement was taken as a distance between fore and hind teats on both the sides which were averaged.

(3) Distance between hind teats

This was measured as a distance between two hind teats at their mid-width at the place of attachment to the two hind quarters.

(4) Length of teats

Teat length was measured to the nearest 0.1 mm. The length was measured from the point of attachment to the quarter where there was a demarcation by a hair line, to the tip of the teat. All four teats were measured. Front and hind teats were scored separately and averaged of the both front and hind teats were taken separately (Fig. 1). For all these measurements, weighted steel tape was used.

(5) Diameter of teats

Teat diameter was measured at the mid-point length by using Vernier callipers. The measurements of both front and hind teats were averaged separately (Fig. 1). All these measurements were taken in cm.

III. The following udder indices were also constructed from the above measurements.

(1) Index of udder volume

This was obtained by averaging udder circumference at the base and circumference at the site of teat attachment (teat placement) and then multiplying by udder depth. This is expressed in volume cm^3 (Davydov, 1939 and Fedotova, 1939).

(2) Index of udder size

This index was obtained by multiplying the length and depth of udder surface (Borodin, 1963).

(3) Index of udder capacity

This index was obtained by multiplying the area of the trapezium circumscribed by the line of teats with length of udder surface. All those animals with uneven teat placement were excluded from the data (Krempa, 1965).

(4) Index of udder efficiency

This was calculated by dividing the milk yield in 300 day lactation by the index of udder capacity (Krempa, 1965).

At all places with the exception of field crossbreds in the Jersey crossbreeding scheme, the cows are being maintained according to the standard nutritional and managemental procedures. Therefore, the environmental conditions for the field crossbreds were by no means well controlled either physically or statistically in this study in as much as they are under different nutritional and managemental regimen.

Statistical analysis

Standard statistical procedures as given in Snedecor (1956) and Kempthorne (1957) were adopted for the analysis of data.

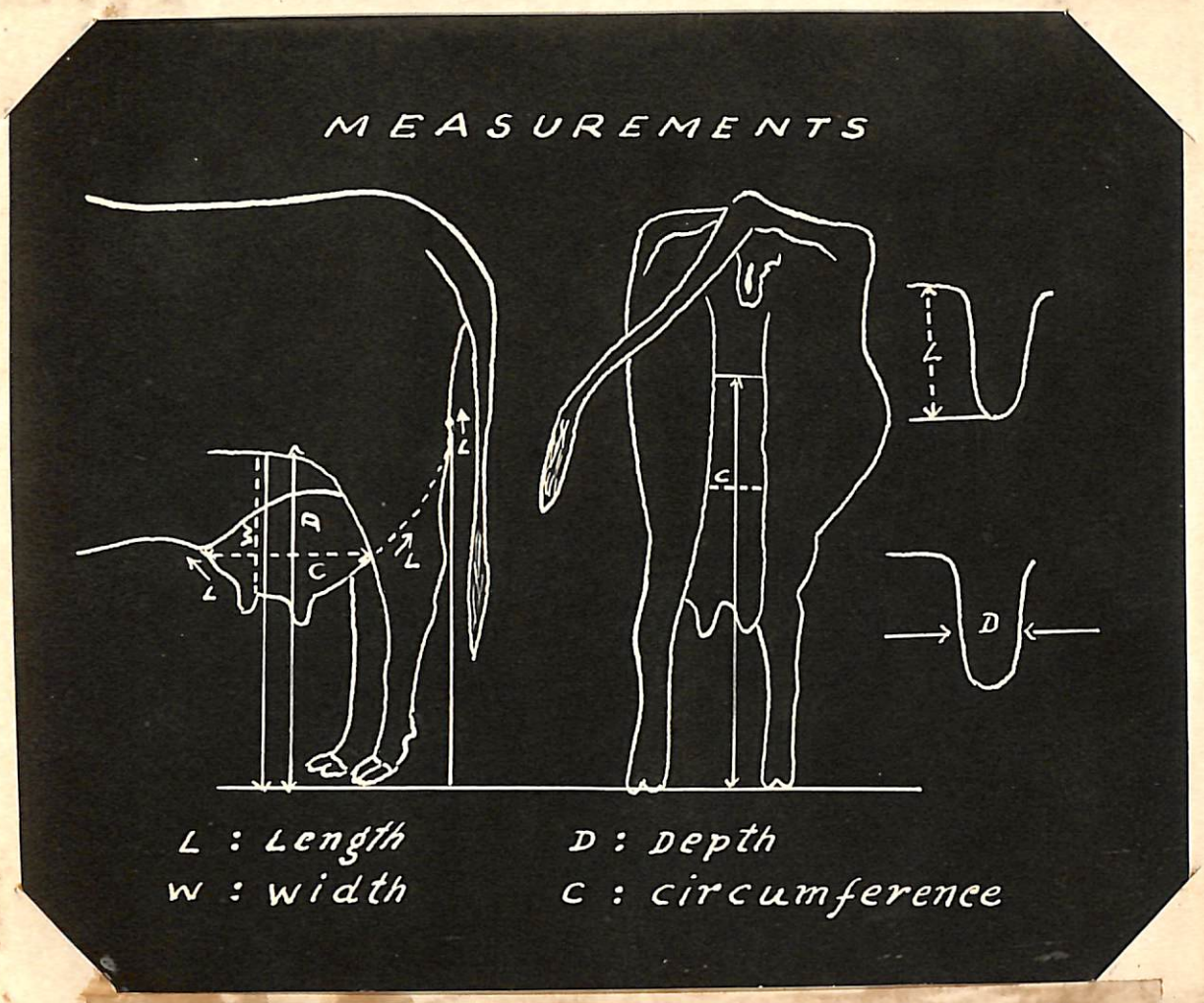
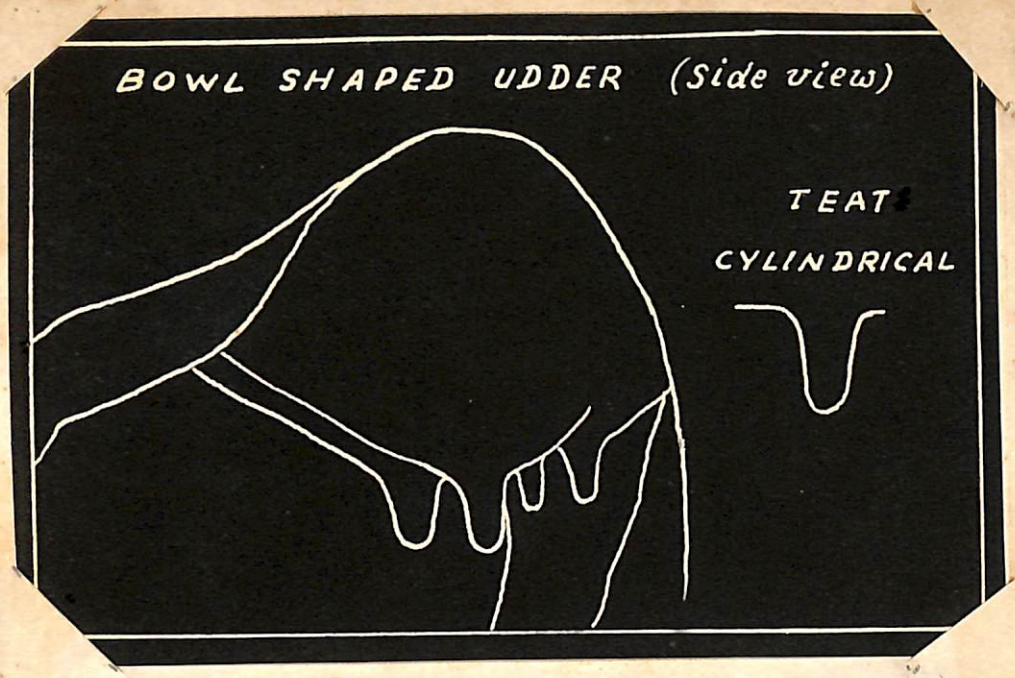
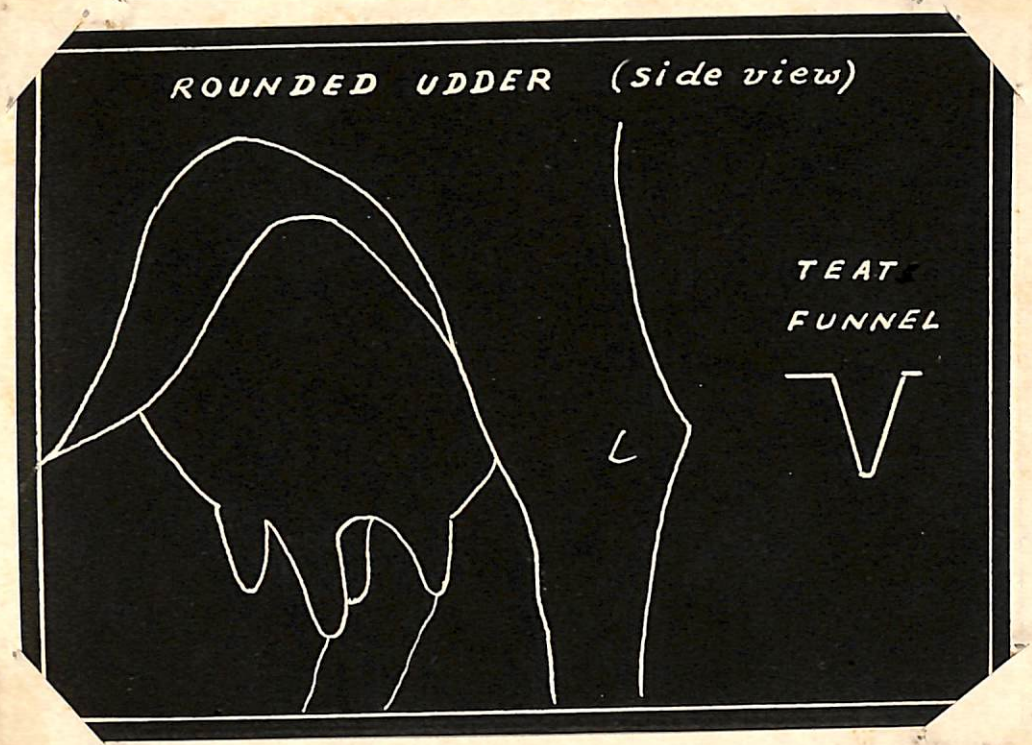


Fig. 1. Diagrammatic sketch of a cow showing the points of measurements of udder and teats


BOWL SHAPED UDDER (Side view)
TEATS
CYLINDRICAL


ROUNDED UDDER (side view)
TEATS
FUNNEL

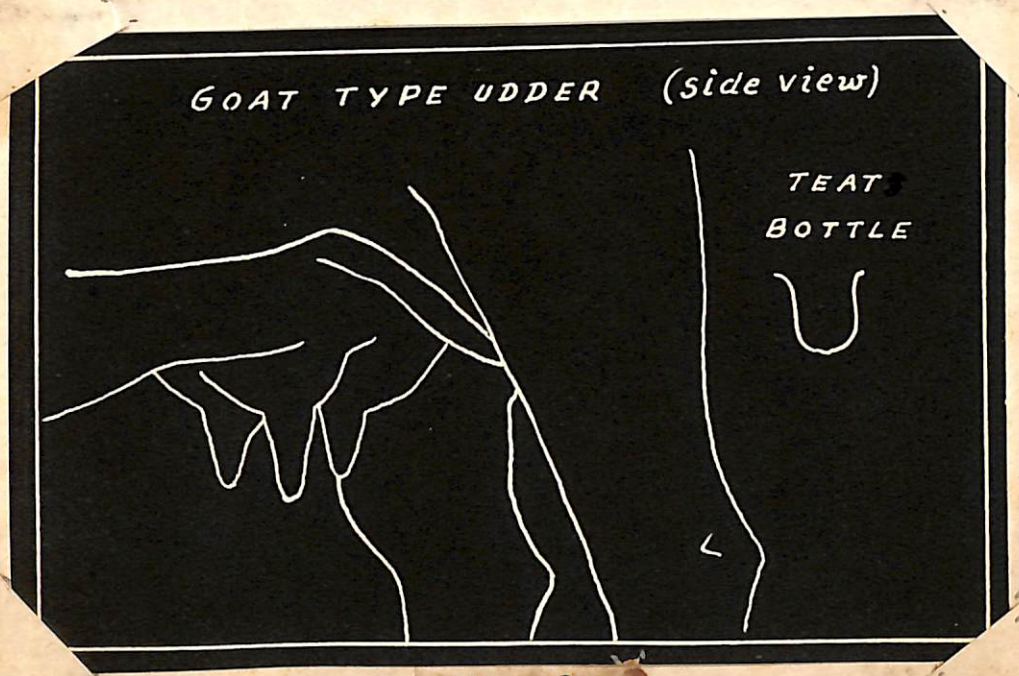

GOAT TYPE UDDER (side view)
TEATS
BOTTLE

Fig. 2

RESULTS

SHAPE OF UDDER AND TEATS

Types of udder

The data concerning different types of udders observed in the different herds of Ongole and Zebu x Jersey crosses are presented in Table 2.

Table 2

Incidence of udder types in different herds of Ongole and Zebu-Jersey cattle

Place	Type of udder (%)		
	Bowl	Rounded	Goat
ONGOLE			
Chinthaladeevi	58.0(67)	20.0(23)	22.0(25)
Mahanandi	63.3(19)	23.3 (7)	13.3 (4)
Overall	59.0(86)	21.0(30)	20.0(29)
CROSSBREDS			
Crossbreeding Scheme (Visakhapatnam) (Field)	74.7(56)	22.7(17)	2.6 (2)
Visakhapatnam (Farm)	72.2(13)	22.2 (4)	5.6 (1)
Overall	74.1(69)	22.6(21)	3.3 (3)
Between breed X^2 value	4.61*	2.53 NS	22.45**

(Figures in parentheses are number of observations)

** denotes the probability of chance occurrence less than 0.01

* " " " " " " 0.05

NS - Non-significant

In both Ongole and Zebu x Jersey crossbreds, the frequency of bowl shaped udders was more and that of goat type udders was less. In Ongole both rounded and goat type udders were about the same level, whereas, in crossbreds, the frequency of goat type udders was significantly less. The difference in the frequency of bowl shaped udders in the two breeds was significant at 5% level, whereas for goat type udders, it was significant at 1% level. However there was no difference between breeds in respect of rounded udders. Within breeds, also no significant difference was observed in the frequency of different type of udders.

Types of teats

Incidence of different types of teats observed in different herds of the Ongole and crossbreds was shown in Tables 3 and 4.

