TITLE

SOW MILK YIELD AND COMPOSITION IN RELATION TO DAM AND LITTER PERFORMANCE

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ABSTRACT

A total of 100 sows involving seven pure and crossbred genotypes of the Large White, Landrace, indigenous pigs of Nigeria and the Duroc x Large White, Duroc x Landrace and reciprocal crosses between the Large White and Landrace were used.

The study embraced the milk production, milk composition and the performances of both sows and their litters.

Results obtained indicate that milk production was quite low with the average eight week production of 73.99 kg of the indigenous sow to 153.21 kg of the Duroc x Large White crosses. However, percentage milk constituents were quite high with values of 19-23%, total solids, 7 - 9.2% fat, 6.9 - 7.5% protein, 4.6 - 6.0% Lactose, 0.7 - 0.9%, 0.19 - 0.35% Calcium and 0.11 - 0.20% phosphorus in both colostrum and milk.

The yields of milk nutrients were similarly high, namely protein 92-175, fat 119--228 and total solids 291--576 g/sow/day and a corresponding yield of protein of 306 - 334, and fat 370 - 412 g/kg dry matter.

Litter size and litter weights at birth were quite comparable with what obtains under temperate conditions yet litter weaning weights were suboptimal in the range of 4.4 - 10 kg per piglet at eight weeks. Contrarily efficiency of milk utilization was very high and in the neighbourhood of 4 - 6 kg milk per kilogram weight gained for the pure breeds and 2 - 3 kg for the crossbreeds.

Milk yield per metabolic body size was insignificantly different with values of 3.7 - 4.3 kg recorded. A high phenotypic correlation between milk and body weight at farrow could be a measure of increasing milk production of the smaller bodied indigenous pigs through selection for body size

While the crossbred sows outweighed the pure breeds in their reproductive

performance, all breeds suffered from seasonal fluctuation which depresses the milk production and reproductive efficiency.

It can be stated that milk production of the sow is not the only limiting factor to higher productivity under the tropical condition. It is a combination of environment and management procedures in that seasonal depression has been implicated in most of the traits studied. Another major contributing factor has been the sub-clinical level of hygiene under which the animals exist.

Reports have indicated that crossbreds are less susceptible to performance problems when they are bred and selected in the environments in which they are expected to perfrom as borne out by the results of this study. Crossbreeding might be a solution to most of these breeding problems especially by incorporating favourable genes of adaptation, disease resistance and some yet to be discovered traits in our indigenous pigs with those of the exotic purebred to develop a new breed of pig in the tropics for the tropics.

The results were therefore discussed in the light of superiority of crossbreeding and adaptation of the indigenous sow.

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CERTIFICATION BY SUPERVISORS

We certify that this work was carried out by Mrs. O.A. Adebambo in the Department of Animal Science, University of Ibadan.

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DEDICATION

Dedicated to the memory of

My Late Aunt

Mrs. Julianah Olabisi Soleye

and my late mother-in-law

Mrs. Christianah Jolaade Adebambo.

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CHAPTER I

GENERAL INTRODUCTION

Pig Production in Nigeria

Pig production on a commercial scale is at its very beginning in Nigeria. Individual pig farmers with large holdings are few although in recent years there has been an increasing awareness of the economic turn-over that may be obtained from a large scale pig enterprise.

There are a few research stations such as the University Teaching and Research farm and livestock stations set up by the former Western and Eastern regional governments at Agege, Oyo, Ado-Ekiti, Benin, Umuahia and Moor Plantation. Other organised pig farms include the West African Cold Storage Company which owns a large piggery at Minna to supply its sausage factory at Lagos, the K-Maroun firm with a big pig operation in Kano. Apart from these, individual pig farmers such as Olaogun, Ogbemudia farms are just beginning their endeavours.

It is obvious that the pig industry is yet a very young one in this country. This fact could have been due firstly to religious taboos and secondly to the high price placed on pork in the local market with the result that it is left for only the high income earners to purchase.

When rapid turn-over of animal protein is the objective, certain attributes of the pig make it superior to other animals as sources of protein. Pigs under intensive management, on concentrate feeding and kept indoors are less affected by seasonal changes.

The pig has the advantage of providing both calories and protein in the human diets. While the population pressure on land makes extensive cultivation of pastures more difficult, pigs will easily convert grains, seeds and waste products unfit for human consumption into meat. The pig serves as an efficient synthesizer and storage depot for fat, protein, vitamins and minerals which taken separately would be very expensive. Furthermore no one has yet produced a synthetic ham or pork chop equal in acceptability to the real thing at any price. Strong dietary preferences for traditional foods exist within individual regions of the world so that there is reluctance to accept esthetically inferior replacements. Since animal products are readily consumed by people throughout the world, when available at reasonable prices, this potential for providing adequate nutrients cannot be overlooked. Thus although the pig is considered by some to be a source of nutrients too luxurious to survive in a world overpopulated with humans, there are both nutritional and esthetic grounds for arguing its survival, and in fact, its increased propagation, until technology has been developed to the point at which other acceptable protein sources are available more cheaply.

Perhaps the most favourable properties of the pig are its fast growth rate, its prolificacy in terms of litter size of 8-16 piglets per litter and shorter generation interval. These characteristics inherently provide this species of livestock with a high reproductive potential for the production of market animals. The pig is an efficient utilizer of concentrates and good converter of feed into edible human food. Its capacity to transform large amounts of concentrate and some other waste products into human food has brought their present prominence in many parts of the world. In Nigeria, there is an increasing amount of by-products becoming available which are not readily acceptable in human diets. Among these are groundnut and palm kernel by-products from the expanding local vegetable oil extraction mills. Large quantities of waste bananas and of cassava and other root crops could be used as sources of energy and legume seeds as sources of protein for swine production.

Pork has in the past provided a major source of animal protein and can be expected to continue to do so during the rest of the present century. It has been predicted (The World Food Problems, 1967) that after 1990 animal proteins will decline in importance in contributing to total protein needs owing to an increase in the direct competition of animals with man for available feed supplies as well as to the appearance of protein sources from unconventional agricultural and non-agricultural production. However this decline will not be as dramatic as it is assumed.

Role of Pig Breeding

The domestic breeds of pigs are thought to be derived from existing wild species "Sus scrofa", the European wild pig and "Sus vittatus" the Asian wild pig. Not only have centuries of active breeding given a wide range of more or less highly specialised types with world wide distribution but with modern methods of husbandry the pig lives under even more unnatural conditions than the other large domestic mammals. The more specialised the conditions, the more the pig keeper finds it necessary to strive to obtain the largest production with least expenditure.

The ideal sow at present is one which begins to breed as early as is compatible with her future productivity; the one which continues to breed as often as she can for a possible length of life and which produces large litters of healthy pigs and rears them to good weaning weight with less loss. In other words her fertility, fecundity, mothering ability and milk production must all be high. It is true that if the recently introduced artificial methods of weaning pigs from a few days of age are widely developed, the sow's ability to produce large litters and to rebreed again within the shortest interval may come to outweigh the importance of her mothering ability and milk production. But it is quite clear that for many years to come and in most parts of the world sows will still be expected to rear their own young. What then are the criteria on which the sows qualities are judged?

Criteria of Productivity

What is to be expected of a sow cannot be stated in general terms. There are two factors interacting, the heredity of the sow and the environment provided. Where the heredity is concerned there are many improved breeds which are widely distributed the world over with the result that differences between lines within breeds are often as large as differences between breeds.

Fecundity and mothering ability have been selected in some lines by groups of experts in different countries. According to Duncan and Lodge (1960) the different standards of selection are related to the average in a particular area as influenced by the types of breeding, feeding and management of that area. These standards have no universal application and cannot be the general expressions of the physiological and genetical capabilities of the sow. It is impossible therefore to calculate a theoretical maximum factor of performance either in terms of fecundity or milk production. It is reported in "Farmer and Stockbreeder" (1957) that an Essex sow mated to a Large White boar gave birth to 18 pigs which at 56 days of age weighed from 46 - 83-1/2 lbs (19-38 kg) with an average of 63 lbs (29 kg) and a total of 1134 lbs (515 kg).

Also reported by Lasley (1972) was a Landrace sow which farrowed a litter of 18 and weaned 16 which at 56 days weighed 687 lbs (312 kg). It is not suggested that such pigs could be reared by all sows but it gives an indication of possible performance. The National Pig Breeders Association of the United Kingdom laid down in 1932 the standards required for sows in their Advance Register of Fecundity. It stated as follows:

> "The sow must be registered in the NPBA (National Pig Breeders Association) Herd Book. She must rear an average of not less than 8 pigs per litter in any 4 consecutive notified litters born within a period of 22 consecutive calendar months. The total weight of the 4 litters at 3 weeks must not be less than 380 lbs (173 kg) and the litters must have been reared by their dam to at least 3 weeks."

The North of Scotland Pig Producers Association decided in 1952 that to qualify for a certificate of breeding merit a sow must reach these standards (Table 1.1) in three of four consecutive litters.

Table 1.1 AVERAGE BREEDING STANDARD FOR SOWS IN POUNDS AND (kg).

No. in Litter	Mean Weight at 3 Weeks		Mean Weight at 8 Weeks	
	Winter	Summer	Winter	Summer
8	12-1/2 (5.68)	13-1/2 (6.13)	36 (16.34)	38 (7.25)
9	12 (5.45)	13 (5.90)	34 (15.44)	36 (16.34)
10	11-1/2 (5.22)	12-1/2 (5.68)	32 (14.53)	34-1/2 (15.66)
11+	11 (4.99)	12 (5.45)	30 (13.62)	33 (15.00)

The German Pig Performance Register (1949) required that in five successive litters the sow must have a minimum of ten pigs born and nine reared per litter with a total weight of 60 kg at 28 days. The standards for registered sows in the Soviet Union require 1.8 - 2.0 litters a year with ten pigs per litter or 18 per year and a mean weaning weight of 16 kg at eight weeks (Popehina and Borc, 1957).

How then does present day productivity compare with these standards? It is true that these set standards are usually based on local performance but the populations on which they are based are probably better than the average. Since the breeder is a specialist whose aim is not necessarily that of a commercial producer most of the information readily available is likely to come from the best breed and best managed herds. Therefore it must be realised that recorded performance data of sows have not only limited significance but probably give a better impression than might be obtained from a total census. However standards have been set for some of the breeds which have been a guide for many pig breeders in many countries.

Table 1.2 AVERAGE LITTER SIZE OF SOME PIG BREEDS IN DIFFERENT COUNTRIES.

Breed	Average Litter Size	Country
German Large White	8.9	Czechoslovakia
Large White	9.6	New Zealand
Danish Landrace	9.7	United States
Danish Landrace	9.9	United Kingdom
Landrace	10.2	Sweden
Large White	10.9	United Kingdom
Norwegian Landrace	11.2	Norway
Large White	11.7	U.S.S.R.
Large White	12.0	Canada

The extent to which these standards have been utilized in Nigeria are yet to be seen.

<u>Some Observations on a Nigerian Farm - University of Ibadan Teaching and Research Farm</u>

Dettmers (1974) gave the litter size and weight at different ages for Landrace and Large White pigs in the Breeding Unit of the University farm between 1970 and 1973 (Table 1.3). The total born alive and the birth weights are quite comparable with what obtains in most swine producing countries yet the weaning weights fall below expectation.

Death at birth seems negligible yet figures of preweaning loss are much too high. The sows lose much weight during the nursing period.

Table 1.3

SOW PERFORMANCE RECORD AT UNIVERSITY OF IBADAN, 1970-1973.

TRAIT	1970		1971			1972						1973	
	LR	LW	LR	LW	LR	LW	Dx LW	LW x LR	LRxLW	INDxLW	INDxLR	LR	LW
No. of litters	45	87	24	70	32	67	3	2	1	2	1	31	57
Litters/sow	1.2	1.3	-	-	-	-	-	-	-	-	-	-	-
Born alive/ litter	7.6	8.1	7.92	8.41	6.86	7.90	7.7	9.5	9.0	8.0	10.0	6.57	8.16
Total born	8.1	8.5	8.29	8.56	6.9	7.9	7.7	9.5	9.0	8.0	10.0	6.6	8.1
Loss at birth %	6.3	3.8	4.5	2.8	0.5	0	0	0	0	0	0	.05	.08
Birth weight (Ib)	-	-	3.1	2.8	2.5	2.6	-	-	-	-	-	2.8	2.7
No. weaned at 8 weeks	6.1	5.1	6.47	5.04	4.3	4.4	7.7	9.5	9.0	8.0	10.0	4.8	5.4
Loss to 8 weeks (%)	20.6	38.1	18.3	40.1	31.2	43.7	0	0	0	0	0	27.5	33.8
Weight at 8 weeks (Ib). (kg)	11.4 (5.18)	10.2 (4.63)	16.8 (7.63)	16.3 (7.40)	14.4 (6.54)	15.3 (6.95)	15.0 (6.8)	15.5 (6.92)	16.8 (7.6)	18.6 (8.45)	15.1 (6.8)	17.6 (8.0)	14.4 (6.6)

In certain cases the piglets have to be weaned earlier and raised artificially on milk sufficient supply of which cannot always be secured. These figures may be the result of several factors, environmental and hereditary acting on both piglets and sow, such as the quality and palatability of creep offered, missed injections against anaemia, frequent lack of protection with antibiotics, unsatisfactory care and mismanagement. Inbreeding in the stock used affecting growth of the piglets and milk producing ability of the sow might also be implicated.

The sow weight losses could be due to the same factors as those responsibile for poor growth rate of the piglets. It can be envisaged that a dam suffering herself from stress and other factors may not be able to produce and supply milk in quantity and quality as needed and hence milk may be one of the major causes for poor performance of her litter.

It can also be reasoned that a purebred dam may suffer to a greater extent from hardship to meet its expected production level. Review of the data given for crossbred dams showed better performance. No pig was born dead and none died till weaning. Pigs were quite uniform although their weaning weights were not higher than the purebreds in every instance. But the number was quite small.

Is it then possible that inbreeding in the present stock could have caused the poor litter performance? Craft (1958) indicated the importance of management in the improvement of the sow's performance. Heritability estimates are very low for litter size, number weaned, and weaning weight, 12 - 20%. While inbreeding reduces the vigour of the offspring and increases mortality, crossbreeding has been postulated to increase hybrid vigour and at times results in heterosis.

Steinbach (1971), studying the preweaning litter traits of 289 Large White and 167 Landrace litters born between January 1967 and December 1969 on the same farm showed that the mean piglet weights at birth were comparable to those reported in the temperate zones but the individual piglet weaning weight was unsatisfactory even at its peak level in August (6.82 kg) at five weeks which is less than 50% of individual piglet weight observed in America and Europe.

He however attributed this to depressive effects of high temperature on preweaning growth rate. The new born pig has a relatively large surface area to body weight. Its capacity for heat conservation is further limited by having a sparce covering of hair and a poorly developed subcutaneous adipose layer which minimises the insulating effect of peripheral vaso-constrictions.

Maclagan and Thompson (1950) stated that piglets could be reared successfully in farrowing houses with an ambient temperature as low as 7^{o}C provided the floor was well insulated. It means then that piglets in the tropics should be expected to grow better with the high ambient temperature and with bedding provided. Chilling could be expected to be much less severe. However, it was shown by Mount (1959) that the pig's metabolic rate is lower during the first day of life so that any environmental factors which affect heat loss can influence the degree of chilling to which the animal is exposed. Since the baby pig normally spends a large proportion of time lying in direct contact with the floor it is clear that conductive heat loss could have an effect large enough to affect growth and be a potential hazard to its survival. Heat stress may interfere not directly with preweaning growth rate but indirectly by its effect on mammary gland development and milk production.

Milk production under stress conditions is limited and may not be sufficient to carry through the large number of piglets reared by the sow. Experience has shown that where the litter size is small like 4-5, the sows are better able to rear them and they attain weights of 35-40 lb (16-18 kg) at eight weeks which is close to what obtains in the temperate countries. Hill (1956) at the University of Ibadan farm reported average weaning weights at eight weeks of 25.87 lb (11.7 kg) for Large White, 31.43 lb (14.3 kg) for Tamworth and 30.78 lb (14.0 kg) for Large Black and Tamworth. It could therefore appear that as the piggery expanded from its former small size, large numbers become the order and management practices deteriorated with increasing numbers resulting in poorer individual weights.

Preweaning mortality of 22% as reported by Steinbach (1971) compares favourably with a majority of reports from temperate countries (Braude et al. 1959). For those in tropical countries Frazer (1966) and Williamson and Payne (1965) reported an average of 29.3%.

Preliminary Work on Milk Production of the Sow

The amount of milk produced, length of lactation, the milk components and other factors could possibly influence to a large extent the performance of the progeny.

Williams (1971) in his study with two sows and three gilts gave an insight into the milk production of the pigs on the University farm.

During an eight week lactation period he determined the milk production of the sows by the weighing method. He found an average milk yield per lactation of 333.45 lbs (151.4 kg). The sows gave more milk than the gilts. The average daily yield was 5.8 lb (2.63 kg) and daily intake per piglet was 0.9 lb (0.41 kg).

There was a great difficulty encountered during the course of the experiment. Weight losses of the sows during the nursing period ranged from 99-191 lb (45-87 kg) with an average of 143 lb (65 kg). This was accounted for by lowered feed intake due to high environmental temperature. Litter weight gains ranged from 96 to 139 lb (44-63 kg) with an average of 110 lbs (50 kg) while the efficiency of milk conversion was remarkably high for all litters ranging from 2.0-3.8 lbs of milk per pound of litter gain (1.8-3.5 kg per kg litter gain). The number of animals studied was small yet variation was large that it appeared this line of investigation should be pursued because the scope of the study did not allow any conclusion.

The study left many questions unanswered such as - reliable methods of determining milk production in the sow and inducement of milk letdown in the sow so as to obtain enough milk for laboratory analysis in order to ascertain its nutritive components. There were no suggestions as to the role of milk constituents and finally, nothing about relationships between the sow milk yield and the piglet performance.

1.6 Objectives of this Study

The objective of this study is an extensive survey of the milk production potential of sows, the composition of the milk and related performance factors of the sow. A larger number of animals will be used in order to answer some of the questions with particular consideration of the tropical environment. Temperate breeds have been introduced into the country and much work has been done on milk yield and composition of these breeds in their places of origin. But the extent to which the results can be extrapolated to pigs in a different environment to predict their relative performance in the tropics is yet unknown. Less work has been done on presumably genetically inferior indigenous breeds in the tropics. It is not known whether it is really true that they have nothing to contribute to pig production. Therefore this study will include besides exotic breeds and their crosses also indigenous swine.

CHAPTER II

LITERATURE REVIEW

2.1 Milk Production

Measurement of the milk yield of the sow started as far back as 1865 by von Gohren according to Schmidt and Lauprecht (1926). It was done by weighing the piglets before and after suckling. Variation in milk yield has been studied in most swine producing countries. It has been related to methods of management, differences in strains and breeds and also to feeding practices of the animals. Failure to produce maximally might be attributable to insufficient hormonal stimulation for secretion rather than to incomplete anatomical development of the glands. Although the udder is regarded as a highly efficient organ, it does not function at maximum capacity for long. This can be explained in nature on the basis of the decreasing need of the young. In contrast, by selection the cow has achieved a level of secretion far in excess of the calf's requirements. In general, the decline in secretion as lactation progresses is the result of wear and tear on the mammary system (involution) and changes in hormonal and nutritional relationships. In fact anything that affects the well being of the sow will be reflected in mammary performance. As lactation progresses, the numbers of actively secreting epithelial cells and their degree of activity decline. The microscopic appearance of the udder of the dry non-pregnant sow is therefore very similar to that of the gilt.

Several factors affect the yield of the sow. Much emphasis has been placed on litter size and vigour of the piglets. The larger the litter size and the more vigorous the piglets the more milk is withdrawn from the number of active teats and the greater will be the response for further stimulation of milk secretion. Most workers agree that milk yield increases with the state of lactation and parity of the sow. Milk production increases till a peak around the third week after parturition and sometimes till the fourth or fifth week and declines thereafter till weaning (Carlyle, 1903; Davis, 1904; Schmidt and Lauprecht, 1926; Olofson and Larson, 1930; Hughes and Hart, 1935; Albig, 1939; Filmer, 1950; Niwa et al.,1951; Smith, 1952 a and b; Berge and Indrebo, 1953; Smith, 1960 b; Smith, 1961; Efimov, 1970).

Individual sows vary in the time required to reach a peak and in persistency to hold an optimum level until the eighth week of lactation once they reach their peak. As total yield increases with parity of the sow, most workers agree that it does so in general up to the third lactation but sometimes up to the sixth (Schmidt and Lauprecht, 1926; Wells, Beeson and Brady, 1940; Smith, 1952a; Berge and Indrebo, 1953; Smith, 1961).

The ratio of weight gain to birth weight is higher in the pigs than in the offspring of other domestic animals. Pigs often more than double their birth weight by the end of the first week of life and may triple it by the end of the second week. The milk production of the sow must therefore play a major role in these rapid weight gains of the pig early in life. Data on milk production of sows obtained from weights of their piglets before and after suckling are given in Table 2.1. Averages vary from 5.2-16.18 lb per day (2.36-7.35 kg). Total milk production for the period of eight weeks also varied from

TABLE 2.1

AVERAGE MILK PRODUCTION OF SOWS

No. of Sows	No. of Lactations	Average No. of Pigs/litter	Daily Milk Production Ib (kg).	Total Milk Production Ib. (kg)	Authors
4	4	6.8	5.2 (2.36)	364.0 (165.26)	Henry and Woll, 1897
12	12	7.2	5.4 (2.45)	469.9 (211.06)	Carlyle, 1903.
1	1	7.0	5.6 (2.54)	389.2 (176.70)	Davies, 1904
12	1	9.0	7.2 (3.27)	404.9 (183.82)	Schmidt and Lauprecht, 1926
2	2	7.5	7.7 (3.50)	539.0 (244.70)	Olofson and Larson, 1930
10	22	8.57	7.1 (3.22)	401.0 (182.05)	Schneider, 1934
4	4	8.5	10.34 (4.69)	508.5 (230.86)	Hughes and Hart, 1935.
20	61	7.1	12.07 (5.48)	674.0 (306.00)	Smith, 1952a
6	28	8.5	16.18 (7.35)	701.2 (318.34)	Berge and Indrebo, 1953.
15	2	8.1		492.5 (223.60)	Smith, 1960b
18	2	9.1		746.0 (338.68)	" 1961
35	6	10.0		(363.0)	Efimov, 1970
5	1	6.4	5.95 (2.70)	334.4 (151.82)	Williams, 1971

334.45-701 lb per sow (152-318 kg). It was found that milk production is a character with low heritability. This implies that any improvement will be environmental. It is therefore not surprising to find as of now that research workers are diverting the trend of their experiments towards ways of improving milk production and performance of the sow through management and improved feeding practises.

2.2 Factors Affecting Milk Production

Owing to genetic improvement several crosses and strains have evolved in pigs with the result that differences among strains are often as high as differences between breeds. Variation in milk production within breeds has been confirmed by several workers (Table 2.2).

Yorkshire females were high producers although with a very wide range of 313.3 lb (142.2 kg) (Williams, 1971) compared to the Landrace. They however produced more milk, 142.2 kg as against 264.0 lb (119.9 kg) (Williams, 1971). This in fact agrees with what was found in an earlier study by Allen et al. (1959) that the Landrace were higher producers than Duroc, Poland China and crosses of Landrace x Poland China but not as high as the Yorkshire. It is however difficult to ascertain whether breeds differ significantly in milk yield since workers carried out their experiments under varying conditions. Only in a few cases were several breeds observed in the same experiment and then breed differences were found.

2.2.1 Stage of Lactation

The average increase in milk production in sows to a peak between the third and fifth week of lactation would be in keeping with what is known about the nutrient requirements of baby pigs. Since pigs are

TABLE 2.2

MILK PRODUCTION OF SOWS BY BREEDS AND CROSSES.

Breed	Parity	Litter size	Total Milk Production Ib (kg)	Authors
Yorkshire	Gilts	8.5	508 (230.6)	Olofson and Larson 1930
Yorkshire	Sows	10.7	767.5 (348.4)	Berber, Braude and Mitchell, 1955
Yorkshire	Gilts	5.0	304.5 (138.1)	Williams, 1971
Yorkshire	Sow 6th	8.5	338.5 (153.6)	Williams, 1971
Yorkshire	Sow 2nd	7.0	366.0 (166.0)	Williams, 1971
Landrace	Sows	8.4	701.0 (318.2)	Berge and Indrebo, 1953.
Landrace	Gilt	5.0	236.0 (107.1	Allen, Lasley and Tribble, 1959.
Landrace x Poland China	Sow	8.8	300.0 (136.2)	Allen, Lasley and Tribble, 1959.
Poland China	Sow	6.0	266.0 (120.8)	Allen, Lasley and Tribble, 1959.

very small during the first few days of life, their capacity to consume milk is limited but increases as they grow bigger with advancing age. During these first two weeks of life the pigs are almost entirely dependent upon milk for their nutrients. The amount of milk produced is very small immediately after parturition but gradually increases with a maximum flow obtained about the fourth week of lactation (Henry and Woll, 1897 according to Allen et al., 1959).

Most investigators agree that the peak in milk production is reached at the third, fourth or fifth week with a gradual decline thereafter (Table 2.3 and Figure 2.1). However after the peak in milk production is passed, the pigs are old and big enough that they can consume supplementary feed and are not entirely dependent on milk for their source of nutrients. Smith (1952a) suggested that the control of the shape of the lactation curve by feeding or management could well result in control of the intake of supplementary feed by the litter. He also found (1952b) in a study of litter behaviour that in the fifth to seventh and to some extent in the eighth week, the pigs first suckled the sow and then went to the creep for additional feed. After this they went to sleep until the next suckling. He concluded that the pigs eat the additional creep ration because they are not receiving a sufficient amount of milk from the sow rather than taking less milk because they are eating supplementary feed.

2.2.2 Age of Sow and Milk Yield

Relatively rapid changes are known to occur in the physiological development of the sow from 10-24 months of age. The same general trend

TABLE 2.3

MILK PRODUCTION AT DIFFERENT STAGES OF LACTATION PER LITTER (ALLEN ET AL., 1959; WILLIAMS 1971)

Period of lactation Weeks	Duroc Sow lb (kg)	Landrace Gilt lb (kg)	Large White Gilt lb (kg)	Sow lb (kg)
1st	33.2 (15.07)	43.4 (19.70)	23.10 (10.48)	42.21 (19.15)
2nd	37.8 (17.16)	50.3 (22.84)	40.53 (18.38)	49.77 (22.58)
3rd	50.6 (22.97)	53.2 (24.15)	102.90 (46.68)	51.45 (23.34)
4th	40.8 (18.52)	56.1 (25.47)	48.93 (22.20)	86.10 (39.06)
5th	39.7 (18.02)	57.1 (25.92)	40.53 (18.38)	60.90 (27.62)
6th	54.4 (24.70)	45.9 (20.84)	23.10 (10.48)	36.75 (16.67)
7th	–	–	11.55 (5.24)	20.79 (9.43)
8th	–	–	13.86 (6.29)	18.06 (8.19)

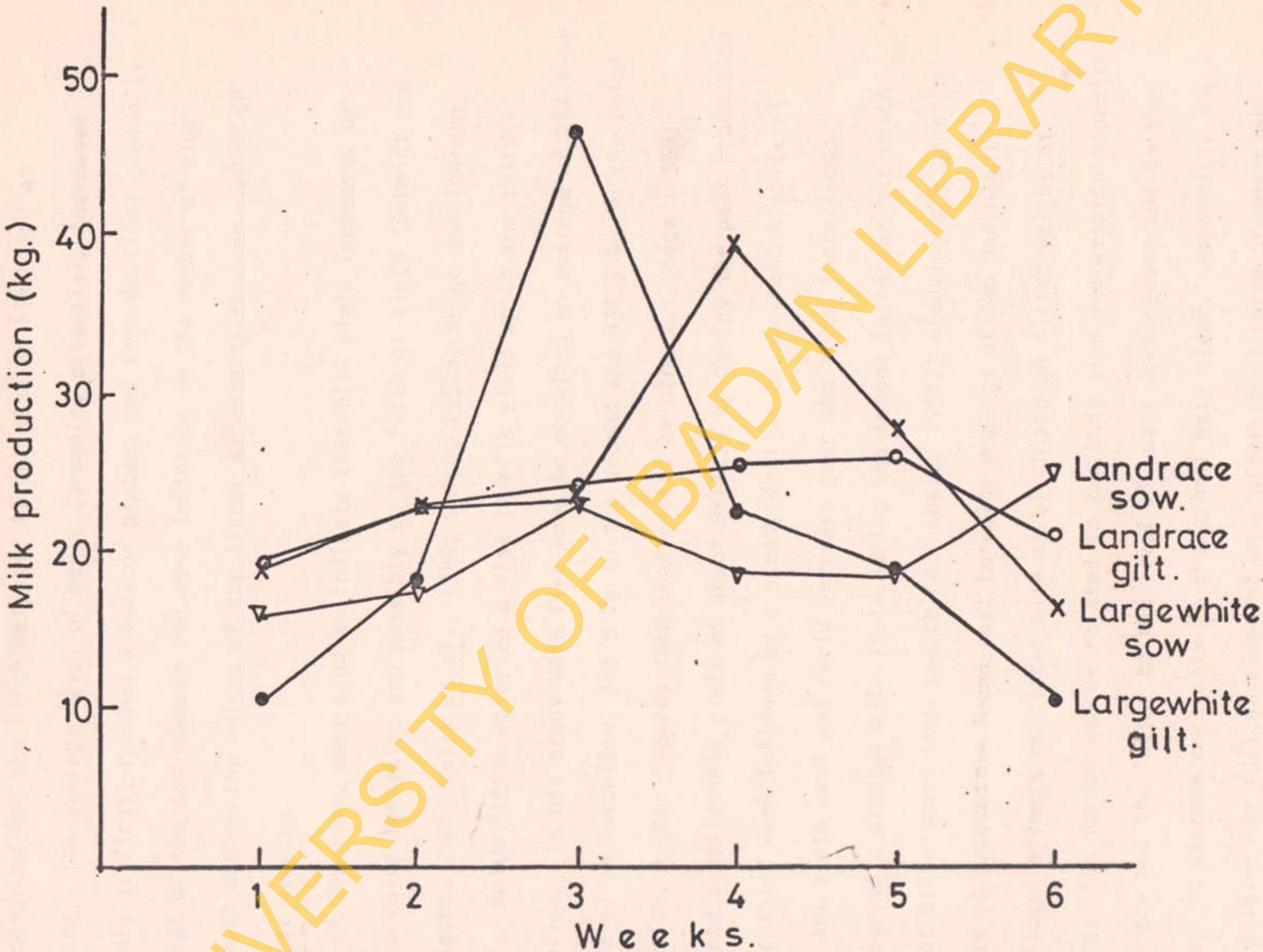

Fig. 2.1 Milk production of sows at different stages of lactation over six weeks - (Allen *et al.* 1959 (Williams. 1971).

was observed for the birth weights, litter size at birth and at weaning. The average level of merit (breeding potential) increased rapidly at first, reached a peak or plateau and then declined gradually. The age of the dam however had more influence on the number of pigs at birth and on the weight of the litter at weaning than on number of pigs at weaning.

In the sows, most studies indicate that milk yield increases up to the third lactation and possibly to the fifth or sixth (Schmidt and Lauprecht, 1926; Wells et al., 1940; Smith, 1952a; Berge and Indrebo, 1953). Smith (1950) observed a rise in milk yield up to the third lactation. In his study with five sows he obtained an average of 272.4 kg in the first lactation, 385.9 kg in the second and 431.3 kg in the third lactation, higher figures than that quoted by others. Lodge (1958) obtained a daily milk yield of about 9-11.35 kg during the peak production in the third week followed by a steady decline or constant high level until the sixth week and rapid decrease over the three lactations. He observed a greater milk yield during the second lactation but which did not differ much from the third. Shelby (1967) studying the genetic aspects of production found that heredity and age of dam had highly significant effects on litter size at birth and on litter weight at weaning. The former can be related to the body size and uterine capacity of the sow and the latter to the level of udder development and so the tendency to secrete more milk as the animal gets older. Apparently the udder attains its full development only after about three pregnancies. Hence he indicated (Table 2.4) an increase in number of pigs and pigs weaning weight up till the third year of age.

TABLE 2.4

AVERAGE VALUES OF MEASURES OF SOW PRODUCTIVITY BY AGE OF DAM (SHELBY, 1967)

Age of dam (years)	No. of litters	Average No. of Pigs at Birth	Average No. of Pigs at Weaning	Survival %	Average Weight of litter at weaning (kg)
1	342	9.4	7.0	75	98
1.5	223	9.8	7.1	72	110
2.0	139	11.0	7.5	68	115
2.5	88	11.4	7.3	64	118
3.0	38	11.7	7.7	66	123
3.5	21	11.2	7.0	62	112
4+	18	12.1	7.8	64	123
Total	869	10.2	7.2	71	108

2.2.3 Body Size and Milk Yield

The relationship between body size and milk yield in cows concerned breeders and scientists for a long time. Touchberry (1951) and Blackmore, Mcgilliard and Lush (1958) reported a very small and non-significant correlation between milk yield and body weight and bull progeny groups.

Miller and McGilliard (1959) showed a positive influence on yield of both weight and age estimated simultaneously, but Clark and Touchberry (1962) showed a large negative genetic correlation between body weight and production.

Brum and Ludwick (1969) correlating certain immature and mature body measurements with first lactation production of Holstein cows found phenotypic correlations between body measurement and milk or milk fat yield from 0.03 to 0.15 and a genetic correlation of 0.34 ± 0.27 to 0.90 ± 0.34; from daughter dam analysis it ranged from -0.45 to + 0.31. They indicated that a 25% increase in accuracy of selection for first lactation milk production might be achieved with the inclusion of a precalving age body measurement in the selection index. Similar selection restricted to body measurements would have been 80% as effective as selection based on milk record alone. They found heritability estimates of 0.38 ± 0.07 for body weight and milk, 0.43 ± 0.13 for milk fat yield during first lactations using parental halfsibs. This is in agreement with reports of Tourchberry (1951) but below values of Blackmore et al. (1958). The phenotypic correlation was however very low with 0.02 at first lactation, 0.14 at one year and none at all at five years.

According to these authors inclusion of four size measurements with milk yield in an index may result in a 1/4 to 1/3 greater genetic progress of first lactation milk yield compared with selection based only on first lactation yield alone. Also selection for milk production restricted to body measurements may be 80-90% as effective as selection based on milk record. They found chest depth the single most important body measurement for predicting breeding value for production, and generally body measurements taken at three months of age as beneficial as those taken at 12 months. Harville and Henderson (1966) and Wills, Young and Cole (1963) however found a very small phenotypic correlation between body weight and yield but correspondingly a large positive genetic correlation.

Recently, Nordskog and Briggs (1968) found in poultry that body condition was more important than body weight and that there was an optimum body weight for each strain and that the productive level suffered if body conditions or fatness exceeded or did not reach this optimum weight.