In both Ongole and crossbreds the highest frequency was that of cylindrical type, followed in order by the funnel and bottle types. In Ongole the difference in the occurrence of funnel types between the places was significant at 5% level, whereas in crossbreds bottle types were observed at one place only. The variation between Ongole and crossbreds in respect of cylindrical and funnel types was also highly significant.

Table 3

Incidence of types of teats (fore quarters) %

Place	Type of teat		
	Cylindrical	Funnel	Bottle
	ONGOLE		
Chinthaladeevi	62.0 (71)	33.0 (38)	5.0 (6)
Mahanandi	76.7 (23)	13.3 (4)	10.0 (3)
Overall	64.8 (94)	29.0 (42)	6.2 (9)
	CROSSBREDS		
Visakhapatnam (Field)	82.6 (62)	8.0 (6)	9.4 (7)
Visakhapatnam (Farm)	83.3 (15)	16.7 (3)	-
Overall	82.8 (77)	9.7 (9)	7.5 (7)
Between breed X^2 value	17.48**	14.28**	1.24 NS

Table 4

Incidence of types of teats (hind quarters) %

Place	Type of teat		
	Cylindrical	Funnel	Bottle
	ONGOLE		
Chinthaladeevi	52.1 (60)	46.1 (53)	1.8 (2)
Mahanandi	63.3 (19)	36.7 (11)	-
Overall	54.4 (79)	44.1 (64)	1.5 (2)
	CROSSBREDS		
Visakhapatnam (Field)	82.6 (62)	13.4 (10)	4.0 (3)
Visakhapatnam (Farm)	77.8 (14)	22.2 (4)	-
Overall	81.7 (76)	15.0 (14)	3.3 (3)
Between breed X^2 value	18.59**	20.44**	1.53 NS

In case of hind quarters also, in both Ongole and crossbreds, cylindrical type was the most frequent, followed in order by funnel and bottle types. In both breeds, bottle types were observed at one place only. Highly significant

variation between breeds was observed in the frequency of cylindrical and funnel types.

The incidence of different types of teats among the three types of udders in Ongole and crossbreds is presented in Table 5.

Table 5

Incidence of types of teats among the three udder types (%)

Type of udder	Type of teat					
	Cylindrical		Funnel		Bottle	
	Fore quarter	Hind quarter	Fore quarter	Hind quarter	Fore quarter	Hind quarter
ONGOLE						
Bowl	72.6	62.0	22.7	37.0	4.7	1.0
Rounded	68.0	60.0	16.0	33.3	16.0	6.7
Goat	41.0	24.0	59.0	76.0	-	-
Between shape X^2 value	12.10**	16.10**	17.50**	15.02**	2.53 NS	5.2 NS
CROSSBREDS						
Bowl	87.0	84.0	9.0	14.5	4.0	1.5
Rounded	81.0	85.7	4.7	11.0	14.3	3.3
Goat	-	-	66.6	66.6	33.4	33.4
Between shape X^2 value	1.63 NS	1.34 NS	12.62**	6.58*	5.05 NS	10.13*

In Ongole the incidence of cylindrical type of teats in both fore and hind quarters was more for bowl shaped and rounded udders, followed in order, by funnel and bottle types. Whereas for goat type udders only cylindrical and funnel types of teats were present, out of which the funnel type of teats were more frequent, and more so in the case of hind quarters. In crossbreds also similar pattern was observed except in the case of goat type udders, where funnel type was more frequent and cylindrical type was absent. The difference in the occurrence of cylindrical and funnel type teats among the three types of udders was significant in Ongole, whereas, the difference was significant with respect of funnel and bottle type teats in crossbreds.

The average first lactation yield and lactation length of the cows having different types of udders and teats are given in Table 6.

The results of the analysis of variance carried out are presented in Table 7.

From Table 7, it will be seen that the average first lactation yields were significantly different among udder types, whereas among teat types, the difference was significant at 5% level only. Critical difference tests revealed that the average yield of goat type udders was less than the average yields of bowl and rounded udders. In the case of teat

Table 6

Average first lactation yields and lactation lengths of *Ongole* cows (Chinthaladeevi) having different types of udder and teats

Character	Type of udder			Type of teats		
	Bowl	Rounded	Goat	Cylindrical	Funnel	Bottle
First lactation yield (kg)	1236.50	1427.05	882.72	1229.88	1115.21	1535.85
First lactation length (days)	317.22	311.42	290.75	305.57	313.53	296.75

The bar denotes the means which are not significantly different on the basis of C.D. test after the analysis of variance (Table 7)

Table 7

Analysis of Variance

ONGOLE

Source of variation	D.F.	Average 1st lactation yield (kg) Mean square	Average 1st lactation length (days) Mean square
Udder shapes	2	1583097.38**	5128.93 NS
Teat shapes	2	366152.99*	549.49 NS
Error	90	86044.48	2225.61

types, the average yield of bottle type teats was more than the average yields of other types (5% level).

Influence of sires on the inheritance of udder and teat types (Ongole)

Udder and teat types of 67 progeny of 11 sires were studied and their occurrence in the progeny of each sire is presented in Table 8.

X^2 test for testing proportions showed no significant differences among sires except in the case of bottle type teats (5% level).

Table 8

Influence of sires on the inheritance of udder and teat types among paternal half-sibs (%) ONGOLE

No. of half-sibs	Type of udder (%)			Type of teats (%)					
				Cylindrical		Funnel		Bottle	
	Bowl	Rounded	Goat	Fore quarter	Hind quarter	Fore quarter	Hind quarter	Fore quarter	Hind quarter
24	66.6	4.2	29.2	79.0	58.4	17.0	41.6	4.0	-
6	33.3	50.0	16.7	100.0	100.0	-	-	-	-
6	66.6	16.7	16.7	66.6	50.0	33.4	50.0	-	-
6	50.0	33.3	16.7	50.0	33.3	33.4	50.0	16.6	-
5	60.0	40.0	20.0	40.0	40.0	40.0	60.0	20.0	-
5	80.0	20.0	-	60.0	60.0	40.0	40.0	-	-
4	75.0	25.0	-	100.0	100.0	-	-	-	-
4	25.0	25.0	50.0	50.0	25.0	50.0	75.0	-	-
3	66.6	33.4	-	33.3	100.0	-	-	66.6	-
2	50.0	50.0	-	50.0	50.0	50.0	50.0	-	-
2	50.0	50.0	-	50.0	50.0	50.0	50.0	-	-
Between sire X^2 value	5.50 NS	11.01 NS	2.24 NS	12.04 NS	13.04 NS	4.06 NS	2.28 NS	9.46*	-

Influence of dams (Ongole)

Dam-daughter comparison for udder and teat types were made in 30 cows and 30 of their daughters. Dams with bowl shaped udders produced daughters, of which 80% of them also had bowl shaped udders and the remaining goat type udders. Most of the daughters of the dams with rounded udders had bowl shaped udders. All the daughters of the dams with goat type udders also had goat type udders. Such comparison was also made for the teat types both in the case of fore and hind quarters. All the dams with cylindrical, funnel and bottle type teats had progeny, 80% of which had cylindrical type and the remaining funnel type in the case of fore quarters, whereas in the case of hind quarters, 75% of the daughters of dams with cylindrical teats also had cylindrical teats and the remaining funnel type teats. Dams with funnel teats had also similar teats in 50% of their daughters. Whereas in the case of dams with bottle teats, 50% of the daughters had cylindrical and the remaining had funnel teats.

SIZE OF UDDER AND TEATS

I. Udder measurements

Results of the data pertaining to the 4 udder measurements viz. length of udder surface, width of udder surface, depth of udder surface and circumference of udder surface are

presented under this heading.

(1) Length of udder surface

In Table 9 are presented the mean udder lengths (cm) for each lactation group along with the respective standard errors (S.E.). Data belonging to the 4 places are shown separately. Stage-wise means for each lactation are also given wherever the stage x lactation effect on the measurements was significant.

Analysis of variance of the above data (Tables 10 and 11) showed that udder length had not varied due to order of lactation and stage of lactation in Ongole and crossbreds with the exception of Ongole (Chinthaladeevi), where it was influenced by stage x lactation effect, the variation being significant at 5% level. The udder length in the second stage of 3rd and 6th lactations was more. Both in Ongole (Chinthaladeevi) and crossbreds, the mean udder length was less in the first two lactations than in later lactations (Table 9) (Fig. 3).

Table 9

Mean udder lengths (cm)

Farm		Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
					ONGOLE					
Chinthaladeevi	Stage I	53.87	51.88	53.44	54.59	57.40	54.33	57.00		
	" II	47.83	50.50	57.80	54.00	56.00	59.50	57.00	0.50	10.00
	" III	48.62	53.35	54.98	52.75	56.33	55.83	55.87		
Mahanandi		56.60 ±1.96	53.33 ±2.02	53.00 ±1.61	54.30 ±1.49	47.50 ±0.49	59.00 ±7.02	54.43 ±1.84	0.94	8.70
									Overall	9.71
					CROSSBREDS					
Visakhapatnam (Field)		48.75 ±1.53	51.52 ±1.50	57.02 ±1.52	56.83 ±1.43	55.14 ±3.05	-	-	0.85	13.86
Visakhapatnam (Farm)		48.44 ±0.92	-	-	-	-	-	-	0.92	8.11
									Overall	13.55

Table 10

Analysis of variance (udder length)

ONGOLE

Source of variation	D.F.	Mean square
	Chinthaladeevi	
Analysis of Means		
Stages	2	55.49 NS
Lactations	6	20.16 NS
Stage x lactation	12	16.10*
Error	94	7.86 (n σ^2)
Individual (n = 0.3104)	94	25.33 (σ^2)
	Mahanandi	
Stages	2	9.03 NS
Lactations	6	33.58 NS
Error	21	20.37

Table 11

Analysis of variance (udder length)

ZEBU-JERSEY CROSSES

Source of variation	D.F.	Mean square
	CROSSBREDS (FIELD)	
Analysis of Means		
Stages	2	29.84 NS
Lactations	4	33.65 NS
Stage x lactation	8	21.11 NS
Error	60	11.53 (n σ^2)
Individual (n = 0.2786)	60	41.40 (σ^2)

Table 12

Analysis of variance (udder length)

Source of variation	D.F.	Mean square
Breeds	1	138.89
Farms within breeds	2	166.07*
Within farms	234	37.24

Breed to breed variation

The mean udder length in Ongole varied from 53.75 ± 0.50 cms to 54.27 ± 0.94 cms and in crossbreds from 48.44 ± 0.92 cms to 53.22 ± 0.85 cms. Between breeds, the variation was not significant, whereas, between crossbreds, the length was significantly (5% level) more for field crossbreds (Table 12). The overall C.V. % for this trait in Ongole was 9.71 and in crossbreds it was 13.55.

(2) Width of udder surface

In Table 13 are summarised the mean udder widths in cm along with their S.E. of the animals in the different herds of Ongole and Zebu-Jersey crosses.

Analysis of variance of the above data (Tables 15 and 16) showed that the udder width had not varied from lactation to lactation as well as from stage to stage within lactation except in the case of Ongole (Chinthaladeevi) where the variation between lactations was highly significant.

Critical difference tests showed that udder width in 1st lactation was significantly less and from 2nd to 5th lactations it has not varied whereas in 6th and 7th lactations, it was significantly more than in other lactations (Fig. 4).

Table 13

Mean udder widths (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
					ONGOLE				
Chinthaladeevi	45.64 ±1.53	51.57 ±0.85	51.02 ±1.25	53.13 ±1.02	53.75 ±1.36	57.56 ±2.35	55.27 ±1.77	0.62	13.05
Mahanandi	52.80 ±4.00	51.83 ±3.67	49.06 ±2.13	51.00 ±2.50	51.00 ±2.00	53.50 ±1.50	56.12 ±2.56	1.10	11.66
								Overall	12.61
					CROSSBREDS				
Visakhapatnam (Field)	49.30 ±1.51	53.73 ±1.86	58.82 ±2.31	59.33 ±1.77	57.42 ±3.50	-	-	1.09	16.06
Visakhapatnam (Farm)	47.88 ±1.29	-	-	-	-	-	-	1.29	11.50
								Overall	14.28

Table 14

Mean udder depths (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
				ONGOLE					
Chinthaladeevi	14.28 ±0.63	17.39 ±0.65	18.58 ±0.48	19.97 ±0.83	18.00 ±0.85	20.43 ±1.38	21.50 ±1.46	0.35	21.05
Mahanandi	15.60 ±0.29	14.83 ±1.11	14.25 ±0.72	15.90 ±1.74	12.50 ±1.24	19.75 ±0.25	17.87 ±1.09	0.51	11.40
								Overall	21.07
				CROSSBREDS					
Visakhapatnam (Field)	17.20 ±0.52	18.42 ±0.68	20.52 ±0.98	21.83 ±0.61	20.28 ±1.54	-	-	0.40	17.98
Visakhapatnam (Farm)	18.61 ±0.61	-	-	-	-	-	-	0.61	14.05
								Overall	17.32

Table 15

Analysis of variance (udder width, udder depth and udder circumference)

ONGOLE

Source of variation	D.F.	Udder width Mean square	Udder depth Mean square	Udder circumference Mean square
		Chinthaladeevi		
Analysis of means				
Stages	2	8.18 NS	0.80 NS	71.79 NS
Lactations	6	53.57**	17.65**	69.64 NS
Stage x lactation	12	5.94 NS	2.46 NS	29.63 NS
Error	94	10.52 ($n\sigma^2$)	2.94 ($n\sigma^2$)	33.36 ($n\sigma^2$)
Individual (n = 0.3104)	94	68.99 (σ^2)	9.48 (σ^2)	107.49 (σ^2)
		Mahanandi		
Stages	2	36.75 NS	14.60 NS	82.69 NS
Lactations	6	26.70 NS	17.67**	64.67 NS
Error	21	39.37	4.44	98.75

Table 16

Analysis of variance (udder width, udder depth, udder circumference)

ZEBU-JERSEY CROSSES

Source of variation	D.F.	Udder width Mean square	Udder depth Mean square	Udder circumference Mean square
		CROSSBREDS (FIELD)		
Analysis of Means				
Stages	2	18.41 NS	4.48 NS	171.55 NS
Lactations	4	50.96 NS	9.53 NS	49.81 NS
Stage x lactation	8	19.88 NS	4.13 NS	135.11*
Error	60	19.22 (n σ^2)	2.72 (n σ^2)	58.04 (n σ^2)
Individual (n = 0.2786)	60	68.99 (σ^2)	9.77 (σ^2)	208.34 (σ^2)

Table 17

Analysis of variance (udder width, udder depth, udder circumference)

Source of variation	D.F.	Udder width Mean square	Udder depth Mean square	Udder circumference Mean square
Breeds	1	260.87 NS	160.29**	10535.79**
Farms within breeds	2	365.32**	53.58*	2366.21**
Within farms	234	56.97	13.24	214.81

The mean width in Ongole varied from 51.32 ± 0.62 cms to 51.85 ± 1.10 cms whereas in crossbreds, it varied from 47.88 ± 1.29 cms to 54.94 ± 1.01 cms (Table 13).

The difference between breeds was insignificant while the difference between crossbreds maintained under field and farmbred conditions was highly significant (Table 17). The overall C.V. % for Ongole and crossbreds was 12.61 and 14.28 respectively.

(3) Depth of udder surface

Summary of the data are presented in Table 14 and the analysis of variance is shown in Tables 15 and 16.

In Ongole, variation in udder depth due to order of lactation was observed in both places, the difference being significant at 1% level. However, in crossbreds, no variation was observed. Critical difference tests showed that in Chinthaladeevi, the udder depth in first lactation was significantly less. Among the later lactations, the mean depth in 5th lactation was also less, which might be due to chance. The mean depth progressively increased in succeeding lactations (Fig. 5).

In case of Ongole (Mahanandi), the mean depth in the last two lactations was significantly more than in the remaining

lactations (Table 14) (Fig. 5).

The mean depth in Ongole varied from 15.85 ± 0.51 cms to 17.90 ± 0.35 cms and from 18.61 ± 0.61 cms to 19.29 ± 0.40 cms in crossbreds (Table 14).

The variation between Ongole and crossbreds was highly significant, the mean depth in crossbreds being more than in Ongole. Within Ongole, the places differed in the mean depth at 5% level (Table 17). The overall C.V. % in Ongole and crossbreds was 21.07 and 17.32 respectively.

(4) Circumference of udder surface

Detailed data are summarised in Table 18 and the analysis of variance in Tables 15 and 16.

At none of the places the variation in the mean circumference in Ongole was significant between lactations as well as stages within lactation. However, for crossbreds (field) the variation due to stages within lactations was significant at 5% level. Further examination showed that the mean circumferences in the first stage of 3rd and 4th lactations and 2nd stage of 5th lactation were more than in other stages in different lactations (Table 18).

The mean circumference in Ongole at Chinthaladeevi and Mahanandi was 72.41 ± 1.01 cms and 76.78 ± 1.78 cms with a

Table 18

Mean udder circumferences (cm)

Farm		Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
					ONGOLE					
Chinthaladeevi		66.10 ±2.36	70.94 ±2.38	74.91 ±2.46	74.80 ±1.89	76.39 ±2.78	76.18 ±1.75	72.00 ±3.90	1.01	15.05
Mahanandi		71.50 ±2.42	76.16 ±6.63	76.50 ±4.21	78.00 ±2.50	77.00 ±9.00	86.75 ±0.25	76.25 ±5.97	1.73	12.39
									Overall	14.66
					CROSSBREDS					
Visakhapatnam (Field)	Stage I	92.66	92.00	102.60	104.30	79.60				
	" II	84.66	89.57	93.50	88.00	120.00	-	-	1.77	17.03
	" III	79.70	85.60	91.20	83.00	83.30				
Visakhapatnam (Farm)		73.11 ±2.03	-	-	-	-	-	-	2.03	11.81
									Overall	15.20

C.V. % of 15.05 and 12.39 respectively. The mean was highest in crossbreds (field) 90.28 ± 1.77 cms and lowest in crossbreds (farm) 73.11 ± 2.03 cms (Table 18) (Fig. 6).

Analysis of variance between breeds and between farms within breeds, revealed highly significant variations. The crossbreds under field conditions had highest mean circumference which was significantly different from Ongole as well as crossbreds at other places.

The overall C.V. % in Ongole was 14.66, whereas in crossbreds it was 15.20.

It was also observed that of all the animals, the crossbreds in field conditions with 75% Jersey inheritance had highest averages for all the four udder measurements. However these differences were not tested for significance for want of sufficient data (Table 19).

Heritability estimates

In Table 20 are presented the estimates of heritability and the S.E. for the udder measurements in Ongole.

All these estimates were calculated from the data on half-sibs which were under different production levels. The heritability of udder width and udder depth was very high

Table 19

Overall farm-wise means, S.E. and C.V. % of udder measurements, udder indices and teat placement and teat measurements

Measurements	Chinthaladeevi Ongole		Mahanandi Ongole		Crossbreeding Scheme Visakhapatnam				Visakhapatnam (Farm)	
					Crossbreds 50%		Crossbreds 75%		Crossbreds 50%	
	Mean ±SE	C.V.%	Mean ±SE	C.V.%	Mean ± SE	C.V. %	Mean ± SE	C.V. %	Mean ± SE	C.V.%
I. Udder measurements										
Length of udder surface	53.75 ±0.50	10.00	54.27 ±0.94	8.70	53.35 ±0.90	13.80	55.40 ±2.50	14.25	48.44 ±0.92	8.11
Width of udder surface	51.32 ±0.62	13.05	51.85 ±1.10	11.66	54.64 ±0.76	11.25	56.90 ±1.70	9.49	47.88 ±1.29	11.50
Depth of udder surface	17.90 ±0.35	21.05	15.85 ±0.51	11.40	19.13 ±0.44	18.87	20.30 ±0.65	10.09	18.61 ±0.61	14.05
Circumference of udder surface	72.41 ±1.01	15.05	76.78 ±1.73	12.39	89.41 ±1.89	17.10	95.90 ±4.90	16.16	73.11 ±2.03	11.81
II. Udder indices										
Index of udder volume	880.55 ±22.73	27.36	803.66 ±38.41	26.18	1132.92 ±45.03	31.77	1273.78 ±81.07	20.09	926.43 ±43.20	19.78
Index of udder size	966.55 ±23.55	26.08	867.68 ±37.81	23.87	1026.66 ±38.66	30.34	1127.50 ±66.67	18.68	906.19 ±47.76	22.36
Index of udder capacity	20.58 ±0.77	38.14	16.96 ±1.20	33.11	30.80 ±0.63	16.36	33.84 ±7.02	65.54	19.36 ±1.71	37.63
Index of udder efficiency	60.36 ±2.60	41.08	48.53 ±3.56	33.64	66.89 ±5.60	41.85	-	-	75.34 ±5.58	27.60

Table 19 (contd)

Measurements	Chinthaladeevi Ongole		Mahanandi Ongole		Crossbreeding Scheme Visakhapatnam				Visakhapatnam (Farm)	
					Crossbreds 50%		Crossbreds 75%		Crossbreds 50%	
	Mean ± SE	C.V.%	Mean ± SE	C.V.%	Mean ± SE	C.V. %	Mean ± SE	C.V. %	Mean ± SE	C.V. %
III. Teat placement and teat measurements										
Distance between foreteats	8.77 ±0.19	23.12	8.48 ±0.35	22.92	9.15 ±0.34	36.34	9.45 ±0.66	22.32	9.00 ±0.52	24.77
Distance between fore and hind teats	5.79 ±0.09	17.50	5.41 ±0.15	16.09	6.31 ±0.16	28.42	7.20 ±0.54	23.86	5.77 ±0.19	14.38
Distance between hind teats	5.00 ±0.11	23.54	4.29 ±0.20	25.84	5.16 ±0.18	29.51	5.30 ±0.45	27.07	5.38 ±0.37	29.36
Length of foreteats	6.68 ±0.14	23.44	6.72 ±0.26	21.72	5.25 ±0.15	24.24	5.10 ±0.31	19.60	5.35 ±0.18	14.34
Diameter of foreteats	2.67 ±0.05	19.82	2.76 ±0.08	16.95	1.92 ±0.04	19.60	1.92 ±0.03	6.56	1.87 ±0.04	9.09
Length of hind teats	5.76 ±0.11	23.66	5.23 ±0.17	18.73	4.69 ±0.11	20.24	4.30 ±0.19	14.41	5.01 ±0.17	13.23
Diameter of hind teats	2.35 ±0.03	17.80	2.20 ±0.05	13.71	1.83 ±0.04	18.93	1.76 ±0.02	4.71	1.94 ±0.04	10.32

Table 20

Heritability estimates of udder measurements

Ongole (Chinthaladeevi)

Character	Heritability	S.E.
Length of udder	0.09	0.15
Width of udder	0.76	0.19
Depth of udder	0.89	0.21
Circumference of udder	0.18	0.10

$\bar{K}$ = 7.77

No. of sires - 10

showing that there was scope for further improvement in these measures through selection. The estimate for udder length, was however, less precise due to high S.E. For udder circumference the value was low.

In Table 21 are summarised the estimates of heritability with respective S.E. for the udder measurements in Zebu x Jersey crossbreds maintained under field conditions.

These estimates were also obtained from the half-sibs in different production levels and maintained under different nutritional and managemental regimen.

Table 21

Heritability estimates of udder measurements

Crossbreds (Field)

Character	Heritability	S.E.
Length of udder	0	-
Width of udder	0.53	0.21
Depth of udder	0.40	0.19
Circumference of udder	0	-

$\bar{K}$ = 6.55

No. of sires - 8

The heritability for udder length and udder circumference was not different from zero. Whereas relatively high estimates were obtained for width of udder and depth of udder. When compared with the respective estimates in Ongole, both these values were low.

B. Indices of udder

Under this heading were dealt (a) the index of udder volume, (b) the index of udder size, (c) the index of udder

capacity and (d) the index of udder efficiency.

1. Index of udder volume

In Table 22 are given the mean udder volume in cm^3 along with the respective standard errors for both the breeds.

Analysis of variance of the data (Tables 23 and 24) revealed that in Ongole (Chinthaladeevi) there was highly significant variation between lactations, whereas in Zebu x Jersey crossbreds (field) the index of udder volume was subjected to variation due to a particular stage in a particular order of lactation. This variation was significant at 5% level only.

Critical difference tests showed that in Ongole (Chinthaladeevi) the mean index of udder volume in the first lactation was significantly less than in second lactation and both these means were in turn significantly less than the means in later lactations.

In case of crossbreds, the mean index of volume was highest in the 1st stage of 3rd and 4th lactations, 2nd stage of 5th lactation as well as in the 3rd stage of 3rd lactation. The means in the 3rd stage of all lactations were less than the other stages (Table 22).

Table 22

Mean indices of udder volume (cm^3)

Farm		Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V. %
					ONGOLE					
Chinthaladeevi		639.11 ±38.34	834.35 ±46.66	934.90 ±38.54	1003.12 ±145.73	957.18 ±59.23	1051.13 ±79.78	1041.43 ±58.12	22.73	27.36
Mahanandi		760.10 ±36.87	727.43 ±106.15	711.03 ±66.14	811.72 ±106.15	678.73 ±14.60	1124.50 ±20.49	915.50 ±121.79	38.41	26.18
									Overall	27.34
					CROSSBREDS					
Visakhapatnam (Field)	Stage I	1082.75	1077.20	1324.10	1541.10	988.60				
	" II	1054.30	1095.10	1251.90	1241.90	1982.50	-	-	30.63	40.73
	" III	857.70	1117.00	1326.40	1124.10	1087.30				
Visakhapatnam (Farm)		926.43 ±43.20	-	-	-	-	-	-	43.20	19.78
									Overall	35.05

Table 23

Analysis of variance (index of udder volume, index of udder size and index of udder capacity)

ONGOLE

Source of variation	D.F.	Index of udder volume Mean square	Index of udder size Mean square	D.F.	Index of udder capacity Mean square
			Chinthaladeevi		
Analysis of Means					
Stages	2	10638.16 NS	3196.24 NS	2	2.38 NS
Lactations	6	77244.22**	90327.08**	6	55.04*
Stage x lactation	12	9960.20 NS	7155.19 NS	12	16.56 NS
Error	94	9702.28 (n σ^2)	13188.77 (n σ^2)	83	17.09 (n σ^2)
Individual (n = 0.3104)	94	31257.37 (σ^2)	42489.61 (σ^2)	83	47.93 (σ^2) (n = 0.3566)
			Mahanandi		
Stages	2	86695.03 NS	60582.29*		
Lactations	6	79819.48 NS	147873.94**		-
Error	21	30070.30	11212.97		

Table 24

Analysis of variance (index of udder volume, index of udder size and index of udder capacity)

ZEBU-JERSEY CROSSES

Source of variation	D.F.	Index of udder volume Mean square	Index of udder size Mean square	D.F.	Index of udder capacity Mean square
		CROSSBREDS (FIELD)			
Analysis of Means					
Stages	2	62165.43 NS	36991.00 NS	2	81.24 NS
Lactations	4	69519.94 NS	81751.75 NS	4	37.73 NS
Stage x lactation	8	74331.42*	54672.00**	8	211.51*
Error	60	28193.54 (n σ^2)	18043.19 (n σ^2)	59	84.98 (n σ^2)
Individual (n = 0.2786)	60	101197.23 (σ^2)	64763.81 (σ^2)	59	304.28 (σ^2) (n = 0.2793)

Table 25

Analysis of variance (index of udder volume, index of udder size and index of udder capacity)

Source of variation	D.F.	Index of udder volume Mean square	Index of udder size Mean square	D.F.	Index of udder capacity Mean square
Breeds	1	3352615.00**	262615.70 NS	1	4256.13**
Farms within breeds	2	438603.57*	246485.10*	2	1135.28**
Within farms	234	93853.27	71217.34	214	177.72

The mean volume index in Ongole ranged from 803.66 ± 38.41 cm^3 to 880.55 ± 22.73 cm^3. In crossbreds, the mean varied from 926.43 ± 43.20 cm^3 to 1151.71 ± 30.63 cm^3.

Between breeds the difference was highly significant and within crossbreds, the difference was significant at 5% level only, the highest mean being present in crossbreds (field) (Table 25). The overall C.V. % in Ongole was 27.34 and 35.05 in crossbreds.

2. Index of udder size

Summary of the data on this index is given in Table 26 and the analysis of variance in Tables 23 and 24.

Analysis of variance of the above data (Tables 23 and 24) indicated that the mean udder size index varied due to order of lactation in Ongole (Chinthaladeevi) as well as in Ongole (Mahanandi). In Zebu x Jersey crossbreds, the stage x lactation effect was highly significant.