In a study on mice, Liljedahl and Neiman-Sørenson(1968) postulated that the feeding level during rearing had no permanent effect on lactation yield and that only in first lactations there was a response to level of feeding during rearing and that there was very little effect of mature size on yield.

2.2.4 Climatic Effects on Milk Yield

The difference in efficiency of milk production between summer and winter is of particular interest and is probably related to environmental temperatures.

There is ample evidence that the efficiency of feed utilization by dairy cows is adversely affected by high environmental temperatures. Observations on sows during summer months leave no doubt as to the distress occasioned at temperatures of 23°C and above. Sows subjected to these conditions exhibit an accelerated respiration rate in an attempt to increase respiratory evaporation.

Heitman and Hughes (1949) in a study specifically designed to measure the effect of temperature variations upon the growth rate and feed efficiency of swine found that the optimum temperature for pigs between 32 and 64 kg weight was 21°C while those between 160 and 260 lb (73 and 118 kg) performed more efficiently in an environmental temperature of 16°C. Lalevic (1953) observed that sows produced more milk during spring farrows (136.34 kg) than in autumn (131.39 kg). Gill and Thompson (1956) determined the effect of air temperature on the amount of milk pigs would suckle during the eight week period. They found no significant differences in the milk consumption of piglets in winter either when on heated or unheated floors but observed a high efficiency of utilization of milk when the temperature was higher than the winter temperatures ($P<0.001$). Roosve (1967) postulated that sows reached their peak earlier between the second and third week in winter than between the fourth and fifth weeks in summer. This evidence suggests that during the hot months lactating sows should be housed in adequately ventilated quarters and in addition, some form of cooling device should be provided, such as wallows or water spray for use during the hotter part of the day.

Whereas the summer heat may depress the efficiency of milk production by the sow it also suggests that cold temperature reduces the efficiency of litter growth. It would appear therefore that since of necessity the sow and the litter must be housed together, two different environments must be provided in the same structure. To make an economically sound decision on the extent of environmental modification to provide during confinement, several predictors of swine response have been reported. Hazen and Mangold (1960) presented curves relating the change in average daily gain and change in feed efficiency to air temperature and observed that the optimum temperature for feed efficiency was 28°C by plotting rate of gain and feed efficiency against air temperature at which pigs were housed.

Bond, Kelly and Heitman Jr. (1963) reported that with an average temperature of 21°C the rate of gain and feed conversion efficiency was better with a constant temperature than with a diurnal temperature cycle. However with a 10°C diurnal cycle from 16°-26°C the difference was not significant but was much worse with a 10°C cycle of 27-37°C. Although Mangold, Hazen and Hays (1967) attempted to thermodynamically model the response of swine to air temperature they failed to adequately describe the internal processes of the animal that determine the heat energy transferred from the animal to the environment. Other methods are therefore based directly on the observed rate of gain of swine obtained from feeding trials and predictors of physiological response of swine exposed to various environmental conditions.

2.2.5 <u>Diet of Sow and Her Milk Yield</u>

The recently published technical review of the nutrient requirements of pigs (Agricultural Research Council, ARC 1967) stressed that information on the effect of dietary protein intake during lactation on the productivity of the sow is very limited. Apart from protein only fat and vitamin A have a significant effect on the milk quantity and constituents respectively.

Fey (1958) studied a herd of "Edelschwein" sows, they were fed 246 to 834g digestible crude protein per day without consideration of the expected milk yield. It was found that the yield was strongly influenced by the protein intake (Table 2.5).

Table 2.5 DEPENDENCE OF MILK YIELD ON PROTEIN SUPPLY
(FEY 1958)

Digestible Crude Protein g/day	Body Protein Mobilised g/day	Total Protein Supply g/day	Milk Protein g/day	Milk Yield kg/day
246	56	302	175	3.61
470	69	539	305	6.19
569	32	601	315	5.89
582	141	673	404	7.81
636	13	699	441	9.08
675	7*	-	-	9.55
736	166	903	549	10.73
=834	89	923	407	7.70

*N balance not studied

=Probably not influenced by the protein supply but by the sows' inherited capacity.

The effect of the sow's nutrient intake during gestation and lactation and the reflection on the litter weight gain was studied by several workers (Lenkeit and Gütte, 1955; Holden, Lucas, Speer and Hays, 1968;

Mahan, Becker, Marmon and Jensen, 1971a). They claimed that level of protein during gestation and lactation markedly affected preweaning gain ($P<0.01$). They concluded that gestation as well as lactation treatments affect preweaning performance of the progeny. This is a reflection of the quantity and quality of the milk produced thereby influencing performance of the sows. Holden et al. (1968) reported that protein content of sows' milk decreased linearly with declining dietary protein intake. Mahan et al. (1971) also stated that the albumin fractions of sow milk decreased with dietary protein but the relative composition of other milk fractions was unaffected by levels of protein to as low as 10%. The authors concluded that a nitrogen equilibrium is necessary to obtain maximum milk production, milk nitrogen and weaning weights. If a negative nitrogen balance occurs, the sow compensates by katabolising her body protein tissue which cannot go on indefinitely. It therefore results in reduced nitrogen output in the milk, depressed milk production and reduced litter weight gains especially when sows were fed 10% protein or less. The animals tend to go off feed and there was a negative nitrogen balance when 10-14% protein was fed compared to 15-18% protein. Milk production and its nitrogen were depressed significantly ($P<0.05$) from 22 days post partum onwards.

Effect of protein intake on milk production and litter performance of sows when given the same dietary treatments for three successive lactations was studied by Macpherson, Elsley and Smart (1969) using levels of 19.0, 16.5 and 14.0% crude protein. They found a significant dietary effect on the milk yield of sows although milk yield of low protein sows were slightly higher than the other two groups of sows in the first lactation. They indicated that for the first three litters lactating sows rearing nine piglets up to six weeks of age did not require more than 750g protein per day during lactation when this was associated with a daily protein intake of 240g during gestation.

There is little information on the amino acid requirement of lactating sows. Salmon - Legagneur (1964) found that sows receiving fish meal as the protein source of a diet formulated to a crude protein content of 14% lost considerably less weight and produced more milk than sows given a diet based on groundnut meal which may be a reflection of the amino acid profile in the different diets.

In the nutrient requirement of farm livestock ARC (1967) the protein requirements of lactating sows was calculated by assuming the gross efficiency of conversion of dietary protein into milk protein by a sow receiving adequate energy and a little excess protein to be 33%.

2.2.6 Plane of Nutrition

The effect of the plane of nutrition could be as pronounced as the total protein content. Lodge (1959a) fed two groups each of four Wessex Saddleback sows on different planes during three successive lactations. The mean meal intake in the course of lactation was 359 and 267 kg. On about the fourth day of each week of lactation the pigs were weighed before and after suckling at intervals of 1-1/4 hours in the first six weeks and 1-1/2 hours in the last two weeks over a period of 7-1/2 hours. The sows on the higher plane of feeding gave more milk than those on the lower with an average difference of 19%. From the curves of production for second and third lactation it was demonstrated that all the sows showed a steep rise of production in the first two weeks. But thereafter the yield of the low plane sows declined steadily while the sows on the higher plane were able to maintain high yields until the sixth week.

Salmon-Legagneur (1965) fed protein levels up to 125% during gestation. He found no effect on the yield of milk even when the fishmeal content was replaced by groundnut meal. But during two successive lactations with groundnut meal he found a depressive effect on milk yield.

Addition of animal protein tankage or fish solubles to rations of maize meal, soyabean meal and alfalfa had no similar effects on total protein or casein contents of milk (Sheffy <u>et al</u>. 1952). But Smith (1959a) got an improvement in milk yield in response to replacement of a concentrate mixture of barley and meat protein by separated milk (skim milk).

2.2.7 Variation of Milk Yield Due to Litter Size

Bonsma and Oosthuizen (1935) considered that although the milk yield of the sow is influenced by the size of the litter, the milking potentialities of the sow are independent of size of litter and that fecundity and milking capacity are separate inherited characteristics. But both fecundity and milk production are closely dependent on the function of the pituitary. So Buchanan- Smith and Donald (1937) suggested that large litters and heavy milk yields may occur together in association with an active pituitary.

Early workers who investigated the milk yield of sows by weighing the pigs before and after they suckled did not attach importance to details such as frequency of suckling which have since been found crucial. Hempel (1928) estimated that for 22 improved "Landschwein" sows the yield in a lactation of eight weeks varied from 150-220 kg with an average of 3.34 kg daily. The amount of milk rose with litter size; for nine sows with a mean of 9.6 pigs the average yield was 193 kg in eight weeks, for nine sows with a mean of 7.5 pigs 178 kg and for three sows with only 3.5 pigs each 106 kg or only 1.9 kg .

Ohligmacher (1928) studied the same herd as Hempel and estimated that yield in a ten week lactation varied from 126-224 kg. Schneider (1934) studied 30 litters of strong healthy pigs by the weighing method. He allowed the pigs to feed only every two hours in the first three weeks and three hours later. There were five litters with six pigs, ten with 7-9 and seven with 10 or more. The mean daily milk yields of sows in these three groups were 2.35, 3.09 and 4.14 kg and the range 1.69-2.72, 2.08-4.64 and 3.24-5.63 kg. The total yields were 130, 173 and 233 kg and the amount per living pig 23, 19 and 22 kg. Bonsma and Oosthuizen (1935) used a similar method as Schneider (1934) with Large Black sows. The average total yield in eight weeks was 167 kg with a range of 84-275kg. Total milk yield rose with litter size from 101.5 kg for four or fewer pigs to 188 kg for nine or ten but the yield per pig fell from 34 to 20 kg. The positive correlation between litter size and total yield and negative correlation between litter size and yield per pig were highly significant. Insofar as the maximal milk potentiality of the sow is not fully exploited the higher the litter size is the higher will be the milk yield. This raises an important point that whichever the estimation process, what is measured is the milk ingestion of the piglets rather than the true milk production of the sows.

As a matter of fact, the piglets are responsible to a large extent for their mothers' performance; the milk yield therefore varies depending on the piglets' health, vigour and efficiency.

An average production of 3.7 kg per day has been reported for sows with small litters and of about 9.2 kg for litters of about 12. Berge and Indrebo (1953) noted increases in milk production from 4.0 kg for a litter size of 3-6, to 10-12 kg for a litter size of 12 and an average of 9.5 kg when litter size was 13.

Average milk consumption per piglet was 1.33, 0.84 and 0.73 kg respectively. These investigators therefore concluded that milk yield increases with litter size linearly from litter size 3-5, slowly from 5-10 and only slightly for litters up to 13 piglets. The two of them and Lalevic (1953) found a positive correlation between litter size and milk production, daily litter growth and milk production of (0.8-0.9). Several workers have therefore suggested that any estimate of total lactation should be related to litter size.

2.2.8 Heredity

Milking capacity is one of the most typical quantitative characteristics of farm animals. It is influenced by such a large number of genes and external factors that application of the classical gene analysis must be regarded as quite meaningless. Cummings et al., (1947) estimated that the heredity of the sow exercised an influence of about 50% on milk yield. Inheritance of milk yield in the sow is not an easy one to estimate if large numbers are required. Most workers were able to handle only a few sows at any one time. The most extensive study has been that of Perrin (1954) who used 44 sows; others are Bonsma and Oosthuizen, (1935) with 25 sows; Schneider (1934) with 30 sows; Berber et al. (1955) with 34 sows.

However since milk yield and its expressivity is dependent on the number of piglets suckled, during the course of weighing any factor that affects the litter size might correspondingly affect milk production of the sow. In a statistical study litter size was found to be negatively correlated with the degree of inbreeding of the sow (Steward, 1944). An adverse effect on litter size could be recognised when the degree of inbreeding reached 25-35% (Craft, 1954) but it is not generally true that crossbreeding increases litter size.

Any estimate of heritability is of value only for the population studied. Heritability of litter size was found to be 22% in one population (Cummings et al., 1947). It follows therefore that heritability of milk yield will be low and any improvement in milk production will have to be environmental. Studying some 57 paternal halfsib families in mice, Jara-Almonte and White (1973) found heritability estimates of 0.17 ± 0.11 for milk yield and a genetic correlation of 0.92 ± 0.35 between milk yield and 21 day body weight.

Heritability estimates of litter size at birth in pigs and at weaning at five weeks by Walker, Bellharz and Dunkin (1972) was 0.05 and 0.25 respectively. Little difference was found between the purebred and crossbred sows, but crossbred sows gave litters with 17% more piglets which were 31% heavier at five week weaning than purebreds.

In as much as many sows cannot be handled to estimate the heritability of their milk production other forms of estimations such as repeatability which gives the upper limit of heritability might be a good indicator in the estimation of the genetic potential of an animal or her offspring for milk production for selection programs. Other factors, such as mothering ability as indirect estimate of milking potential might also be resorted to, especially in a place where sophisticated equipment such as a milking machine for sows cannot be easily got and the patience of the sow cannot always be guaranteed over prolonged intervals of time during manual stripping of the udder.

2.3 Factors Influencing Milk Yield By The Piglets

The different conditions under which various experiments were carried out and the wide range of breeds used must be borne in mind when determining the milk yield in the sow. Berber et al. (1955) observed that the number of times that the pigs were allowed to suckle during the period when their suckling was under control had a significant effect on the yield of milk obtained. They agreed with Olofson and Larson's (1930) report that the frequency of suckling allowed was significant in determining the milk yield of the dams.

2.3.1 Frequency of Nursing

Olofson and Larson (1930) emphasized the significance of suckling frequency in determining milk yield of sows. This was confirmed by Wells, Beeson and Brady (1940). Sows on an hourly suckling frequency gave approximately one third more milk than those on a two hour frequency. Smith (1950, 1952) introduced the method of recording the number of times a litter was fed on one day and then taking them away for weighing trials the next day and allowing them the same number of feedings.

Five purebred Berkshire sows were studied in their first three lactations. For 15 litters the mean interval between feedings in the eight weeks of lactation were 60, 59, 62, 63, 64, 71, 70 and 75 minutes and the general average was 60 minutes by day and 67 minutes by night. Compared with Bonsma and Oosthuizen's (1935) result, the milk yields were much larger and the peak of lactation was reached later. The larger yields in this experiment were so striking that the method of more frequent feeding was adopted by most subsequent investigators.

Roosve (1967) observed that piglets suckle on the average 13 times per day. Most milk was obtained at night or in the early morning contrary to what Berge and Indrebo found in 1953, that the average suckling per day was 19-28 times, less often between 1.00 p.m. and 6. 00 p.m. and most frequent between 6 00 p.m. and midnight. Mahan _et al_. (1971a) found milk production constant during the day and a reduced frequency of nursing between 12.00 and 4.00 a.m. The quantity of milk obtained per pig was above average when the nursing interval was 70 minutes. They however concluded that milk production decreases as duration of measurements increased.

2.3.2 Suckling Interval

Suckling interval increases with advancing lactation. It is also slightly longer during the night than during the day.

Berber et al. (1955) showed that under natural suckling conditions with no interference with the piglets except during feeding and cleaning, the average suckling interval was 1 - 1-1/4 hour. They found that for five litters of pigs the mean interval between suckling rose from 51 minutes in a litter of six days old pigs to 63 minutes for a litter of 51 days old ones. The range was 25 to 96 minutes but most intervals were within a few minutes of the average. There was a slight tendency to more frequent suckling by day than by night. When a frequency of 2-1/2 to 3 hours was imposed there was an adverse effect on both pigs and dams. Yields were consistently lower and the amount of milk used by the pigs per gram of liveweight gain was very high.

Milk yield as measured over 48 hours was fairly consistently lower in the second 24 hours. The decline was ascribed to the disturbance caused to the sow. Three litters of gilts were studied in this way weekly for eight weeks and they did not perform as well as the herd average. Total milk yield for the 12 gilts was estimated to be 400.4 kg, 347.8 for 11 gilts and 297.4 kg for the third set of 11 gilts (Berber et al 1955).

Gill and Thompson (1956) used an interval of 1-1/2 hours for the first 40 days and then an interval of two hours. They obtained total yields ranging from 202 - 347 kg calculated from the third to the fifty-sixth day. They had daily yields of 3812 to 6548g and yields of 33.4 to 57.4 kg per pig per feeding. They noted that each pig suckled 16 times, had to be handled 32 times daily; which might account for the fact that the weaning weights, like those obtained by Berber et al (1955) were below normal.

Salmon-Legagneur (1956) made day and night studies on 21 sows and found that the mean interval between suckling was 65.5 $\pm$ 20.6 minutes with no significant difference between day and night. The range was 22 to 133 minutes but 56% of the intervals were between 45 and 75 minutes. So the time adopted for the experiment was 75 minutes and the period of study six hours from 6 a.m. to 12 noon. The error in using six hours instead of 24 hours was estimated to be about 8%. In two sows the error in weekly compared with daily studies was 4.5 and 6%. So, weekly records were thought to be acceptable. When 30 lactations were studied with these intervals the mean daily yield was 5.9 kg and the total in eight weeks was 330 kg for a mean litter of nine pigs. Subsequently Salmon-Legagneur (1956) applied the findings of this study to 71 lactations of Large White sows with a mean of 8.2 pigs weaned per litter. The mean daily yield was 5.3 kg. The highest average was for a sow in her second lactation; she gave 9.64 kg per day with a peak of 12.6 kg.

Evans (1958) observed a nursing interval of 60 minutes till the end of the second week and of 86.4 minutes before weaning. The explanation was given that as the piglets grew older, their capacity for milk consumption increased and this coupled with their supplementary feed consumption made them less frequent at the udder than during the early nursing period.

2.3.3 Suckling Behaviour

The process of suckling by the pigs was described by Hughes and Hart (1935) and Donald (1937a). Three distinct stages were observed during the suckling process. These consisted of the udder nosing period of about 55-140 seconds duration, followed by a quiet phase of 16-23 seconds when passive withdrawal of milk occurred without let down and finally the true suckling period when piglets remained quiet and withdrew milk by rapid suckling for about 13-37 seconds with an average of 19 seconds (Niwa et al., 1951; Berber et al., 1955). An additional phase of vigorous massaging of the udder after the true suckling phase was described by Gill and Thompson (1956) and Allen et al. (1959). This phase included more active suckling, it was more prolonged while only a small quantity of milk was obtained. Turner (1952) stated that during the first phase, the stimulus of nosing and massaging causes the discharge of the "let down" hormone from the posterior pituitary gland but that the milk is unavailable to the piglets until the contraction of the myoepithelial cells surrounding the alveoli and ducts occurs and expels the milk.

Carlyle (1903) observed that the actual nursing time varied from 1-2 minutes with half of the time fully spent in getting the flow of milk started, while Hughes and Hart (1935) showed that the pigs actually obtained milk for a period of 60 seconds whereas Donald (1937b) estimated this stage to vary between 35 and 45 seconds. In a more detailed study by Whittemore and Frazer (1974) five characters of milk ejection and suckling behaviour were described.

First, the piglets jostled for position on the udder, secondly, there was a period with vigorous up and down movements of the head. The third phase is "quiet" during which the piglets suckled the teats with slow mouth movements about one per second of large amplitude. Fourth followed suckling with rapid mouth movements about three per second of smaller amplitude. The piglets also displayed slight movements of the head and a rhythmic movement of the snout during this phase. The fifth was a brief return to suckling with slow mouth movement and nosing of the udder.

During the first few days of the lactation, this pattern of suckling behaviour was not so fully developed and the distinction between phases 3 and 4 was frequently not quite clear. Jostling for teats was not always present nor was it always a distinct stage in behaviour. Sometimes two or three piglets would continue vigorous competition long after their litter mates had progressed to stages 2 or 3. Nosing the udder was always present but was highly variable in duration ranging from 26-182 seconds with a mean of 67 seconds and a coefficient of variation of 43%. The change from phase 2 to 3 was not always clear cut. In some instances the animals commenced phase 3 more or less at once, but in other cases individual piglets alternated a number of times between nosing and slow suckling. For this nursing phase 3 was said to have begun when all the piglets made the change for the last time. Using this criterion, the duration of phase 3 ranged from 4-45 seconds with a mean of 20.5 seconds and a coefficient of variation of 40%.

In most cases the beginning of phase 4 was clear when judged by the change in rate and amplitude of the piglets' mouth movement. In addition, the litter invariably commenced this phase in unison. The duration of phase 4 ranged from 7-33 seconds with a mean of 129 seconds and a coefficient of variation of 34%. The beginning of phase 5 defined as the time when piglets stopped suckling with rapid mouth movement was usually obvious but the phase included a number of different activities.

Sometimes the piglets returned to slow suckling and then to nosing the udder. Sometimes they switched from one teat to another. Often individual piglets left the udder to eat supplementary feed. Frequently the phase was terminated within a few seconds by the sow standing up, but on other occasions it ended gradually after many minutes as the piglets fell asleep on the udder.

2.3.4 Milk Yield in Relation to Nursing Vocalization and Suckling Behaviour.

It has been shown that the rate of grunting can in some situations be altered by a change in the stimulation which the udder receives (Frazer, 1973). Some stimulus such as erection of the teats or a preliminary secretion of milk might occur a fixed time before the main milk flow and then cause the piglets to change from the phase of rapid udder nosing to the "quiet" phase (Berber et al., 1955). The resulting change in the stimulation of the udder by the piglets might cause the increase in the sow's rate of grunting. Alternatively or in addition the rapid grunting might be directly linked with the physiological events bringing about milk ejection. In this case the beginning of the rapid grunts might serve as a signal to the piglets that milk flow would soon occur. The interval between increase in grunt rate and the flow of milk was usually 25-30 seconds. In comparison, Whittlestone (1953) found that 15 seconds normally elapsed between the injection of exogenous oxytocic hormone into the blood stream and the ejection of milk.

Folley and Knaggs (1966) assayed the milk ejection activity and related this to the phases of suckling by the piglets. They reported that milk ejection as judged by suckling behaviour lasted from 13-58 seconds but since they were using the phases of suckling as described by Gill and Thompson (1956) it is possible that phases 3 and 4 may not have been distinguished. Whittemore and Frazer (1974) studied the milk yield and suckling behaviour in 83 lactations. In 70 cases the piglets displayed a rapid suckling phase and the weight gain per litter was 423 $\pm$ 7g. In the remaining 13 cases, rapid suckling was not seen and no increase in weight was recorded. Under these experimental conditions, the sows differed ($P<0.01$) in the incidence of unsuccessful nursing.

2.4 Milk Yield

Very early studies have shown that lactation can be initiated in cows by giving a crude extract of the hypophysis, purified lactogen and adrenotrophic hormone. This method was used to increase milk production and to keep it at a prolonged and constant level (Espe and Smith, 1952). An immediate flow of milk known as "let down" can also be induced by intravenous injection of posterior pituitary extracts, since this has the same effect as nursing or hand milking. In cows, it was believed that a nervous reflex caused release of oxytocin into body fluids. Upon reaching the udder, this would initiate the contraction of the contractile tissue and thus expel the milk. It is now known that the posterior lobe of the pituitary gland contains two principles, the pressor and the oxytocic principle of which, when separated, the latter is more effective. It is widely used as a treatment in cases of lack of milk let down in all kinds of farm animals. It has a fast effect; its half life when injected into goats for example was 82 seconds (Hafez, 1969).

2.4.1 Let down (Ejection of Milk)

An animal cannot hold up the milk but can fail to let it down. The greater part of the milk secreted is stored in the millions of alveoli which make up the secretory system. Small amounts of smooth muscle are associated with each alveolus and it is necessary for these muscles to contract if milk is to be forced out into the larger ducts. This problem has been extensively investigated by Ely and Petersen (1941) and others. It is now accepted that the let down of milk is a reflex action involving sensory nerves which stimulate the posterior pituitary gland which in turn secretes a hormone oxytocin which then stimulates the smooth muscle around the alveoli and results in the ejection of milk.

This principle is utilized in the administration of oxytocin to stimulate milk ejection in the sow. The hormone causes contraction of the cells of the alveoli and the tubules in the udder thereby increasing the intramammary pressure to induce milk flow.

The production of maximum quantities of milk requires that the milk be removed from the udder as soon as possible after the hormonal "let down" stimulus has been given. There is considerable evidence available in a wide variety of species that fright or emotional stress result in an almost instantaneous release of epinephrine into the blood stream causing vasoconstriction of the blood vessels thereby inhibiting milk let down.

Braude and Mitchell (1950) obtained evidence that the amount of milk secreted and the length of milk flow are directly related to the amount of oxytocin in the blood. This they determined by injecting varying levels of oxytocin into the blood of sows (1, 3, 5 and 10 units) and hand milking them two hours after natural suckling. Brumby (1954) using pitocin intravenously concluded that the volume of milk in the glands and the rate at which milk was removed influenced the duration of milk ejection and that it appeared that at least in the sow cessation of milk ejection was brought about not only by the enzymatic inactivation of the milk ejection factor but also by a reduction in the volume or pressure of milk within the gland.

Shaw (1942) found in the cow no significant difference in the milk production and milk fat content when milking was done at two hourly intervals over 24 hours. Any reduction in milk fat he thought, might be due probably to the inhibiting action of the oxytocin to the passage of blood fat into the glandular tissue. However the rate of milk secretion from hour to hour could be comparatively constant and was not changed by the removal of milk from the gland at regular milking intervals. Contrary to this, Smith (1947) found an increase in milk fat content during the first week when oxytocin was injected. From this it may be assumed that milk obtained from sows injected with oxytocin is approximately normal although it might be slightly high in fat. The sampling error involved in milking by this method is much smaller than when attempting to milk by hand without injection as the complete evacuation of the mammary gland in sows cannot be obtained without injection of oxytocin.

Whittlestone (1953) studied the time lapse between injection of oxytocin and milk ejection in the sow. He found an average delay of 15 seconds ranging from 12-21.4 seconds and a reaction time of 28.8 seconds with a range of 18-41.1 seconds when 0.5 units of oxytocin were administered. However half life of oxytocin in the blood stream of several species of animals was found to vary between one and eight minutes (Denamur, 1965)

(Table 2.6).

Table 2.6 HALF LIFE OF OXYTOCIN IN THE BLOOD STREAM (Minutes) (Denamur 1965)

Species and Condition	Half Life
Rat	1.73
in estrous	1.19
lactating	2.01
pregnant	1.65
Rabbit	3.30
Cat	8.50
Doe	1.23
Cow	1.08 - 1.58
Ewe	1.00

Several workers agreed that injection of oxytocin caused complete drainage of the glands as would be the case with normal milking (Turner and Slaughter, 1930; Ely and Petersen, 1941; Shaw, 1942). Others reported a sudden increase in blood pressure following the injection (Ott and Scott, 1910; Mackenzie, 1911; Hammond, 1913; Hill and Simpson, 1914 and 1915; Maxwell and Rothera, 1915; Schaffer, 1915; Gaines, 1927 and Turner and Slaughter, 1930). Hill and Simpson (1915) however observed a lessening effect when the administration was continued for a period of time. Both of them and Hammond (1913) are of the opinion that the response to the pituitrin injection is caused by a direct action of the principle on the secreting tissue of the gland and that it is not due to the contraction of the smooth muscles around the secreting cells.

2.4.2 Mode of Action of Oxytocin

Measurement of oxytocin levels in the blood stream has been of limited success because of a lack of sensitive bioassay methods. But recent evidence indicates increase in blood oxytocin concentration in mammals with milking or suckling stimulus (Denamur, 1965).

Denamur suggested that the first stage of hormone action is the formation of a disulphide bond between the oxytocin molecule and the protein of specific receptors (that is the myoepithelial cells). Nothing is known about the effect beyond this particular stage. The myoepithelial cells in mice, rats and goats are also sensitive to mechanical stimulation. The milk ejection response can be produced by mechanical stimulation in the presence of general anaesthesia, local mammary gland anaesthesia and intense vasoconstriction of the mammary gland blood vessels.

During active suckling both the mechanical and oxytocic stimulation of the myoepithelial cells appear to contract the alveoli and increase the diameter of the ducts to produce a high rate of milk flow to the exterior of the gland. (Cross, 1954; Findley <u>et al</u>., 1967 and 1969).

2.4.3 Inhibition of Milk Ejection

An inhibitory effect of adrenalin on milk ejection occurs both centrally in the brain and in the mammary gland. Adrenalin and noradrenalin intervene at several points of the central nervous system such as the synaptic transmission of the supra optic nuclei, the posterior hypothalamus and at the level of the mesencephalic reticulum. The peripheral inhibitory effect is twofold.

(1) Inhibition is brought about by the vasoconstriction of the blood vessels leading to the mammary gland, this prevents the oxytocin from reaching the myoepithelial cells.

(2) This is a direct inhibitory effect on the myoepithelial cells in which adrenalin acts as a physiological antagonist to oxytocin.

Adrenalin injection to lactating animals before oxytocin injections causes vasoconstriction of the blood vessels by its actions on the alpha-receptors probably located in the mammary blood vessels. When oxytocin and adrenalin are injected simultaneously, the inhibitory effect on milk ejection is mediated through the beta-receptors which are most likely situated in the myoepithelial cells. When agents blocking beta-receptors are injected with adrenalin and oxytocin, a normal milk ejection occurs. On the other hand adrenalin neither prevents contraction of the myoepithelial cells in living mouse mammary gland tissue when the oxytocin was applied topically nor inhibits milk ejection response to mechanical tap stimulus applied to the mammary gland (Cross, 1955; Linzell, 1955; and Bisset et al., 1967).

2.4.4 Estimation of Milk Yield

When compared to other domestic animals on the basis of daily dry matter secreted as milk per kilogram live weight, the sow gives 6 kg compared to 5 kg in the goat, 3 kg in the cow and 1 kg in the woman. It follows that the sow is a heavy milker and individual milk production of more than 10 kg per day is not uncommon (Salmon-Legagneur, 1968).

The fact that the sow will not let down her milk voluntarily as other mammals do precludes the investigator from obtaining the milk by manual expression or machine milking without injecting oxytocin or directly weighing the milk as the case in the cow or goat. The indirect weighing procedure is therefore usually adopted as mentioned earlier. The total lactation yield using this method is obtained by adding the weekly yields estimated by multiplying the 24 hour yield during the controlled suckling periods by 7. Most of the work cited in the literature was based on the indirect weighing method although some have questioned the validity of the results obtained by it.

Berber et al. (1955) obtained a decrease in milk let down in the sow when the controlled suckling period was extended over 48 hours. They found that the amount of milk in the second 24 hours was much lower than could be valid as the correct milking capacity of the animal. They thought this reaction might be a result of the interference and disturbance. They therefore considered a 24 hour controlled suckling period as adequate for the estimation of milk yield in the sow as representative of average daily milk yield per week.

Since the majority of investigators agreed that for most part of the lactation period the natural suckling interval is rarely in excess of 60 minutes (Shepperd, 1928; Wohlbier, 1928; Olofson and Larson, 1930; Schneider, 1934; Berber et al., 1955; Salmon-Lagagneur, 1956, 1958 and Evans, 1958), it is suggested that in any weighing experiment the suckling interval should be close to one hour. Wells et al. (1940) arrived at one third more milk when they imposed hourly nursing intervals on pigs as compared to yield from suckling intervals of 2-3 hours.

Berber et al. (1955) noted that the frequency of nursing during controlled experiments is an important factor with regard to obtaining yields representative of those produced by sows under uncontrolled suckling. They also got conclusive evidence that milk yield and live weight gain of pigs during a 24 hour period were much higher when suckling was allowed every hour than when extended.

Loss of urine and faeces by piglets between weighings before and after each suckling results in a decrease in the weights of piglets. This represents a source of error when obtaining the actual milk yield by the indirect weighing method. Since the milk available to the piglets per suckling is normally small per piglet, losses in weight from sources mentioned above will tend to be exaggerated during weighing. Correction factors have been suggested to account for these losses. Wöhlbier (1928) suggested an addition of 4-6g per letdown while Berber et al. (1955) recommended 5-10% increase per total yield as correction.

Todorovsky (1961) studied different methods of estimating milk yield in the sow. In addition to the indirect weighing of the litter he weighed the sows immediately before and after each suckling and took the difference in weight to be the amount of milk produced. In determining milk yield of the sow by weighing the litter before and after suckling loss of weight due to metabolic processes have been considered (Lenkeit and Gütte, 1955; Gütte and Lenkeit, 1960 and Vanspaendonck and Vanschoubrock, 1964). They tried to investigate the loss of weight of piglets caused by metabolic processes between two consecutive weighings and the relationship between this loss on the one hand and the body weight and the age of the piglet on the other. Weight change of 15 Landrace litters of an average of 9.8 piglets were studied during 66 weighing periods of 16 minutes by putting the pigs in a cage fixed on a differential balance. Each weighing consisted of eight periods of two minutes so that in all loss of weight was studied during 528 two minute periods.

They calculated the relationship between loss of weight and age, body weight and the two at the same time. From the equations:

$$L = 0.3863 + 0.0226A \pm 0.5025$$
$$L = 0.2712 + 0.0928W \pm 0.4397$$

(Vanspaendonck and Vanschoubrock, 1964)

$$Y = 1.77 + 0.0113X$$ (Gütte and Lenkeit, 1955)

Where

L and Y = loss of weight

A and X = age

W = body weight

they estimated

$$L = 0.4292 - 0.0233A + 0.1598\,W \pm 0.4245.$$

A close agreement was found between the loss of weight calculated according to both body weight and age and loss of weight calculated according to body weight only. It is therefore sufficient for practical milk yield determinations to reckon loss of weight according to body weight only. It was indirectly deduced that losses of saliva seem to be of little importance and that loss of weight during suckling is almost exclusively due to metabolic processes.

These investigators extrapolated for a sow nursing ten piglets 20 times a day a corresponding loss of weight of 124 - 1,988g per day.

Therefore with a milk yield of 8 kg a day an error of up to 25% may exist if losses of weight caused by metabolic processes are neglected. It is true that milk yield determination by the indirect weighing method does not represent the true milking capacity of the sow but the suckling ability of the piglets (Salmon-Legagneur, 1968). This is in view of the fact that complete removal of milk from the glands and their stimulation for greater milk secretion depends largely on the vigour of the piglets. More vigorous litters will do a more complete job of removing milk from all functioning teats and thereby stimulate greater milk production than less vigorous ones. Milk yield by this method will therefore measure a relative rather than the actual milk produced by the sow.

2.4.5 Maintenance of Milk Secretion

The maintenance of a high rate of milk secretion following parturition is of great concern to a dairy man and for that matter to the producer of all farm animals.

The most outstanding dairy cows are persistent milk producers. The rate of decline of lactation is slow by comparison with the average or inferior cow. It appears logical to assume that the rate of decline is in some way related to the level of secretion of the lactogenic hormone. The correctness of this assumption has been borne out by experimental evidence but the exact nature of the controlling mechanism is not wholly understood. It is well known that the removal of milk from the mammary gland is quickly followed by the secretion of more milk. If milk is not withdrawn involution of the udder sets in. It has been shown that the suckling stimulus increases the secretion and discharge of the lactogenic hormone by the pituitary and assists in the maintenance of the mammary gland in functioning condition. Milk secretion is a complex process requiring the cooperation and coordination of all the body organs and systems. High milk production cannot be attributed to any one factor, such as the mammary size, level of lactogen secretion, feeding capacity, nutritional status or a single gene (Duncan and Lodge, 1960).