Further examination of the data revealed that the mean was highest in the 6th and 7th lactations. The mean in first two lactations was less. From 3rd-6th lactation, no variation was present and did not differ among themselves while, in 7th lactation, it was significantly more in Ongole (Chinthaladeevi). In Ongole (Mahanandi) there was no

Table 26

Mean indices of udder size

Farm		Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V. %
					ONGOLE					
Chinthaladeevi		721.35 ±39.76	905.78 ±47.79	1017.23 ±45.91	1076.12 ±45.30	1030.10 ±17.37	1156.10 ±65.28	1207.97 ±52.56	23.55	26.08
Mahanandi		885.10 ±14.82	791.50 ±72.13	760.50 ±55.36	870.40 ±113.58	652.50 ±52.64	1163.50 ±123.82	990.80 ±92.08	37.81	23.87
								Overall		26.03
					CROSSBREDS					
Visakhapatnam (Field)	Stage I	924.60	961.80	1158.40	1379.00	937.00				
	" II	975.30	973.80	1124.40	1135.30	1794.00	-	-	28.94	34.75
	" III	760.00	939.60	1284.80	1096.00	1073.30				
Visakhapatnam (Farm)		906.19 ±47.76	-	-	-	-	-	-	47.76	22.36
								Overall		29.92

significant difference in the first 5 lactations, while the mean in the 6th and 7th lactations was high. This indicated a gradual increase in the udder size, as the animal advanced in age. In the case of Zebu x Jersey crossbreds, the means in the 1st stage of 4th lactation and the 2nd stage of 5th lactation were higher. However highest mean was observed in the 4th lactation (Table 26).

The variation due to breeds was insignificant, whereas within crossbreds, the field crossbreds had significantly higher mean index of udder size (Table 25).

The means in Ongole varied from 867.68 ± 37.81 to 966.55 ± 23.55 with overall C.V. % of 26.03. In crossbreds, the values ranged from 906.19 ± 47.76 to 1040.10 ± 28.94 with overall C.V. % 29.92.

3. Index of udder capacity

In Table 27 are summarised the data and the analysis of variance in Tables 23 and 24.

Analysis of variance in Ongole was carried out for Chinthaladeevi only. The variation between lactations was significant at 5% level only. In Zebu x Jersey crossbreds, the stagexlactation effect was significant at 5% level.

Critical difference tests in Ongole showed that the variation between first and second lactations was insignificant,

LIBRARY.

Table 27

Mean indices of udder capacity

Farm		Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V. %
					ONGOLE					
Chinthaladeevi		15.22 ±0.83	17.15 ±1.16	21.60 ±1.09	21.25 ±1.50	29.13 ±2.80	22.32 ±2.91	24.51 ±2.12	0.77	38.14
Mahanandi		21.87 ±3.04	14.96 ±6.01	14.69 ±2.51	17.94 ±2.51	13.78 ±1.01	25.68 -	18.56 ±2.84	2.35	28.25
									Overall	37.12
					CROSSBREDS					
Visakhapatnam (Field)	Stage I	48.23	33.92	34.69	38.34	25.32				
	" II	26.41	22.50	32.85	23.59	67.50	-	-	2.08	57.34
	" III	21.65	36.26	26.03	33.26	25.20				
Visakhapatnam (Farm)		19.36 ±1.71	-	-	-	-	-	-	1.71	37.63
									Overall	59.07

while, both these were significantly less than in the remaining lactations. The mean gradually increased with number of lactations.

In the case of crossbreds, the means in the first stage of 1st and 4th lactations and in the 2nd stage of 5th lactation were higher.

Breed to breed variation as well as, place to place variation within breeds (Table 25) was found to be highly significant. Among all the mean of the crossbreds (field) was significantly higher. The means varied from 16.96 ± 1.20 to 20.58 ± 0.77 in Ongole and from 19.36 ± 1.71 to 31.21 ± 2.08 in crossbreds. The overall C.V. % in the two breeds were 37.12 and 59.07 respectively.

4. Index of udder efficiency

In Table 28 are summarised the data on the subject and analysis of variance in Table 29.

Analysis of variance was carried out to find out the variation due to shapes, lactations and shape x lactation effect in Ongole (Chinthaladeevi), crossbreds (field). No significant variation was observed in both breeds.

Breed to breed variation was significant at 5% level only (Table 30). The mean in crossbreds was significantly more than in Ongole. The means varied from 48.53 ± 3.56 to

Table 28

Mean indices of udder efficiency

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
				ONGOLE					
Chinthaladeevi	50.76 ±3.01	63.57 ±5.01	45.97 ±5.50	46.42 ±5.75	59.11 ±12.50	45.02 ±5.38	-	2.60	41.08
Mahanandi	41.47 ±7.01	33.19 -	59.57 ±10.21	51.27 ±10.00	49.82 ±1.58	-	43.22 ±1.91	4.26	39.26
								Overall	40.41
				CROSSBREDS					
Visakhapatnam (Field)	50.42 -	34.57 ±4.04	46.79 ±2.46	60.07 ±4.03	85.60 ±38.15	-	-	5.60	41.85
Visakhapatnam (Farm)	75.34 ±5.58	-	-	-	-	-	-	5.58	27.60
								Overall	37.72

Table 29

Analysis of variance (index of udder efficiency)

Source of variation	Ongole Chinthaladeevi D.F.	Ongole Chinthaladeevi Mean square	Crossbreds Field D.F.	Crossbreds Field Mean square
Analysis of Means				
Shapes	2	414.86 NS	1	8.40 NS
Lactations	5	171.49 NS	3	100.77 NS
Shape x lactation	10	214.30 NS	3	462.82 NS
Error	74	215.34 (n σ^2)	17	427.87 (n σ^2)
Individual	74	571.20 (σ^2)	17	873.21 (σ^2)
(n = 0.3770)				(n = 0.4900)

Table 30

Analysis of variance (index of udder efficiency)

Source of variation	D.F.	Mean square
Breeds	1	2428.40*
Farms within breeds	2	105.25 NS
Within farms	146	610.48

60.36 ± 2.60 in Ongole and from 66.89 ± 5.60 to 75.34 ± 5.58 in crossbreds. The respective C.V. % were 40.41 and 37.72.

Heritability estimates

In Table 31 are presented the heritability estimates with the respective standard errors for the udder indices in Ongole and crossbreds.

The heritability estimates for index of udder volume and index of udder size in Ongole were very high. The value for index of udder capacity was less and that for udder efficiency was not significantly different from zero.

In the case of crossbreds (field), these estimates were very low. Only the estimate for index of udder size

Table 31

Heritability estimates of udder indices

Character	Ongole		Crossbreds	
	Herita-bility	S.E.	Herita-bility	S.E.
Index of udder volume	0.91	0.21	0.03	0.12
Index of udder size	0.63	0.17	0.25	0.16
Index of udder capacity	0.29	0.12	0.06	0.12
Index of udder efficiency	0	-	-	-
$\bar{K}$	7.77		6.55	
No. of sires	10		8	

was precise, while the estimates for index of udder volume and capacity were less precise due to high standard error. The heritability for the index of udder efficiency could not be calculated for want of sufficient data.

III. Teat placement and teat measurements

Under this heading are dealt (a) teat placement - (1) distance between fore teats, (2) distance between fore and hind teats and (3) distance between hind teats; (b) teat measurements - (1) length of fore hind teats and (2) diameter of fore and hind teats.

III. (a) Teat placement

1. Distance between fore teats

Data are tabulated in Table 32 and analysis of variance in Table 34 for Ongole and in Table 35 for crossbreds.

Analysis of variance of the data showed no significant variation between stages and lactations in both breeds.

Between breeds and between places there was no significant variation. The means in Ongole varied from 8.48 to 8.77 cms and in crossbreds from 9.00 to 9.19 cms. The respective C.V. % for the breeds were 23.09 and 28.27 (Table 32).

2. Distance between fore and hind teats

In Table 33 are summarised the data and the analysis of variance in Tables 34 and 35.

In both breeds the variation was not significant due to stages and lactations.

Between breeds the variation was highly significant. Between places, in crossbreds also there was variation (Table 36). The means varied from 5.41 to 5.79 cms in Ongole and from 5.77 to 6.43 cms. in crossbreds. The C.V. % was 17.43 and 21.64 respectively.

Table 32

Mean distances between fore teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
				ONGOLE					
Chinthaladeevi	8.09 ±0.34	8.28 ±0.42	8.85 ±0.48	8.77 ±0.38	10.35 ±0.63	8.87 ±0.64	9.08 ±0.68	0.19	23.12
Mahanandi	9.10 ±0.91	6.83 ±0.60	8.37 ±0.80	8.60 ±0.65	8.50 ±2.50	10.25 ±0.25	8.37 ±1.16	0.35	22.92
								Overall	23.09
				CROSSBREDS					
Visakhapatnam (Field)	9.12 ±0.77	8.65 ±0.50	10.32 ±0.50	9.33 ±0.68	7.85 ±0.84	-	-	0.30	28.97
Visakhapatnam (Farm)	9.00 ±0.52	-	-	-	-	-	-	0.52	24.77
								Overall	28.27

Table 33

Mean distances between fore and hind teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
				ONGOLE					
Chinthaladeevi	5.07 ±0.15	5.71 ±0.27	5.99 ±0.09	5.83 ±0.21	6.42 ±0.30	6.12 ±0.42	6.33 ±0.43	0.09	17.50
Mahanandi	6.02 ±0.49	5.56 ±0.58	4.97 ±0.33	5.35 ±0.26	4.65 ±0.35	6.25 ±0.25	5.50 ±0.28	0.15	16.09
							Overall		17.43
				CROSSBREDS					
Visakhapatnam (Field)	5.91 ±0.39	6.28 ±0.26	6.88 ±0.32	6.95 ±0.26	6.28 ±0.60	-	-	0.16	22.20
Visakhapatnam (Farm)	5.77 ±0.19	-	-	-	-	-	-	0.19	14.38
							Overall		21.64

Table 34

Analysis of variance (teat placement, length and diameter of fore teats)

Source of variation	D.F.	Distance between fore teats Mean square	D.F.	Distance between fore and hind teats Mean square	Distance between hind teats Mean square	Length of fore teats Mean square	Diameter of fore teats Mean square
				Chinthaladeevi			
Analysis of Means							
Stages	2	1.16 NS	2	0.41 NS	0.15 NS	0.67 NS	0.06 NS
Lactations	6	1.15 NS	6	0.75 NS	1.12 NS	3.21**	0.55**
Stage x lactation	12	0.86 NS	12	0.55 NS	0.49 NS	0.19 NS	0.16 NS
Error	94	1.30 (n σ^2)	93	0.32 (n σ^2)	0.39 (n σ^2)	0.63(n σ^2)	0.06(n σ^2)
Individual	94	4.19 (σ^2)	93	0.98 (σ^2)	1.18 (σ^2)	1.90 (σ^2)	0.20 (σ^2)
(n = 0.3104)				(n = 0.3342)			
				Mahanandi			
Stages	2	5.53 NS		0.62 NS	2.65 NS	6.23 NS	0.54 NS
Lactations	6	2.91 NS		1.01 NS	1.86 NS	1.34 NS	0.39 NS
Error	21	3.86		0.70	1.25	1.93	0.19

Table 35

Analysis of variance (teat placement, length and diameter of fore teats)

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Source of variation	D.F.	Distance between fore teats Mean square	Distance between fore and hind teats Mean square	Distance between hind teats Mean square	Length of fore teats Mean square	Diameter of fore teats Mean square
			CROSSBREDS (FIELD)			
Analysis of Means						
Stages	2	2.70 NS	0.34 NS	0.57 NS	0.13 NS	0.0050 NS
Lactations	4	1.59 NS	0.70 NS	0.29 NS	1.10 NS	0.1450**
Stage x lactation	8	1.34 NS	0.19 NS	0.63 NS	0.43 NS	0.0112 NS
Error	60	1.99(n σ^2)	0.54(n σ^2)	0.63(n σ^2)	0.34(n σ^2)	0.0354(n σ^2)
Individual (n = 0.2786)	60	7.14 (σ^2)	1.96 (σ^2)	2.27 (σ^2)	1.25 (σ^2)	0.1275 (σ^2)

Table 36

Analysis of variance (teat placement, length and diameter of fore teats)

Source of variation	D.F.	Distance between fore teats Mean square	Distance between fore and hind teats Mean square	Distance between hind teats Mean square	Length of fore teats Mean square	Diameter of fore teats Mean square
Breeds	1	10.87 NS	19.38**	7.42*	17.45**	34.08**
Farms within breeds	2	1.30 NS	4.85*	6.42*	0.13 NS	0.11 NS
Within farms	233	5.18	1.42	1.86	2.51	0.35

3. Distance between hind teats

Data are summarised in Table 37 and analysis of variance is given in Tables 34 and 35.

The variation was not significant in both the breeds due to stages and lactations.

However the variation between breeds and between places within breeds was significant at 5% level only (Table 36).

The mean in Ongole varied from 4.29 to 5.00 cms and in crossbreds from 5.18 to 5.38 cms with overall C.V. % of 24.70 in Ongole and 29.26 in crossbreds.

III. (b) Teat measurements

1. Length of fore and hind teats

Data are tabulated in Table 38 while the analysis of variance is presented in Tables 34 and 35.

Analysis of variance carried out on the data showed that in Ongole and crossbreds the stage x lactation effect was found to be insignificant for the length of fore and hind teats separately. However, in Ongole (Chinthaladeevi), the variation due to lactation was highly significant for both fore and hind teats.

Table 37

Mean distances between hind teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
					ONGOLE				
Chinthaladeevi	4.42 ±0.17	4.63 ±0.22	4.85 ±0.24	5.32 ±0.25	6.10 ±0.29	5.12 ±0.40	5.70 ±0.40	0.11	23.54
Mahanandi	4.80 ±0.47	3.00 ±0.50	4.00 ±0.43	3.94 ±0.45	5.00 ±0.15	4.50 -	5.00 ±0.54	0.20	25.84
								Overall	24.70
					CROSSBREDS				
Visakhapatnam (Field)	4.95 ±0.36	5.31 ±0.37	5.29 ±0.29	5.83 ±0.56	4.50 ±0.21	-	-	0.17	29.20
Visakhapatnam (Farm)	5.38 ±0.37	-	-	-	-	-	-	0.37	29.36
								Overall	29.26

Table 38

Mean lengths of fore teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
ONGOLE									
Chinthaladeevi	5.64 ±0.21	6.49 ±0.29	6.66 ±0.29	6.85 ±0.29	7.24 ±0.42	7.60 ±0.44	8.75 ±0.48	0.14	23.44
Mahanandi	5.77 ±0.27	6.83 ±0.60	6.63 ±0.64	6.80 ±0.57	6.50 ±0.15	8.00 ±1.00	7.43 ±1.13	0.26	21.72
								Overall	23.04
CROSSBREDS									
Visakhapatnam (Field)	4.75 ±0.21	4.71 ±0.14	5.55 ±0.32	5.69 ±0.31	6.42 ±0.68	-	-	0.14	23.74
Visakhapatnam (Farm)	5.35 ±0.18	-	-	-	-	-	-	0.18	14.34
								Overall	26.28

Table 38 (contd)

Mean lengths of hind teats (cm)

Farm	Order of lactation							S.E.	C.V.%
	I	II	III	IV	V	VI	VII		
				ONGOLE					
Chinthaladeevi	5.08 ±0.18	5.42 ±0.22	5.79 ±0.18	6.04 ±0.26	6.28 ±0.41	6.13 ±0.28	8.00 ±0.47	0.11	23.66
Mahanandi	4.95 ±0.27	4.83 ±0.30	5.34 ±0.47	4.55 ±0.33	5.87 ±0.12	6.25 ±0.74	5.68 ±0.49	0.17	18.73
								Overall	20.80
				CROSSBREDS					
Visakhapatnam (Field)	4.26 ±0.15	4.35 ±0.15	4.88 ±0.26	4.88 ±0.30	5.47 ±0.33	-	-	0.11	20.03
Visakhapatnam (Farm)	5.01 ±0.17	-	-	-	-	-	-	0.17	13.23
								Overall	18.67

Critical difference test showed that difference in 2nd, 3rd and 4th lactations was significantly more than in 1st lactation, while there was no significant difference among 4th and 5th lactations and 5th and 6th lactations. In the 7th lactation the mean was significantly more than the rest. Similarly, in the case of hind teats there was no difference in the first three lactations which differed significantly from the rest. The mean in last lactation was significantly more than in other lactations (Table 38).

Between breeds there was highly significant variation, the mean lengths of fore and hind teats being more in Ongole, while the place to place variation was insignificant (Table 36). The mean length of fore teats in Ongole varied from 6.68 to 6.72 cms and for hind teats from 5.23 to 5.76 cms. In crossbreds, the mean fore teat length varied from 5.23 to 5.35 cms and for hind teats from 4.64 to 5.01 cms.

The overall C.V. % in Ongole for fore and rear teats were 23.04 and 20.80 and in crossbreds 26.28 and 18.67 respectively. The difference between fore and hind teats was not significant statistically, both in Ongole and crossbreds.

2. Diameter of fore and rear teats

Details are presented in Table 39 and analysis of variance in Tables 34 and 35.

Table 39

Mean diameters of fore teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V.%
ONGOLE									
Chinthaladeevi	2.29 ±0.08	2.51 ±0.09	2.58 ±0.05	2.71 ±0.11	3.05 ±0.16	3.27 ±0.13	3.30 ±0.10	0.05	19.82
Mahanandi	2.30 ±0.03	2.90 ±0.17	2.66 ±0.19	2.80 ±0.09	2.70 ±0.10	3.20 ±0.12	3.20 ±0.34	0.08	16.95
								Overall	19.20
CROSSBREDS									
Visakhapatnam (Field)	1.78 ±0.04	1.78 ±0.05	2.07 ±0.01	1.95 ±0.07	2.28 ±0.21	-	-	0.04	19.23
Visakhapatnam (Farm)	1.87 ±0.04	-	-	-	-	-	-	0.04	9.09
								Overall	17.75

Table 39 (contd)

Mean diameters of hind teats (cm)

Farm	Order of lactation I	II	III	IV	V	VI	VII	S.E.	C.V. %
				ONGOLE					
Chinthaladeevi	2.07 ±0.06	2.20 ±0.06	2.27 ±0.05	2.47 ±0.07	2.70 ±0.12	2.71 ±0.14	2.77 ±0.16	0.03	17.80
Mahanandi	2.24 ±0.09	1.90 ±0.05	2.17 ±0.14	2.14 ±0.11	2.15 ±0.05	2.60 ±0.20	2.30 ±0.12	0.05	13.71
								Overall	17.31
				CROSSBREDS					
Visakhapatnam (Field)	1.72 ±0.04	1.70 ±0.05	1.91 ±0.01	1.89 ±0.07	2.12 ±0.21	-	-	0.03	17.53
Visakhapatnam (Farm)	1.94 ±0.04	-	-	-	-	-	-	0.04	19.32
								Overall	18.47

Results showed that in Ongole (Chinthaladeevi) significant variation due to lactation was observed for both fore and hind teats. On critical difference test, it was further seen that 1st and 2nd lactation front teat diameter differed significantly from the remaining lactations while there was no difference amongst 2nd, 3rd and 4th. 5th, 6th and 7th lactation means also differed from the remaining while the difference amongst them was insignificant. In case of hind teats, the means in the first 3 lactations did not vary among themselves. Among 3rd and 4th also there was no difference. Means in 5th, 6th and 7th were significantly different from the remaining, while the difference among themselves was insignificant.

In crossbreds (field), the mean diameter of both fore teats and hind teats showed highly significant variation due to order of lactation. 1st and 2nd lactations did not differ among themselves, while both differed significantly from the remaining. In the case of hind teats also the same trend was observed.

The variation between breeds was highly significant. In Ongole, for both fore and hind teats, the diameter was more (Table 36).

It was observed that teat placement measurements increased, while teat measurements decreased with increase of Jersey inheritance (Table 19).

Heritability estimates

In Table 40 are presented the heritability estimates of teat placement and teat measurements for Ongole and crossbreds.

Table 40

Heritability estimates of teat placement and teat measurements

Measurement	Ongole Chinthaladeevi		Crossbreds (Field)	
	Herita-bility	S.E.	Herita-bility	S.E.
Distance between fore teats	0.25	0.11	0	-
Distance between fore and hind teats	0.34	0.13	0	-
Distance between hind teats	0.67	0.18	0.01	0.11
Length of fore teats	0	-	0.58	0.22
Length of hind teats	0.43	0.14	0.33	0.18
Diameter of fore teats	0.97	0.22	0.16	0.14
Diameter of hind teats	0.61	0.17	0	-
$\bar{K}$	7.77		6.55	
No. of sires	10		8	

In Ongole, among the teat placement measurements, the distance between hind teats, was having the highest value. The heritability of length of fore teat was not significant from zero while estimates for diameter of fore and hind teats were very high.

In the case of crossbreds all the teat placement measurements were having the values not different from zero. Among the teat measurements, both for fore and hind teats, the estimates were very high in spite of the high environmental variation. This indicates that these traits are highly heritable. The estimate for diameter of hind teats was not significant from zero, whereas for fore teat, the value was low.

Correlation studies

Correlation coefficients were calculated between the various udder and teat measurements and udder indices with the yield during the day of the measurement. Correlations obtained for each measurement within breed were tested for homogeniety and pooled estimates were given wherever they were homogeneous. Results are given in Table 41 for Ongole and in Table 42 for crossbreds.

Table 41

Correlation coefficients between udder and teat measurements and udder indices with one day milk yield

Measurement	ONGOLE		
	Chinthaladeevi	Mahanandi	Pooled estimate
Length of udder	0.462**	0.296 NS	-
Width of udder	0.385**	0.775**	-
Depth of udder	0.175 NS	0.310 NS	-
Circumference of udder	0.527**	0.327 NS	-
Index of udder volume	0.510**	0.364*	0.460
Index of udder size	0.314**	0.388*	0.331
Index of udder capacity	0.495**	0.320 NS	-
Index of udder efficiency	0.125 NS	0.269 NS	-
Distance between fore teats	0.426**	0.108 NS	-
Distance between fore and hind teats	0.381**	-0.002 NS	-
Distance between hind teats	0.212 NS	0.142 NS	-
Length of fore teats	-0.179 NS	0.350 NS	-
Length of hind teats	0.221 NS	0.073 NS	-
Diameter of fore teats	-0.257*	0.250 NS	-
Diameter of hind teats	0.202 NS	0.170 NS	-

Table 42

Correlation coefficients between udder and teat measurements and udder indices with one day milk yield

Measurement	CROSSBREDS		
	Field	Farm	Pooled estimate
Length of udder	0.724**	0.722**	0.725
Width of udder	0.463**	0.646**	0.500
Depth of udder	0.457**	0.060 NS	-
Circumference of udder	0.655**	0.312 NS	-
Index of udder volume	0.638**	0.665**	0.640
Index of udder size	0.621**	0.392 NS	-
Index of udder capacity	0.593**	0.859**	0.685
Index of udder efficiency	-0.355 NS	0.341 NS	-
Distance between fore teats	0.509**	0.746**	0.565
Distance between fore and hind teats	0.638**	0.344 NS	-
Distance between hind teats	0.511**	0.467*	0.490
Length of fore teats	0.086 NS	-0.162 NS	-
Length of hind teats	0.048 NS	-0.028 NS	-
Diameter of fore teats	-0.069 NS	0.123 NS	-
Diameter of hind teats	0.214 NS	0.313 NS	-

Results showed that in Ongole (Chinthaladeevi) all the udder measurements except the depth of udder showed highly significant correlation with milk yield on the day of measurement, whereas in Mahanandi only udder width has showed significant correlation. Among the udder indices, all except index of udder efficiency had significant correlations with one day milk yield in Chinthaladeevi, while index of udder volume and index of udder size showed significance at 5% level in Mahanandi.

In Ongole (Chinthaladeevi) only the distance between fore teats and distance between fore and hind teats were having highly significant correlations with one day yield, while the diameter of fore teats was negatively correlated with one day yield at 5% level. None of the correlations in Mahanandi were significant.

Results in crossbreds showed very high significantly positive correlations between udder measurements and one day milk yield in case of crossbreds (field) while in the case of crossbreds (farm) only length and width were having highly significant correlations. Among the indices of udder, all except the index of udder efficiency in case of crossbreds (field), index of udder volume and index of udder capacity in crossbreds (farm) were having highly positive significant correlations with one day milk yield.

In the case of crossbreds (field) all the teat placement measurements were highly correlated with one day yield, while in crossbreds (farm) distance between fore teats and distance between hind teats were having significant correlations at 1% and 5% level respectively with one day yield. None of the teat measurements showed significant correlations with one day yield both in field as well as farm crossbreds.

Genetic, environmental and phenotypic correlations

Genetic, environmental and phenotypic correlations were calculated in Ongole (Chinthaladeevi) between udder measurements, indices of udder and teat measurements with 90 day milk yield in the current lactation. For crossbreds, data was not available.

The analysis of variance and covariance and genetic and environmental components of variance and covariance among the various measurements and 90 day milk yield are presented in Table 43.

Results are tabulated in Tables 44 and 45 for Ongole (Chinthaladeevi).

Among the udder measurements, in 3 out of 4, the genetic correlations exceeded the value of 1. However for udder width and 90 day yield, the genetic correlation was positive and significant.

Table 43

Analysis of variance and covariance between 90 day milk yield (Y) and udder measurements (X) among paternal half-sibs and genetic and environmental components of variance and covariance in ONGOLE cows

Measurement	Source of variation	D.F.	M.S.$_{(X)}$	M.P.$_{(XY)}$	M.S.$_{(Y)}$
Length of udder surface	Between sires	10	43.48	459.31	14435.95
	Within sires	42	33.74	320.90	13319.25
	1/4 Genetic (σ^2_S)	-	2.26	32.11	259.09
	Environmental	-	26.96	224.57	12541.98
Width of udder surface	Between sires	10	90.60	366.31	14435.95
	Within sires	42	51.46	296.97	13319.25
	1/4 Genetic (σ^2_S)	-	9.08	16.09	259.09
	Environmental	-	24.22	248.70	12541.98
Depth of udder surface	Between sires	10	26.73	222.96	14435.95
	Within sires	42	12.66	69.38	13319.25
	1/4 Genetic (σ^2_S)	-	3.26	35.63	259.09
	Environmental	-	2.88	-37.51	12541.98
Circumference of udder surface	Between sires	10	216.31	229.96	14435.95
	Within sires	42	135.05	721.63	13319.25
	1/4 Genetic (σ^2_S)	-	18.85	-114.07	259.09
	Environmental	-	78.50	1063.84	12541.98

Table 43 (contd)

Measurement	Source of variation	D.F.	M.S.(X)	M.P.(XY)	M.S.(Y)
Length of fore teats	Between sires	10	1.90	25.13	14435.95
	Within sires	42	1.87	52.17	13319.25
	1/4 Genetic (σ^2_S)	-	0.0059	-6.27	259.09
	Environmental	-	1.86	70.98	12541.98
Diameter of fore teats	Between sires	10	0.26	13.83	14435.95
	Within sires	42	0.23	17.30	13319.25
	1/4 Genetic (σ^2_S)	-	0.0056	-0.80	259.09
	Environmental	-	0.2191	19.70	12541.98
Index of udder volume	Between sires	10	99018.91	16960.44	14435.95
	Within sires	42	77126.15	15636.19	13319.25
	1/4 Genetic (σ^2_S)	-	5079.52	307.25	259.09
	Environmental	-	61887.59	14714.44	12541.98
Index of udder size	Between sires	10	134381.82	21535.59	14435.95
	Within sires	42	63577.19	9268.01	13319.25
	1/4 Genetic (σ^2_S)	-	16427.98	2846.30	259.09
	Environmental	-	14295.19	729.11	12541.98

$\bar{K}$ = 5.95

Table 44

Genetic, environmental and phenotypic correlations of udder measurements with 90 day milk yield in Ongole cows

Components	Udder length	Udder width	Udder depth	Udder circumference
		ONGOLE - CHINTHALADEEVI		
Genetic correlation	1.32±0.78	0.33±0.06**	1.22±0.34	-1.63±1.35
Environmental correlation	0.36	0.45	-0.19	1.07
Phenotypic correlation	0.50±0.12**	0.34±0.13*	0.21±0.13 NS	0.43±0.12**
No. of sires	11	11	11	11
No. of observations	53	53	53	53

Table 45

Genetic, environmental and phenotypic correlations of udder indices and teat measurements with 90 day milk yield

Components	Index of udder volume	Index of udder size	Length of fore teats	Diameter of fore teats
		ONGOLE - CHINTHALADEEVI		
Genetic correlation	0.26±0.22 NS	1.37±0.62	-4.44	-0.66±0.90
Environmental correlation	0.52	0.05	0.46	0.35
Phenotypic correlation	0.47±0.12**	0.359±0.13**	0.29±0.13*	0.29±0.13*
No. of sires	11	11	11	11
No. of observations	53	53	53	53

The phenotypic correlations with the exception of udder depth were significant.

Among the indices of udder the genetic correlation for index of udder size exceeded 1 and for index of udder volume it was insignificant.