Of the hormones other than oestrogen, progesteron and lactogenic hormone those of the thyroid and adrenal glands are probably next in importance. The thyroid gland through the mediation of its hormone thyroxine is concerned chiefly with the regulation of general body metabolism. The removal of the thyroid gland in the lactating animal is followed by a rapid drop in milk production. In contrast, the administration of thyroxine during the decline phase of lactation is frequently followed by increased milk production and an increase in the fact content of the milk (Meites and Turner, 1948).

The adrenal glands are essential for continued milk secretion. The secretion of cortisone from the adrenal cortex is concerned with the metabolism of proteins and carbohydrates, other cortical hormones influence electrolyte and fluid balances. Because of the variety and quantity of precursors necessary for milk secretion, the adrenal glands are essential.

It is believed that ketosis in cattle may be due to the failure of the adrenal glands to produce sufficient cortical hormones. A reduction in blood glucose and an increase in blood and urinary ketones follow adrenal failure. The parathyroid glands are concerned with calcium and phosphorus metabolism and skeletal development and thus with skeletal muscle irritability and milk secretion.

2.4.6 Milk Yield and Sow Weight Loss

Nearly all sows lose weight in every lactation. Duncan and Lodge (1960) detected that sows which lost from 10 to 20 kg while suckling their first litters subsequently had more litters with more pigs born and reared per litter than sows which lost either more or less weight. Pregnancy did not affect growth of sows, but lactation retarded growth. Pregnant young sows even when well fed, but especially when poorly fed, were shorter at the withers at 18 months of age than litter mates not bred. Sows with small first litters often gained weight throughout lactation but those with larger litter continuously lost weight during lactation. They began to gain weight again only the third week after the litters were weaned. Lactational weight changes in sows have been studied by several research workers (Wallace et al., 1934; Zeller et al., 1937; Niwa et al., 1951; Schaffer and Granz, 1955; Lodge, 1959a; Lodge and Macpherson, 1961; Adam and Hargreaves, 1970; Steinbach, 1971). All agree that lactational weight loss is a general feature in swine although the amount of weight lost varies from 2.3 kg (Adam and Hargreaves, 1970) to 57 kg (Wallace et al., 1924). However conclusions as to the causes of weight loss are conflicting.

While Mackenzie (1928) using Duroc Jersey sows fed on different planes of nutrition for successive generations, found that liberally fed sows lost more weight than moderately or poorly fed ones, Lodge (1959), Lodge et al., (1961) and Adam and Hargreaves (1970) reported that increases in the levels of feeding reduced weight loss during lactation. Similarly, the relationship between litter size and litter weight gain on the one hand and lactational weight loss of the sow on the other has remained controversial. Liberally fed sows with large litters lost more weight more quickly than moderately or poorly fed sows; mean losses to the tenth week after farrowing were 21, 15.9 and 10.4 kg for liberally, moderately and poorly fed sows but the sows which lost more weight gave more milk and reared bigger pigs (Mackenzie, 1928).

Hostetter <u>et al</u>. (1930) who were primarily interested in the economics of pig feeding, found that 68 sows with 239 litters gained on the average 12.25 kg while they were suckling; they weaned on the average 5.6 pigs weighing 12.24 kg and costing ₦4.10. While another 171 sows with 239 litters lost on the average 19.97 kg these weaned 6.9 pigs weighing 12.71 kg each, costing only ₦3.22.

Schneider (1934) reported for mean litter size of 5.6, 9.2 and 10.5 pigs that losses in eight weeks were 4.2, 14.1 and 21.4 kg. Two sows in the first group gained 5 kg each, one in the second group gained 15 kg and none in the third group gained.

Breirem (1934) found that sows after the farrow of autumn litters lost 26 kg while their corresponding weight loss in summer was 38 kg. In the tropics, lactational weight losses were studied at the University of Ibadan (Steinbach, 1971). He found in 148 sows lactational weight losses varying from 0.9 to 50 kg with an overall mean of 18.61 kg. The lactational weight loss was significantly lower during the second half of the year (July-December). The mean weight loss increased during the first five weeks of lactation and then levelled off. Monthly analysis revealed that lactational weight loss was small in

April during the rains and most pronounced in August (dry season). The difference was more than threefold, 8.6 vs. 28.1 kg and highly significant (P<0.001) despite the great individual variability. However the breeds Large White and Landrace did not differ significantly in their lactational weight losses. Steinbach (1971) thus showed seasonal effect on lactational weight loss. Sows which farrowed during the cooler wet periods gained more during pregnancy and had larger lactational weight loss compared with sows which farrowed during the dry months. They gained less and lost less. This might be an effect of temperature on nitrogen metabolism of the sows as reported in cows by Kamal et al. (1962). There was a positive correlation of r = 0.33 between lactational weight loss and the corresponding physiological effective temperature. It was therefore concluded that environmental conditions affect the metabolism of pregnant sows and that the pregnancy weight gain to a great extent affects lactational weight loss.

Domanski (1965) found a correlation of r = 0.318 between lactational weight loss and milk yield. It was lower in older pigs than in primiparous sows, namely 0.355 and 0.590 respectively.

Vestal (1936) conducted an experiment with spring farrowing sows fed either maize alone or maize, oats and tankage in quantities to produce fat or medium condition. Sows in medium condition produced the heavier and stronger pigs at birth and weaned more of them than fat sows. Zeller et al. (1937) found that the sows which gained most weight during pregnancy when they were self fed were on the whole those which had previously weaned large litters and lost much weight. There is then a need for care in culling sows at weaning since the most prolific and best milking sows at weaning might be discarded because of their thin and poor appearance at that time. Donald and Fleming (1938) were unable to confirm the relation found by Zeller et al. (1937) between weight gain during pregnancy and the size of the litter at weaning. Their sows were liberally fed during pregnancy and gained from 22.7 to 136 kg; the mean weight gain from mating to after farrowing was 54.8 kg, and the mean weight of the litter at birth was 13.1 kg. Their attempt to increase the birth weight of the litter by liberal feeding of the sow failed.

Lodge (1959a) gave sows two planes of nutrition in three successive lactations. The ration was the same one with 16% crude protein and a calculated value of about 2825 Kcal per g. The high plane sows each of four pairs were given an amount of meal based on their weight at farrow and the number of pigs in their litter; their low plan sisters received 2.9 kg meal and 0.454 kg per piglet daily. In 12 lactations the four high plane sows ate corresponding amounts of 305-385 kg, mean 359 kg meal and the low plane sows 245-303 kg and mean 267 kg. Nearly all sows lost weight in every lactation, the mean loss was 11.8 kg on the high plane and 26.8 kg on the low plane.

The most interesting finding was that all the sows lost more weight immediately after the weaning of each litter and this loss was greater in the high plane sows so that by three weeks after weaning they were only about 10.8 kg heavier than the low plane sows. Lodge suggests that the greater feed intake of the high plane sows and presumably greater water intake could partly conceal the loss of body tissue during lactation, and a sudden drop in feed intake at weaning could account for a large loss of 'fill' and probably also of water content. But such an explanation would hardly account for a continuous loss of weight for three weeks.

2.4.7 Weight Gain in Piglets

The litter performance during the nursing period is very essential in the economy of pig production. The pig is the most efficient converter of feed into live weight with the exception of carefully managed broilers among all domestic animals.

Pigs double their birth weights a week after birth and should attain 15-20 times their birth weight when weaned at eight weeks (Legagneur and Févrler, 1960). Rapid live weight gain depends on the availability of adequate milk in quantity and quality during the first three to four weeks of nursing and later also on the amount of creep feed consumed. There is a high positive correlation between the daily milk production and the daily litter gain of r = 0.8 - 0.9 (Berge and Indrebø,1953). Therefore if litter weights are to be maintained any increase in the reproductive performance of the sow resulting in larger litter size must be accompanied by a higher milk yield by the sow or an earlier use of supplementary creep feed.

Thompson (1931) observed that in pigs with approximately the same birth weight those receiving greater amounts of milk per day made greater weight gains than those receiving less during the 56 days nursing period and for 60 days after weaning. For the first few weeks after bith the piglets are under the direct environmental influence of their dam and respond directly to the amount of milk ingested. The genetic ability to utilize feed is not expressed at this period but as they grow older, the effect of heredity on the efficiency of feed utilization and live weight gains becomes more manifested (Allen et al., 1959). These findings show the importance of the nursing period in the production of thrifty pigs and the vital role played by the milk production of the sow in this regard.

Legagneur and Février (1960) estimated that 4 kg of milk are required to produce 1 kg of liveweight in suckling pigs, but Allen et al. (1959) found significant differences between breeds and crosses as to milk required per kilogram of gain. With the Durocs it was 4.5 kg of milk per kg of gain, Polands 5.9 kg, Landrace 4.8 kg and Landrace x Poland crosses 5.2 kg. These authors noted that although the Duroc sows were among the least efficient in converting feed to milk, their piglets were the most efficient in converting milk and feed to flesh. In their study of the relationship between the amount of milk and quantity of creep feed consumed by the piglets, they found between breeds a positive correlation of r = 0.96 - 0.99 indicating that the litter that obtained most milk also consumed the greatest quantity of creep feed. Probably they grew faster and had a better capacity to cope with the feed.

Since the sows milk yield declines after about the third week of lactation, artificial feeding and early weaning have been suggested and practised as an approach to economically efficient production. Legagneur and Février (1960) stated that the use of supplementary diets high in 20-30% nitrogenous matter with 5-10% lard, 50-60% glucocides and minerals, vitamins, trace elements and antibiotics have scored some success in rearing early weaned pigs.

Smith (1952b) however found that it required more milk per kilogram of liveweight during the first four weeks (8.6 kg) than during the last four weeks (5.9 kg). This increase in efficiency of feed conversion he attributed to the fact that the piglets ate more supplementary feed to augment the declining milk production of the sow.

2.4.8 <u>Causes of Variation in the Growth and Development of the Pigs</u>

Growth from birth to weaning in the naturally reared pig is influenced largely by three variables:

1. Its weight and physiological development at birth;
2. the amount and composition of milk it obtains from its dam;
3. the amount and quality of supplementary feed which it eats.

The relative influence of these three factors on weaning weight was assessed by Lodge and Macdonald (1959) from data on 208 pigs in 24 litters. Of the total within litter variance in weight at eight weeks 30% was associated with variation in birth weight (r = 0.55), and 25% with variation due to milk consumption (r = 0.50). No information was available on variation in creep feed eaten within litters, but between litters, variation in creep feed consumed accounted for 77% of the variation in eight weeks weight (r = 0.88). The relatively high correlation between birth weight and weaning weight agrees with similar findings by other workers such as r = 0.53 within litter reported by Blunn, Warwick and Wiley (1954) or r = 0.31 by Combs <u>et al</u>. (1959), while Holder (1959) found no correlation at all.

competitive conditions. The extent of variation in birth weight between individuals in a litter is such that usual production conditions would appear to place more severe environmental restriction upon the expression of innate growth capacity in the smaller pigs than in the larger ones. Rearing of litters under carefully controlled conditions would appear to offer a means of removing many of the environmental influences assumed to be competitively disadvantageous to the smaller pigs.

2.5 Milk Composition

The marked success in terms of growth rate that the suckling pig achieves during the first ten days of its life suggests that sow milk should be a reasonable prototype upon which to formulate an early weaning ration.

Blaxter (1961) and Lucas and Lodge (1961) have discussed the detailed chemical composition of sow milk in relation to the young pig's nutritional requirement. Its overall composition is remarkable in that it provides some 6,000 Kcal of digestible energy and more than 275g of highest quality protein per kg dry matter.

A knowledge of the quality of the sow milk in terms of gross energy content, protein and other nutrients and their variation with the different stages of lactation, season and nutritional regime of the sow is as important as the total amount of milk produced by the sow as far as the nutrition of the piglet is concerned.

It is important in the understanding of the relative growth rate of the suckling piglets at different stages of lactation and gives room for adjustment either in the sow's nutritional regime or that of the piglets to meet their nutrient requirements for maximum milk production and growth respectively. In comparison with other species (Table 2.7) sow milk most closely resembles that of the ewe in composition except for the sow's higher ascorbic acid and lower riboflavine content (Braude, Coates, Henry, Konsk, Rowland, Thompson and Walker, 1947). Sow milk also contains higher percentages of total solids, fat, solids-non-fat, protein, ash, calcium and phosphorus than cow or goat milk. The lactose level tends to be the same in the three species Braude et al. (1947) found variation in the composition of colostrum and later milk according to season, as well as definite lactational trends in the content of total solids, protein fat and lactose.

Table 2.7 MILK COMPOSITION OF DIFFERENT SPECIES (%) (Espe and Smith, 1952)

Species	Fat	Protein	Lactose	Ash	Water	Total Solids
Sow	7.0	6.0	4.0	0.9	82.1	17.9
Cow	4.4	3.8	4.9	0.7	86.2	13.8
Goat	4.1	3.7	4.2	0.8	87.2	12.8
Ewe	6.2	5.4	4.3	0.9	83.2	16.8

2.5.1 Comparative Analysis of Colostrum and Milk

Comparative studies of the sow colostrum and milk by several investigators (Table 2.8) indicate a high transitional stage in the different components between the colostrum and the milk of the sows as in other animals (Wohlbier, 1928; Olofson and Sigfrid, 1930b ; Hughes and Hart, 1935; Albig, 1940; Bowland, Grummer, Phillips and Bohstedt, 1949a; Perrin, 1953; Evans, 1958; Salmon-Legagneur, 1965). All agreed that protein content of the colostrum is higher than that of normal milk while the fat content increases with stage of lactation.

There is a higher amount of total solids and solids-non-fat in colostrum than in milk. However the mineral and fatty acid components seem similar. In addition to changes in composition which occur during the transition from colostrum to normal milk, the percentages of the major constituents of sow milk change during the course of lactation.

Table 2.8 COMPOSITION OF SWINE COLOSTRUM AS COMPARED TO LATER MILK.

Constituents	Colostrum % (Von Neuhaus, 1961)	Milk 1-8 Weeks % (Bowland *et al*., 1949a)	Milk 2-8 Weeks % (Perrin, 1955)
Solids	23 - 33.1	20.1	21.2
Fat	2.7 - 7.7	6.8	9.3
Protein	9.9 - 22.6	7.3	6.2
Lactose	2.0 - 7.5	5.1	4.8
Ash	0.59 - 0.99	0.99	0.95
Calcium	0.05 - 0.08	-	0.25
Phosphorus	-	-	0.15

- Not Determined

Few workers sampled milk from the sow regularly throughout the lactation (Table 2.9). They agreed that the ash percentage increases steadily; protein tends to decline until the second or third week and then rises.

TABLE 2.9

COMPARATIVE ANALYSES OF SOW MILK (%)

No. of Sows	No. of Samples	Total Solids	Fat	Solid-non-fat	Protein	Lactose	Ash	Authors
4	7	19.08	7.06	12.02	6.20	4.75	1.07	Henry and Woll, 1897
5	5	17.72	5.97	11.75	5.12	5.81	0.82	Woll, 1899
12	24	19.49	6.89	12.60	6.06	5.64	0.98	Carlyle, 1903
2	10.20	17.98	6.77	11.68	6.22	4.27	0.97	Hughes and Hart, 1935
6	12	16.96	5.99	10.77	5.07	5.09	0.81	Vinogradsky, 1939
35	43	16.35	5.29	11.06	4.86	5.28	0.92	Wells _et al_, 1940
20	37-67	19.87	6.81	13.27	7.36	5.12	0.99	Braude _et al_, 1947
9	40-76	19.35	8.17	11.67	5.79	4.81	0.94	Bowland _et al_, 1949b
44	68	20.08	9.58	11.65	6.11	4.62	0.92	Perrin, 1953
8	24	21.23	8.60	11.40	5.70	4.70	0.89	Lodge, 1959
–	1,500	18.40	6.17	12.23	5.83	5.42	0.92	Salmon-Legagneur, 1965
31	124	19.00	6.30	12.70	5.40	6.26	1.04	Fahmy, 1972

Lactose tends to decline steadily throughout lactation. The fat is evidently very variable and fluctuates widely from week to week and possibly from day to day. Some observed a tendency for it to decrease (Braude <u>et al</u>., 1947; Bowland, Grummer, Phillips and Bohstedt, 1949b, 1951; Heidebrecht, Mcvicar, Ross and Whitehair, 1951; Smith, 1952a and b; and Berber <u>et al</u>., 1955). Others noted a tendency to rise (Hughes and Hart, 1935; Willet and Maruyama, 1946; Niwa, Yokoyama and Motsuka, 1951; Lodge, 1957), while still others observed no significant trend either way (Berge and Indrebo, 1953).

2.5.2 <u>Changes in Milk Components During Lactation</u>

Hughes and Hart (1935) reported the highest average value of 31.86% for total solids obtained from 13 sows milked during farrowing, but by 10-40hours after farrowing the mean for seven sows had fallen to 23.5% and after four to seven days the mean was 18.39%. No other estimate approached their highest value, although other workers also milked sows during parturition.

The highest value obtained by Braude <u>et al</u>., (1947) for eight sows milked during parturition was 27.2% and the mean was 23.9%. Braude and his colleagues were conscious of the fact that large errors were possible because the udder was not completely emptied. They were the first to use oxytocin to ensure complete evacuation (Braude <u>et al</u>., 1947) and the mean value for total solids in colostrum went up to 25.8% and the maximum to 29.2%.

Perrin (1953) took weekly samples by milking machine from sows given oxytocin; she reported average values for 68 lactations of 44 sows, so her data are probably the most extensive available. She found little variation in total solids between the seventh and fifty-sixth day of lactation. (Table 2.10).

Table 2.10 LACTATION CHANGES IN THE SOW OVER 8 WEEKS (%)
(Perrin, 1953)

Constituents	Weeks						
	2	3	4	5	6	7	8
Total Solids	21.20	21.29	21.67	21.33	21.26	21.05	21.07
Fat	10.12	10.34	10.45	9.86	9.37	8.70	8.21
Solids-non-fat	11.08	10.95	11.22	11.51	11.89	12.35	12.86
Protein	5.35	5.31	5.60	5.92	6.35	6.84	7.38
Lactose	4.85	4.82	4.70	4.64	4.57	4.44	4.31
Ash	0.79	0.79	0.84	0.89	0.97	1.04	1.10

For the other constituents she found that the fat content increased slightly during the first three weeks and decreased thereafter; protein decreased steadily till a minimum around the sixteenth day post partum and then increased to more than 7% at the end of lactation. The lactose component was constant for over a fortnight, then fell off slightly to the end of lactation. Ash content increased throughout the lactation except between the second and third weeks. Shefchick et al. (1950) showed that although the total protein content was higher on the first day of lactation than at 15 or 30 days, the casein content was uniform. In later work Sheffy, Phillips, Dymsa, Grummer and Bohstedt (1952b) obtained similar results; their means for total protein on the first, fifteenth and 30th day of lactation for 25 gilts were 10.5 ± 0.29, 5.15 ± 0.17 and 5.5 ± 0.26% and for casein 4.35 ± 0.15, 3.53 ± 0.18 and 3.6 ± 0.29%. Other nitrogen made up a much higher proportion of the colostrum than of later milk, such as albumin nitrogen, globulin, proteose, peptone, non-protein nitrogen, ammonia, urea, creatinine, creatine, uric acid and -amino nitrogen.

Bowland *et al.* (1949b) reported a decreased fat content with advanced lactation; after an initial rise in colostrum a minimum was reached at about the third week of lactation, then followed by an increase. Total solids and solids-non-fat percentages tended to increase after the third week and protein content decreased until the third week then rose gradually. These workers found it difficult to establish any trend in the lactose content which was more or less constant in the milk after the initial rise in colostrum. The proportion of ash showed a very definite rise from 0.7 to 1.2 or 1.3% in the 8th week. This is quite contrary to what obtains in cows especially with regard to fat secretion. This may be due to differences in the physiology of fat secretion between the two species.

Lodge (1959a) studied the relationship between protein and lactose content of milk in an eight week lactation period. He reported that there is a great fluctuation between protein and lactose contents over 24 lactations. Differences were significant ($P<0.01$), when one was relatively high the other was relatively low. When the time effect on the changes with stage of lactation was eliminated, there was still a highly significant negative correlation of $r = -0.62$ ($P<0.001$) between protein and lactose contents.

Explanations given for the inversed relationship were:

(1) that the milk protein and lactose may be formed from body tissue, that is from the proteins directly and the lactose also from the glucogenic residues after deamination;

(2) that both the precursors of milk proteins that is the amino acids and of lactose, the blood glucose and glucose freed from glucoproteins in the synthesis of milk proteins may supply energy to the mammary gland during milk secretion and one may exert a sparing effect on the other;

(3) that since all sows lost weight during lactations it may be assumed that the protein fed during lactation was not sufficient to meet the protein requirement for milk production.

It would therefore seem that both amino acids in the diet and possibly from body tissues were deaminated and the glucogenic residues converted into carbohydrate for the provision of energy in addition to that yielded from body fat.

Studying milk components in different breeds (Fahmy, 1972) found significant breed differences in the fat, sodium and magnesium contents of milk and also potassium content of colostrum. There were significant differences in energy, ash, total solids, and phosphorus content. The Yorkshire, Hampshire and Lacombe had generally higher proportion of milk constituents and the Berkshire and Large Black had generally lower values compared with the Duroc and Landrace. Significant changes in total solids, protein, ash, calcium and phosphorus occurred as lactation progressed. Overall means corrected for the effect of breed and stage of lactation were for energy 1.11 Kcal/g; ash 1.04; total solids 19.00; fat 6.3; protein 5.4; calcium 0.20; sodium 0.04; potassium 0.10; magnesium 0.02 and phosphorus 0.17%.

2.5.3 Effect of Diet on Milk Components

Numerous observations on the composition of sow colostrum and milk have been reported but literature citations have dealt primarily with either proximate analysis of fat, protein, total solids, minerals or the various vitamins. A limited number of reports have evaluated the effect of several feed components on the composition of sow milk and colostrum. The two major ones that have been thoroughly dealt with are the dietary protein and fat levels. Due to the nutritional demand imposed on the lactating animal, the need for protein is increased during lactation. Although low level of protein has been shown to have no effect on yield of milk and the protein content, severe underfeeding of protein to dairy animals has been found to cause a reduction in the solids-non-fat percentage in addition to drop in milk yield. Slight underfeeding of protein causes a slight decrease in the milk yield and small decreases in the milk content of proteoses, globulin and non-protein nitrogen.

Increasing the protein content of the diet above normal recommended standards has no effect on yield and causes only a slight increase in the non-protein nitrogen content of the milk (Rook, 1961). About 3-4% fat is needed in the concentrate portion of the ration for maximum milk and fat yields for cows. Addition of excessive fat causes digestive disturbances, leads to loss of appetite and fall in milk yield while effect of specific fats has been reported to modify the milk fat content without affecting milk yield. However the results are variable and often transient.

Milk protein is made up of a number of specific proteins. Among the major components are casein, alpha-lactalbumin and beta-lactoglobulin. Each major component is broken down into subunits based upon their molecular weights, iso-electric point and other chemical properties. The chemical composition of some of the components is determined by the genetic make-up of the animals. It is now possible to relate the variants of the milk protein to the blood type of the animal.

Rook (1960) has related the low immunity of animals during their first few weeks of life to low protein in colostrum and high lactose content leading to high incidence of scours. This was classified as a good point of examination in blood assay of animals. Studies on the arterio-venous difference across the mammary gland, the relation between the protein uptake by the mammary gland and composition of the amino acids in milk protein have also been initiated.

Salmon-Legagneur (1964) demonstrated that protein quality was much less critical during gestation than during lactation. The protein needs during lactation were estimated from 750g (National Research Council, 1968) to 1080g (ARC, 1967).

Mahan, Becker, Norton and Jensen (1971b) found that milk production and its nitrogen content were significantly depressed ($P<0.05$) from 22 days post partum onwards in sows fed a 10% protein diet but not in gilts. They found that there was a highly significant ($P<0.01$) linear increase in nitrogen balance while those on 18% were in positive nitrogen balance and that nitrogen equilibrium was obtained with approximately 588g protein daily. These results indicate that a nitrogen equilibrium is necessary to obtain maximum milk production, milk nitrogen and weaning weights. Milk production and milk nitrogen were maintained up till the 19th day post partum independent of the protein level fed. Those animals fed the low protein diet were probably in positive nitrogen balance from farrowing until the 19th day. It appears likely that a labile body protein source exists but that a large demand over an extended period can exhaust the supply, subsequently resulting in reduced milk production.

Ralph, Vandernoot, Gilbreath and Fisher (1971) stated that the protein content of colostrum was slightly greater from sows that received a 15% protein diet while the milk protein from sows fed dietary protein as low as 10% remained equal up to the 21st day of sampling. This report agrees with those of others (Pond, Van Vleck and Hartman, 1962; Rook and Witter, 1968; Vetra, 1965; Earle and Stevenson, 1965; Bowland et al., 1966) and suggests that dietary protein levels may have exerted a slight effect on colostrum but did not affect the protein composition of milk.

However, Holden et al. (1968) found that the crude protein level in sow milk increased linearly with increasing dietary protein. Protein content of colostrum varied widely from sow to sow but was higher than that of milk at seven days post partum or thereafter. The fat content of colostrum ranged from 4-16% and for milk from 4-9.4%, there was a small increase in average fat content in colostrum and milk from sows that received 15% protein in the diet.

The average ash content of colostrum of 0.72% for sows fed 15% or slightly lower protein diets equalled that reported by Salmon-Legagneur and Gueguen (1962) and Earle and Stevenson (1965). Total solids and solids-non-fat content in the colostrum were greater with a 15% protein diet. These contents did not differ in the milk between seven and 21 days post partum indicating no dietary effect on these components.

For the mineral constituents, calcium values were similar to those reported by Miller (1967) and Salmon-Legagneur (1968). Calcium in colostrum was low but increased three to fourfold by the 7th day in milk while phosphorus content in colostrum was higher than in milk at each sampling and averaged 0.16 and 0.11% respectively. The mineral content of colostrum and milk however appeared not affected by the level of protein in the sow's diet. Similarly, the lactose content was not affected.

From the above it seems that colostrum composition may vary widely and be influenced by protein intake of the sow prior to parturition and not by the lactational dietary protein level.

Early reports from the Wisconsin Agriculture Experiment Station (1897) according to Bowland et al. (1949a) stated that the fat content of normal milk from sows averaged 7.06%. Henry and Woll (1897) from only seven samples of milk and Woll (1899) reported a mean fat percentage of 5.97 for five samples and Davies (1904) obtained values ranging from 4.55 - 9.54%. Hughes and Hart (1935) calculated 6.9% gross fat using two sows with 8.3% for normal milk and 5.1% for colostrum.

Estimates of fat more than any other constituent show the effect of oxytocin, for there is almost always more fat in samples taken since the use of oxytocin was introduced.

Without oxytocin Braude et al. (1946) obtained from sows in the first two weeks of farrowing colostrum with a fat content of 1.7 to 5.8% and a mean of 3.4% and when oxytocin was used (Braude et al., 1947) from 2.7 to 5.4% and a mean of 4.4%. The difference here is slight but Perrin (1955) found that in the early stages of lactation colostrum was readily obtained without oxytocin, only later when the control of let down began was oxytocin needed. Koziner (1950) stated that milk from the first four pairs of teats of sows might have a higher fat content than milk from posterior teats and that pigs trained to feed on the front teats grew better. Perrin (1958) therefore stressed the need to obtain milk from all the teats for representative analysis. Neither Perrin (1958) nor Whittlestone (1952a) was able to demonstrate a variation in the fat content in several samples taken in the cause of one milking after the injection of oxytocin like the increase found in cows (Ely and Petersen, 1941). Although the fat content of milk fell from the first to fifteenth and thirtieth days of lactation, phospholipids increase as percentage of fat rose (Shefchick et al., 1950). The iodine number of colostral fat was consistently higher than that of milk fat, but saponification number and percentage of 'soluble' fatty acids did not vary with stage of lactation.

Willett and Maruyama (1946) studied the fat content of milk from sows fed on swill, concentrates or two parts of swill to one part concentrate. The concentrate mixture consisted of 66% barley, 10%

cane molasses, 5% pineapple bran, 9% meat and bone meal, 9% soyabean meal and 10% salt and all the sows had green grass. The swill contained 17% crude protein and 27% ether extract. The fat content of the milk rose with stage of lactation and also with the amount of swill eaten. In later experiments the means of fat were 6.3% with concentrates and 11.5% with swill.

A most detailed and systematic study was conducted by Salmon-Legagneur (1965) to find the effect of amount and type of fat on milk constituents. He used lard, lard plus fish meal and lard as replacement for an isocaloric amount of basal diet added to a low fat diet. He found that fat content of the sow milk increased by about 17%. There was an increase in milk yield but the proportion of saturated fatty acids decreased and of the unsaturated ones (oleic, linoleic and arachidonic) increased.

Using maize oil (45% linoleic acid) there was an increase in the fat content. The linoleic acid content increased, and so did the oleic and palmitoleic acids to a limited extent.

Coconut oil (rich in lauric and to a lesser extent myristic acid) gave similar effects to a less marked degree. There was an increase in lauric and myristic acids at the expense of oleic and to a lesser extent palmitic and palmitoleic acids.

Similar effects were confirmed by Asplund (1960), de Man and Bowland (1963) and Tollerz and Lindberg (1965) when tallow, linseed oil (rich in linolenic acid), cottonseed oil (rich in linoleic acid) were used respectively. They found an increase in milk fat and major acids of the dietary fat.

Bowland et al. (1951) reported a low fat content in the colostrum of sows kept indoors and fed to appetite on a ration of 75.1% maize meal, 0.9% soyabean meal, 6% tankage, 4.5% gluten meal, 5% lucerne meal, 0.9% ground limestone and 0.5% iodinated salt. After the colostral stage, their milk had as much fat as that of sows kept on pasture with the same ration in summer and indoors with extra lucerne meal in winter.

Although it appears that the amount and composition of the fat may be more readily influenced by diet than are other constituents of the milk, very little is known about the extent of modification possible.

2.6 Genetic Influence

2.6.1 Inbreeding of Dam

Comstock and Winters (1944) indicated that a moderate amount of inbreeding can be successfully practised in the production of purebred livestock if it is accompanied by judicious selection of breeding animals. But generally, on the average inbred animals are less vigorous than random bred or outbred stock.

It could be said that the founders of our modern purebreeds must have exercised considerable skill in selection since it is known that at the same time, selection and inbreeding may improve the breeds.

Bereskin et al. (1968a, 1970), studying some litter performance traits on 3389 litters found that inbreeding of dam significantly lowered total number of pigs farrowed in the litter, total born alive, birth weight and average weight per pig farrowed in the litter. A linear partial regression of 0.31 pigs born per 10% increase in dams' inbreeding was noted while Comstock and Winters (1944) reported a corresponding value of 0.09 pigs for total farrowed and also a regression of 0.06 pigs per 10% inbreeding increase for number of pigs born alive. Evidence in support of a curvilinear inbreeding effect has been reported. Such curvilinearity was noted only for litter traits involving weights rather than for those involving numbers. There were consequently inbreeding depressive effects on average pig weight and total litter weight at weaning. Studies of some Minnesota data (Comstock, et al 1942) according to Comstock and Winters (1944) revealed that the age of gilt at first farrowing affects the litter size by about 1/3 live pig for every monthly deviation from 12 months of age. Secondly, pigs out of sows average about 1.82 kg heavier than pigs out of gilts throughout the pre-weaning period, and thirdly feed requirements increase with increasing weight at weaning. This agreed with the results reported by Ashton and Crampton (1943). In order that selection may be as effective as possible, it is imperative that all records of performance be gathered under as uniform conditions as possible and where this is impracticable, suitable correction factors ought to be introduced.

2.6.2 Heritability of Litter Size

On some reproductive performance traits of sows Walker, Bellharz and Dunkin (1972) calculated heritability estimates. Traits considered were litter size and litter weights at birth, weaning and pre-weaning litter mortality. They found a low heritability for litter size at birth of $h^2 = 0.05$ in general agreement with other studies (Urban, Shelby, Chapman, Whatley and Garwood, 1966; Strang and King, 1970). They also found a low heritability of litter weight at birth of 0.26 but a reasonably strong genetic correlation between the two traits.

Heritability estimates of litter size at birth, weaning at five weeks and pre-weaning mortality were 0.05, 0.25, and 0.12 respectively and corresponding repeatabilities were 0.14, 0.26 and 0.16 respectively.

Heritability estimates of litter weight at birth and at weaning were 0.26 and 0.18, corresponding repeatabilities were 0.26 and 0.17 respectively. There was little difference between purebred and crossbred litters of purebred sows but crossbred sows gave litters with 17% more piglets on the average 31% heavier at birth and 19% more pigs and 46% heavier at five weeks weaning than purebreds. The heritability of litter size at five weeks weaning was greater than the 0.19 reported by Louca and Robinson (1965) and Strang and King (1970) for eight weeks weaning but agreed with 0.21 and 0.19 found by Blunn and Baker (1947) and Urban _et al._ (1966) for litters at eight weeks.

Repeatability estimates were found to decline as more parities were included. Culling eliminates the lower producing sow and thus reduces the between sow variance component. For this reason the repeatability pertaining to parities 1-2 sows are considered to be the best estimates compared with parities 1-3 or 1-4.

2.6.3 Heritability of Growth Rate

The extent to which growth genes with persistent effects operate in determining heritability and variation in growth rate of piglets is of interest in swine breeding research. Information of this kind is required to attain maximum accuracy in measuring breeding value and

and hence to make most efficient use of selection. Growth rate is the sum of:

(1) Genetic sources composed of the average effects of all genes which influence growth rate;

(2) litter environment comprising all effects which influence the litter as a whole;

(3) a residual source, including the effects of dominance, epistasis and environmental factors peculiar to individual pigs.

Then growth rate in the i^{th} period is:

$$X_i = G_i + L_i + E_i = 1 + 2 + 3.$$

Hazel, Marvel and Reinmiller (1943) correlating this, found that genetic variance constituted only a small fraction of the observed variances in growth rate from birth to 56 days which is about 15%. However genetic correlations were larger than the corresponding environmental correlations ($r = 0.437$) indicating that genes with persistent effects were responsible for much of the genetic variation. Consequently heredity has a less important but more constant influence upon growth rate than the environmental source.

2.6.4 <u>Crossbreeding</u>

Breed comparisons (Lasley, 1972) revealed that crossbred pigs from purebred sows had a better survival and growth rate than the purebred pigs. Two breed and two breed backcrossed litters at weaning contained on the average 6% more pigs and were 25% heavier than purebred litters, there were 6% and 5% more pigs respectively at eight weeks weaning which were 14% and 10% heavier at that age than purebred litters.