The phenotypic correlations for both these indices were highly significant.

Among the teat measurements, value more than 1 was obtained for length of fore teat and for diameter of fore teat, the correlation was insignificant. The phenotypic correlations for both these measurements were significant at 5% level.

Regressions

Regression of yield on the day of measurement and 90 day yield in the current lactation on udder measurements and udder indices in Ongole (Chinthaladeevi) are given in Table 46.

All the regressions were linear and significant.

Table 46

Regression of one day yield and 90 day yield on measurements (Ongole)

Character	Regression of milk yield (kg)	S.E.
	One day yield	
Udder length	0.4824	0.0095
Udder width	0.0704	0.0213
	90 day yield	
Udder length	9.7520	2.3600
Udder width	5.2631	1.9800
Index of udder volume	0.1950	0.0500
Index of udder size	0.1506	0.0530

Regression equations are given below :

Character	One day yield
Udder length	Y = -22.49 + 0.48 X
Udder width	Y = -0.41 + 0.07 X
	90 day yield
Udder length	Y = -103.72 + 9.75 X
Udder width	Y = 151.78 + 5.26 X
Index of udder volume	Y = 246.60 + 0.19 X
Index of udder size	Y = 273.24 + 0.15 X

Where Y is the expected yield in kg and X is rise in measurement.

Partial correlations

Partial correlations were calculated between udder length, udder width and udder depth with yield on the day of measurement in Ongole (Chinthaladeevi).

Results are presented in Table 47.

Partial correlations were significant between length and one day yield, when width, depth and width and depth were held constant respectively. In the case of width and one day yield, it was significant only when depth was held constant. In the case of udder depth none of the partial correlations were significant.

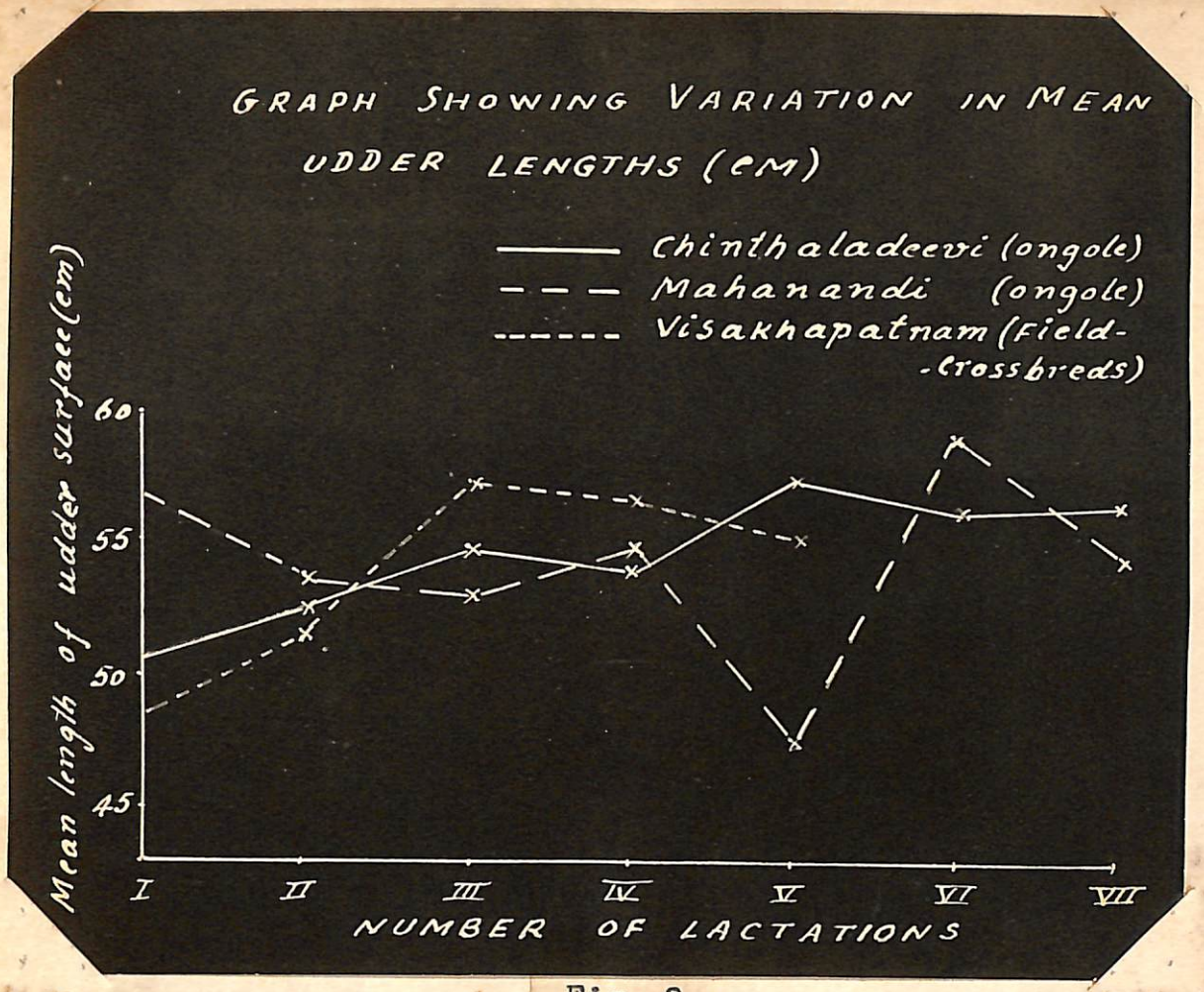
GRAPH SHOWING VARIATION IN MEAN
UDDER LENGTHS (CM)
Chinthaladeevi (ongole)
Mahanandi (ongole)
Visakhapatnam (Field-Crossbreds)
Mean length of udder surface (cm)
60
55
50
45
I
II
III
IV
V
VI
VII
NUMBER OF LACTATIONS

Fig. 3

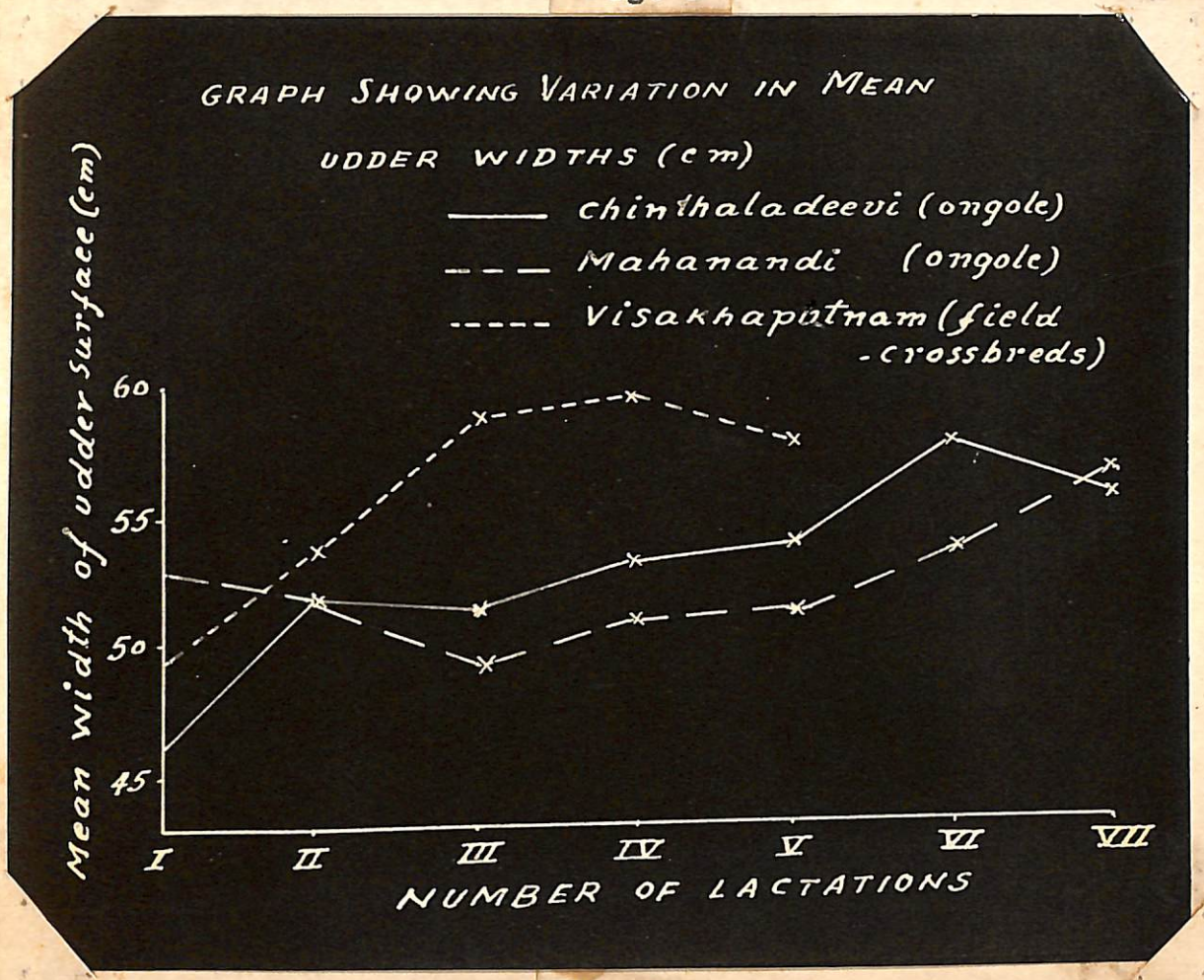
GRAPH SHOWING VARIATION IN MEAN
UDDER WIDTHS (cm)
Chinthaladeevi (ongole)
Mahanandi (ongole)
Visakhapatnam (field-crossbreds)
Mean width of udder surface (cm)
60
55
50
45
I
II
III
IV
V
VI
VII
NUMBER OF LACTATIONS

Fig. 4

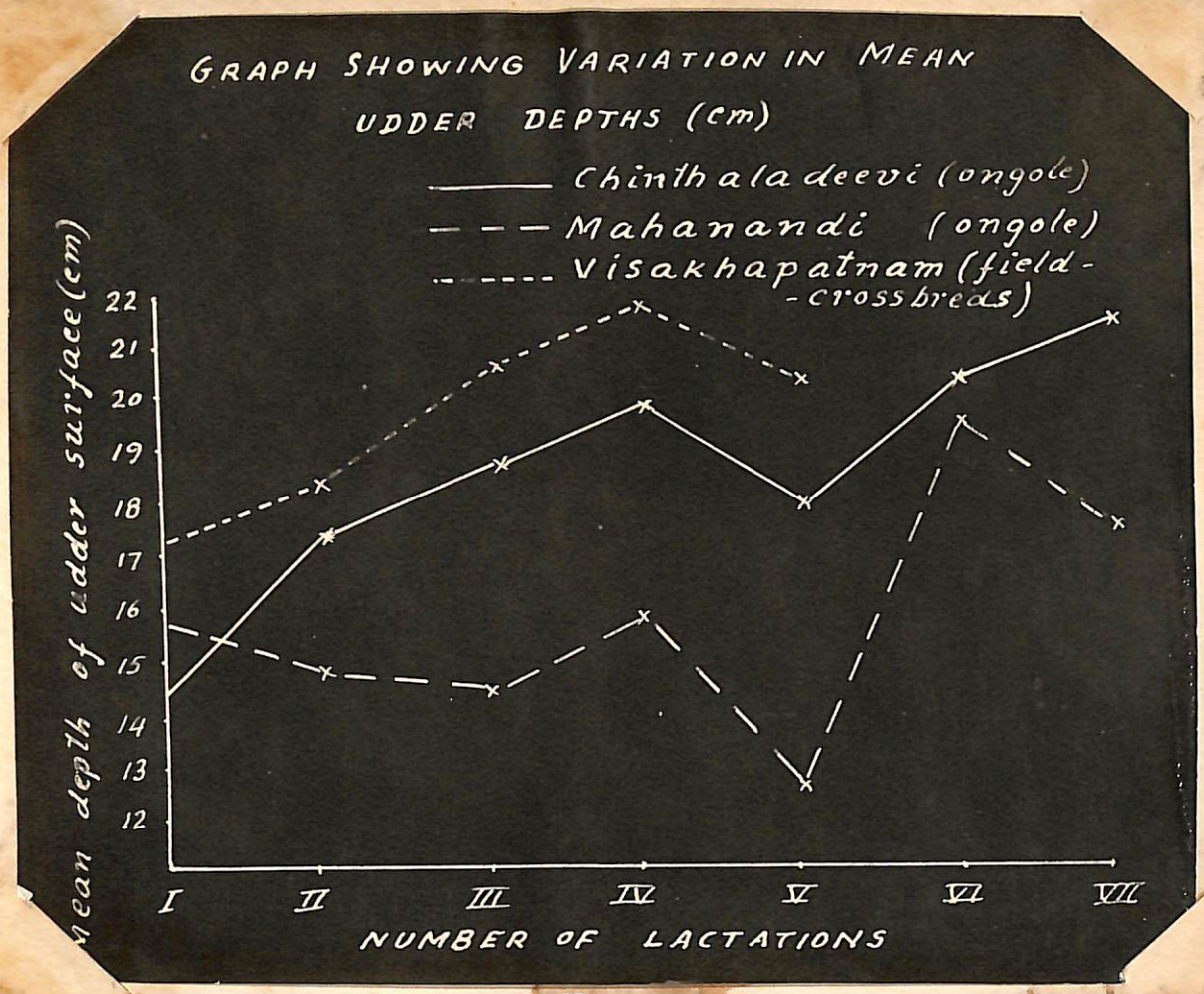
GRAPH SHOWING VARIATION IN MEAN
UDDER DEPTHS (cm)
Chinthaladeevi (ongole)
Mahanandi (ongole)
Visakhapatnam (field-crossbreds)
Mean depth of udder surface (cm)
22
21
20
19
18
17
16
15
14
13
12
I
II
III
IV
V
VI
VII
NUMBER OF LACTATIONS