The greatest improvement in litter productivity came from crossbred Large White and Landrace sows backcrossed to one of the parental breed (two breed backcrossed litters). There were benefits at birth as well as at weaning which were to be expected if heterosis in the dam had an effect on the prenatal life of the litter. These advantages were more marked than those reported by Smith and King (1964) who found that by comparison with purebred, litters from crossbreed sows had 5% more pigs at birth and 8% at weaning and were 11% heavier.

Fredeen (1957) suggested that three breed crosses may exhibit further hybrid vigour in comparison with two breed backcrosses. Jara-Almonte and White (1973) studying genetic relationships among milk yield, growth, feed intake and efficiency in laboratory mice using 57 paternal halfsib families and 537 lactating female progeny estimated daily milk production from 6-21 days by isolating litters for six hours and weighing them before and after 1.5 hour nursing period. They found heritability estimates of 0.12 $\pm$ 0.10 to 0.22 $\pm$ 0.12 for gain, 0.14 $\pm$ 0.11 to 0.24 $\pm$ 0.13 for feed intake and 0.05 $\pm$ 0.9 to 0.33 $\pm$ 0.13 for body weight and 0.17 $\pm$ 0.11 for milk yield.

The genetic correlation was 0.92 $\pm$ 0.35 for 21 day body weight and milk yield. The low heritability indicated that in a study for response to selection for increased milk yield some consideration should be given to the use of progeny testing or some other family selection. The heritability of 12 day litter weight as a measure of lactational performance was reported by Young <u>et al</u>. (1965).

The heritability was 0.08. Miller, Legates and Cockerham (1963) got 0.11; Eisen, Legates and Robinson (1972) ... 0.24; Jara-Almonte and White (1973).

Effective selection for 12 day litter weight was demonstrated by Eisen et al. (1972) and Eisen (1973) but failed to affect mechanically extracted milk yield and percentage composition of total solids, lipids, and protein (Hanrahan and Eisen, 1970) in mice.

Consequently with the small number of sows generally handled in milk production studies, it has not been possible to calculate heritability nor the effect of inbreeding of the sow or the litter on the milk production. But from the depressive effects that occur with increase in the degree of inbreeding relative to other reproductive traits such as litter size at birth and at weaning, litter weights at birth and at weaning (all aspects of mothering ability) one could expect a corresponding effect on the total milk production of the dam.

According to Stewart (1945) improvement of livestock in one or several characteristics through selection depends not only on the genetic variability of the population in which selections are made but also on the proportion of available animals that are required for breeding purposes. Because the heritability of prolificacy is low (8.8 - 17%) progress from selection for it in outbred stock in which the fertility is low will be very slow.

2.7 Conclusion

In conclusion, milk production in sows in most swine producing countries was obtained by the indirect weighing method. However it is very essential to determine the intervals between suckling of the sow during natural suckling periods in order to estimate yield of milk closer to the amount obtained under natural suckling conditions.

Milk yield was found to be highly dependent on the age of the sow, her body weight, diet especially during gestation, climatic effects and the plane of nutrition. However the milk yield or composition or both vary with litter size, litter birth weights, frequency of nursing and suckling interval. Milk composition also differed in the various breeds of sows studied by different authors and was low under temperate conditions negative to high milk produced by the animals. The different milk components vary between colostrum and milk and change with stage of lactation.

While protein content of 10% and above were found not to influence protein content of the milk, fat content varied with percent and type of dietary fat. Growth and reproduction are two important traits in livestock production. Breeding of animals for these traits can only be achieved through the development of sire lines with fast growth and dam lines with efficient reproduction for eventual crossing or selection within the lines on an index value representing these two traits. Although the theory of index selection has been well described much less experimental examination of this theory has been undertaken.

Different breeds of livestock live in various parts of the world. The description of many of them exists together with estimates of their reproductive potential. Such estimates have often been obtained only for the environment in which each breed is maintained, so that genetic differences in productivity between breed cannot be separated from environmental effects. It is likely that indigenous breeds have become adapted to their environment and may be capable of greater productivity there than exotic breeds. They might also be able to contribute genes useful in other environments. The proof of this has not been given or utilized in the tropics since in swine, exotic breeds readily adapt to the hazards of the environment. For the future performance of pigs however, whether fatteners or breeders, the replacement stock which depends essentially on the milk production of their dam within the first 56 days of life cannot be overlooked. A persistently high milk flow is essential from a good dam as it is required for best performance and growth of her offspring to qualify them for selection and future replacement stock.

As seen from the literature review indigenous breeds of the tropics have been neglected while the reproductive potential of the exotics has not been fully exploited under such conditions. Several questions relating to milk production of the sow are yet to be answered.

There is a need to investigate the relationship of several factors influencing milk yield and its constituents, factors dependent on it and some genetic aspects of milk production of the sow in this part of the world.

CHAPTER III

MATERIALS AND METHODS

3.1 The Environment

The 160 hectare University of Ibadan farm has been adequately described by Olaloku (1972).

3.1.1 Ecology of Ibadan

The ecology of Ibadan, a town 144 km inland in the Oyo State of Nigeria was also described by Olaloku (1972) along with the vegetation and climatic variation during the period of 20 years 1950-1970. The mean monthly minimum and maximum temperatures recorded during the last five years 1970-1975 (Fig. 3.1a) were 22.0°C and 31.8°C respectively. There was a reduction to 21.6 and 31.0°C respectively during the period of this study. Although there is little variation in temperature throughout the year the range between the maximum and minimum temperature is greater during the dry season especially in the months of November to February inclusive. Monthly maximum and minimum daily temperatures are given in Appendix Table 3.I.

The average annual precipitation over the same period was 122.94mm, the peak periods of rainfall being in May and September (Fig. 3.1b). In the period 1974 except for the short break in July, there was a normal distribution of rainfall from the month of February to October. The same pattern occured in 1975 with no break at all and a very short interval of two to three months dry season November to January inclusive. This therefore accounted for the lower average minimum and maximum temperatures during this period. The average annual precipitation recorded was then 126.54mm which is a little higher than in the previous years 1970-1973. However the average relative humidity of 72.63% during the period of this study was higher than the overall

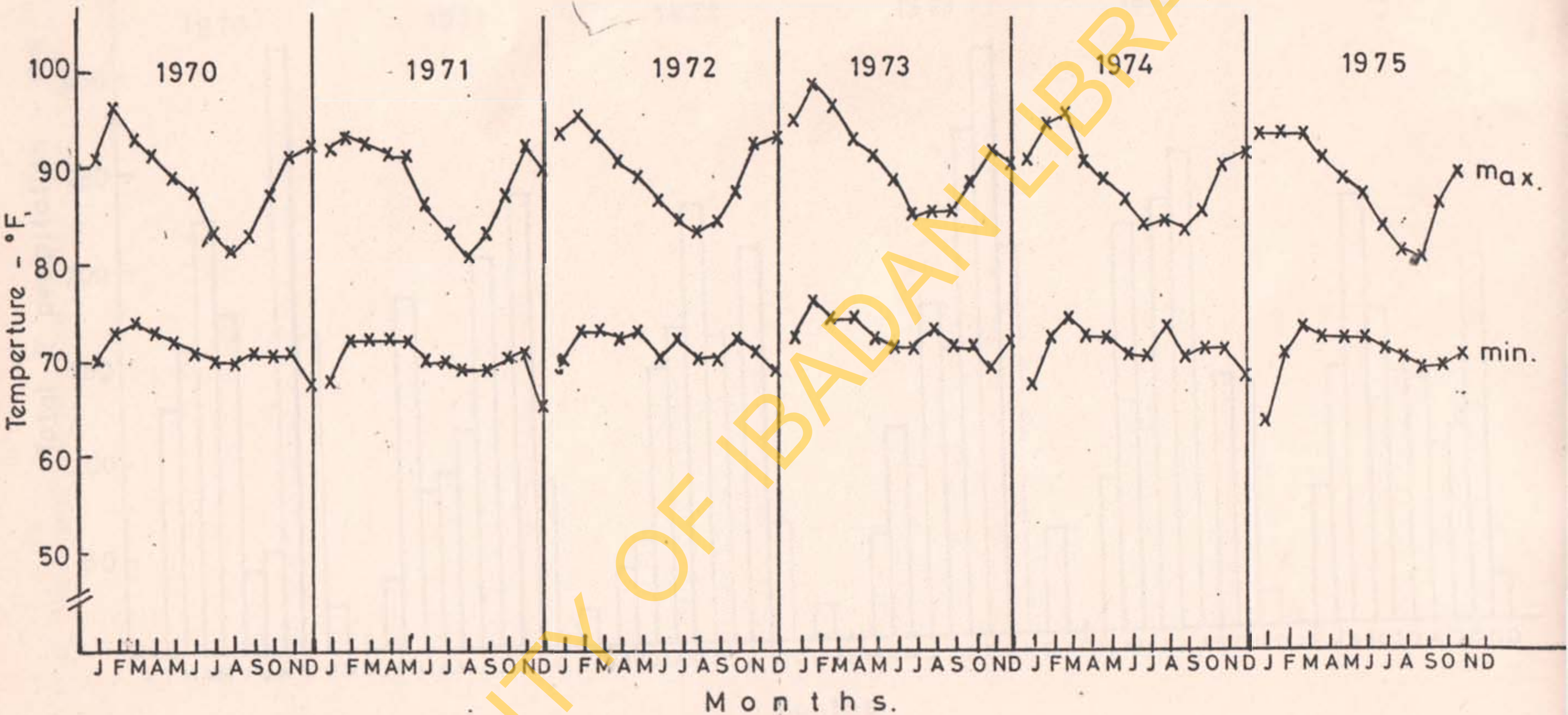

Fig. 3.1a. Temperature pattern 1970 - 1975 U.I.

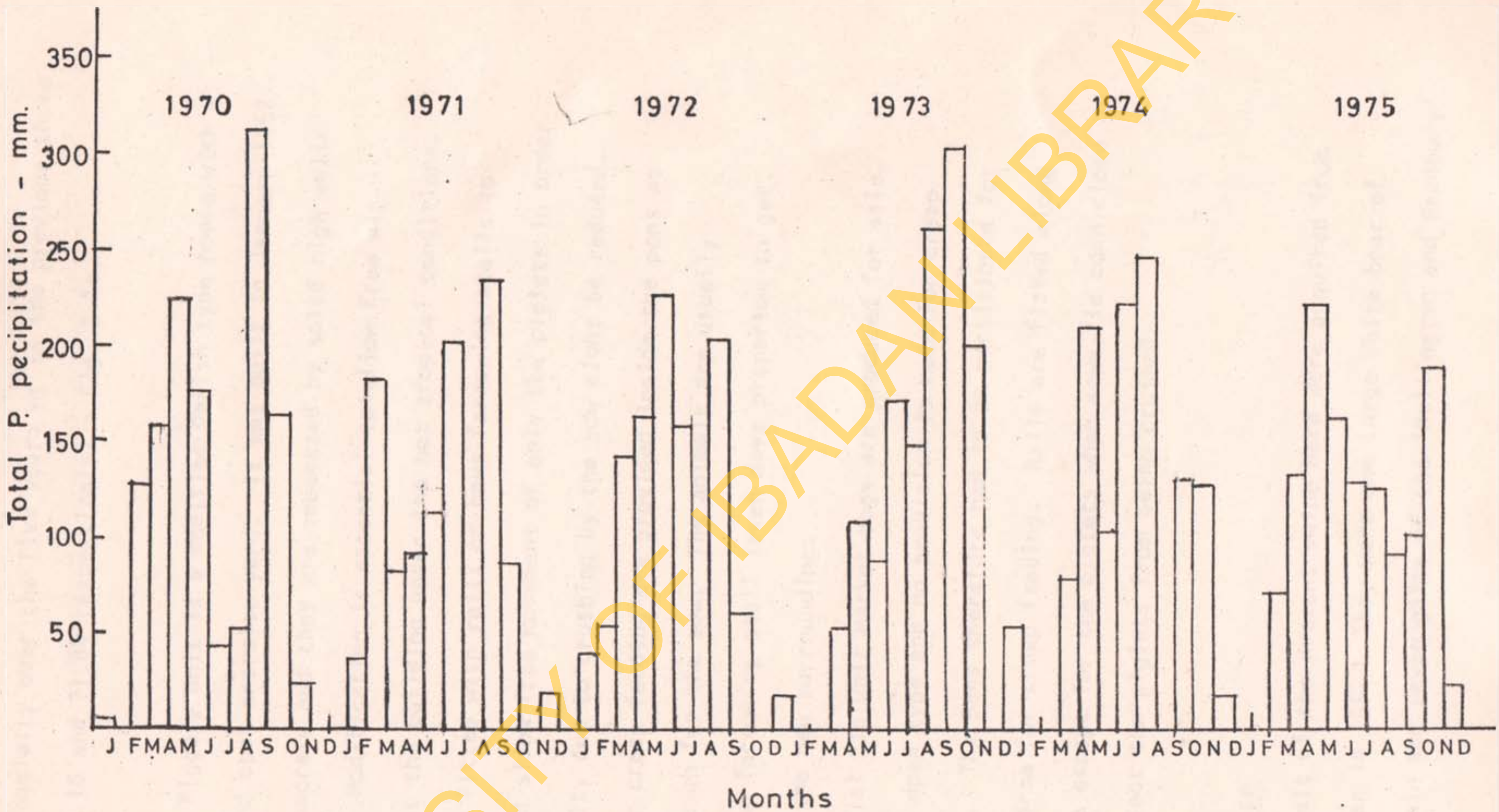

Fig. 3 . 1b Rainfall pattern 1970 - 1975 U. I .

average relative humidity over the five years or in the previous three years 1970-73 (72.10 and 71.84 respectively) - Fig. 3.1c.

3.1.2 Housing

The Breeding Piggery Unit is a modified Danish type house with a central passage and open exercise yard. It was built in January 1952. All pens are of concrete and they are separated by solid high walls (0.9 metre high). Modification is essential to allow free air movement throughout the building under the hot tropical conditions. Farrowing pens are fitted with rails or have farrowing stalls to enclose the sow and allow free movement of only the piglets in order that piglet mortality due to crushing by the sow might be reduced.

Facilities for creep feeding are provided inside the pens as well as a water trough for the sow. The animals are usually transferred into the farrowing stall seven days prepartum to get them accustomed to the new surrounding.

In the Commercial Pig Unit market hogs are produced for sale. The pens are of the open type and no provision is made for creep feeding the piglets. The pens therefore had to be partitioned for this to provide an area for creep feeding. Rails are fitted along the walls to provide escape for the piglets when sows lie down close to the wall and protect the piglets from being crushed.

3.2 Animals

3.2.1 The Large White

Foundation animals of the present swine herd were acquired from Moor Plantation Ibadan in 1952. They were one Large White boar of the 'Mollington' strain and seven gilts of the 'Mollington and Bradbury'

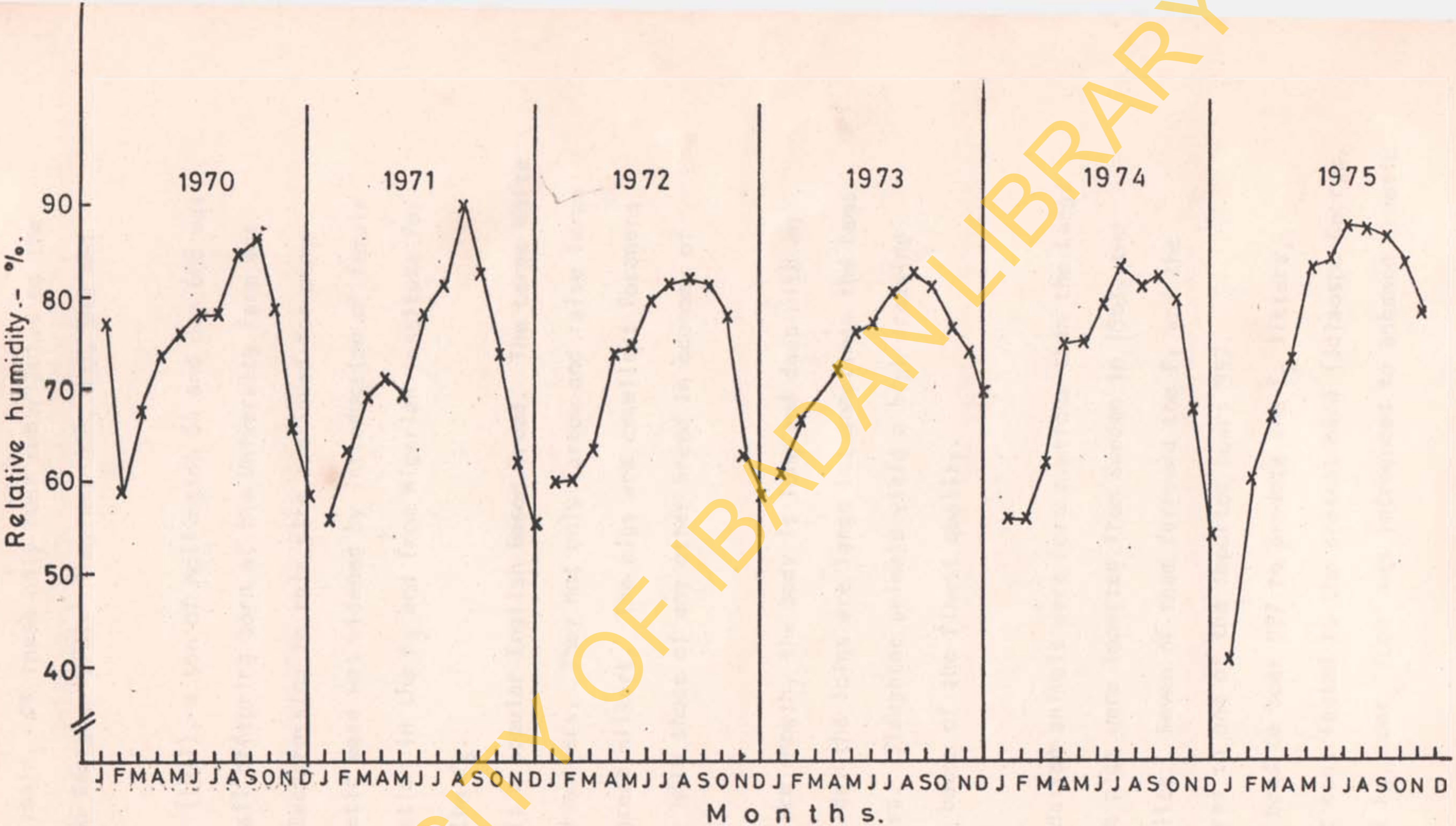

Fig 3.1c. Relative humidity pattern 1970 - 1975 U.I.

strains from Great Britain. Of these only four contributed to the present herd (Jolaosho-George, 1973). They are 608, 893, 940 and Mollington 64 boar.

The boar 'Laddi' (1871), a son of Mollington 64 and dam 608 was extensively used and all offspring born at the University farm are related to 'Laddi'. Backcrossing to this sire continued for many generations. The genetic base was widened by introduction of female stock from Moor Plantation in the F_3 and from Nigerian Institute for Oil Palm Research in the F_6.

The Large White is a popular English bacon breed. The Large White sows are noted as good mothers. They not only farrow and raise large litters but they are great milkers. The pigs are excellent foragers and compare favourably with those of any other breed in economy of gains. Plate 3.1.

Large White hogs are smooth, the body is long and deep with an especially long deep side; the loins are large but sometimes the hams lack depth and plumpness. Slaughter animals yield a high dressing percentage and produce bacon of the finest quality.

<u>The Landrace</u>

The Landrace foundation animals were more numerous than the Large White. Twelve Landrace pigs were imported from Sweden in 1963, two boars and ten in-pig gilts. Seven of them farrowed the F_1 and the remaining three were bred to one of the imported boars 997.

The F_1 gilts were bred to boar 997 to produce the F_2 litters, out of these only eight contributed to the present herd (Jolaosho-George, 1973). But in the 1972 F_6, boar 'Togo' was introduced to enhance genetic

PLATE 3.1 LARGE WHITE SOW AND HER LITTER

variability and to counteract possible inbreeding. One son of his has been added since as herd sire. His main contribution so far is large litter size (Fasunloye, 1975).

The Landrace breed of hogs is native to Denmark where it has been bred and fed to produce the highest quality bacon in the world. It is white in color and the breed is characterised by its long deep side; square ham; relatively short legs, trim jowl; heavy lop ears, sometimes low back and frequently weak pasterns. The breed is noted for prolificacy and for efficiency of feed utilization - Plate 3.2.

With the introduction of new genes at F_3 and F_6 Akinkuolie (1967) found that level of inbreeding was low, 1-26% for the Large White and 6-16% for the Landrace and found no adverse effect on performance, litter size, birth and weaning weights even at the highest degree of inbreeding observed (26%). The drastic reduction in the average number of sows in the herd from 159 in 1966 to 104 in 1967 and 80 in 1968 (Steinbach, 1968) might have also enhanced improvement of the productivity of the herd due to selection effect.

It is a well known fact that close inbreeding is nearly always accompanied by lowered fertility, reduction of libido, increased gametic sterility and embryonic mortality as well as reduction in the viability of the newborn.

However crossing of inbred lines has resulted in improvement of the breeding lines. Johansson and Rendel (1972) reported a greater influence of the degree of inbreeding of dam on the size of the litter at birth than did the inbreeding of the sire. Not only does inbreeding impare the growth rate of the dam but an inbred dam provides a less

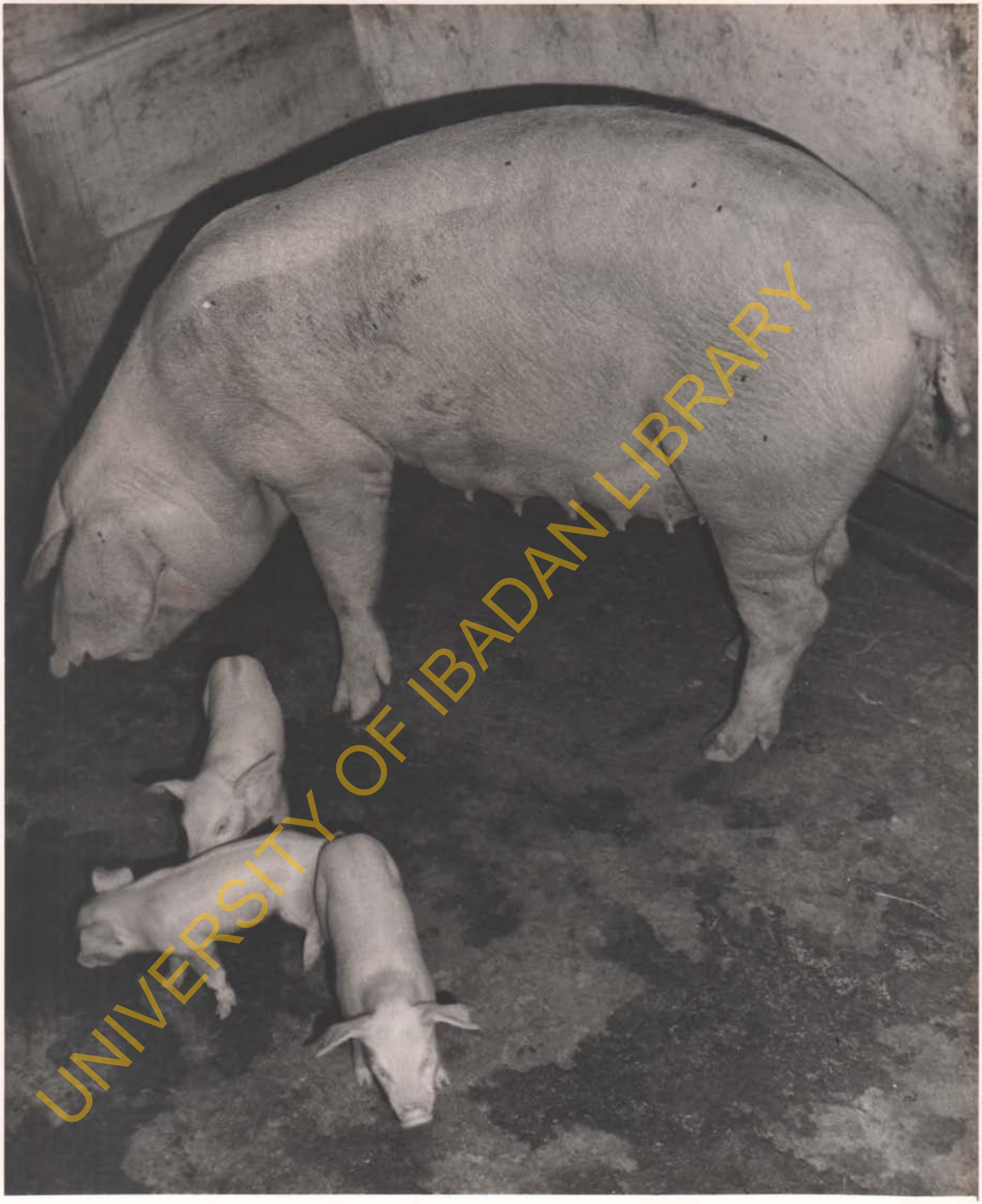

PLATE 3.2 LANDRACE SOW AND HER LITTER

favourable intra-uterine environment for the foetuses than when not inbred.

It is possible that inbreeding increases the frequency of foetal malformations not because it increases the segregation of lethal and semi-lethal genes but because of its general depressive effect on metabolism and growth rate.

The Duroc Boar

The Duroc boar was got from Fashola from a litter of crossbreds and is being used in the commercial herd for crossbreeding purposes with the Large White and Landrace sows.

The Duroc is red in colour with its origin in the North Eastern section of the United States. The shade varies from light to dark. The great popularity of the breed is attributed to the valuable combination of size, feeding capacity, prolificacy and hardiness (Plate 3.3). The pigs have short dropping ears and an arched back. Their carcasses are firmer than any other breed. The quality has been markedly improved since selection has shifted towards meat hogs.

The Local Pigs

A herd of indigenous swine is presently being built up and both boars and gilts were purchased from local farmers in the then Western State of Nigeria.

The local pig has been shown to be of a small body size, short and shallow compact and of timid disposition. It is slow growing and a poor feed utilizer (Hill, 1956).

PLATE 3.3 DUROC BOAR

Unpublished data (Hill, 1956) showed that under the best conditions of management, the growth rate and mature body weight of the local Nigerian pig was by far inferior to that of the exotic breeds. Since the realization of the inherent poor performance of the local Nigerian pig, it was considered not a useful tool in an attempt to rapidly produce large numbers of animals for commercial purposes. However, Fetuga, Babatunde and Oyenuga (1976) in comparing the performance of the indigenous pigs of Nigeria with that of their exotic counterparts found comparable litter size but low birth and weaning weights and pre-weaning mortality. Daily gain, feed intake and feed conversion efficiency were also lower and the local pigs had maximum growth rate between 45.5 and 56.8 kg live weights. Tissue growth rates were lower and efficiency of tissue deposition poorer. The economy of gain beyond the 57 kg live weight was presumed very doubtful. It was therefore considered undesirable to attempt to rear indigenous pigs to comparable weights to which exotic pigs are reared.

Despite the works of Vohradsky (1968), Ashton and Cameron (1969) in which the local pigs of Ghana were declared unsuitable for breeding purposes especially as purebreds or as dams in crossbreeding it is still on record that optimum performance of these local pigs could be achieved at lower dietary levels than with the exotic pigs (Ilori, 1974; Fetuga et al., 1976). Large scale commercial pig production based on this breed of pigs may not be a profitable venture, on the other hand, successful pig raising based on imported breeds and strains are only possible where pig production ideas are favourable and their

PLATE 3.4a INDIGENOUS SOW AND HER LITTER

PLATE 3.4b LITTER OF INDIGENOUS PIGS

PLATE 3.5 BREEDING GROUP OF INDIGENOUS PIGS

but otherwise healthy and surviving as scavengers without any care by man whatsoever. Small animals in the tropics have rather evolved in the course of evolution, as one of the means of adaptation to tropical conditions is reduced size (Bergman's and Allen's rule according to Dobshansky, 1953). From an economical standpoint it is not known as yet whether improvement in its body size could be achieved through breeding and proper management. However the genetic potential of the Nigerian indigenous pig has not been fully assessed.

The birth weight of the local pigs is low compared to that of the exotic breeds (0.5 - 1.2 kg) with an average of about 0.8 kg. The weaning weight varies from 2.5 - 8 kg at eight weeks. The mature weight at 180-225 days is about 20-50 kg rarely exceeding to 70 kg. Their small size is therefore a rule rather than exception. Under free roaming conditions the pigs have thrived for a long time. They have been exposed to prolonged periods of under and malnutrition, disease infection and unfavourable weather conditions. The resultant effect is a permanent adaptation to low and varying feed intake, slow growth and generally low productivity.

Crossbreds

Crossbreeding was first initiated on the University of Ibadan farm in 1956 (Hill, 1956) when the average coefficient of inbreeding for Large White had risen to 0.2443 (0.0625 - 0.3125). Inbreeding was due to parent x offspring and brother x sister matings for two generations while backcrossing to the Mollington foundation sire continued for some four years. There was a reduction of about 1.23 piglets per litter alive in the average number of inbred Large White sows weaned, in 1956 further increased losses by 10% per litter at weaning occurred compared to the foundation stock.

Losses from weaning to selling weight increased from 2 to 10% and average gains per day from weaning to seven months were less in the inbred lines. Inbred fatteners took 32 weeks to reach baconer weight (90 kg) in 1956 compared with 30 weeks for the 1952/53 litters.

For these reasons di-and trihybrid crosses of the Large White, Large Black and Tamworth were initiated.

Dihybrid crosses and reciprocal crosses of the three breeds had higher weaning weight than either the inbred or non-inbred Large White. There was an overall culling rate of 8% from weaning to market weight but no deaths and no marked differences in average daily weight gains compared to the purebreds.

In the limited number of feeding trials carried out (Hill, 1956) feed conversion was satisfactory. The more rapid maturity of the trihybrids indicates that with existing conditions maintenance of vigour and rapid growth depends more on the quality of the parent stock than on the quality of feeding stuffs available in Nigeria. It is a well known fact that crossbreeding is now practised in production of market hogs.

In the trihybrids, linecrossing of the three breeds appeared to give highly satisfactory results compared with purebred or two line crossbred litters. Although the number of the trihybrid litter was small number weaned and weaning weight were higher than average for all non-inbred and inbred lines or dihybrid crosses.

Despite these findings the programme was dropped but was taken up again by Dettmers in 1972 with the intention of producing better market hogs in the commercial swine unit. The crossbreds then are crisscrosses of Large White (LW) and Landrace (LR) pigs (LW x LR) and single and three way crosses with a Duroc boar (DU) Duroc x Large White (DU x LW); Duroc x Landrace (DU x LR) and using the F_1 as the female. So presently there are LW x LR reciprocal crosses, DU x LW or DU x LR single crosses and further DU x (LWLR) or DU x (LRLW) Plate 3.6 - 3.8.

3.3 Management

To a pig farmer who manages his animals intensively with the present cost of ration components in the market, his interest is not just in the number of animals raised but how best the pigs could be managed to attain a marketable weight.

This could be achieved by utilizing selected superior stock and avoiding close breeding.

Supply of feed and water in adequate quantity and quality is essential.

The employment of hard working knowledgeable labourers who are interested in the wellbeing of the animals and ensure clean surroundings and adequate supervision is necessary.

Essential drugs, antibiotics, worm elixiers, delousing powders, iron compounds, sulphur ointment and palm oil must be available.

Finally there must be proper veterinary care available whenever difficulty and disease problems are encountered. Any of the above mentioned in short supply will surely jeopardise the thriftiness of the pigs.

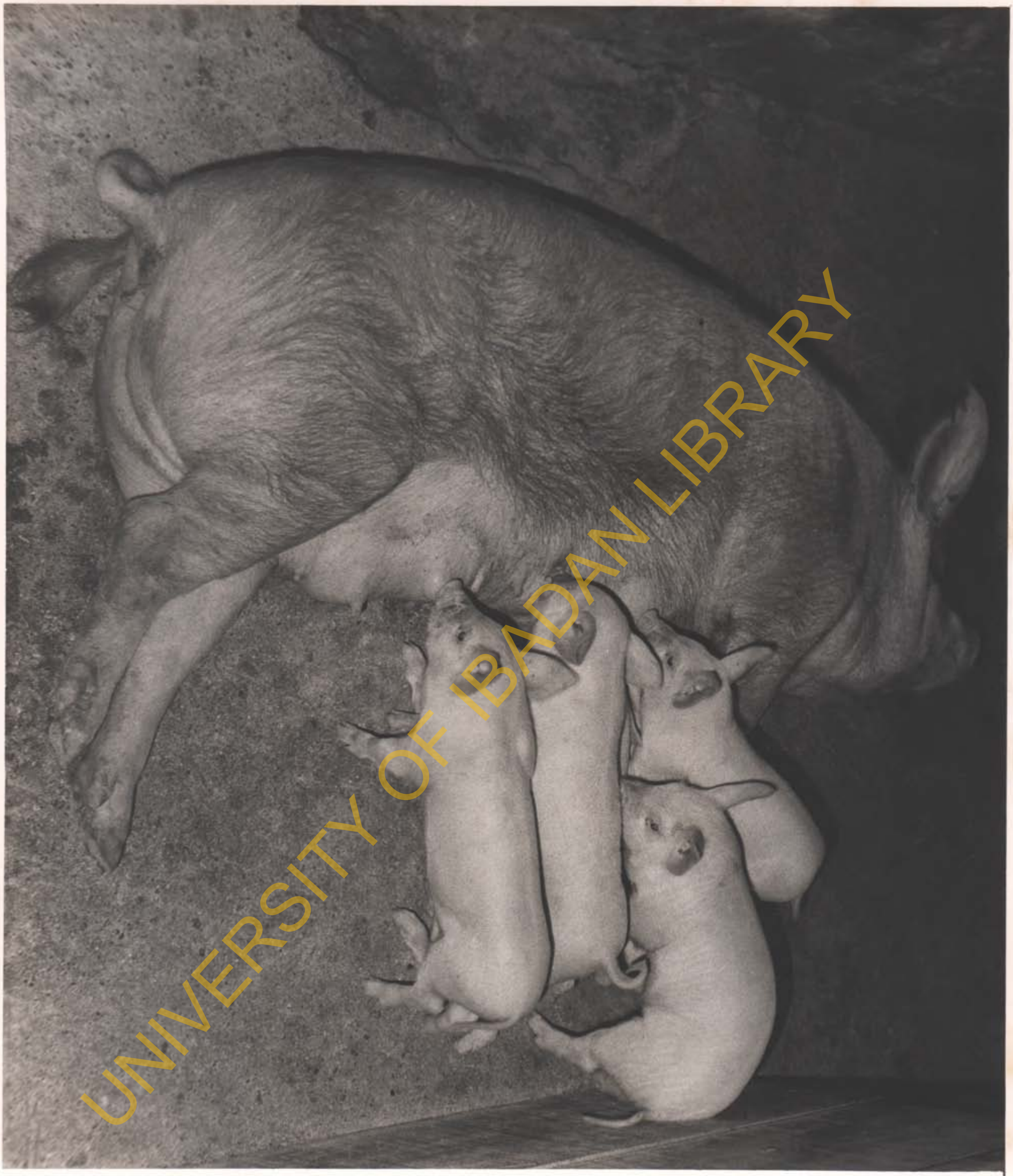

PLATE 3.6 DUROC AND LARGEWHITE SOW AND HER LITTER

NOTE - Hair Cover (brownish)

PLATE 3.7 DUROC AND LANDRACE SOW AND HER LITTER

NOTE - Hair Cover (brownish)

PLATE 3.8 RECIPROCAL LARGEWHITE AND LANDRACE SOW AND HER LITTER

General management entails routine exercise of the breeding sows to keep them trim and delousing fortnightly with gammaxane. In case of skin problems, such as scaly dandruff, they are rubbed with sulphur ointment in palm oil.