Fig. 5

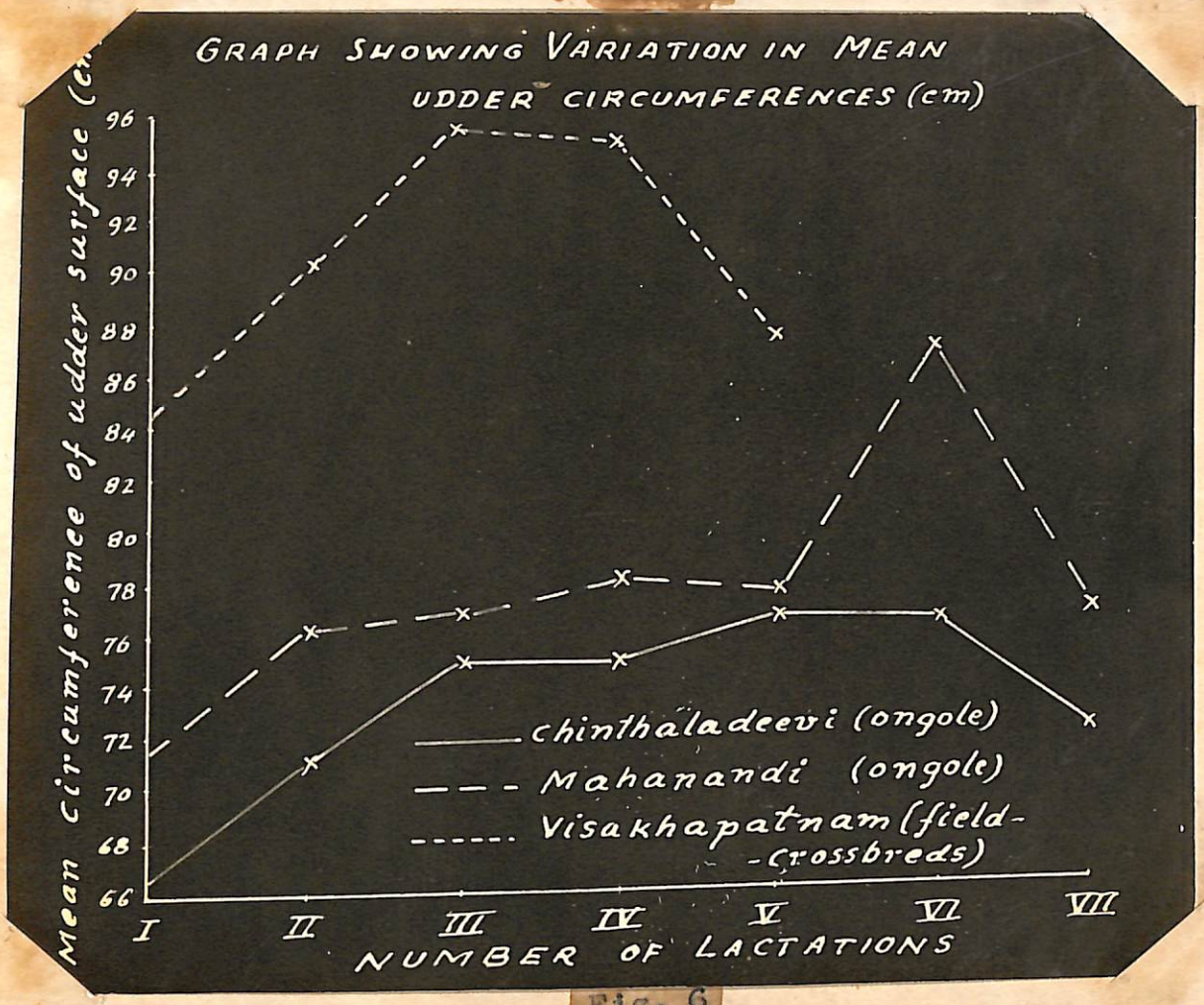
GRAPH SHOWING VARIATION IN MEAN
UDDER CIRCUMFERENCES (cm)
Mean circumference of udder surface (cm)
96
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
Chinthaladeevi (ongole)
Mahanandi (ongole)
Visakhapatnam (field-crossbreds)
I
II
III
IV
V
VI
VII
NUMBER OF LACTATIONS

Fig. 6

DISCUSSION

The present study was undertaken with a view to find out the extent and nature of variation in Ongole and Zebu-Jersey crosses in respect of shape and size of udder and teats. An attempt was also made to find out association both genetic and phenotypic, if any, between udder shape and size and actual performance of Ongole and Zebu-Jersey crosses.

In both breeds, it was observed that the incidence of bowl shaped udder was the highest, followed by rounded and goat like udders in order. Of the bowl and goat type udders, the former were more common in crossbreds, while the latter in Ongole. No differences however, were observed in the incidence of rounded udders in the two breeds.

Byckov (1959) reported the incidence of 53.2%, 30.1% and 16.7% cup shaped, rounded and goat type udders respectively in Black Pied cows. Tavildarova et al. (1961) observed 66% rounded udders in crossbreds and only 2-3% goat like udders in breeds studied by them. Barysnikov (1964) found 78.3% bowl shaped udders and the remaining rounded udders in Kurgan cows, while Gimatidinov et al. (1964) reported 42% bowl udders in dairy type cows Vs. 31% of milk meat females. Sharma (1967) reported the incidence of 93.3%, 2.6% and 4.1% of bowl shaped, rounded and goat type udders respectively in Hariana Vs. 80.9%, 2.0% and 8.1% in Tharparkar. Our results agreed with

the findings of Byckov (1959) with respect to Ongole, while in respect of crossbreds with Barysnikov (1964).

Among teat types, our results show the preponderance of cylindrical types especially in crossbreds over funnel and bottle types. Funnel types were more in Ongole than in crossbreds, while bottle types were about the same level. The same trend was seen for hind quarters also except for the higher incidence of funnel types both in Ongole and crossbreds. Barysnikov (1964) reported higher incidence of cylindrical teats in Kurgan cows. Sharma (1967) observed 76.2%, 22.8% and 1% of cylindrical, funnel and bottle type teats respectively in Hariana Vs. 77.0%, 14.9% and 8.1% in Tharparkar for fore quarters. With respect to hind quarters the incidence was 63.7%, 35.8% and 0.5% respectively for cylindrical, funnel and bottle types in Hariana Vs. 61.5%, 29.1% and 9.5% in Tharparkar. These results agreed with our findings here.

Incidence of teat types among the three udder types varied in both the breeds. Highest incidence of cylindrical teats for bowl and rounded udders and funnel teats for goat type udders was observed in both the breeds. This clearly indicated the association between goat type udders and funnel teats.

The average first lactation yield of the cows in

Ongole (Chinthaladeevi) with bowl, rounded and goat type udders were 1236 kg, 1427 kg and 882 kg respectively and the corresponding 1st lactation length in days were 317, 311 and 290 respectively. The mean yield of cows with goat type udders was significantly less than other cows, while there was no significant difference in the first lactation length. Between teat shapes also, the bottle type teats yielded significantly (5% level) more milk than other types.

Nesterenko (1957) recorded 22.4% more milk for cows with bowl shaped udders than those with rounded udders and 41.2% more than those with goat type udders in Black Pied cattle. Cerkascenko (1958) reported that bowl shaped udders yielded 905.7 kg more milk than did those with rounded udders and 1600.3 kg more than those with goat type udders in a 300 day lactation in the breed studied by him. Hickman (1964) found no differences in yields between teat shapes and sizes. Barysnikov (1964) reported higher yields with bowl shaped udders than those with rounded udders in Kurgan cows. Brantov (1965) recorded that the average lactation yield of cup shaped udders was 12% greater than the goat type udders, and that of rounded udders was intermediate in Red Steppe cows. Starkov (1966) recorded lowest milk yields for cows with goat type udders in Black Pied breed. Maskovskaja (1967) gave the average lactation yields of 3883 kg, 3193 kg and 2803 kg

for cows with bowl shaped, rounded and goat type udders in Bestuzhev cows.

Our results agreed with these workers with respect to goat type udders. However, no significant difference was observed between the yields of cows with bowl and rounded udders. This is clearly suggestive that goat type udders should be descriminated against in selection of dairy cows. The higher incidence of goat type udders in Ongole than the crossbreds and the two other Indian dairy breeds viz. Hariana and Tharparkar might be due to the fact that Ongole is a dual purpose breed. From the results, it was obvious that Jersey inheritance clearly improved udder conformation in crossbreds.

Studies on the influence of sires on udder and teat types among paternal half-sibs in Ongole showed that only with regard to the inheritance of bottle type teats was any influence seen. Byckov (1959) found that udder shape was similar, in a high percentage of the daughters sired by individual bull in Black Pied breed. Brodauf (1963) reported that 'bottle teat' was a fairly common inherited defect in German Simmental cows. Our results agreed with the findings of Brodauf (1963) with respect to bottle type teats only.

Dam-daughter comparisons for udder and teat types in Ongole showed that dams had definite influence on the shape of

udder and teats of their daughters.

Cerkascenko (1958) found that dams with bowl shaped udders had daughters of which the greater percentage had bowl shaped or rounded udders. About 1/3 of the daughters of the dams with rounded udders had goat like udders. Over 50% of the daughters of the dams with goat like udders also had goat like udders. Byckov (1959) observed that 30.9%, 10.8% and 9.4% respectively of the daughters of the dams with cup shaped, rounded and goat type udders also had these udder shapes in Black Pied cows. Our results agreed with the findings of Cerkascenko (1958) with respect to bowl shaped udders only.

The mean udder length varied from 53.75 cms to 54.27 cms in Ongole and from 48.44 cms to 53.22 cms in Zebu-Jersey crosses. In case of Ongole (Chinthaladeevi) the stage x lactation effect on udder length was considerable. The average length was seen to increase progressively with the number of lactations in both Ongole and crossbreds. The maximum average length was observed in 5th lactation in Ongole (57.07) and in 3rd lactation in crossbreds (57.02 cm) (Fig. 3). The difference between breeds was insignificant although there was significant difference between field and farm crossbreds. This might be due to the fact that all the crossbreds (farm) were primiparous. The coefficient of variation percentage in crossbreds (13.55) was higher than in Ongole (9.71). This might be due to

difference in environmental conditions for the crossbreds.

The mean udder width varied from lactation to lactation in Ongole (Chinthaladeevi). It was also seen to increase progressively with the number of lactations, the highest mean width being in 6th lactation in Ongole (Chinthaladeevi) (57.56 cms) in 7th lactation in Mahanandi (56.12 cms) and in 4th lactation in crossbreds (59.33 cms) (Fig. 4). No breed to breed difference was seen except the difference between field and farmbred crossbreds. The C.V. % was more in crossbreds (14.28) than in Ongole (12.61).

In Ongole the mean udder depth varied from 15.85 cms to 17.90 cms,whereas in crossbreds it varied from 18.61 cms to 19.29 cms. Order of lactation has significant influence on mean udder depth in Ongole (both places). The mean increased progressively with number of lactations and the highest mean was seen in 7th lactation (21.50 cms) in Ongole and in the 4th lactation (21.83 cms) in crossbreds. Within Ongole, the places differed in mean depth and the crossbreds had significantly more mean depth (Fig. 5). The C.V. % was more in Ongole (21.07) than in crossbreds (17.32%).

The mean udder circumference varied from 72.41 cms to 76.78 cms in Ongole and from 73.11 cms to 90.28 cms in crossbreds. While no significant variation was seen due to

stage and order of lactation in Ongole, the influence of the same was significant in crossbreds. The highest means were observed in the first stages of 3rd and 4th lactations and 2nd stage of 5th lactation. The field crossbreds had highest mean circumference which was significantly more than in farm crossbreds as well as in Ongole (Fig. 6). The C.V. % in crossbreds (15.20) and in Ongole (14.66) were about the same level.

For all these udder measurements the highest means were seen either in 5th or 6th lactation in Ongole and in 3rd or 4th lactation in crossbreds. Variation due to stage x lactation was also observed with respect to length in Ongole and circumference in crossbreds. From the results, it was revealed, that udder measurements were highly variable and vary from stage to stage and lactation to lactation. Among the crossbreds, these udder measurements increased with the increase of Jersey inheritance (75%).

Krippl (1961) had found in German Brown and Fleckvich cattle, a gradual increase in udder proportions from 1st to 3rd lactation. Similar results were obtained by Fielder (1962) and Andreae (1963). Brantov (1965) reported increase in the udder measurements upto 4th calving and gradual decrease after the 6th-7th lactation in Red Steppe cows. Piotrowska et al. (1965) also reported similar results in Black Pied

Lowland cows. Suchanek (1965) and Makaveev (1966) reported that udder measurements decreased during lactation and vertical measurements increased more than horizontal measurements in succeeding lactations. Witt et al. (1967) found that in Black Pied Lowland cows, the udder length and width were primarily affected by stage of lactation, whereas depth was affected by number of lactation. Sharma (1967) also reported similar results in Hariana and Tharparkar. Our results were in complete agreement with the results of above workers except in respect of udder length, width and depth in crossbreds and udder circumference in Ongole.

Gercikov (1959), Horn et al. (1960), Lebedov et al. (1960), Lenschov et al. (1963) reported better udder conformation in Jersey crossbreds. Our results in this study also showed better udder conformation with the increase of Jersey inheritance.

Very high heritability estimates were obtained for udder width and udder depth in Ongole and Zebu-Jersey crossbreds, and this showed that they are highly heritable and reliance can be placed on selection for rapid improvement of these measures. However, the values for udder length (0.09) and for udder depth (0.18) were low in Ongole, whereas, in crossbreds they were not different from zero. The reason for this was due to the fact that in crossbreds, the environmental

variation was very high.

Krippl (1961) reported that the genetic effect was less in udder length and circumference in the breeds studied by him. Klossner (1962) concluded that the principal udder and teat characteristics were relatively strongly inherited in Black Pied Lowland cows. Fielder (1962) reported high heritability for all the most important udder measurements in Yellow hill cattle. Freter (1963) reported heritability of 0.06 for depth of udder at front in Black Pied Lowland cows. Our results were in agreement with the work done by the earlier workers.

Significant correlations were obtained between udder length, udder width (udder circumference at one place) in case of Ongole and udder length, udder width (udder depth and udder circumference at one place only) in crossbreds, with yield on the day of measurement. The correlations were more in case of crossbreds than in Ongole for all these measurements.

Krempa and Prawdzik (1954), Fuhrer (1961), Suchanek (1961), Borodin (1964), Pandza (1965), Brantov (1965), Ruzevskii et al. (1965), Makaveev (1966), Sharma (1967) reported positive significant correlation between udder measurements and milk yield on the day of measurements. Our

results agreed with the findings of the above workers with the exception of udder depth in Ongole and farm crossbreds and udder circumference in Ongole (Mahanandi) and farm crossbreds.

The present study showed genetic correlations (Ongole) between udder measurements and 90 day yield in the current lactation, all the values exceeded one with the exception of udder width where it was 0.33 and significant. All the phenotypic correlations were lower than the genetic correlations and significant except for udder depth, indicating that environmental factors were having pronounced role in the expression of genetic relationships. Selection for morphological udder characters should therefore bring about indirect response in milk production, in as much as there was genetic association between these traits and production traits.