With the known cycle of worms from piglets to their dams and vice versa, pregnant sows are dewormed two weeks before farrowing and three days before weaning.

When all conditions are adequately met (regular supply of feed and water, provision of all essential ingredients in the ration and proper handling of the animals) the gilts come into heat early and are bred between the ages of 8 and 12 months, so that they farrow between 12 and 16 months. Teaser or vasectomised boars are used in detecting heat, the gilt or sow is then bred naturally or by artificial insemination in special cases.

The bred females are transferred to the farrowing crates a week before parturition. When farrowing occurs at day time, the sow and piglets are kept under vigilance and necessary aid rendered when required.

The piglets are weighed immediately after farrowing or the following morning, if born during the night. They are ear-notched for individual identification at the same time and helped to the udder when necessary. Shots of iron compound (pigdex or ferrofax) are given on the second and twenty-eighth day. Warm bedding is provided by spreading wood shavings on the floor of the pen to reduce chilling. This is swept out every morning or when wet and replaced with dry ones.

3.4 Feeding

3.4.1 Feeding of Sows

The sows are fed twice daily at 8 a.m. and 4 p.m. respectively. They are handfed a standard ration as slop of the following composition:

Maize or guinea corn	- 62.50%
Groundnut cake	- 18.00
Blood meal	- 5.00
Rice bran	- 6.00
Bone meal or DCP*	- 1.75
Brewers grain	- 5.00
Salt	- 0.50
Oyster shells	- 0.75
Palm oil	- 0.50

*DCP = Dicalciumphosphate

Actual proximate analyses of the ration were carried out on weekly samples during the time of investigation. The ration is fed at the rate of 2.7 kg per sow and 0.23 kg per live piglet in two parts daily. In addition limited quantities of legumes and grasses are fed fresh once daily or small quantities of mixed legume and grass hay. Feeding the ration as slop increases the water intake thus reducing the incidence of constipation, a common occurrence when high fibre concentrates are fed. Water is available ad libitum.

3.4.2 Feeding of Piglets

The piglets are offered creep feed from the second week of age. The feed is kept in a corner separated off the pen out of reach of the sow.

The creep is of the following composition:

Yellow maize	-	54.50%
Groundnut cake	-	22.00
Blood meal	-	6.00
Fish meal	-	4.00
Rice bran	-	3.00
Bone meal or DCP	-	2.00
Oyster shells	-	0.75
Salt	-	0.25
Ad - vit	-	1/2 tin/1/2 ton
*Molasses	-	7.50

(*Depends on availability, otherwise quantity of yellow maize is increased).

The baby pigs are treated against piglet anaemia with ferrofax or pigdex 100, 2ml per piglet. This is injected intramuscularly two days after birth and repeated at 28 days of age. Skimmilk is also offered to supplement the supposed inadequate sow milk (piglets becoming less thrifty). They are weaned usually at eight weeks of age. When a sow is run down due to oversuckling or with too many piglets (litter of ten) which are not getting sufficient nourishment they are weaned at about five weeks of age. The piglets are retained in the pen and supplied with creep feed and some terramycin in the ration to sharpen their appetite. Milk is supplied in a separate trough twice daily. Clean water is also supplied <u>ad libitum</u>. When diarrhoea occurs, terramycin or progene is added to the drinking water of the sow and at times to the ration of the piglets too. Piglet scours has been the major disease problem encountered during the preweaning period of the piglets. This has often been associated with low protein and high lactose content of sow milk and probably to the sub-hygienic level of the surrounding of the pigs.

3.5 Methods

3.5.1 Chemical Analysis of Feed Samples

At weekly intervals throughout the experimental period, samples of the sows' and piglets' rations were taken to be analysed in the laboratory. All chemical analyses followed the conventional A.O.A.C. (1970) methods. Determinations were made in duplicate from samples of different bags or batches and their mean obtained. The results were expressed on dry matter basis.

(a) Residual Moisture

A 2g sample of ground material was dried to constant weight at 105°C in an electric oven for 24 hours at the end of which samples were cooled in the dessicator and weighed. The difference in weight expressed as a percentage of initial weight is the residual moisture. Then the dry matter percentage is 100 - moisture percentage.

(b) Total Ash

Dried material was ignited at 600°C in a muffle furnace until grey or nearly white. The weight of the ash so obtained after cooling in the dessicator is expressed as a percentage of original weight.

(c) Crude Protein (Total Nitrogen)

This was determined by the Macro Kjeldahl method using the sodium sulphate-mercury catalyst mixture for the macro digestion followed by micro distillation using the Markham distillation apparatus. Boric acid was used as the receiving medium. The crude protein (CP) was calculated by multiplying the total nitrogen content by the factor 6.25.

(d) Ether Extract

This was obtained by extracting moisture free samples with petroleum spirit at boiling point 40-60% in a Soxhlet extraction chamber for eight hours.

(e) Calcium

A wet digest of the sample was made with 1 : 4 ratio of perchloric acid to nitric acid. Sample and standards were then prepared and read through the flame photometer. The calcium percentage =

$$\frac{\text{Parts per Million} \times \text{Dilution factor}}{10,000 \times \text{weight of sample.}}$$

(f) Phosphorus

Aliquot samples of the wet digest were prepared along with phosphorus standards. The colour was developed by using 20ml phosphovanado molybdate solution for two hours and then read on the Cecil Spectrophotometer at 425 mμ wave length.

The phosphorus percentage =

$$\frac{\mu\text{g P off curve} \times \text{Dilution factor}}{1,000 \times \text{weight of sample}}$$

Analysis of Sow Milk Samples

Milk samples were taken on two consecutive days each week. The first sample was frozen, thawed the following day. The two samples were then lumped together and analysed fresh in duplicates.

(a) Fat

On account of differences in composition of cow and sow milk especially in the greatly increased protein and fat content of the latter and the associated difficulty in preparing a protein free filtrate, the modified Perrin (1955) method for sow milk fat estimation was used.

Fat was determined by the Gerber Test (British Standards Institution, 1936) using an 8ml pipette for the milk. 8ml of sow milk was added to sulphuric acid followed by amyl alcohol and diluted with 3ml of distilled water in a Gerber milk fat tube. It was shaken, centrifuged for four minutes at 11,000 revolutions per minute. Percentage fat was then read off the graduated stem of the tube.

(b) Protein

The nitrogen in the milk was determined by the macro Kjeldahl method using 2g of fresh milk and then distilled in the Markham steam distilling apparatus. The nitrogen content multiplied by 6.38 (nitrogen content of animal substances) gives the total protein content.

(c) Total Solids

A 5g milk sample run into about 3g asbestos was dried over a water bath for 30 minutes and in an oven to a constant weight at 105^{o}C. The difference in weight before and after drying is the moisture content.

Total solids = 100 - moisture content

Solids not fat = Total solids - fat content or (Lactose, protein, and ash).

(d) Ash

Ash was determined by igniting the dried milk sample in a muffle furnace at 550^{o}C till white or grey. Final weight expressed as percentage of original milk sample weight gives the ash percentage.

(e) Lactose

Lactose concentration was determined by using the colorimetric phenol - sulphuric acid method of Barnett and Tawab (1957) modified by Marier and Boulet (1959).

Lactose percentage =

$$\frac{\text{mg Lactose} \times \text{Dilution factor} \times 100}{1000}$$

(f) Phosphorus and Calcium

These were estimated by the use of spectrophotometer and flame photometer respectively to read the optical density of the milk.

Percentage phosphorus and calcium were obtained as in the feed sample analyses.

The yields of milk fat, protein, lactose, ash and total solids were computed from the percentages of these components and the total milk yield.

3.6 Statistical Data Analysis

The major objective of this studywas to elucidate the effect of the tropical environment on pig production, to detect any degree of adaptability in the performance of the imported exotic breeds and their crosses and more also to compare their performance with that of the indigenous sows of Nigeria.

Variables used are the milk production and the milk constituents; sow performance, feed utilization for milk production and weight changes during lactation; litter size at birth and weaning, litter performance, litter birth, weaning weights and preweaning weight gains, covering a period of two years 1973-75. The Analysis of Variance(AOV) served to determine effects of season, differences between breeds or whether age (sows and gilts) has any influence on reproductivity of the pigs. Nested classification was the AOV adopted.

Analysis and Variance.

Nested or hierarchal classification (Snedecor and Cochran, 1972) was used to account for more degrees of freedom (df) and consideration of differences between variables colluted from gilts or sows from different breeds, and during the dry and wet season. The seasonal effect when removed shows the effect of breeds within each season. Likewise after accounting for breed effect variations can be determined due to age of the dam (gilt or sow). The error finally accounted for sources of variation between the variables and due to chance. The statistical model employed was:

$$Y_{sbax} = M + E_s + E_{sb} + E_{sba} + e_{sbax}, \text{ where}$$

M = mean
E = effect due to s = season
sb = season and breed
sba = season, breed and age.
and e_{sbax} = error due to variables not accounted for.

Regression Analysis

Trends in interrelationships are revealed by regression analysis.

Multiple linear regression coefficient of milk produced by the different groups of sows on the different components was estimated from the model:

$$Y = \mu + b_1 x_1 \ldots\ldots b_k x_k + e$$

where

μ = mean of the milk produced

b = individual regression coefficients of the different components.

e = error of estimate

When all other values are held constant dependency of the variables was determined by the model:

$$\hat{Y} = \bar{y} + b(x - \bar{x}) + e, \text{ where}$$

$\bar{y}$ = mean of milk produced

x = milk constituents

$\bar{x}$ = mean of constituents

e = error of estimate

An IBM 360 computer was used

CHAPTER IV

PRELIMINARY INVESTIGATIONS

4.1 Introduction

The theme of the thesis is based on:

(1) Estimation of milk production by the sows;

(2) Evaluation of the milk nutrient components.

These are then related to performance of the sow and her litter. However the milk yield of the sow in an experimental condition where there is no sophisticated equipment like a milking machine for sows had to be estimated by the indirect weighing method (by weighing the piglets before and after suckling and the difference in weight taken as the milk ingested).

Accurate determination of the milk by this method therefore means that the number of times the piglets are weighed must conform with the rate at which they suckle under natural and uncontrolled condition.

In this type of experiment errors encountered are often due to urination, defaecation or water taken by the piglets immediately after suckling. This cannot be reduced unless the suckling behaviour of the piglets is studied or understood in an uncontrolled environment.

Secondly some investigators have come up with differences in the varying fractions of milk from sows. The first and final fractions are thought to be richer in fat than the middle fractions. It only means that the udder must be totally evacuated if estimates of the milk components are to be reliable.

On the basis of these three considerations preliminary investigations were carried out:

(1) To estimate natural suckling frequency of the piglets and their nursing behaviour.

(2) To extrapolate amount of oxytocin required for complete evacuation of the udder of the sow for the determination of milk nutrients.

4.2 Estimation of Natural Suckling Frequency and Nursing Behaviour of the Piglets

The number of times that piglets are allowed to suckle during the period when their suckling is under control has a significant effect on the yield of milk obtained. Olofson and Larson (1930) emphasized the significance of suckling frequency in determining milk yield of sows since in most cases milk yield estimation is by the indirect method. Several workers suggested intervals of one hour to seventy-five minutes. They found that sows on hourly frequency gave one third more milk than those on a two hour frequency.

With the present assumption that sows in the tropics might be producing less milk than their counterparts in the cooler regions as measured from the rate of growth of the piglets which is far short of expectation it can be overruled that the piglets frequent the udder more often comparatively to satisfy their probably insatiable appetite. Therefore it appeared justified to estimate the natural suckling pattern of sows over an entire lactation period in the environment provided for this study.

4.2.1 Materials and Methods

Ten sows of both the Large White and Landrace breeds were placed under observation between November 1973 and January 1974. The animals were housed in the farrowing stalls of the University of Ibadan Farm Breeding Unit. The natural suckling frequency was recorded for a period of 24 hours from 6 a.m. to 6 a.m. the following day, from the end of the first week of lactation.

When it became obvious that it is necessary to study the suckling behaviour and estimate time spent at the udder, seven sows of both the Large White and Landrace breeds were again placed on observation. Time spent at the udder by piglets of each animal was studied four times in a day starting from the first week. Time spent was differentiated into three periods:

(1) The nosing period before actual suckling begins (pre-nosing);

(2) The actual suckling time when milk was withdrawn; and

(3) The nosing period after suckling (post nosing) .

Averages of the four observations was then taken as the suckling period spent at the udder.

4.2.2 Results and Discussion

Interval Between Nursing

The average suckling interval for the animals for the first and the last 12 hours, the standard deviation and coefficient of variation are shown in Table 4.1.

The average total suckling interval was shortest between the first and third weeks of lactations - 39 minutes compared to 62 minutes in the middle three weeks and 74 minutes in the last two weeks. The range was 36.1 to 159.6 minutes (Appendix Table 4.1). There was less variation in minutes (CV = 3-7%) during the first three weeks either

Table 4.1

AVERAGE SUCKLING INTERVAL MINUTES

No. of Sows	Average number of piglets	Weeks	Interval between suckling					
			0-12 hrs.	SD	CV%	12-24hrs.	SD	CV%
10	7.5	1-2	41.87	2.15	5.1	37.16	1.27	3.4
10	7.0	2-3	39.67	2.54	6.4	39.05	2.62	6.7
10	6.6	3-4	54.58	15.82	29.0	66.24	17.20	26.0
10	6.4	4-5	57.54	13.71	23.8	70.79	13.85	19.6
10	6.4	5-6	55.06	6.29	11.4	70.47	15.45	21.9
10	6.4	6-7	71.04	27.98	39.4	79.98	16.83	21.0
10	6.4	7-8	73.44	18.10	24.7	73.11	31.10	42.5

during the first 12 or last 12 hours of the day. However the variation was large and inconsistent during the last two weeks of lactation, (CV = 21-43%) compared to 11-29% during the middle three weeks. The range in intervals was 36.1 to 46.5 minutes during the first three weeks, 39.8 - 107.5 in the middle three and 41.2 to 159.6 minutes in the last two weeks. There was no significant difference in the two periods considered, (6 a.m. - 6 p.m. and 6 p.m. - 6 a.m.). However there was a highly significant difference ($P<0.01$) between the first three, the middle three and the last two weeks of lactation. (Fig. 4.1).

Although results on this type of experiment are scanty, most workers used their initiative to estimate probable nursing interval for piglets to be able to determine the milk production of the sow. Only a few investigators actually carried out an experiment with a limited number of sows (Olofson and Larson, 1930; Berber et al., 1955; Roosve, 1967; and Mahan et al., 1971a) while Smith (1950 and 1952) introduced the method of recording the number of times a litter was fed on one day and then taken away for weighing trials the next day and then allowed again the same number of feedings.

The above findings were actually in agreement with other reports especially for the fourth to eighth weeks of lactation. The frequency of the piglets at the udder in the first three weeks cannot be unconnected with the fact that the rate of milk secretion of the sow at this period is very slow. For the piglets to satisfy their appetite and secure enough nutrient required for their growth at this critical period during which they are expected to almost triple their birth weight

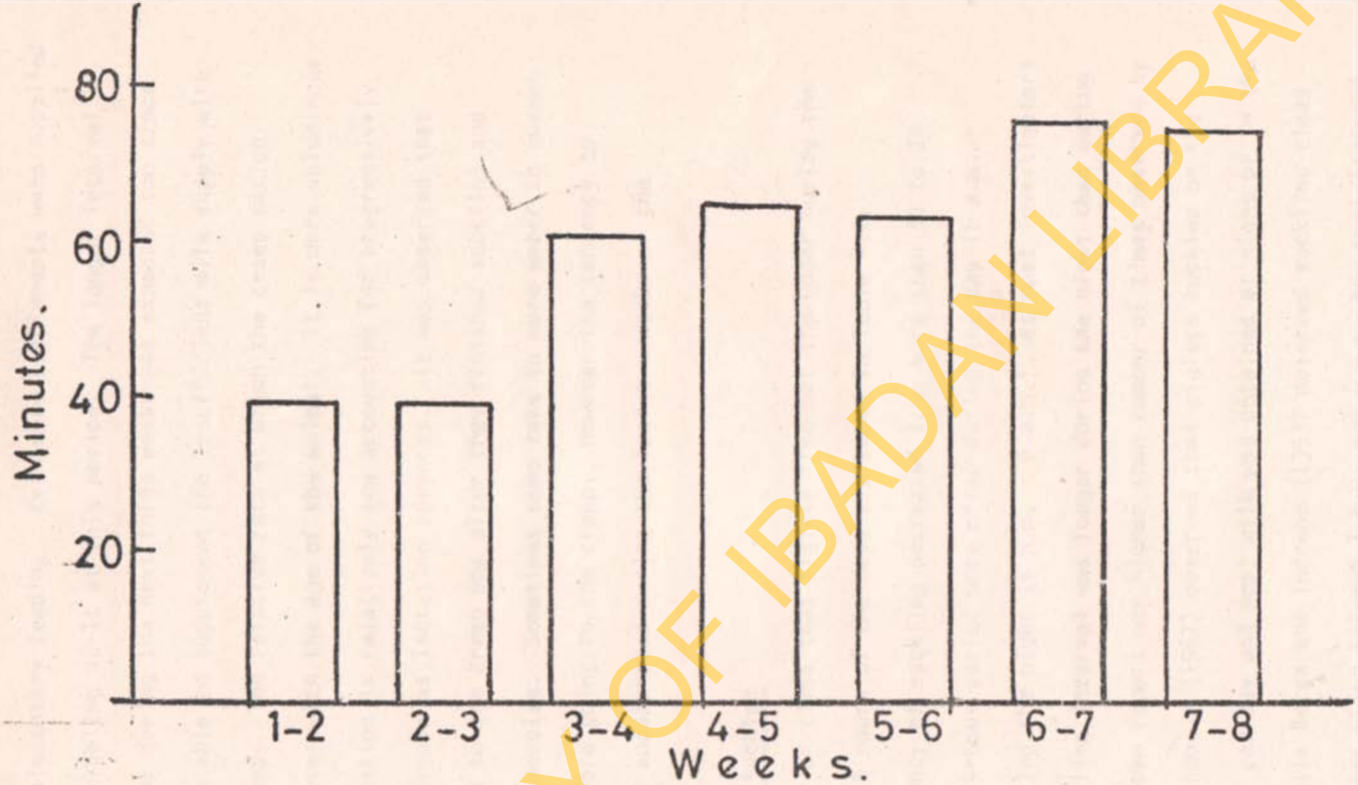

Fig. 4.1 Interval between nursing - minutes

without any supplementary feeding. Even when supplements were supplied they were only nibbling at it at this period. The longer interval of about one hour during the next three weeks was expected too since the piglets were able to supplement the insufficient milk supply with high protein creep. The relative rate at which the creep ration was taken increases with the age of the animal. It is more voluminous and rate of digestion is relatively low accounting for progressively longer time intervals as lactation advances. It was observed that most piglets ran to the creep box after they finished suckling and not before the exercise. Sometimes some take in more water to quench their thirst before going to the creep. However the tendency to run to the creep accelerated during the last two weeks of the lactation.

Number of Times Suckled

The number of times that piglets frequent the udder during the first and last 12 hours of the days are shown in Table 4.2.

The frequency of suckling decreased from more than 30 to 20 times over the 24-hour period more often during the day (6 a.m. - 6 p.m.) than during the night (6 p.m. - 6.a.m.), as most investigators agreed that suckling interval was longer during the night than during the day. The above report was higher than number of times observed by other workers. Roosve (1967) observed that piglets suckled on the average 13 times per day and most milk was obtained at night or in the early morning while Berge and Indrebo (1953) observed suckling times of 19-28 times less often between 1 p.m. and 6 p.m. and most frequent between 6 p.m. and midnight. Mahan et al. (1971a) reported constant

Table 4.2 NUMBER OF TIMES SUCKLED PER DAY

No. of Sows	No. of Piglets	Weeks	Number of Times Suckled		
			0-12 hrs.	12-24 hrs.	Total
10	7.5	1-2	16.6	17.0	33.6
10	7.0	2-3	15.0	12.6	27.6
10	6.6	3-4	12.8	9.5	22.3
10	6.4	4-5	14.1	9.0	23.1
10	6.4	5-6	11.9	8.2	20.1
10	6.4	6-7	10.1	10.8	20.9
10	6.4	7-8	10.8	10.0	20.8

frequency during the day and lesser between 12.00 and 4.00 a.m. The report here indicated constant frequency in the last two weeks of lactation both during the day and night (10 times) and much lower frequency compared to 12-17 times during the day for the first six weeks. While it was 13-17 times during the first three weeks at night it was more or less constant with 8-9 times between four and six weeks during the night.

Suckling Behaviour

Observations on the suckling behaviour are presented in Table 4.3. Although there was no significant difference observed in the total time spent at the udder (2-1/2 - 3 minutes) at every nursing, (Appendix Table 4.ii) a look at the histogram in Fig. 4.2 revealed a slight decrease in prenosing period between the first and fourth week followed by an increase till the seventh week. Post-nosing similarly decreased

Table 4.3 TIME TAKEN PER SUCKLING PERIOD (Seconds)

No. of Sows	No. of Piglets	Weeks	Prenosing	Suckling	Postnosing	Total
7	7.0	1-2	58.1	60.0	32.9	151.0
7	6.8	2-3	55.4	65.0	45.6	166.0
7	6.8	3-4	52.6	75.4	30.5	158.5
7	6.8	4-5	74.6	63.9	13.0	151.5
7	6.8	5-6	82.1	48.1	27.8	158.0
7	6.8	6-7	89.6	42.6	34.3	166.5
7	6.8	7-8	71.4	36.4	66.2	174.0

from the first to the fifth week and then increased till the end of lactation. Contrary to these, actual suckling period when milk was actually withdrawn from the udder and the piglets remained quiet and withdrew milk by rapid suckling increased from 60-75 seconds during the first four weeks and then declined to 36 minutes in the last week of lactation. This somehow depicts the pattern of the lactation curve observed in most breeds.

Nursing behaviour was described by some workers (Carlyle, 1903; Hughes and Hart, 1935; Donald, 1937a; Gill and Thompson, 1956; Allen et al., 1959; Folley and Knaggs, 1966 and Whittemore and Frazer, 1974).

Carlyle (1903) reported actual nursing time of 1-2 minutes with half the time spent in getting the flow of milk started Hughes and Hart (1935) showed that pigs actually obtained milk for a period of 60 seconds whereas Donald (1937b) estimated this stage to vary between

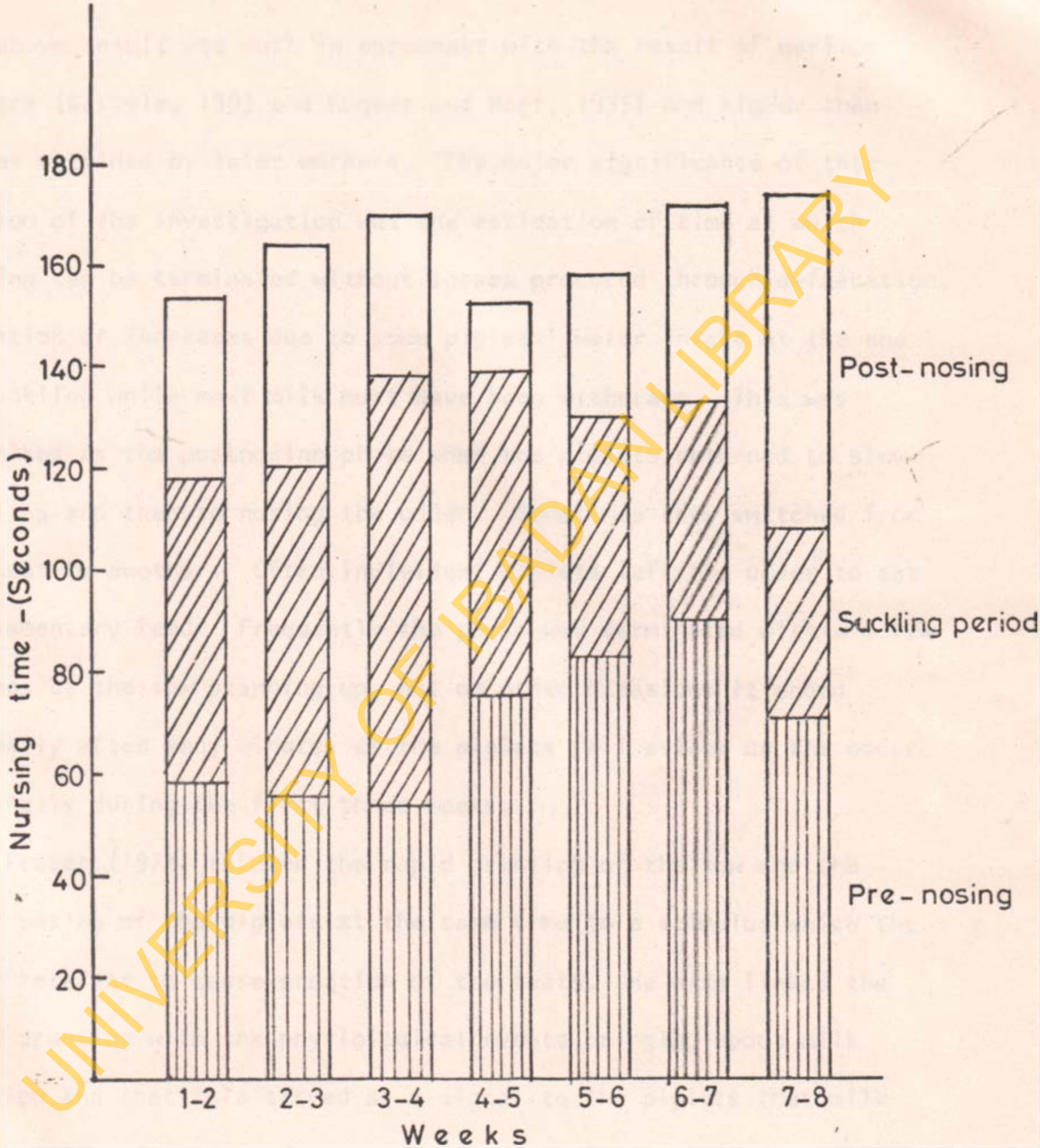

Fig: 4.2 The suckling behaviour of piglets-total nursing period-seconds.

35 and 45 seconds. However Whittemore and Frazer (1974) obtained a duration ranging from 7-33 seconds with a mean of 12•9 seconds. The above result was much in agreement with the result of earlier workers (Carlyle, 1903 and Hughes and Hart, 1935) and higher than values obtained by later workers. The major significance of this section of the investigation was the estimation of time at which nursing can be terminated without losses procured through defaecation, urination or increases due to some piglets' water intake at the end of suckling while most milk must have been withdrawn. This was described as the postnosing phase when the piglets returned to slow suckling and then to nosing the udder. Sometimes they switched from one teat to another. Often individual piglets left the udder to eat supplementary feed. Frequently the phase was terminated within a few seconds by the sow standing up, but on other occasions it ended gradually after many minutes as the piglets fell asleep on the udder especially during the first three weeks.

Frazer (1973) related the rapid grunting of the sow and the udder nosing of the piglets at the same time to a stimulus which the udder receives to cause erection of the teats. He also linked the rapid grunting with the physiological events bringing about milk ejection and that this served as a signal to the piglets that milk flow would soon occur.

Whittemore and Frazer (1974) however studied the milk yield and suckling behaviour in 83 lactations. In 70 cases the piglets displayed the rapid suckling phase and the weight gained per litter was 423 ± 7g while in the remaining 13 cases rapid suckling was not seen though the piglets stayed at the udder, however no change in weight was recorded. It would then be relayed that unsuccessful nursing is quite possible when piglets stay at the udder and still cannot secure milk let down. This however could be the case when piglets continued the postnosing period for a long time especially in the last two to three weeks of laction.

In conclusion from the summary of results, Table 4.4, intervals between suckling was decidedly between a range of 40 & 45 minutes for the first two weeks of lactation which is 12 weighings by multiples of three; 60 minutes between the third and fifth week, a total of 12 weighings multiplied by two and 75 minutes in the last three weeks which is ten weighings multiplied by two. However at all occasions udder nosing will be terminated after the first ten seconds when the piglets are taken en batch to be weighed before they could run to creep feed or to water.

Table 4.4 SUMMARY OF RESULTS.

	Weeks						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
Intervals between Suckling (minutes)	39.52 ±0.66	39.66 ±0.57	60.41 ±3.84	64.17 ±3.36	62.77 ±3.12	75.51 ±5.13	73.28 ±5.54
No. of times suckled	34	28	22	23	20	21	21
Postnosing period (seconds)	33	46	31	13	29	34	66

4.3 Sow Milk Sampling For Analysis

In assessing the composition of sow milk it is essential that the udder is completely emptied in order to obtain uniform samples for reliable analytical procedure.

In several swine producing countries the milk has been analysed. For a country in the tropics much has been said on the effect of tropical temperature on metabolic rates and therefore nutritive value of milk obtained from breeds of tropical origin and other breeds imported to this region.

Attempts to obtain milk samples from sows have often failed, not only because pigs are difficult to handle or control but more importantly because they will not let down their milk except during the natural suckling period by their piglets. The sows prefer to lie on their sides during suckling and only few stand on their feet as cows or goats will do. Milking of sows by hand as done in cows or goats is therefore not applicable. Hand stripping with and without stimulus by piglets as well as the use of teat pumps were actually attempted but were without success. A special method of withdrawal had to be adopted.

4.3.1 Materials and Methods

An experiment was carried out (Adebambo and Dettmers, 1975). Twenty animals were used of which twelve were sows and eight gilts. The sows were in their second or third lactation. Seven of them were Large White and five Landrace, the gilts were also five Large White and three Landrace.

Milk was collected on two consecutive days during the second and third week of lactation.

The colostrum was not collected because it has been found that within the first ten hours after parturition it is quite possible to obtain colostrum samples without any stimulus (Bowland, 1966). During the second and third week the sow must have fully recovered from stress of paturition and pigs will have established their suckling frequency and choice of teat. Teats that are not in use will then have regressed.

Milking by hand was done twice daily namely in the early morning between 6.30 and 7.00 a.m. and in the evening at 15.00 p.m. following the milking schedule in the cow.

Oxytocin was used to induce milk letdown. It is commercially available as a sterile solution containing oxytocic principle of the posterior lobe of the pituitary. It can be obtained in ampules with a pH of 3.0 - 4.0 containing one ml or ten units of oxytocin per millilitre and not more than one unit vasopressor activity per 20 units oxytocin. It is used mainly for the initiation of strong contraction of the uterus and letdown of milk. A minimum vasopressor content is essential in the solution to avoid certain complications with its use, such as the risk of coronary constriction, other forms of cardiovascular collapse, abnormal retention of body fluids, undue vasoconstriction at the site of injection and unfavourable effects on the gastro-intestinal tract.

Although intravenous injection of oxytocin was the recommended procedure in both cows and as used by some investigators in swine, but with animals which are not used to handling here intraveous injection was not successful. Intramuscular injection into the neck muscle behind the ear or into the thigh muscle were then adopted. Plate (Plate 4.1) using a 4 cm hypodermic needle behind the ear or 6 cm into the thigh muscle. The udder was washed with clean water, dried and massaged to induce 'letdown' (Plate 4.2). The milk was withdrawn from the standing sow.

4.3.2 Results and Discussion

In general, most animals required 1-2 ml of oxytocin to induce release of milk. However delay time was about 104 minute while reaction time was much prolonged, 5.5 to 24 minutes (Table 4.5).

The dosage applied was higher than recommended. However the prescription on the commercial oxytocin package does not distinguish between species of animals. In about 70% of injection milk was withdrawn within 1-4 minutes. (Appendix Table 4.VI). In 5% a second dosage was required while in 1.6% there was absolutely no letdown at all. Yield of milk samples length of withdrawal and volume of oxytocin are given in Appendix Table 4.VII

Table 4.5 MILK LETDOWN IN MINUTES AFTER STIMULATION WITH OXYTOCIN.

Minutes till letdown	Number of Injections	Percentage of total injections
1 - 4	89	69.5
5.- 8	17	13.3
9 - 20	9	7.0
20	4	3.1
0	2	1.6
1 - 8*	7	5.5

*Response after second injection.

PLATE 4.1 INJECTING AN INDIGENOUS SOW WITH OXYTOCIN

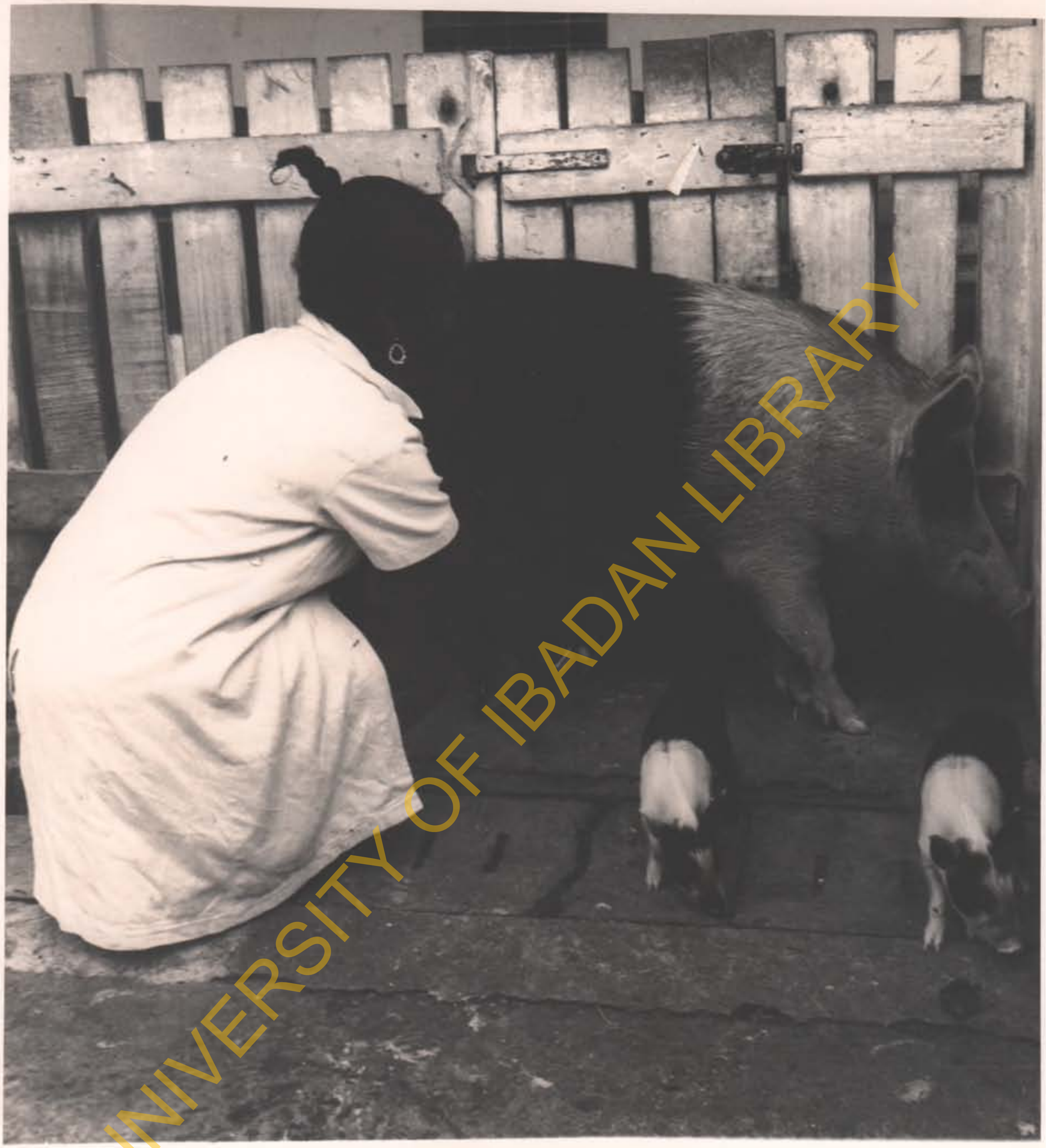

PLATE 4.2 MILK SAMPLING FROM AN INDIGENOUS SOW

Contrarily, Whittlestone (1953) found a delay of just 15 seconds with a range of 15-21.4 seconds and reaction time of 28.8 seconds with a range of 18-41.4 seconds when only 0.5 units of oxytocin was administered. The prolonged interval could be a result of a slow rate of secretion in this animal due to the intramuscular injection. Whittlestone however injected intravenously and extracted the milk with the milking machine. Hill and simpson (1915) and Hammond (1913) were of the opinion that response to the pituirin injection is caused by a direct action of the principle on the secreting tissue of the gland and not due to the contraction of the smooth muscles around the secreting cells.

Although there was no breed difference in the milk produced per unit volume of oxytocin (Appendix Table 4.111) nor in the milk produced at the different times of day (Appendix Table 4.IV) only 12% of the injection resulted in milk production of 100-200 ml (Table 4.6) and parity difference was observed among the landrace breed. Appendix Table 4.V.

Table 4.6 MILK SAMPLES

N		% of sample	Yield ml.
32		30.5	1 - 25
28		26.6	26 - 50
21		20.0	51 - 75
11		10.5	76 - 100
6	5.7)		101 - 500
6	5.7)	12.4%	151 - 200
1	1.0)		7 - 200

There is considerable evidence for a wide variety of species that fright or emotional stress results in an almost instantaneous release of epinephrine into the blood stream causing vaso-constriction of the blood vessels thereby inhibiting milk letdown. Similarly, Ely and Petersen (1941), Braude and Mitchell (1950) and Brumby (1954) all using oxytocin intravenously, concluded that the amount of milk secreted and the length of milk flow are directly related to the amount of oxytocin in the blood.

The volume of milk in the glands and the rate at which milk was removed influenced the duration of milk ejection. It also appeared at least in the sow that the cessation of milk ejection was brought about not only by the enzymatic inactivation of the milk ejection factor but by a reduction in the volume or pressure of milk within the gland.

In agreement with results of other workers complete drainage of the mammary gland cannot be achieved except with injection of oxytocin as would be the case with normal milking. Only Hill and Simpson (1915) observed a lessening effect when the administration was continued for a prolonged period of time.

It could therefore be extrapolated that one ml. of the oxytocin injected intramuscularly was able to induce in most cases (88%) less than 100 mls of milk which took more than 20 minutes to withdraw. As the amount of milk secreted and the length of milk flow are directly related to the amount of oxytocin in the blood, a higher dosage of about 2 ml at a time might do a complete job of draining the udder in a shorter time interval when injected intra-muscularly.

CHAPTER V

MILK PRODUCTION AND MILK COMPOSITION IN SEVEN GENOTYPES OF SWINE

5.1 Introduction

Milk production in swine has been studied in most pig producing countries from the standpoint of both total yield and composition. Experimental data and literature reviews have been recently presented for yield (Allen and Lasley 1960; Smith 1960, 1961; Efimov, 1970) in the temperate countries and Williams (1971) in the tropics. On the composition of sow milk the most recently reviewed include work by Jylling and Sørensen (1960), Neuhaus (1961); Salmon-Legagneur (1965) and Fahmy (1972) in the temperate region and Egesimba (1974) in the tropics.

Generally, pigs are reared mainly for pork production and not for milk. This could be attributed to the difficulty in securing sow milk. From the estimated amount of milk on the basis of dry matter secreted per kilogram liveweight the sow was found to be the highest milk producer of all domestic animals with values as high as 6-10 kg followed by the goat.

But unlike the goat and cow the sow will not voluntarily eject her milk in response to any stimulus other than that provided by the suckling piglet. With the injection of oxytocin to stimulate ejection it becomes highly uneconomical to obtain this milk for any other use. Its unavailability for human or other animal consumption partly accounts for the little research work on sow milk. As a result, information on the milk production of the sow and the composition of the milk is limited.

All data so far collected have been on the milk of exotic breeds in both temperate and tropical countries and on very limited numbers of animals. With reports that exotic breeds in the tropics require a different nutritional regime, the effect of climatic factors on most exotic breeds in the tropics and the current awareness of boosting the production and performance of indigenous domestic animals, it is highly essential that this different section of the research project be taken up in Nigeria. The objective of this portion of the research is therefore:

(i) To evaluate the milk production of exotic breeds of pigs, the indigenous and crosses of the exotic breeds available on the University of Ibadan farm;

(ii) to determine the major constituents of the milk of all the breeds throughout the entire lactation period using as many animals as are available on the farm.

5.2 Materials and Methods

As described in Chapter III, a hundred females of the Landrace (LR), Large White (LW), Indigenous (IND) pure breeds , crosses of the Duroc with Large White and Landrace (D.LW and D.LR) and reciprocal crosses of the Large White and Landrace (LR.LW and LW.LR) were used in evaluating milk production. This included both gilts and sows during the wet season (March-September) and dry season (October-February) of the year 1973-1975. Thirteen of the gilts were used again as sows due to shortage of sows in an attempt to have two or more sows to represent each genotype. The animals farrowed throughout the year so that they could be divided into season as in the design (Table 5.1).

Immediately after parturition and not longer than 24 hours in case farrowing occurred in the night, the piglets were weighed to the nearest second place of decimal as litters. They were earnotched and given shots of iron injection (Pigdex). The dams were also taken to the scale (a few metres distance) and weighed.

Milk production was estimated on days 7, 14, 21, 28, 35, 42, 49 and 56 for each animal. Following the results of the preliminary experiment (Chapter 4.1), milk estimation was by weighing the piglets before and after suckling. Due to the low sensitivity of the scale, the piglets had to be weighed en batch as litters. The scale was adjusted to zero eliminating the weight of the jute bag used in weighing.

This procedure was carried out at 40 minutes, hourly and seventy-five minutes intervals during the first two weeks, the following three and last three weeks of lactation respectively for 12 hours.

Errors due to defaecation or urination were avoided as much as possible but where it did occur averages of the weight previous and subsequent to the one during which the errors were encountered were used. However the piglets were often disturbed to effect urination or defaecation some five minutes before they were allowed access to the dam.

The average of the first and last weights of the litter during the day of evaluation was taken as the weight of the litter for that day.

Multiples of the 12 hours milk yield were then taken as the milk produced by the sow in a whole day and for the seven days of the

TABLE 5.1

EXPERIMENTAL DESIGN AND INDIVIDUALS USED

TOTAL N = 113

WET SEASON N = 59

Genotypes	LW		LR		IND		DLW		DLR		LWR		LRW	
	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows
	70x	3929	357	773	182	1	195	21	626	34	990	203	58	66
	893	4567	16	882	173	11	175	15	406	37	136	990	306	62
	464	293	796	2158	174	2	394	24	425	212		205		685
	517	4509	384	2158	183	6	411	11		58		618		
		893	283		172	7		49						
		844	234			263								
		455												
N =	4	7	6	4	5	6	4	5	3	4	2	4	2	3

DRY SEASON N = 54

Genotypes	LW		LR		IND		DLW		DLR		LWR		LRW	
	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows	Gilts	Sows
	104	3033	795	1863	92	182	457	27	98	38	367	74	66	681
	844	3469	797	764	3	173	85	184	97	249	613	75	68	376
	865	453	764	797	4	174	661	557	126	226	995	706	197	914
	158	453	547	357	914			26		49			62	
	401	70x		16										
				726										
N =	5	5	4	6	4	3	3	4	4	3	3	3	4	3

COMPUTATION OF SS FOR AOV

$$C = \frac{(\Sigma x)^2}{N}$$

Between Seasons $= \frac{(\Sigma Dry)^2}{54} + \frac{(\Sigma Wet)^2}{59} - C$

" Breeds $= \frac{(\Sigma LW)^2}{21} + \frac{(\Sigma LR)^2}{20} + \frac{(\Sigma IND)^2}{18} + \frac{(\Sigma DLW)^2}{16} + \frac{(\Sigma DLR)^2}{14} + \frac{(\Sigma LWR)^2}{12} + \frac{(\Sigma LRW)^2}{12} - \text{Season}$

" Age $= \frac{(\Sigma sow)^2}{60} + \frac{(\Sigma gilts)^2}{53} - \text{Breed}$

week. Appendix Table 5.1 gives the detailed individual milk production over the entire lactation period.

The dams and piglets were also weighed on the 56th day of lactation to estimate the weaning weight and weight gained by the piglets and weight lost by the sows. To make sure that feeding of both the dam and the litter remained the same regular checks were made on the feed samples by analysis.

5.3 Results and Discussion

5.3.1 Milk Yield

The mean yield of milk, standard deviation (SD) and coefficient of variation (CV) for the different genotypes of the pigs are shown in Table 5.2. Individual weekly weighings are listed in Appendix Table 5.11.

There is clear evidence from the tables (Appendix Table 5.111) that more milk was produced during the wet season namely 133.64 kg as compared to 122.85 kg in the dry season. And within the breeds sows produced more milk than the gilts with 135.14 kg as against 120.94 kg respectively.

Between the breeds (Table 5.2), the Duroc sired crosses produced the largest volume of milk with 148.32 and 153.21 kg for the DLW and DLR respectively while the indigenous breed produced the least 73.99 kg. The exotic purebreds produced amounts very close to each other, 137.68 and 133.35 kg respectively. One of the reciprocal crosses, the LR.LW, showed an improvement in amount of milk produced over the purebreds. It might be due to heterotic effect or better feed utilization for milk production, better nicking quality of these two genotypes and mothering ability when the Large White represents the dam (LW genotype).

Table 5.2 TOTAL MEAN MILK PRODUCTION FOR SEVEN DIFFERENT GENOTYPES (kg).

Genotype	N	Mean	SD	CV %
LW	21	137.68	42.20	30.65
LR	20	133.35	44.18	33.13
IND	18	73.99[a]	17.51	23.67
D.LW	16	148.32	34.02	22.94
D.LR	14	153.21	39.65	25.88
LW.LR	12	129.18	33.31	25.79
LR.LW	12	144.69	39.36	27.21
Level of Significance		**		

LW = Large White
LR = Landrace
IND = Indigenous;
D.LW = Duroc x Large White
D.LR = Duroc x Landrace
LW.LR = Large White x Landrace
LR.LW = Landrace x Large White cross breds, the boar is always given first.

a = mean with superscript differs significantly from the others.

** $P<0.01$

The multiple range test (Appendix Table 5.IVa) however indicated no significant difference between the production of the exotic purebreds (LW and LR) the Duroc sired crosses (D.LW and D.LR) and the reciprocal Large White-Landrace crosses. However all the genotypic groups were significantly different from the indigenous genotype.

In sows most studies indicate that milk yield increases up to the third lactation and possibly to the fifth or sixth (Schmidt and Lauprecht, 1926; Wells et al., 1940; Smith, 1952a and Berge and Indrebo, 1953). An increase in milk production of the sows compared with that of the gilts is much in agreement with reports of previous workers. The case of the Landrace sows is however an exception and might be due essentially to the lower litter production of the sows.

Milk production or composition in first lactations have been reported to be independent of nutritional status of the animal. Gilts are clearly able to maintain milk output while losing body weight on a low energy and protein level (McPherson et al., 1969; Mahan et al., 1971 and O'Grady, 1971) but in second and third lactations milk yields were significantly poorer suggesting that sows could not continue as in the first lactation to maintain milk yield through the use of body reserves.

A highly significant ($P<0.01$) difference was found between the breeds in milk produced throughout the entire lactation period (Table 5.3). Significant age and season effect was also detected ($P<0.05$).

The most striking is that this finding is in agreement with the result of the work first reported on the milk yield of the Large White and Landrace sows of the same herd by Williams (1971). But the values were lower than those reported in the temperate countries. While Williams (1971) obtained 142.1 kg yield for the Large White and 119.9 kg

Table 5.3 ANALYSIS OF VARIANCE - MILK (MEAN SQUARES)

Sources of Variation	Df	Milk Yield	Milk/Piglet	Efficiency of Utilization	Milk/$W^{0.73}$
Season (s)	1	3277.92*	14.71	0.07	1.81*
Breed w/s (b)	12	9212.76**	156.36*	16.37*	0.39
Age w/b (a)	14	3250.72*	69.04	5.12	2.60*
Within variables	85	1228.17	50.09	5.23	0.90

* $P < 0.05$
**$P < 0.01$

for the Landrace, Olofson and Larson (1930) and Berber et al. (1955) got values almost twice the amount reported here, 230.6 and 348.4 kg respectively for the Yorkshire breed and 318.21 kg for the Landrace sow. A lower value of 107.1 kg was however reported for the Duroc sow, 120.8 kg for the Poland China and 136.2 kg for the Poland x Landrace cross in a six-week lactation (Allen et al., 1959).

5.3.2 Lactation Trend

The amount of milk produced weekly during the eight week lactation by the different breeds are shown in Table 5.4.

Although there were differences in amount of milk produced the trend was remarkably similar. The Large White, Indigenous, the Large White sired and the Duroc sired crosses attained peak production in the third week of lactation, the Landrace and Landrace sired crosses however peaked during the fourth week (Fig. 5.1).

There were genotypic differences in the degree of persistency. It is more abrupt in the exotic than in indigenous. While the exotic pure and crossbreds declined sharply after their peak, the indigenous pigs had a relatively gradual decline up to the fifth week of lactation

TABLE 5.4

LACTATIONAL TRENDS IN MILK PRODUCTION: MILK PRODUCED PER LITTER (Kg) BY SEVEN GENOTYPES

Period of lactation (wks)	LW	LR	N IMD	D.LW	D.LR	LW.LR	LR.LW
N	21	20	18	16	14	12	12
1	15.64	14.21	7.87	15.79	18.17	12.26	16.18
2	22.27	22.75	10.38	21.07	25.07	19.53	19.44
3	25.79	25.06	12.30	26.91	29.07	22.54	21.66
4	23.89	25.96	11.61	25.28	26.66	19.82	25.14
5	16.64	16.26	11.48	20.87	19.80	18.15	22.43
6	13.03	11.44	8.82	15.79	13.08	14.93	16.58
7	11.08	10.46	7.09	12.55	12.25	11.39	12.84
8	9.39	8.26	5.88	11.50	9.09	10.56	10.41
Mean Litter Size	6.93 ± 0.41	5.08 ± 0.42	4.83 ± 0.46	7.97 ± 0.42	7.68 ± 0.39	6.96 ± 0.86	7.04 ± 0.90
Mean Milk Yield	137.68 ± 9.21	133.35 ± 9.89	73.99 ± 4.13	148.32 ± 8.51	153.21 ± 10.61	129.18 ± 9.63	144.64 ± 11.38

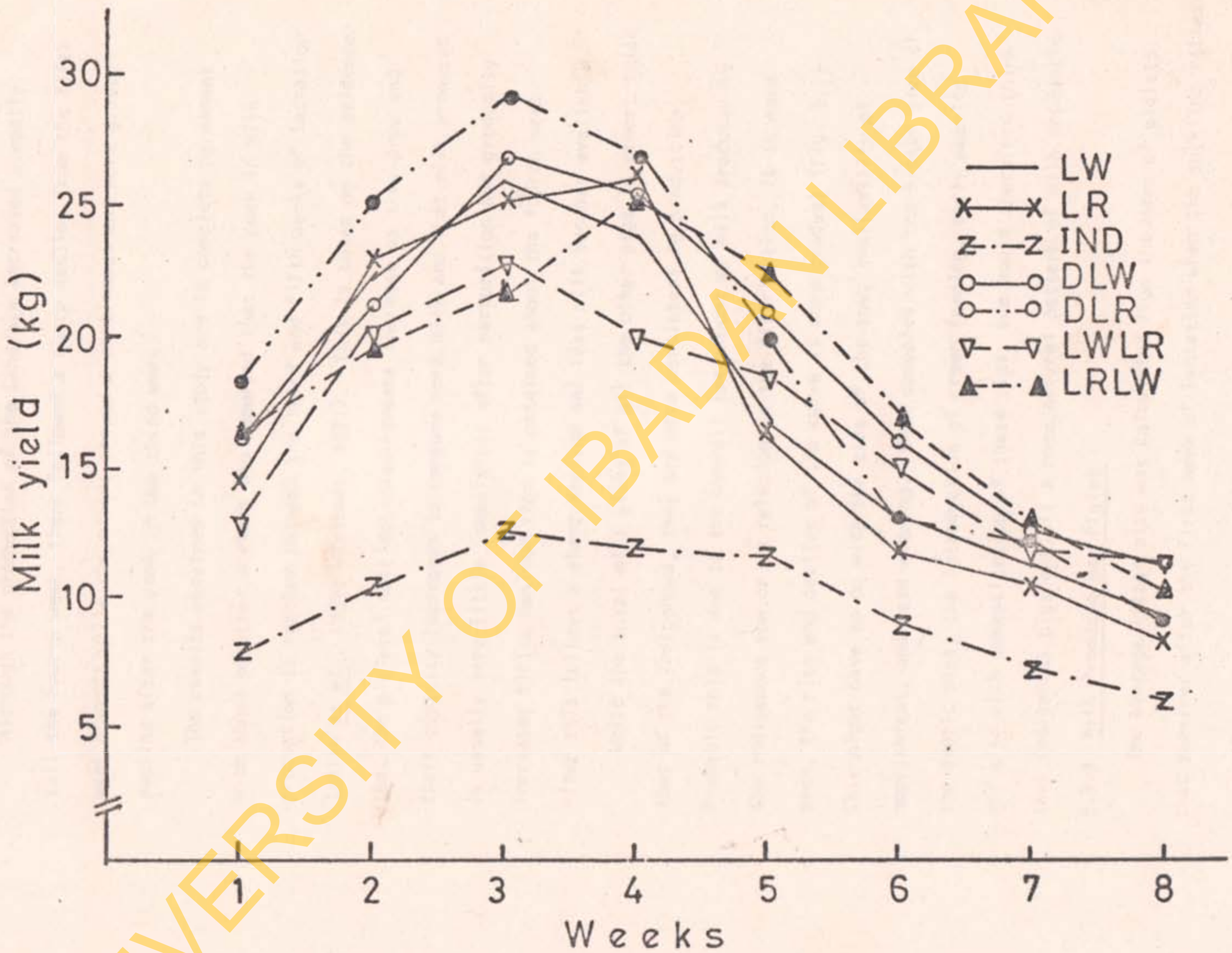

Fig. 5.1 Lactation trend in milk production.

after which a further drop was experienced.

Although the production of the Landrace increased steadily till the fourth week, there followed a sharp decline from the fifth week onwards while the others showed a continuous and more gradual decline after the peak in the third week.

The results obtained in this study are in complete agreement with those of other workers who reported that the peak in milk production is reached between the third and fifth weeks of lactation (Allen et al., 1959; Williams, 1971). This is based on the evidence that the piglets' nutrient requirements increase as they grow and their capacity increases to consume more milk and that milk produced is usually very little immediately after parturition but gradually increases till a maximum flow is obtained about the fourth week. After this follows a sharp decline and less milk becomes available.

While the total milk yield of all the other pigs is almost twice that of the indigenous, they are more persistent in production. Probably this is due to the overall low amount of milk produced by the indigenous sow or in relation to the distribution, it is more even, the rise and decline of the curve is more gradual (Fig. 5.1). This might have to do with the size of the sow, availability of nourishment, and late weaning. When compared with the bigger size of the exotic pigs, the introduction of creep feeding, early weaning and also with domestication of these pigs, one would therefore think that indigenous pigs exhibit a more natural pattern of milk production.

5.3.3 Milk Produced per Piglet

The average litter size was calculated from the mean of piglets that survived after the first week of lactation when the suckling reflex has been established and the total number of pigs weaned in the eighth week. Total milk produced divided by the average litter size was taken as the average milk produced per pigling.

The amount of milk produced per piglet is quite remarkable in that the actual differences were not too large (Table 5.5).

Table 5.5 AVERAGE MILK PRODUCED PER PIGLING (kg)

Genotype	N	Mean L.S.	Mean Production	SD	CV (%)
LW	21	6.93 ± .41	20.14	4.39	21.80
LR	20	5.08 ± .42	27.71[ab]	7.28	26.27
IND	18	4.83 ± .46	16.01[ac]	4.34	27.11
D.LW	16	7.97 ± .42	18.75[b]	2.98	15.89
D.LR	14	7.68 ± .39	20.34	5.05	24.83
LW.LR	12	6.96 ± .86	24.85[c]	13.91	55.98
LR.LW	12	7.04 ± .90	24.35	10.49	43.10

* $P < 0.05$

a - c = means with same superscript differ significantly from each other.

Even though the indigenous was significantly different from all other breeds in the total amount of milk produced, most especially from the D.LW, when the litter size was taken into account (Appendix Table IVb) milk intake was only different from that of the LR and LW.LR. There was no difference in the piglet intake of the indigenous and the D.LW although they were both different from the Landrace.

Despite the fact that the coefficient of variation was less variable among the genotypes it is most surprising that the LW.LR reciprocal crosses varied twice as much as that of the LW, LR pure breds which might be due to variability of litter size of these pigs.

Analysis of variance showed no significant age and seasonal effect on the volume of milk ingested by the individual piglets as previously indicated in Table 5.3. However there were still significant breed differences ($P<0.05$).

Seasonal variation indicated a higher intake during the wet season (22.06 kg compared to 21.34 kg) per piglet in the dry season (Appendix Table V). On age basis, there was virtually no difference between the genotypes. Average production per piglet was 21.48 as against 21.92 kg in the gilts and sows respectively.

A significant breed difference was found between the indigenous, the Landrace (LR) and the Large White sired crossbreds (LWR) while the Duroc sired Large White (D.LW) was significantly different only from the Landrace (Fig. 5.2).

A good indicator of milk production and a major variable affecting milk yield in the sow is litter size. Measured on the intake of milk per litter, piglets from breeds with smaller litter sizes with the exception of the indigenous pigs had more milk ingested than those that nursed larger litters. This is in the order of LR > LW.LR > LR.LW > D.LR > LW > D.LW with average litter sizes of 5.1, 6.5, 7.0, 7.7, 6.9 and 8.0 pigs and average total milk intake of 27.7, 24.9, 24.3, 20.1 and 18.8 kg respectively. This is supported by the work of Bonsma and Oosthuizen (1935); Schneider (1934); and Lalevic (1953) who gave total yields of 130, 173 and 233 kg for 6, 7-9 and

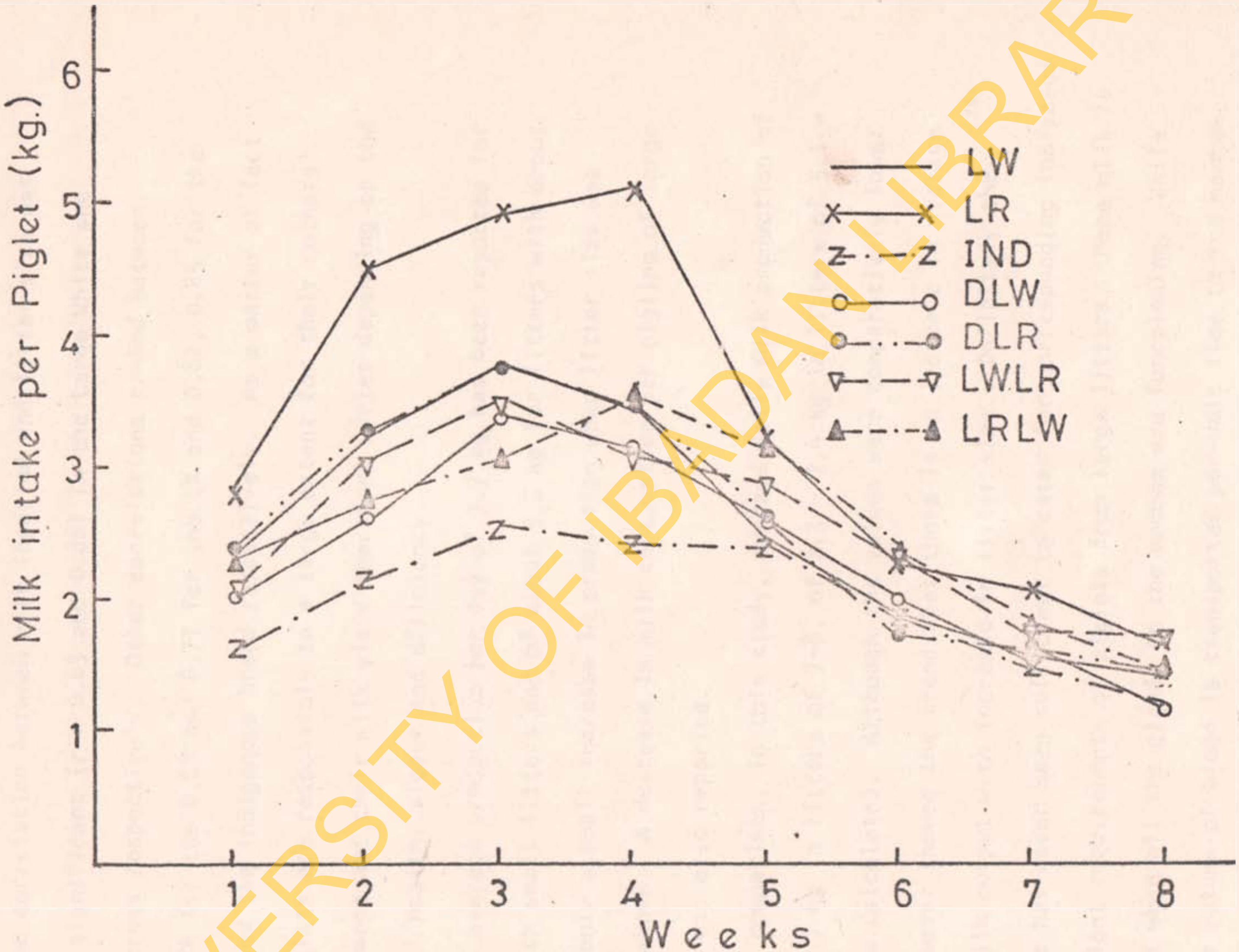

Fig. 5.2 Average milk yield per Piglet - 8 weeks.

10 or more piglets per litter and average intake of 23, 22 and 19 kg milk per pigling.

The correlation between milk ingested and litter size was highly significant (r = 0.63 and 0.86) in the Large White and LR.LW cross respectively. Other correlations ranked between, r = 0.74 for the D.LR and 0.77 for the LR and 0.82, 0.85 for the LW.LR and the indigenous breed respectively. As a matter of fact the piglets are responsible to a large extent for their mothers' performance and their milk yield therefore varies depending on the piglets' health, vigour and efficiency.

An average production per day of 3.7 kg has been reported for sows with small litters and of about 9.2 kg for litters with about 12 and only a small increase in production when litter size was 13 and above. A decrease in milk consumption per pigling of large litters was also reported.

In comparison, in this study, average daily milk production of 2.5 - 2.7 kg in litters of 7-8, of 2.3 - 2.4 kg in litters of 5.1 - 6.5 were calculated. Although the values were comparatively lower they however showed the trend that there is an increase in average daily milk output with increase in litter size. Definitely the increase has never been sufficient to cater for corresponding increases in nutrient requirements of piglets from large litters. More milk is secreted when all the glands on the mammae are functioning. While the same volume of blood is transported per unit time to the mammae, individual glands will extract less nutrient from the blood varying in proportion to the number of functioning glands of the mammae.

The lower the number of functioning glands (unused glands regress) the greater the volume of milk and milk nutrients per gland and so is the availability to the piglets. As piglets from smaller litters get nutrients in excess of their requirement especially during the early part of lactation, piglets from large litters compete heavily for the available nutrient.

5.3.4 Efficiency of Milk Utilization

Efficiency of milk utilization was calculated as the amount of milk ingested per kilogram of liveweight gained by the litter (Table 5.6).

Table 5.6 MILK INTAKE (kg) PER UNIT WEIGHT GAINED BY THE LITTER

Genotype	N	Average Intake	SD	CV (%)
LW	21	4.79	1.26	26.30
LR	20	4.66	1.74	37.34
IND	18	5.93^{abc}	3.38	57.00
D.LW	16	3.52	1.30	36.93
D.LR	14	2.97^{a}	0.53	17.85
LW.LR	12	2.92^{b}	0.67	22.95
LR.LW	12	3.14^{c}	0.93	29.62

* $p<0.05$

a-c = means with similar superscript differ significantly from each other.

Between the breeds, the most efficient utilizer of milk for growth are the offspring of crossbred dams in the order of LW.LR, D.LR, LR.LW and D.LW with values of 2.92, 2.97, 3.14 and 3.52 and no significant difference among them.

The least efficient of the breeds are the piglets suckled by indigenous sows followed by the two exotic purebreds with values of 5.93, 4.79 and 4.66 kg per kilogram liveweight gained for the indigenous, Large White and Landrace offspring respectively. There was no significant age and season effect on the efficiency of milk utilization by the piglets but a significant breed difference ($P<0.05$) Table 5.3). A closer look at the data brought out the fact that piglets from sows exhibited a slight increase in efficiency of milk utilization of 3.95 kg per kilogram litter weight gain as opposed to 4.46 kg in piglets suckled by gilts (Appendix Table 5.VI). There was only a slight improvement in efficiency during the dry season of 4.09 kg as against 4.30 kg per kilogram gain in the wet season. As a matter of fact the difference might be due to experimental error.

Significant breed differences were observed only between the indigenous and the D.LR and the Large White-Landrace reciprocal crosses (Appendix Table IVc).

As much as the milk production of the dams in this study is very low compared with reports of workers in the temperate countries, the efficiency with which the milk was utilized for growth was much in agreement. Legagneur and Fevrier (1960) estimated that 4 kg of milk are required to produce 1 kg of liveweight in suckling pigs. Allen et al. (1959) found significant differences between breeds and crosses as to the milk required per kilogram gain. The purebred dams were comparatively in line with values of 4.79, 4.66 and 5.93 for LW, LR and Indigenous breeds in this study compared to 4.5, 5.9, 4.8 and 5.2 for the Durocs, Polands, Landrace and Landrace x Poland crosses. The crossbreds in this study were far more efficient with values of 2.92 - 3.52 kg per kilogram weight gained. A higher milk production in the crossbred dams can be due to the fact that better mothering ability, milk production and efficiency of feed utilization are usually the objectives of the breeder for cross-breeding. This is borne out by the increase in average litter size of the crossbred dams resulting in higher milk production and a faster rate of growth in the piglets with a higher efficiency of milk utilization.

The lesser milk produced by the indigenous sows is not at all surprising, they have smaller litters of smaller pigs at birth. They themselves are of lower mature weight with relatively small udders and teats compared to the other breeds. However once the few piglets have established their teat the unused ones dry up, in most cases the piglets don't switch between teats.

A general increase in milk production with parity was observed in all breeds except for the Landrace. This might be connected with the average litter size and pig birth weights. Since milk production is a measure of the vigour and size of the litters a more vigorous litter will do a complete job of evacuating the milk from all functioning teats. Secondly, more of the glands will be in production when litter size is large since milk is produced in the gland itself from precursors transported there by the blood.

When the significant seasonal effect observed in amount of milk ingested by the piglets is taken into consideration a general increase in total yield during the cooler season of the year was contradictory to the findings of Lalevic (1953) and Gill and Thompson (1956) who had no significant differences in milk consumption of the piglets in winter when on a heated or unheated floor but obtained a high efficiency of milk utilization at the same time. However they too observed that more milk is produced during spring farrow (136.34 kg) than in autumn (131.39 kg). Heitman and Hughes (1949) measuring the effects of temperature variation upon growth rate and feed efficiency of swine found that optimum temperatures for pigs between 32 and 64 kg was 21°C. From the meterclogical data, the average temperatures during the period of this experiment were 17.2°C minimum and 26.7°C maximum and 72% mean relative humidity which indicated that the animals might have suffered little or not from climatic stress and therefore the depressive effect on milk production is not as pronounced.

5.3.5 Outstanding Producers

Despite the overall low milk yield, outstanding individual high producers are found. They were more frequent among the crossbreds (Table 5.7) which indicates some heterotic effect of crossbreeding. Among the crossbreds, producers of 200-231 kg are found with litter sizes of 8-11 and average daily production of 3-4 kg of milk and probably some 3-6 kg of milk per day at peak production coupled with a higher degree of persistency.

Conversely, that persistent producers among the purebred exotic dams are those with small litter sizes (2-6 pigs) and low milk production over a prolonged period is not surprising.