The index of udder volume in Ongole (Chinthaladeevi) varied with the order of lactation, whereas in field crossbreds, stage and lactation effects were profound. In Ongole a gradual increase with succeeding lactations was noticed, the highest mean being in the 6th lactation. In crossbreds, the highest means were in the 1st stage of 3rd and 4th lactations the 2nd stage of 5th lactation as well as in the 3rd stage of 3rd lactation. The means were less in the last stages of all lactations. Crossbreds had higher values.

The index of udder size showed variation due to order of lactations in Ongole (both places). In crossbreds stage x lactation effect was significant. Between breeds there was no significant variations whereas within crossbreds, the field crossbreds had higher mean index of udder size.

The index of udder capacity showed variation due to lactations in Ongole and due to stage x lactation in crossbreds. Breed to breed differences as well as place to place variation within breeds for both Ongole and crossbreds was observed. The overall C.V. % for crossbreds was more in crossbreds (59.07) than in Ongole (37.12).

The index of udder efficiency was not observed to vary from lactation to lactation and between udder shapes in both Ongole and crossbreds. The crossbreds had significantly higher mean efficiency (67.85) than in Ongole (58.14). The overall C.V. % for both Ongole (40.41) and crossbreds (37.72) was more indicating high variability of the trait. Since this index measures the relative efficiency of the udder, it should be a useful parameter for comparing breeds.

Krippl (1961), Maskovskaja (1967) reported variation of these udder indices with the order of lactation. Our results were in agreement with the above workers. Both index of udder volume and udder size varied in different stages of different lactations.

Heritability estimates were very high in the case of index of udder volume and udder size, and moderate for udder capacity and not different from zero for udder efficiency in Ongole. In the case of crossbreds, these estimates were negligible with the exception of index of udder size.

These results were in agreement with the findings of Klossner (1962) and Fielder (1962) in the breeds studied by them.

Significant positive correlations were obtained between indices and the yield on the day of measurements in Ongole and crossbreds with the exception of index of udder efficiency. Davydov (1938), Liebenberg (1957), Sandvick (1957), Bartsch et al. (1960), Fuhrer (1961), Suchanek (1961), Borodin (1964), Avizov (1965), Pandza (1965) and Maskovskaja (1967) reported significant correlation between the udder indices and one day yield. Our results agreed with the findings of the above workers.

Genetic correlation between index of udder size and 90 day yield in the current lactation exceeded one. The value for index of udder size was 0.26. The phenotypic correlations were significant for these indices in Ongole. These indicated positive association with milk yield.

Thus these biometrical studies on morphological udder

characters giving an idea of the shape and size of udder are valuable in evaluation of udder of lactating cows and provide firm basis for assessing milk yield.

Distance between fore teats, distance between fore and hind teats and distance between hind teats were also studied. No significant variation due to stage and order of lactation was observed. The crossbreds had significantly more averages. Relatively high heritability estimates were obtained in Ongole indicating their importance in selection, whereas in crossbreds these estimates were not significantly different from zero.

Correlations between distance between fore teats and distance between fore and hind teats with milk yield on the day of measurement were significant in Ongole (Chinthaladeevi). In crossbreds all the three measures were significantly correlated with one day yield. The crossbreds had good even placement of teats when compared to Ongole.

Our results were in general agreement with findings reported by Suzuki et al. (1963) and Sharma (1967).

Ongoles had longer front and hind teats than the crossbreds. The variation due to order of lactation was significant in Ongole, whereas, in crossbreds no such variation was observed for both fore and hind teats. In Ongole the mean

fore teat length varied from 6.68 cms to 6.72 cms and from 5.23 cms to 5.35 cms in crossbreds. In the case of hind teats, the means varied from 5.23 cms to 5.76 cms in Ongole and 4.64 cms to 5.01 cms in crossbreds. Ongole had significantly longer fore and hind teats than in crossbreds. However difference between fore and hind teats was insignificant in both breeds. The means for both fore and hind teats gradually increased in succeeding lactations in both the breeds. It was also observed that mean teat length decreased with the increase of Jersey inheritance (75%). Krempa and Prawdzik (1954) reported that fore teats on an average were 1 cm longer than the rear teats. Tavildorova et al. (1961) observed that though there was no statistically significant difference between front and hind teats, the front teats appeared to be longer than hind ones. Krippl (1961) reported that teat length increased with age and hind teats were approximately 1 cm smaller than fore teats in the breeds studied by him. Sharma (1967) observed significant difference between fore and hind teats in both Hariana and Tharparkar. Our results were in agreement with the findings of earlier workers.

The mean diameter of front teats varied from 2.67 cms to 2.76 cms in Ongole and from 1.87 cm to 1.92 cm in crossbreds. Significant variation occurred due to order of lactation in one place of Ongole (Chinthaladeevi) and in crossbreds. Similarly for hind teats, the mean diameter varied from 2.30 cms

to 2.35 cms in Ongole and from 1.82 cm to 1.94 cm in crossbreds. Lactation to lactation variation was significant in Ongole (Chinthaladeevi) and in crossbreds. The means gradually increased in succeeding lactations in Ongole and crossbreds in respect of both fore and hind teats. Breed to breed variation was also significant. These results also agreed with the findings of Tavildarova (1964), Krippl (1965) and Sharma (1967).

Heritability estimates for length of fore and hind teats were 0 and 0.43 respectively in Ongole and 0.58 and 0.33 respectively in crossbreds. The values for diameter of fore and hind teats in Ongole were 0.97 and 0.61 respectively, whereas in crossbreds the values were 0.16 and 0 respectively. Krippl (1961) reported that teat length was highly heritable in the breeds studied by him. Freter (1963) reported the heritabilities of 0.50 and 0.11 for length of fore and hind teats and 0.77 and 0.60 for width of fore and hind teats respectively in Black Pied Lowland cattle. Our results agreed with the findings of earlier workers with the exception of length of fore teats in Ongole and diameter of hind teat in crossbreds.

Only in Ongole (Chinthaladeevi) was there any significant correlation between diameter of fore teat and yield on

the day of measurement. These findings were in agreement with the findings of Tomar and Tomar (1960), Naito (1965) and Sharma (1967). In respect of diameter of teats, Sharma (1967) reported significant correlation with milk yield in Hariana and Tharparkar. Our findings in this respect did not agree with his results. Donald (1960) reported that cows with short teats milk faster and had higher yields than cows with longer teats. It would therefore appear that as long as the teats were sufficiently large to facilitate flow of milk and milking there was no need to give undue weight to these traits. However, too large and long teats were undesirable, as they were liable to get injured.

Genetic correlations between diameter of fore teat and 90 day milk yield in Ongole, showed insignificant negative correlation. The value for length of fore teat exceeded (-1). However the phenotypic correlation for these two were significant at 5% level. This might be explained that due to the present milking practices, significant phenotypic correlations were obtained, otherwise, there was no association between teat proportions and milk yield.

Partial correlations were studied between length, width and depth and one day yield. Significant partial correlations were obtained between udder length and one day yield when the

influence of width, depth, and width and depth were eliminated.

Regression of one day yield and 90 day yield on measurements were found to be linear and significant.

SUMMARY

1. An investigation was carried out on morphological udder characters in Ongole and Zebu-Jersey crossbred animals in India, to find out the extent of variation present in shape and size of udder and teats. The genetic basis of these characters was also investigated and correlations with milk yield determined. A total of 145 cows belonging to Ongole and 93 Zebu-Jersey crossbred cows located at two places each were included in the study. Of the crossbreds, 75 were under field conditions.

2. Three types of udder namely, bowl, rounded and goat were recognised. Their incidence in the two breeds was respectively 59.0%, 21.0% and 20.0% in Ongole and 74.0%, 23.0% and 3.0% in Zebu-Jersey crosses. Bowl shaped udders were significantly more in crossbreds whereas goat types were more frequent in Ongole than in crossbreds.

3. Three types of teats were noticed. They were cylindrical, funnel and bottle types and their respective incidences were as follows :

	Cylindrical %	Funnel %	Bottle %
	Fore quarters		
Ongole	65.0	29.0	6.0
Crossbreds	83.0	10.0	7.0
	Hind quarters		
Ongole	54.0	44.0	2.0
Crossbreds	82.0	15.0	3.0

In both breeds, the highest incidence was that of cylindrical type, followed in order by funnel and bottle types. While there was not much variation between places, the breed to breed variation was present. Cylindrical teats were significantly more in crossbreds, whereas funnel type were more in Ongole.

4. In Ongole, dams had more influence on the shape of udder and teats among daughters than the sires.

5. In Ongole, the average first lactation yield was significantly less for the cows with goat type udders. The yields for the cows with bottle type teats were also more.

6. The mean udder length in Ongole varied from 53.75 cms to 54.27 cms, as opposed to 48.44 cms to 53.22 cms of crossbreds. The variation due to stage x lactation was significant in Ongole (Chinthaladeevi) only. The mean udder width varied from 51.32 cms to 51.85 cms in Ongole and from 47.88 cms to 54.94 cms in crossbreds. It showed significant variation due to order of lactation in Ongole (Chinthaladeevi). Breed to breed variation was not present for both udder length and width, while the field crossbreds were having significantly more averages. In Ongole, the mean udder depth varied from 15.85 cms to 17.90 cms and from 18.61 cms to 19.29 cms in crossbreds. Variation existed due to order of lactation in Ongole (both places). Variation due to farms in Ongole and

due to breeds was significant. The mean udder circumference varied from 72.41 cms to 76.78 cms in Ongole and from 73.11 cms to 90.28 cms in crossbreds. Variation existed due to stage x lactation in crossbreds. Variation due to breeds and due to places in crossbreds was also significant (Figs. 3 to 6).

7. Following estimates of heritability were obtained for the udder measurements in the two breeds.

Character	Ongole	Crossbreds
Udder length	0.09 ± 0.15	0
Udder width	0.76 ± 0.19	0.53 ± 0.21
Udder depth	0.89 ± 0.21	0.40 ± 0.19
Udder circumference	0.18 ± 0.10	0

8. Significant correlations were obtained in Ongole and crossbreds (with the exception of udder depth in Ongole) between the udder measurements and one day milk yield. Positive genetic correlations in Ongole between udder width and 90 day yield was significant. For other measurements the values exceeded one. Partial correlations between length and one day yield after eliminating the influence of width, depth and width and depth were significant.

9. In Ongole, the mean index of udder volume varied from 803.66 cm^3 to 880.55 cm^3 and from 926.43 cm^3 to 1151.71 cm^3 in crossbreds. Variations due to order of lactation in Ongole

and due to stage x lactation in crossbreds were significant. The mean index of udder size varied from 867.68 to 966.55 in Ongole and 906.19 to 1040.10 in crossbreds. The variation due to stage x lactation was significant in crossbreds, whereas in Ongole (both places) variation due to order of lactation was present. The mean index of udder capacity varied from 16.96 to 20.58 in Ongole and from 19.36 to 31.21 in crossbreds. Variation due to order of lactation in Ongole (Chinthaladeevi) and due to stage x lactation in crossbreds was significant. The index of udder efficiency varied from 48.53 to 60.36 in Ongole and from 66.89 to 75.34 in crossbreds. No variation was observed due to order of lactation and due to udder shapes in both the breeds. Among the udder indices, breed to breed variation was significant for index of udder volume and index of udder capacity, whereas place to place variation in Ongole was significant for index of udder capacity and in crossbreds it was significant for all the indices.

10. Following heritability estimates were obtained for udder indices in the two breeds.

Character	Ongole	Crossbreds
Index of udder volume	0.91 ± 0.21	0.03 ± 0.12
Index of udder size	0.63 ± 0.17	0.25 ± 0.16
Index of udder capacity	0.29 ± 0.12	0.06 ± 0.12
Index of udder efficiency	0	-

11. Significant positive correlations were obtained both in Ongole and crossbreds between these indices and one day yield, with the exception of index of udder efficiency in both these breeds.

12. The teat placement was found to be more even in crossbreds than in Ongoles. The means were as follows :

	Distance between fore teats (cms)	Distance between fore and hind teats (cms)	Distance between hind teats (cms)
Ongole	8.48 to 8.77	5.41 to 5.79	4.29 to 5.00
Crossbreds	9.00 to 9.19	5.77 to 6.43	5.18 to 5.38

These measurements were not observed to vary due to order and stage of lactation. Between breeds and within crossbreds the variation however, was significant with the exception of distance between fore teats.

13. The following estimates of heritability were obtained for teat placement in both Ongole and crossbreds.

Character	Ongole	Crossbreds
Distance between fore teats	0.25 ± 0.11	0
Distance between fore and hind teats	0.34 ± 0.13	0
Distance between hind teats	0.67 ± 0.18	0.01 ± 0.11

14. Significant correlations between distance, between fore teats, distance between fore and hind teats with one day yield were obtained only at one place in Ongole (Chinthaladeevi), whereas in crossbreds, correlations were significant in respect of all the measurements.

15. The mean teat measurements varied in Ongole and crossbreds as follows :

Character	Ongole (cm)	Crossbreds (cm)
Length of fore teats	6.68-6.72	5.23-5.35
Length of hind teats	5.23-5.76	4.64-5.01
Diameter of fore teats	2.67-2.76	1.87-1.92
Diameter of hind teats	2.20-2.35	1.82-1.94

The variation due to order of lactation for both fore and hind teats was significant in Ongole. In the case of diameter of fore and hind teats, variation due to order of lactation was significant in Ongole (Chinthaladeevi) and in crossbreds. In Ongole, the fore teats were about 0.96-1.45 cm longer than hind teats, whereas in crossbreds, they were 0.34-0.50 cm longer. Breed to breed variation was also significant, in respect of all the four measurements.

16. The following estimates of heritability were obtained.

Character	Ongole	Crossbreds
Length of fore teats	0	0.58 ± 0.22
Length of hind teats	0.43 ± 0.14	0.33 ± 0.18
Diameter of fore teats	0.97 ± 0.22	0.16 ± 0.14
Diameter of hind teats	0.61 ± 0.17	0

17. No significant correlations were obtained between these measurements and one day yield with the exception of diameter of fore teats in Ongole (Chinthaladeevi). Genetic correlations were negative for length of fore teats and diameter of fore teats with 90 day yield. The value for length of fore teats exceeded one.

18. Partial correlations were obtained in Ongole (Chinthaladeevi) between udder measurements and one day yield. Udder length had significant partial correlations.

Regression of milk yield-one day and 90 day yield on measurements was linear and significant.

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