TABLE 5.7

OUTSTANDING PRODUCERS AND THEIR PERSISTENCY

Genotype	Animal	Litter Size	Peak Attained (wks)	Milk Yield (kg)	Yield/ day (kg)	Yield at Peak (kg)
LW	104	6.0	4-6	120.82	2.16	3.78
	453	8.0	3-7	214.11	3.82	5.54
	455	4.0	6	68.14	1.22	1.64
LR	357	2.0	5	66.88	1.19	1.42
	16	3.0	5	119.84	2.19	2.92
LND	92	5.0	6	79.61	1.42	2.02
	3	2.0	6	48.00	0.88	1.22
	182	5.0	6	84.40	1.51	1.88
	174	4.0	5	73.24	1.31	1.85
	173	3.0	5	65.66	1.17	1.90
	183	1.5	5	36.25	0.65	1.04
	172	3.0	5	53.47	0.95	1.49
	1	7.5	5	92.38	1.65	2.29
	11	6.5	5	64.80	1.16	1.73
	263	6.0	5	86.24	1.54	2.12
D.LW	557	8.5	5	139.86	2.50	4.08
	15	9.0	6	201.32	3.60	5.00
	49	11.0	7	211.96	3.79	4.55
D.LR	425	8.0	5	220.04	3.93	5.22
LR.LW	197	4.5	5	98.00	1.75	2.94
	62	2.0	5	93.70	1.70	2.80
	306	10.5	5	180.56	3.22	3.87
	376	9.0	5	142.52	2.55	3.76
	58	8.5	7	177.60	3.17	3.79
	66	3.0	5	116.48	2.08	2.96
	685	10.0	5	230.72	4.12	5.60
LW.LR	618	10.0	6	209.40	3.74	4.67
	74	9.5	5	130.62	2.33	3.74

Persistent producers are classified as those that are able to produce at fairly high level and maintaining this level for a prolonged period of time. Fetuga (1972) claimed that when litter sizes are small, the piglets are better reared and the sows are not run down before the eighth week of lactation just as was found for the purebreds here. Similarly the persistency of the indigenous pigs is associated with smaller size of the litter reared and their adaptation to their own environment. About 56% of them were able to maintain their supposed maximum level of production till the fifth and some till the sixth week of lactation.

5.3.6 Milk Constituents

For determination of milk constituents 82 animals were used, 12 from each of the purebreds and the Duroc sired crosses and 11 from the reciprocal Large White-Landrace crosses.

Milk samples were collected after oxytocin injection (Chapter IV) on consecutive days 7, 8; 14, 15; 21, 22; 28, 29; 35, 36; 42, 43 and 56, 57 of lactation from all functioning teats of the mammae.

The dam's udder was thoroughly washed with clean water, dried and the sow groomed. She was then injected with 2 mls of the pitocin oxytocic solution intramuscularly into the neck muscle behind the ear. In most cases within the first six hours of farrow no injection was given to induce letdown of the colostrum. The piglets were mainly taken off the udder and colostrum samples were collected without necessarily disturbing the resting sow, from all teats of the mammae by manual hand stripping.

Both gilts and sows in the dry and wet periods of the two years were used. The chemical analysis of milk samples was done on the same day they were sampled to avoid changes in composition due to storage or aging. Individual milk constituents over the entire lactation period are given in Appendix Table 5.VII. and Appendix Table 6.IX for the first and last four weeks.

5.3.7 Milk Analysis and Computation of Yield of Milk Nutrients

The chemical analysis of the weekly milk samples were carried out as outlined in Chapter IV.

The yield of milk nutrients expressed in kilograms for milk fat, protein, total solids, lactose and minerals were computed from figures of percentage chemical composition of the total yield of milk of each sow.

5.3.7.1 Colostrum

Average contents of total solids, fat, solids-non-fat, protein, lactose, ash, calcium and phosphorus in percent are given in Table 5.8 for each of the seven genotypes studied.

High colostral values were reported for all constituents studied except for calcium and phosphorus in comparison to later milk. Total solids content ranged from 19.62% in the LW to 22.84% in the indigenous pigs with an overall mean of 21.89%. Fat and protein also ranged from 7.28 and 6.97 to 9.22 and 7.53 for the two genotypes respectively. Values recorded for solids-non-fat were 12.35 - 14.71 for the LW and the DLR while lactose had 4.66 - 6.02 in the LW and DLW respectively with averages of 13.79 and 5.18. Ash and the minerals percentage were virtually less variable with values of 0.71 - 0.83 and a mean 0.77 for ash, 0.19 - 0.29 and a mean 0.24 for calcium and 0.11 - 0.17 with a mean 0.14 for phosphorus.

TABLE 5.8

MEAN OF COLOSTRUM CONSTITUENTS IN % FOR SEVEN GENOTYPES OF SWINE

Determinations	All + SE	LW	LR	IND	D.LW	D.LR	LW.LR	LR.LW
No. of Samples	82	12	12	12	12	12	11	11
Total Solids*	21.89 ± 0.85	19.62 ± 0.82^{abc}	21.87 ± 0.57	22.84 ± 0.11^{a}	21.92 ± 0.99	22.66 ± 0.54^{b}	21.72 ± 0.55	22.65 ± 0.71^{c}
Fat	7.98 ± 0.45	7.28 ± 0.34	8.10 ± 0.40	9.22 ± 0.56	7.63 ± 0.46	7.94 ± 0.67	7.6 ± 0.65	8.01 ± 0.90
S.n.f.**	13.79 ± 0.53	12.35 ± 0.55^{ab}	13.83 ± 0.50	13.62 ± 0.65	14.12 ± 0.57	14.71 ± 0.81^{b}	13.94 ± 0.47	14.69 ± 0.66^{a}
Protein*	7.91 ± 0.35	6.97 ± 0.34^{a}	7.81 ± 0.44	7.53 ± 0.48	7.38 ± 0.33	8.70 ± 0.71	8.16 ± 0.44	8.93 ± 0.67^{a}
Lactose*	5.18 ± 0.10	4.66 ± 0.31^{a}	5.28 ± 0.28	5.31 ± 0.29	6.02 + 0.29^{ab}	5.18 ± 0.24	4.85 ± 0.22	4.75 ± 0.17^{b}
Ash	0.77 ± 0.10	7.13 ± 0.09^{a}	0.71 ± 0.11^{b}	0.78 + 0.08	0.75 ± 0.09	0.83 ± 0.09	0.81 ± 0.05	0.83 ± 0,15^{ab}
Calcium	0.24 ± 0.001	0.21 ± 0.018	0.19 ± 0.02	0.27 ± 0.027	0.23 ± 0.027	0.22 ± 0.027	0.28 ± 0.033	0.29 ± 0.027
Phosphorus*	0.14 ± .002	0.11 ± 0.010	0.13 ± 0.012	0.17 ± 0.016	0.16 ± 0.010	0.14 ± 0.010	0.15 ± 0.011	0.12 ± 0.009

* = Significant $P < 0.05$.

** = Highly significant $P < 0.01$.

a-c = Means followed by similar letters are significantly different from each other.

Analysis of variance (Table 5.9) showed no appreciable age differences in all constituents studied. There was a significant breed difference in some major constituents ($P<0.05$) for total solids, protein, lactose, and also phosphorus. Highly significant breed effects ($P<0.01$) occurred in solids-not-fat content (Appendix Table 5.VIII). In all cases the colostrum of the Large White was significantly different from that of the other pigs. The indigenous sow which produced the lowest volume of milk ranked highest in all the major constituents. There was a significant difference in the total solids content in the colostrum of the indigenous with 22.84 ± 1.10 compared to 19.62 ± 0.82 of the Large White, all other breeds fall within the range, D.LR followed by LW.LR, D.LW, LR and LW.LR respectively.

Although the indigenous breed recorded the highest value of fat with $9.22 \pm 0.56\%$ it was not significantly different from the content in the other sows. The lowest fat content was in the colostrum of the D.LW cross. The LW had the lowest s.n.f. content of 12.35 ± 0.55 followed by the indigenous with $13.62 \pm 0.65\%$, and both were significantly different from the D.LR and LR.LW crosses while the other values were in between.

The only significant difference in protein percent was that between the LW and the LR.LW crosses of 6.97 ± 0.34 compared to $8.93 \pm 0.67\%$, the other genotypes ranked within this range.

A significant difference in lactose content was recorded between the D.LW crosses with 6.02 ± 0.29 and the $4.66 \pm 0.31\%$ produced by the LW and 4.75 ± 0.17 of the LW.LR crosses. All the other breeds ranked in between.

TABLE 5.9

ANALYSIS OF VARIANCE FOR COLOSTRUM (MEAN SQUARE) CONSTITUENTS, %

Source of Variation	d.f	Total Solids	Fat	Protein	Ash	Solids not fat	Lactose	Ca	P
Season (s)	1	26.689*	38.864**	7.517*	0.002	0.464	3.420**	0.046**	0.001
Breed w/s (b)	12	17.602*	6.487	8.644*	0.015	11.912**	1.688*	0.012	0.004*
Age w/b (a)	14	5.423	0.355	1.248	0.011	3.289	1.067	0.007	0.001
Between variables	54	5.783	3.815	2.397	0.010	3.423	0.662	0.007	0.002

* $P < 0.05$

** $P < 0.01$

There were however no significant differences in ash and calcium percentages among breeds and the only significant difference for phosphorus was between the indigenous and the LW purebreds with 0.17 ± 0.16 as against 0.11 ± 0.01%. Highly significant seasonal variations were found in fat, lactose and calcium contents ($P<0.01$) and significant differences in protein and total solids ($P<0.05$).

Although there was no significant difference in the solids-not-fat (snf), phosphorus (P) and ash contents, there tended to be a slight increase in snf and P contents during the wet season from 13.81 to 13.96% and 0.124 to 0.137% respectively and a slight decrease in the ash content from 0.778 to 0.769% in the wet season (Appendix Table 5.IX).

The protein, total solids and solids-not-fat reported in this study were lower than figures of these constituents in colostrum reported in the temperate countries. While Bowland et al. (1949b), Pond et al. (1962), Salmon-Legagneur and Guéguen (1962), Vetra (1965), Earle and Stevenson (1965), Ralph et al. (1971) and Fahmy (1972) reported protein values of 12-17%, total solids of 25-31% and solids-not-fat of 17-23%, the results of the constituents were within the range of 19-25% total solids, 6.1-9.7% protein and 12.2-15.3% solids-not-fat obtained by von Neuhaus (1961) and Bowland (1966).

The ash, fat, lactose and phosphorus contents were in agreement with values of 0.77 - 0.80% ash, 0.55 - 0.81% fat, 2.0 - 7.5% lactose and 0.08 - 0.12% phosphorus reported by von Neuhaus (1961), Salmon-Legagneur and Guéguen (1962), Earle and Stevenson (1965), Miller (1967), Ralph et al. (1971) and Fahmy (1972). However the calcium content was higher than 0.049% obtained by Fahmy (1972) and 0.05 - 0.08% reported by von Neuhaus (1961), Miller (1967), and Ralph et al. (1971).

The colostrum is composed of milk constituents that were secreted by the mammary gland prior to parturition, the constituents are therefore dependent on the pregnancy feed intake. Stothers and Milne (1964) and Holden et al. (1968) found that high protein diets during gestation affect similarly high protein in colostrum and milk during the first week after farrow. Although an adverse effect was not reported even with protein values as low as 8% but it is possible that some nutrients other than amino acids might be limiting in the diets resulting in lower protein and total solids output of the colostrum. This might then be one of the factors responsible for lower protein output in the colostrum of these pigs.

5.3.7.2 Milk Composition

The mean composition of the milk samples from the various dam genotypes are contained in Table 5.10. Although the contents did not appear to differ widely but from analysis of variance and the multiple range test it was revealed that the means vary significantly.

Total solids ranged from 19-22% in the LW and the indigenous pigs, the fat 7-9%, protein 6-7%, ash 0.73 - 0.86%, and phosphorus 0.14 - 0.20% in the LW and indigenous breeds respectively; the others falling in between the range. Lactose content varied from 4.9 - 5.6% in the LW and D.LW, solids-not-fat 12 - 13% in the LW and the LW.LR and calcium 0.27 - 0.35% in the LR and the D.LW sows.

The analysis of variance, Table 5.11, shows a highly significant breed, season and age effect and variations due to stages of lactation

TABLE 5.10

COMPOSITION OF MILK OF SEVEN GENOTYPES - %

Genotype	N	TS	Fat	Protein	Ash	Lactose	Snf	Ca	P
LW	96	18.82^{a}	7.18^{b}	6.09	0.73^{b}	4.93	11.72	.285	.139^{a}
LR	96	19.30^{b}	7.15^{a}	6.16	0.73^{a}	5.35	11.25	.268^{a}	.147^{d}
IND	96	22.09^{ab}	9.09^{ab}	7.00	0.86^{abc}	5.14	12.98	.320	.196^{abcdef}
D.LW	96	20.09	7.63	6.22	0.75^{c}	5.56	12.52	.349^{a}	.151^{e}
D.LR	96	20.97	8.33	6.42	0.80	5.45	12.66	.308	.146^{c}
LW.LR	88	20.97	8.33	7.01	0.84	5.16	13.27	.307	.160^{f}
LR.LW	88	20.61	8.30	6.74	0.83	5.13	12.90	.298	.141^{b}
		**	**		**			**	**

a-f = mean with similar superscripts are significantly different from each other.

** = P<0.01

TABLE 5.11

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR MILK CONTENT BY SEASON, GENOTYPE, AGE AND STAGE OF LACTATION.

Sources of Variation.	Df	TS	Fat	Protein	Ash	Lactose	Snf	Ca	P
Season(s)	1	39.95**	9.64*	8.32**	0.002	0.299	13.24*	0.029*	0.0114**
Breed w/s (b)	12	79.57**	31.63**	7.31	0.129**	4.37	14.31	0.045**	0.023**
Age w/b (a)	14	11.79**	5.33*	2.47	0.028	2.78*	5.76	0.008	0.0025**
Stage of lactation w/a	196	7.05**	3.64	0.843	0.016**	0.799	2.24	0.010**	0.0055**
Within samples	432	5.14	2.59	0.865	0.008	0.916	2.39	0.005	0.008

* = $P < 0.05$

** = $P < 0.01$

on almost all the constituents studied in the milk, while this was most pronounced in the total solids, fat and phosphorus contents ($P<0.01$). Protein and solids-not-fat (snf) contents varied between the ages and with season but remained almost constant throughout the entire lactation. The ash followed the same trend but with no seasonal variation while lactose remained virtually constant throughout the lactation. Calcium was unaffected by age.

Breed differences (Table 5.10) were significant (Appendix Table 5.X) between the indigenous and the purebred exotics for total solids and fat content and the D.LW crossbreds for the ash content while only D.LW crosses and the LR purebreds were significantly different from each other in calcium content. The indigenous sows differ mainly in the phosphorus secreted from that of all the other breeds. However no differences were observed in the lactose, protein and solids-not-fat secretion.

Variation in milk constituents by week of the entire lactation is recorded in Table 5.12 and shown in Fig. 5.3 - 10.

Percentage total solids differed significantly ($P<0.01$) between the colostrum and milk contents as it is between the first two weeks and the last week of lactation (Appendix Table 5.XI). After the initial fall of total solids in the colostrum there tended to be a gradual increase in all breeds from a mean value of 21.89% to a lowest value of 19.19% in the second week and high value of 22.02% in the eighth week of lactation (Fig. 5.3).

Fat content followed a similar trend from 7.98% in colostrum dropping to a minimum of 7.13% in the first week followed by a gradual

TABLE 5.12

MEAN WEEKLY MILK COMPOSITION, %
(Genotype combined)

Constituents	Colostrum	1	2	3	4	5	6	7	8
Total solids **	21.89	19.22^{b}	19.19^{a}	19.70	19.95	20.56	21.25	21.36	22.02^{ab}
Fat	7.98	7.13	7.20	7.60	7.90	8.09	8.56	8.58	8.08
Snf	13.79	11.96	12.00	12.22	12.19	12.44	12.70	12.77	13.21
Protein	7.91	6.11	6.20	6.30	6.34	6.33	6.58	6.64	6.94
Lactose	5.18	5.21	5.09	5.25	5.08	5.34	5.35	5.30	5.36
Ash **	0.774	0.72^{ad}	0.73^{be}	0.73^{cf}	0.76	0.79	0.81	0.85^{def}	0.86^{abc}
Calcium **	0.240	0.250^{ac}	0.262^{b}	0.292	0.294	0.319	0.328	0.352^{ab}	0.344^{c}
Phosphorus **	0.138	0.140^{a}	0.144^{c}	0.142^{b}	0.153	0.151	0.166	0.167	0.178^{abc}

a-f: mean with similar superscripts are significantly different.
** = $P < 0.01$

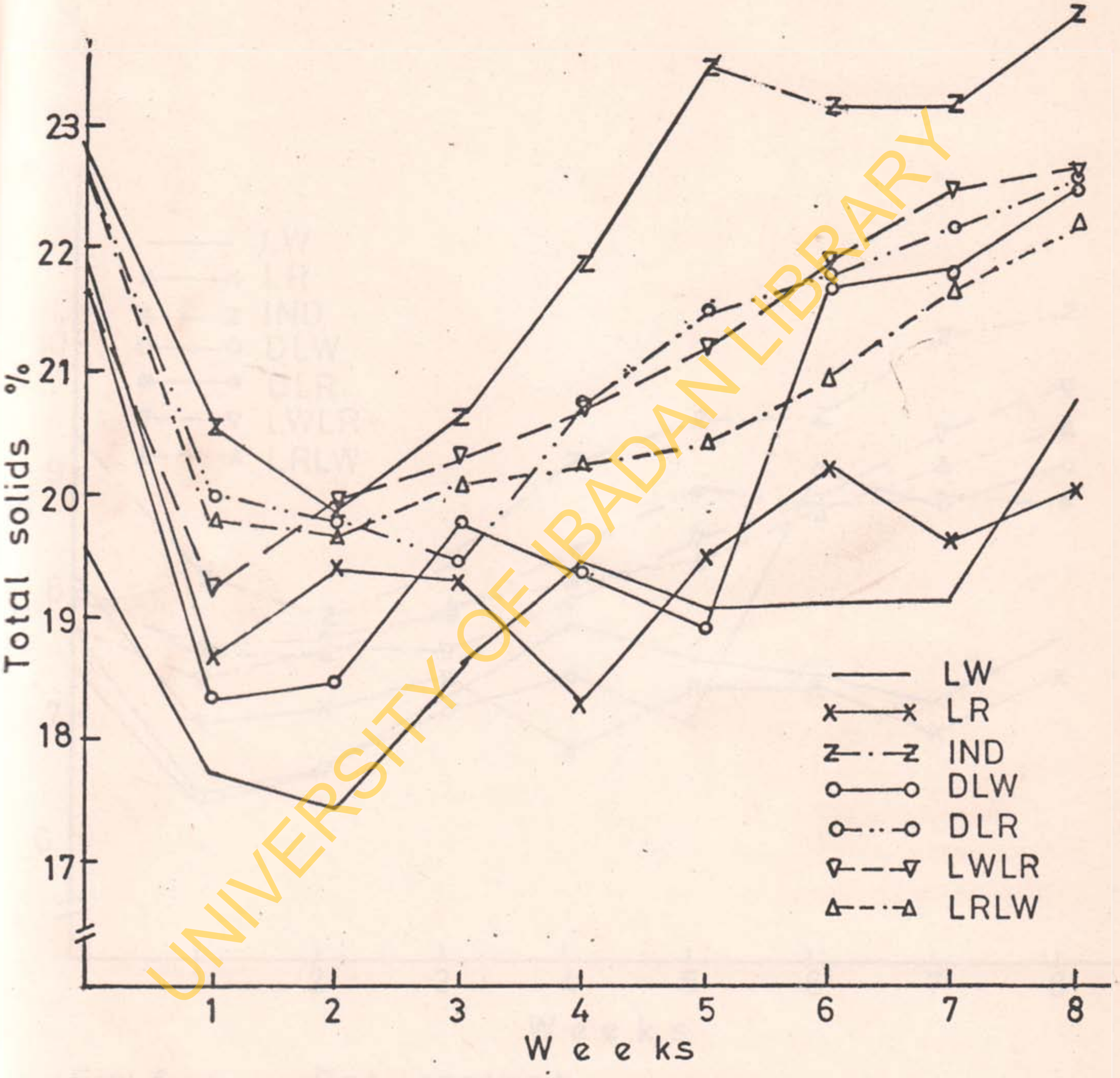

Fig. 5.3 Total solids content.

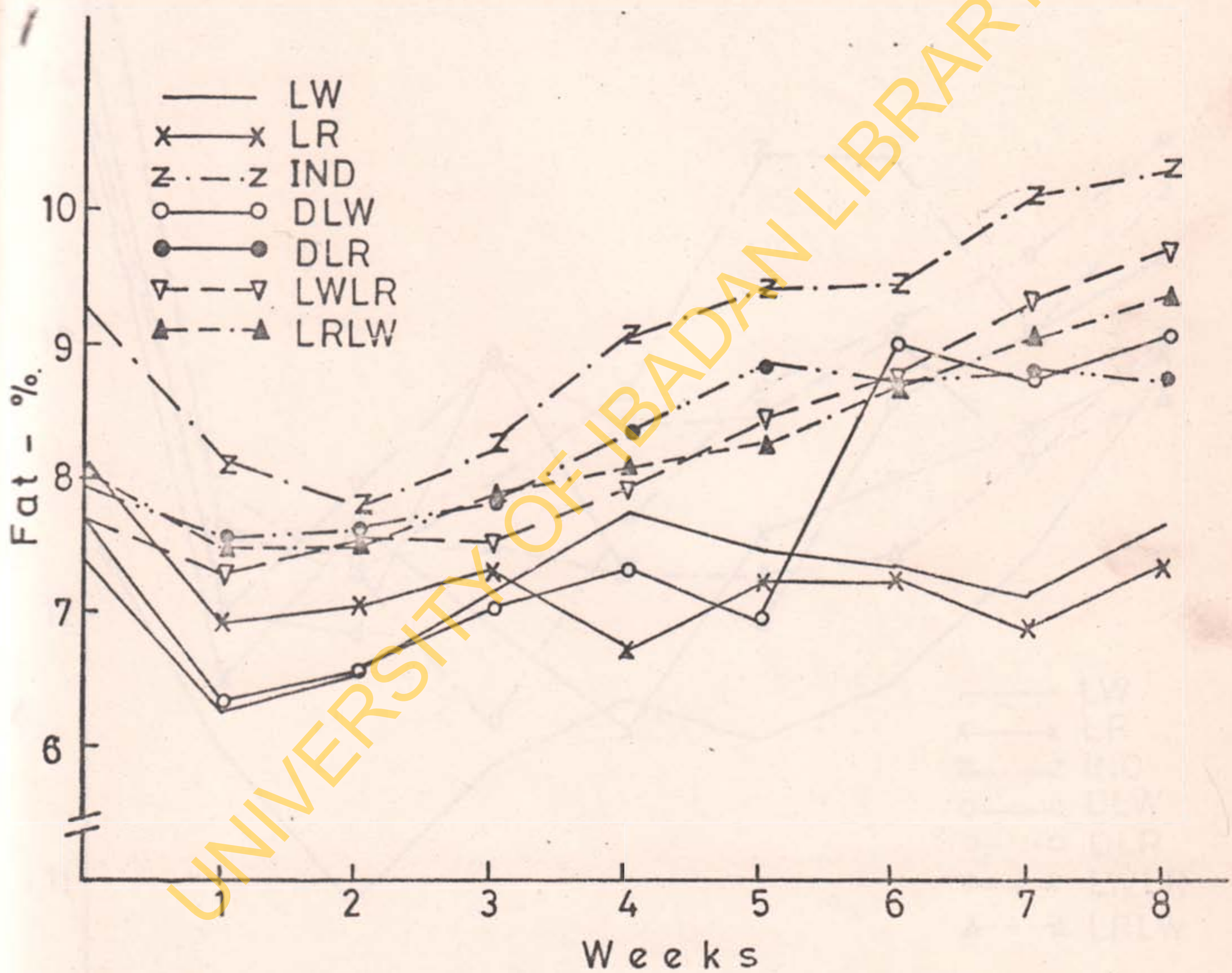

Fig. 5.4 Fat content.

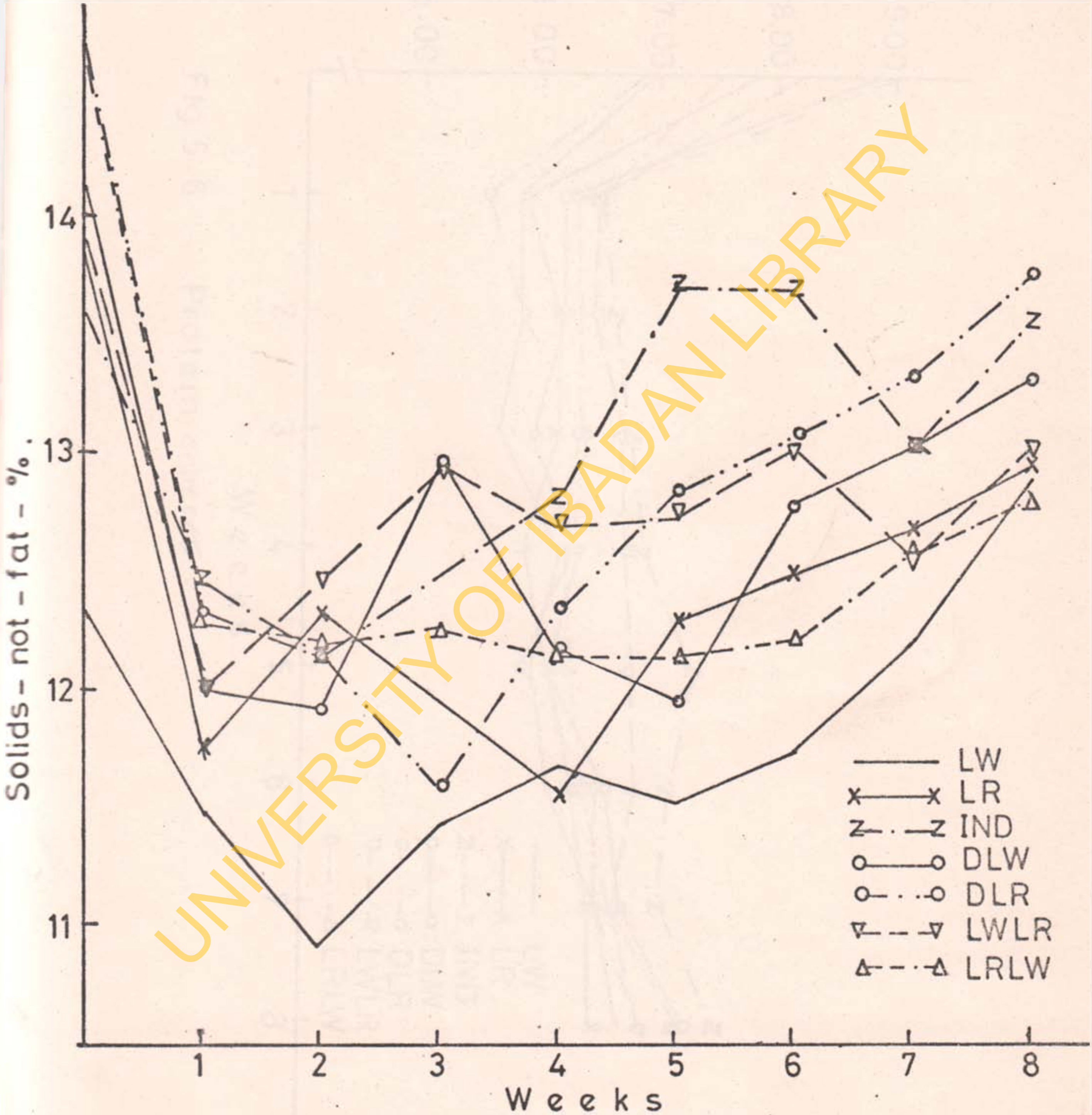

Fig. 5.5 Solids - not - Fat. content

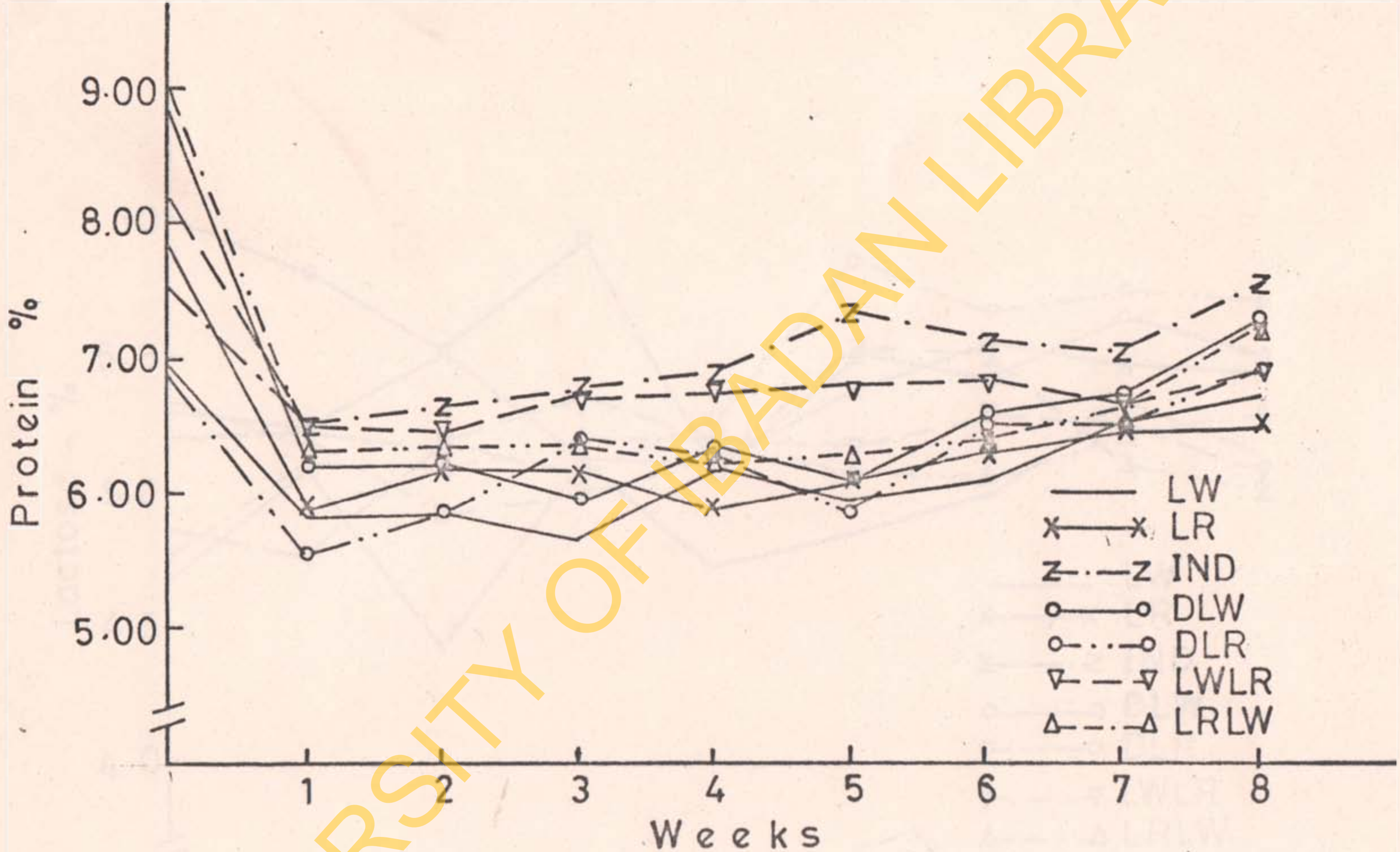

Fig. 5.6 Protein content

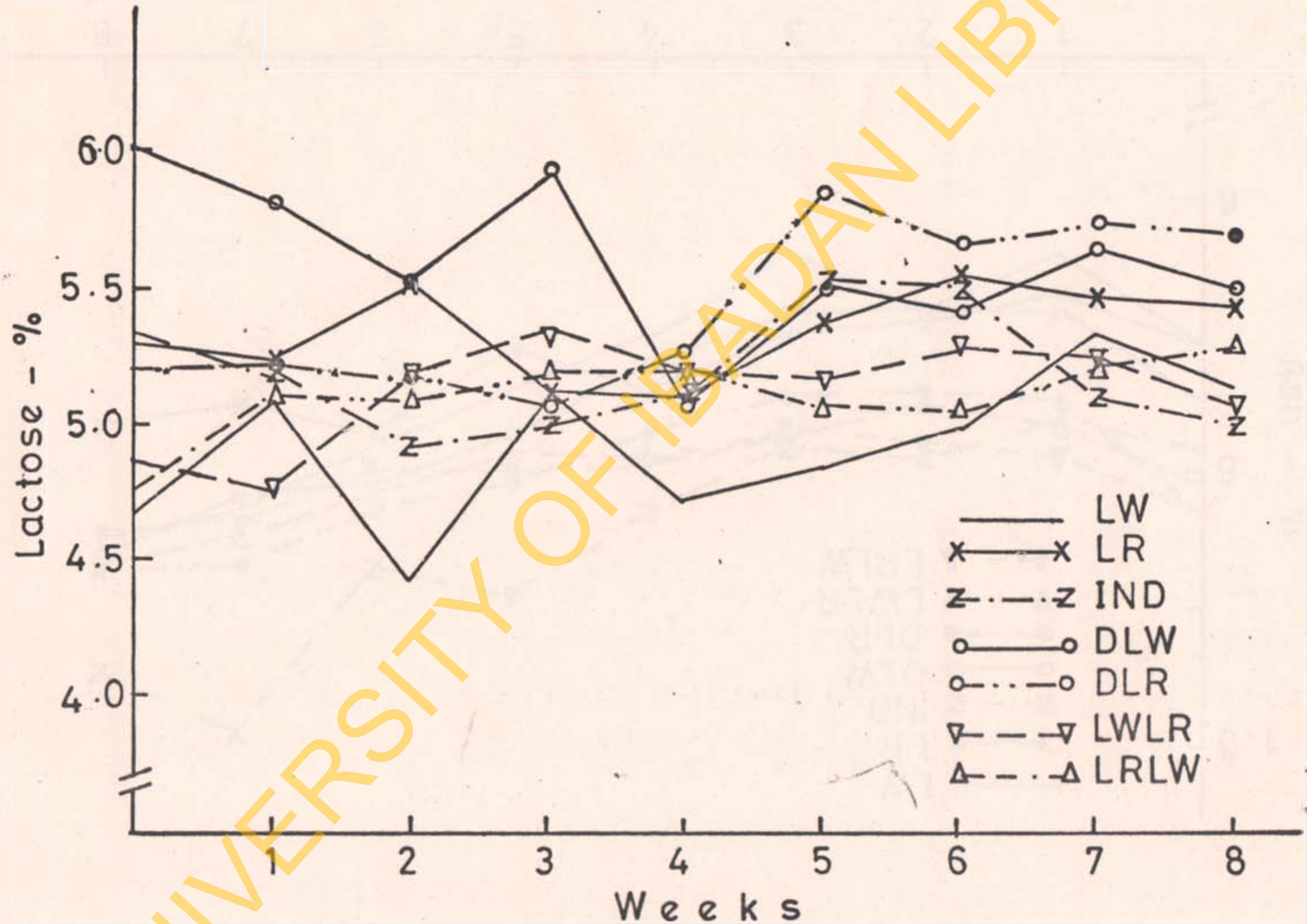

Fig. 5.7 Lactose content.

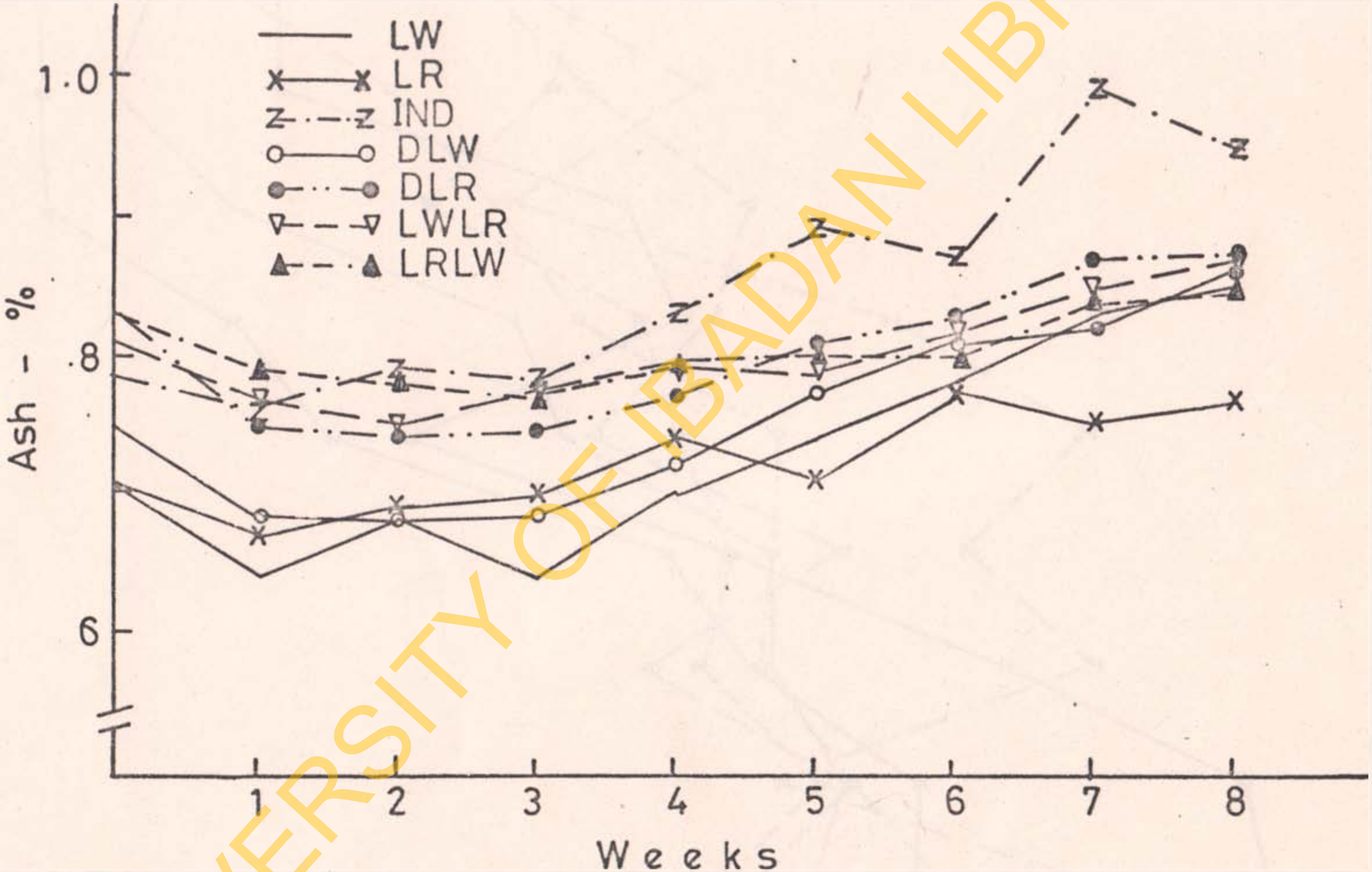

Fig. 5.8 ASH content.

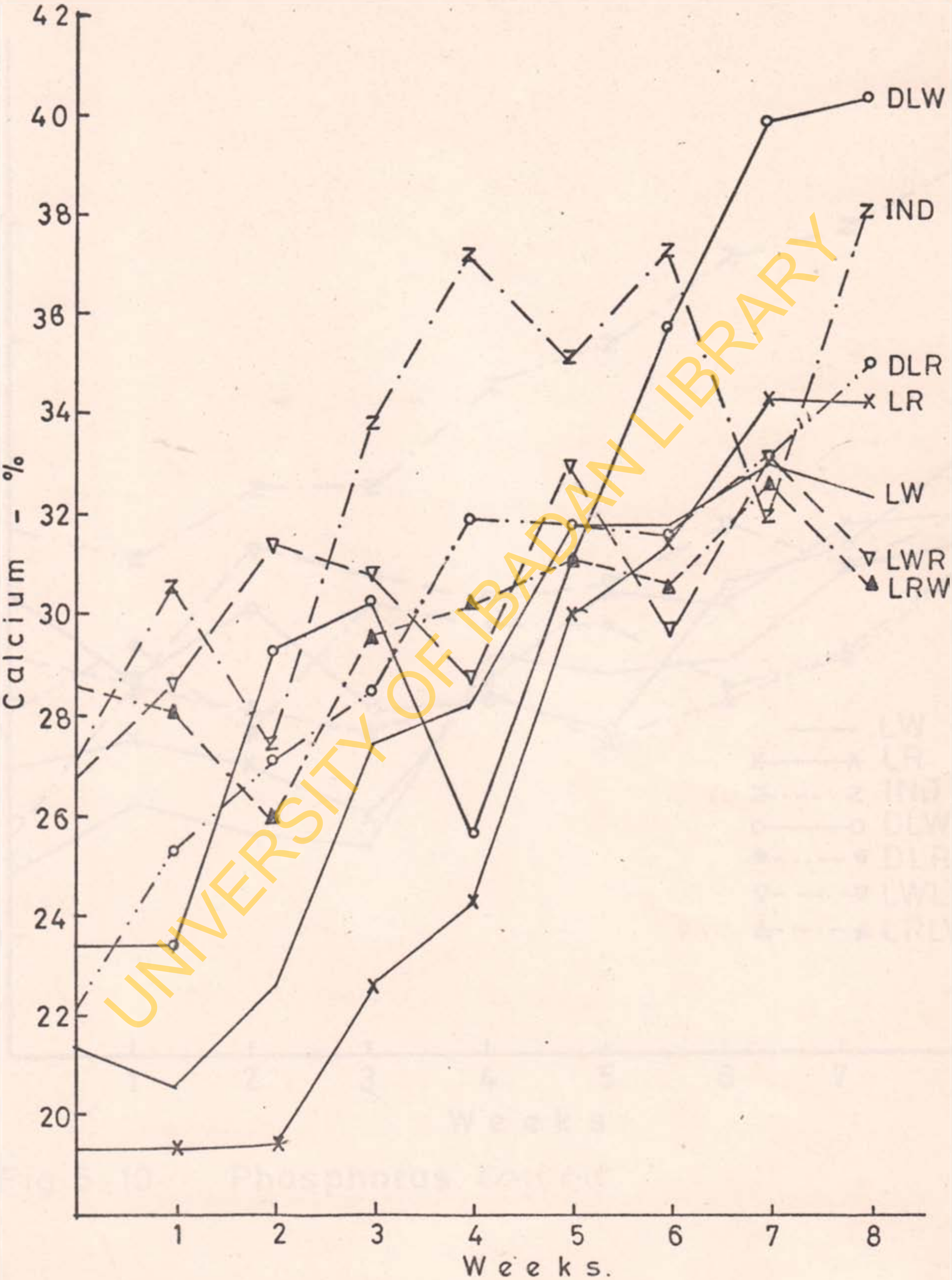

Fig. 5.9 Calcium content

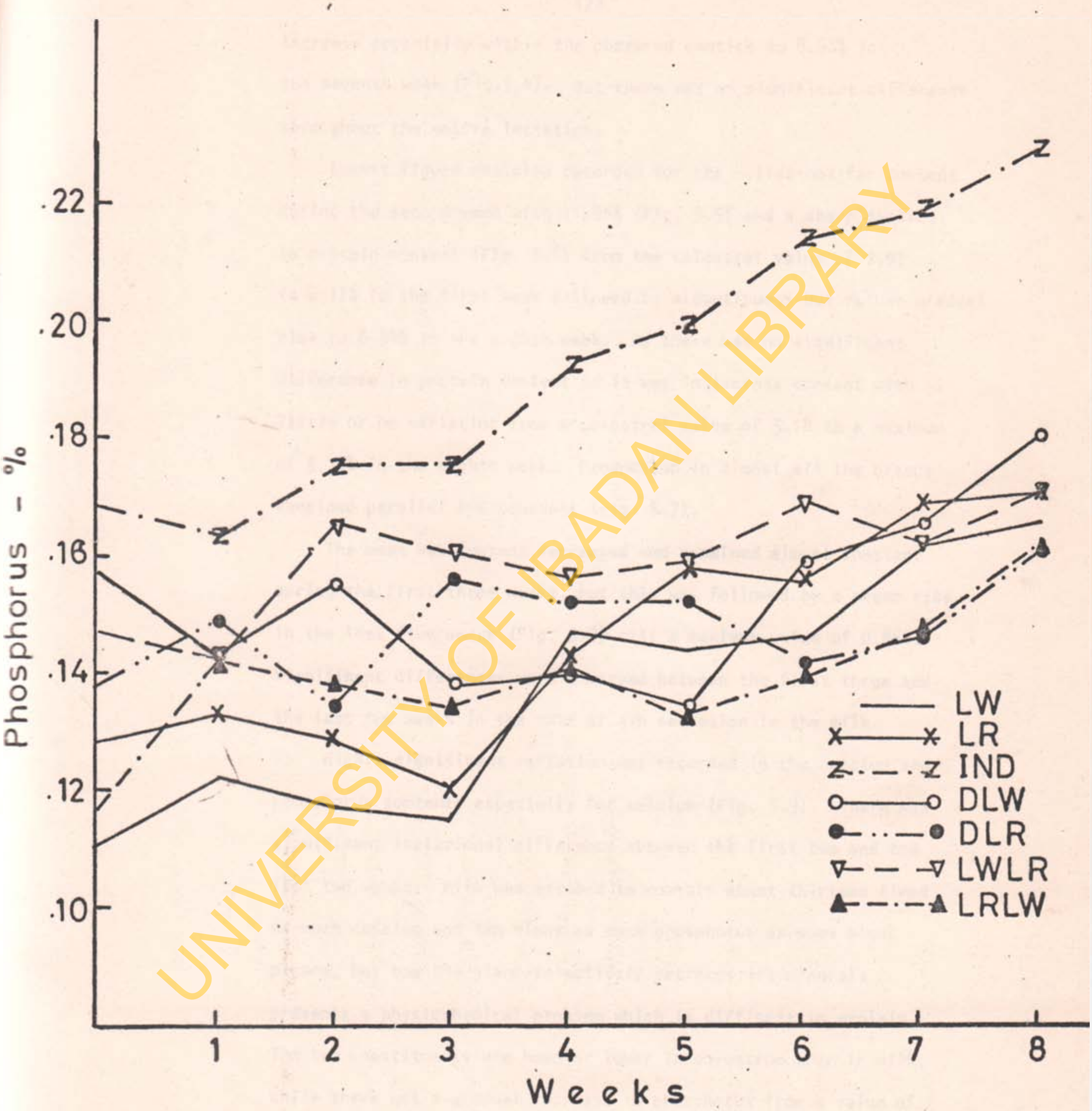

Fig. 5.10 Phosphorus. content

increase especially within the purebred exotics to 8.58% in the seventh week (Fig.5.4). But there was no significant differance throughout the entire lactation.

Lowest figure was also recorded for the solids-not-fat content during the second week with 11.96% (Fig. 5.5) and a sharp decline in protein content (Fig. 5.6) from the colostral value of 7.91 to 6.11% in the first week followed by a continuous but rather gradual rise to 6.94% in the eighth week. As there was no significant difference in protein content so it was in lactose content with little or no variation from a colostral value of 5.18 to a maximum of 5.36% in the eighth week. Production in almost all the breeds remained parallel and constant (Fig. 5.7).

The mean ash content decreased and remained almost constant during the first three weeks, but this was followed by a steep rise in the last five weeks (Fig. 5.8) till a maximum value of 0.86%. Significant differences were observed between the first three and the last two weeks in the rate of ash secretion in the milk.

Highly significant variation was recorded in the calcium and phosphorus contents especially for calcium (Fig. 5.9). There was significant lactational difference between the first two and the last two weeks. Milk was assumed to contain about thirteen times as much calcium and ten times as much phosphorus as does blood plasma, but how the gland selectively secretes its minerals presents a physiochemical problem which is difficult to explain. The two constituents are however lower in colostrum than in milk. While there was a gradual increase in phosphorus from a value of

0.14 to 0.18% in all breeds, the indigenous pigs seem to stand out from the others with a steep rise to a value of 0.24% in the eighth week (Fig. 5.10).

In almost all the constituents within the breed there was a decrease in the amount from a high colostral value till a minimum during the first or second week followed by a gradual increase except in the mineral content in which the rate of secretion increased from a low colostral value with the stage of lactation.

Seasonal Effect

Variation in colostrum and milk content with season are shown in Table 5.13.

Table 5.13 SEASONAL EFFECT ON MILK CONSTITUENTS, %

Constituents	COLOSTRUM		MILK	
	Dry	Wet	Dry	Wet
Total solids	22.46	21.29**	20.64	20.15**
Fat	8.66	7.28**	8.04	7.95*
Protein	7.61	8.22**	6.54	6.31**
Ash	0.78	0.77	0.781	0.780
Lactose	5.38	4.97**	5.27	5.23
S.n.f.	13.81	13.96	12.72	12.30
Ca	0.263	0.216**	0.312	0.298*
P	0.124	0.137	0.150	0.159**

* P<0.05

** P<0.01

For all genotypes highly significant seasonal variation in milk constituents was recorded. All constituents except phosphorus were more concentrated in the milk produced during the dry season than in the wet season. Total solids content in the milk was 20.64% in the dry season against 20.15% in the wet season. Similar trends were recorded for other constituents. Total solids, protein and phosphorus were highly significant (P<0.01) while differences in ash and lactose concentrations were not significant. It is however significant to note that with the exception of lactose, ash, calcium and phosphorus all the other components especially the protein and total solids fluctuate with season in the indigenous breed (Appendix Table 5.XII). They were more concentrated in the milk produced during the dry season.

Mean Yield of Milk Nutrients

The mean yield of milk fat, protein, lactose, ash and total solids are summarized in Table 5.14 (Appendix Table 5.XIII).

Table 5.14 MEAN TOTAL YIELD OF MILK NUTRIENTS BY GENOTYPES (kg)

Genotypes	Protein	Fat	TS	Lactose	Ash
LW	9.07^{c}	10.89^{d}	28.46^{f}	7.41^{d}	1.10^{c}
LR	8.26^{e}	9.48	25.66^{d}	6.96^{e}	0.98
IND	5.18^{abcde}	6.71^{abcd}	16.32^{abcde}	3.79^{abcde}	0.64^{abcd}
D.LW	8.80^{d}	10.97^{c}	28.76^{c}	7.97^{b}	1.08^{d}
D.LR	9.81^{a}	12.74^{a}	32.28^{af}	8.40^{a}	1.24^{a}
LW.LR	8.17	10.09	25.50^{e}	6.27	0.98
LR.LW	9.67^{b}	12.08^{b}	30.65^{b}	7.58^{c}	1.20^{b}
Level of significance	**	**	**	**	**

a-f = mean with similar superscripts differ from each other
** = P<0.01

Similar trends were observed for the fat, lactose, ash and total solids with mean values of 11.47, 7.56, 1.13 and 29.30 kg respectively for the crossbreds, 10.19, 7.19, 1.04 and 25.06 for the exotic purebreds and significantly different values of 6.71, 3.79, 0.64 and 16.32 kg yield for the indigenous breed. On daily basis (divided by 56 days), corresponding total solids yields of 576.4g - 291.4g per sow per day were obtained for the D.LR and the indigenous pigs, fat varied from 227.5 - 119.8g and protein from 175.2 - 92.5g per sow per day.

Despite the wide variation in total yields of nutrients between the exotic and the indigenous breeds average daily intake of nutrients per piglet were less variable (Table 5.15) with values ranging from 19.5 - 30.4g protein intake per piglet per day and fat from 24 - 37g in the D.LW and the LW.LR pigs respectively. Total solids varied from 67 - 96g in the indigenous and the LW.LR, while lactose was from 14.0 - 24.5g in the indigenous and the LR, and ash from 2.36 - 3.46g intake per piglet per day in the indigenous and the LR.

There were highly significant differences in daily intake of milk protein and total solids per piglet ($P<0.01$) mostly between the Landrace, the D.LW, the indigenous and LW.LR pigs while fat, lactose and ash were significantly different ($P<0.05$). While the difference was between the indigenous, D.LW and LW.LR for fat content only the indigenous and LR were significantly different in the average daily intake of lactose and ash (Appendix Table 5.XIV).

Table 5.15 MEAN DAILY NUTRIENT INTAKE/PIGLET (g)

Genotype	L.S.	Protein	Fat	T.S.	Lactose	Ash
LW	6.93	22.68	27.51	79.05	19.10	2.83
LR	5.08	29.20	33.35	95.57	24.48[a]	3.46[a]
IND	4.83	20.10	25.96	67.22[a]	14.00[a]	2.36[a]
D.LW	7.97	19.50[a]	24.04[a]	71.79	17.86	2.42
D.LR	7.68	23.30	30.34	83.74	19.52	2.88
LW.LR	6.96	30.36[a]	37.26[a]	93.17[a]	16.09	2.51
LR.LW	7.04	25.10	32.84	87.25	19.23	3.04
Level of significance		**	*	**	*	*

a = means with similar superscripts differ

* = $P<0.05$

** = $P<0.01$

It is however worthwhile to note that despite all these variabilities in yield of protein and fat of the indigenous sows from the others average daily yield of protein and fat on dry matter basis bore no significant difference between the genotypes. The Indigenous pigs secreted the highest amount of fat with 412g compared to 370g of the Landrace per dry matter per day while protein yields were 306 - 334g in the D.LW and the LR pigs per dry matter per day (Table 5.16).

Comparing the results obtained in this study with those of other workers who have explored lactation trends of milk constituents, the greatest difference is apparent in the fat figures. Willett and Maruyama (1946) reported a definite increase of fat content

Table 5.16 YIELD OF PROTEIN, FAT AND TOTAL SOLIDS g/sow/day AND ON DRY MATTER BASIS g/kg Dm.

Genotype	g/sow/day Protein	Fat	T.S.	g/kg Dm Protein	Fat g/kg DM
LW	162.03	196.46	508.21	323.59	381.51
LR	147.50	169.29	458.21	319.17	370.46
IND	92.50[a]	119.82[a]	291.43[a]	316.88	411.50
D.LW	157.14	195.89	514.57	309.61	379.79
D.LR	175.18	227.53	576.43	306.15	397.23
LW.LR	145.89	180.18	455.36	334.29	397.23
LR.LW	172.62	215.71	547.32	327.02	402.72
Level of significance	**	**	**		

** = $P < 0.01$

a = mean with similar superscript differs significantly.

Yield g/kg DM = $\frac{100}{\% \text{ T.S.}} \times$ % Nutrient.

with advancing lactation whereas Braude et al. (1947), Bowland et al. (1949) and Perrin (1954) show an initial increase followed by an appreciable decrease as lactation advances. In the present work the third week is the most critical period in which for all constituents studied except ash, lactose, calcium and phosphorus there is a decline from a high colostral value to a minimum during the second or third week followed by a gradual increase till the eighth week.

Comparing the milk of the sow with the milk of other mammals it must be emphasized that in the case of the sow, the change in composition of her milk has been observed only during the course of a 56 day lactation period at the end of which milk flow is suddenly stopped (by weaning the piglets). In many sows the milk production is still quite high. It might be that the high fat yield in the milk produced by the animals in this study as lactation progresses might be connected with the sharp decline in milk production after the peak in the third or fourth week in most breeds. There might not have been such a sudden decrease in the animals studied by other workers.

The protein and total solids content of milk obtained in the study were higher than the 4.9 - 6.0% and 18-19.8% respectively obtained by Bowland et al.(1949b), Pond et al. (1962), von Neuhaus (1961), Earle and Stevenson (1965), Vetra (1965), Miller (1967), Salmon-Legagneur and Guéguen (1962), Ralph et al. (1971) and Fahmy (1972), but within the range of 19.6 - 22% obtained by Perrin (1955.)

Perrin (1954) showed considerable variation from day to day especially during the first three weeks of lactation. While the average values support the trend mentioned earlier the fluctuations were taken care of by preparing composite samples for each sow from two milk samples within the week.

Among the few reports in which milk constituents of more than one breed were compared, Heidebrecht et al. (1951) found no consistent differences between the Hampshire, Duroc and Chester White breeds, but observed considerable individual variation within breeds. Unfortunately most of the studies on milk constituents in swine were carried out on very limited numbers of animals which makes the detection of any real breed differences difficult. The present study showed that genotype and breed differences in milk and colostrum composition actually do exist. This is confirmed by the work of Egesimba (1974). His levels of milk constituents of the indigenous breed were strikingly higher than that of other breeds, but were closely followed by that of the crossbreds while the purebreds were much lower in all constituents studied. This is also reflected in reports by Allen and Lasley (1960), Smith (1959) and Fahmy (1972) in which highly significant ($P<0.01$) breed differences were observed.

The low yield of milk nutrients might be connected with the relatively lower yield of milk output. Daily yield of milk protein on dry matter basis was higher than the amount obtained per kilogram dry matter according to Blaxter (1961), Lucas and Lodge (1961). They extrapolated daily nutrient production and obtained protein yields of about 275g per kilogram dry matter per day compared to the high value of 306-334g obtained in this investigation.

5.3.8 <u>Milk Yield and Body Size</u>

The relationship of body size and milk yield are shown in Table 5.17 for each genotype and age of dam.

Table 5.17 MILK PRODUCED PER UNIT METABOLIC SIZE (kg).

Genotype	LW	LR	IND	D.LW	D.LR	LW.LR	LR.LW
Gilts	4.35	3.98	3.63	3.63	3.68	3.08	3.44
Sows	3.23	3.38	4.13	4.75	4.80	4.02	4.55
Average	3.71	3.68	3.88	4.26	4.24	3.63	3.99 ns

ns = not significant

Average milk production per metabolic size did not differ significantly by breed. The values ranged from 3.63 in the LW.LR to 4.26 in the D.LW even the indigenous breed with low production figures ranked fourth on the scale of production per unit metabolic size and even higher than the purebred LW and LR. However seasonal and parity variations were significantly different ($P<0.05$) with values of 3.76 kg (Table 5.3) (page 140) during the dry season and 4.02 kg during the wet season, 3.75 kg for the gilts against 4.02 kg for the sows (Appendix Table 5.XV).

A closer look at the milk produced per metabolic body weight of the LW and LR purebreds needs further interrogation. It might be found that it is connected with the rate of weight loss by these animals with every subsequent lactation.

A highly significant positive correlation between milk yield and unit metabolic body size or body weight at farrow was observed. It varied from r = 0.56 in the LR to r = 0.79 in the indigenous pigs per unit metabolic size (Table 5.18) and from r = 0.53 to r = 0.75 in the indigenous pigs per unit body weight at farrow (Table 5.19). Regression coefficients of milk on unit metabolic body size ranged from 2.274 to 4.245 kg for every kilogram increase in metabolic size compared to 0.573 to 0.767 kg obtained per unit body weight at farrow.

It is very pertinent to note that milk production per unit metabolic size is not significantly different between the breeds (Table 5.17). Differences in the production between the ages could be inferred from the fact that metabolic rates decrease with age.

Table 5.18 PHENOTYPIC CORRELATIONS BETWEEN MILK PRODUCED AND METABOLIC BODY SIZE.

	'r'	Regression equation	Level of significance
LW	0.699	$\hat{Y} = 22.99 + 3.099x$	**
LR	0.560	$\hat{Y} = 32.28 + 2.717x$	*
IND	0.786	$\hat{Y} = 26.67 + 2.274x$	**
D.LW	0.750	$\hat{Y} = 24.54 + 4.245x$	**
D.LR	0.690	$\hat{Y} = 32.41 + 3.130x$	**
LW.LR	0.696	$\hat{Y} = 33.96 + 2.457x$	*
LR.LW	0.700	$\hat{Y} = 30.04 + 3.095x$	*

* = $P<0.05$
** = $P<0.01$

Table 5.19 PHENOTYPIC CORRELATIONS BETWEEN MILK PRODUCED AND BODY WEIGHT AT FARROW

	'r'	Regression equation	Level of significance
LW	0.681	$\hat{Y} = 31.17 + 0.767x$	**
LR	0.532	$\hat{Y} = 48.88 + 0.601x$	*
IND	0.745	$\hat{Y} = 36.73 + 0.574x$	**
D.LW	0.714	$\hat{Y} = 38.47 + 0.813x$	**
D.LR	0.639	$\hat{Y} = 50.41 + 0.696x$	*
LW.LR	0.631	$\hat{Y} = 45.87 + 0.573x$	*
LR.LW	0.664	$\hat{Y} = 46.12 + 0.704x$	**

* = $P<0.05$
** = $P<0.01$

Seasonal variation may be expected since basal metabolism is affected by various activities both within and outside the animal body which fluctuates with season.

It can be concluded that the level of milk production potential of these breeds of animals can be classified as about the same and that any method that can improve the size of the indigenous breed might as well increase the level of milk output of these animals.

A high correlation coefficient of r = 0.56 - 0.79 between milk yield and body weight confirms this statement.

Less variable milk production per unit increase in metabolic size from a low value of 2.274 in the indigenous to 4.245 in the D.LW pigs relates the importance of body weight to milk production. These observations are in line with the work of Miller and Mcgilliard (1959) in which a positive influence on yield of both weight and age was reported for cows.

Brum and Ludwick (1969) working with cows reported a low but positive correlation of r = 0.15 between milk and mature body weight of the animals. They postulated that a 25% increase in accuracy of selection for first lactation milk production might be achieved with the inclusion of precalving age body measurements in the selection index. They secondly stated that similar selection restricted to body measurements would be 80% as effective as selection based on milk records alone. In actual fact correlations of body weight to milk production in sows are scarce in the literature so the validity of the results will have to be tested further when more research is initiated along this line.

From the results there would appear to be very little to choose between the two terms body weight at farrow and metabolic body size in predicting milk production as the correlation coefficients in the equation relating them to the other variables were similar and attained similar levels of significance. Although the F values of $W^{0.73}$ kg were marginally higher than those of the body weight at farrow in relation to milk, it seems easier and more practical to use the body weight at farrow.

5.3.9 Relationship Between Milk Yield and Some Milk Constituents

Correlation and linear regression coefficients were computed for milk production and milk constituents between the first four weeks of rising milk production, the last four weeks of declining milk yield and the whole lactation period. At no instance was a significant correlation found between milk and constituents (Table 5.20) of the fresh milk samples.

Striking inferences could be drawn from the correlation of lactose, ash and total solids percentages with milk production. While lactose and total solids were negatively correlated with milk produced in all genotypes during the first four, the last four and the entire lactation, ash was positively correlated. The animals were grouped according to their genotypic differences in milk production the purebred LW and LR, the indigenous, the Duroc sired crosses and the reciprocal Large White and Landrace crosses making up four groups. The corresponding phenotypic correlations among milk constituents are presented in Table 5.21.

It has been known for a long time that fat and protein content of milk are fairly highly correlated not only within breeds during

TABLE 5.20

PHENOTYPIC CORRELATIONS BETWEEN MILK YIELD AND CONSTITUENTS - %

	1 - 4 Weeks				5 - 8 Weeks				1 - 8 Weeks			
	LW + LR	IND	DL WLR	LW x LR	LW + LR	IND	DL WLR	LW x LR	LW + LR	IND	DL WLR	LW x LR
Protein	0.08	-0.16	-0.35	0.19	-0.06	-0.05	-0.12	-0.17	-0.04	-0.04	-0.18	-0.20
Fat	0.005	-0.09	-0.11	-0.37	0.10	-0.38	0.03	-0.30	0.06	-0.23	0.02	-0.37
Lactose	-0.24	-0.03	-0.09	-0.15	-0.16	-0.23	-0.11	-0.32	-0.26	-0.14	-0.04	-0.26
Ash	0.26	0.18	0.05	0.38	0.28	0.14	0.14	0.25	0.31	0.14	0.14	0.32
Total Solids	-0.11	-0.09	-0.05	-0.27	-0.02	-0.21	-0.10	-0.44	-0.11	-0.14	-0.05	-0.38

TABLE 5.21

CORRELATION BETWEEN FRESH MILK COMPONENTS, %

	LW + LR	IND	DL WLR	LW x LR	LW + LR	IND	DL WLR	LW x LR	LW + LR	IND	DL WLR	LW x LR
Protein & Fat	-0.30	0.81**	-0.15	-0.46	-0.14	0.51*	-0.24	-0.28	-0.14	-0.78**	-0.20	-0.42
Protein & Lactose	-0.06	0.36	-0.32	-0.16	-0.34	0.56*	0.52	0.39	0.18	0.65*	0.12	0.15
Fat & T. S.	0.69**	0.90**	0.90**	0.72**	0.55*	0.94**	0.44	0.50**	0.68**	0.94**	0.74**	0.59*
Lactose & T.S.	0.78**	0.27	0.47*	0.28	0.60*	0.87**	0.57**	0.51*	0.69**	0.77**	0.41	0.39
Protein & T.S.	0.18	0.97**	0.11	0.14	0.50*	0.64*	0.58*	0.40	0.40	0.92**	0.14	0.27

* = P $<$ 0.05

** = P $<$ 0.01

the course of lactation but also between individuals and breeds. It is necessary to know the correlation of the various milk constituents in order to assess the possibilities of altering their proportion.

Table 5.21 shows positive fairly high significant correlations between fat, lactose and protein contents in relation to total solids during the first four weeks, the declining period and the entire lactation. On the other hand protein and fat were negatively correlated in the exotic pure-and crossbreds while they were positively highly correlated in the indigenous breed. Similarly is the correlation between protein and lactose in this particular breed. These constituents were negatively but not significantly correlated during the first four weeks in the exotics and positively correlated in the last four weeks and the whole lactation period.

When correlations were determined between milk yield and kilogram yield of milk nutrients, highly significant positive values were obtained in all cases (Table 5.22), r = 0.71 - 0.95 for protein, 0.60 - 0.90 for fat, 0.83 - 0.89 for lactose, 0.89 - 0.97 for ash, and 0.76 - 0.98 for total solids in the overall lactation.

Similar results were obtained between the yield of the different components within genotypes (Table 5.23).

From the correlations the low association between milk and protein of r = 0.36 during the first four weeks of lactation and similarly between protein and fat and protein and lactose of r = 0.22 and 0.28 during the same period for the purebred exotics it might be deduced that an increase in milk does not necessarily

TABLE 5.22

CORRELATION BETWEEN MILK YIELD AND KG MILK COMPONENTS

	1-4 Weeks				5-8 Weeks				1-8 Weeks			
	LW + LR	IND	DLW, LR	LW X LR	LW + LR	IND	DLW, LR	LW X LR	LW + LR	IND	DLW, LR	LW X LR
Protein	0.36	0.75	0.91	0.74	0.90	0.69	0.95	0.95	0.95	0.71	0.94	0.94
Fat	0.92	0.71	0.83	0.83	0.85	0.49	0.91	0.89	0.90	0.60	0.89	0.88
Lactose	0.80	0.94	0.89	0.93	0.72	0.65	0.82	0.89	0.85	0.85	0.83	0.89
Ash	0.98	0.90	0.94	0.95	0.98	0.84	0.97	0.96	0.97	0.89	0.96	0.95
Total Solids	0.96	0.85	0.95	0.98	0.95	0.52	0.98	0.98	0.97	0.76	0.97	0.98

TABLE 5.23

CORRELATION BETWEEN YIELD OF MILK COMPONENTS (kg)

	1-4 Weeks				5-8 Weeks				1-8 Weeks			
	LW + LR	IND	DLW, LR	LW X LR	LW + LR	IND	DLW, LR	LW X LR	LW + LR	IND	DLW, LR	LW X LR
Protein & Fat	0.22	0.93	0.69	0.71	0.79	0.85	0.84	0.82	0.82	0.89	0.81	0.78
Protein and Lactose	0.28	0.78	0.72	0.87	0.69	0.85	0.86	0.90	0.80	0.86	0.75	0.87
Fat and T.S.	0.97	0.94	0.94	0.89	0.90	0.93	0.92	0.90	0.95	0.95	0.94	0.92
Lactose and T.S.	0.91	0.85	0.92	0.94	0.78	0.90	0.86	0.91	0.89	0.91	0.88	0.91
Protein and T.S.	0.33	0.98	0.86	0.94	0.94	0.86	0.97	0.96	0.94	0.97	0.93	0.95

bring about corresponding higher increases in protein content of the milk during the earlier stages of lactation, neither was an increase in protein content associated with corresponding increases in the fat and lactose contents. However corresponding increases in total solids were observed per unit increase in kilogram yield of protein, fat and lactose of the milk. In any case they are the major constituents that make up the total solids content of the fresh milk.

5.3.10 Prediction of Milk Yield from Components

Regression equations to estimate milk yield from constituents were rather too low and so prediction from the figures will be unreliable due to the fact that correlation coefficients between milk and the components were very low (r = +0.005 to 0.38 for fat, r = -0.04 to 0.35 for protein, r = 0.03 to 0.32 for lactose r = 0.05 to 0.38 for ash and r = -0.02 to 0.44 for total solids).

Using multiple regression equations comprising the protein, fat, lactose, ash and total solids contents (Appendix Table 5.XVI) it was found that the correlation coefficients were higher and significant for the indigenous, the Duroc sired and the reciprocal Large White-Landrace crosses during the first four weeks with r = 0.21-26 for the crosses and 0.43 for the indigenous. Equations for the LW & LR purebreds, the indigenous and the reciprocal crosses were significant in the last four weeks with r = 0.24 to 0.50 while only the LW + LR purebreds and the reciprocal crosses were significant in the overall lactation with r = 0.25 to 0.33 (while r = 0.20 and above was significant for the exotics with N = 22-24, r = 0.40 and above was the level of significance for the indigenous with N = 12).

Table 5.24

RELATIONSHIP BETWEEN MILK YIELD AND FAT %

Genotype	$Y = \bar{Y} + b_x + b_2x^2 + b_3x^3$	r	% variation due to regression	SE of estimate
First four weeks of lactation.				
LW + LR	$4154.98 - 1664.96x + 224.753x^2 + 10.005x^3$	0.269	7.2	± 29.53
Local	$1336.32 - 465.410x + 54.834x^2 - 2.123x^3$	0.641*	41.06	± 8.27
Duroc crosses	$-38.595 + 60.734x - 9.140x^2 + 0.452x^3$	0.145	2.1	± 26.40
Reciprocal crosses	$3463.69 - 1238.26x + 149.695x^2 - 5.994x^3$	0.599	35.89	± 19.39
Last four weeks of lactation.				
LW + LR	$-949.873 + 393.230x - 50.23x^2 + 2.089x^3$	0.373	13.89	± 16.92
Local	$725.668 - 213.926x + 21.625x^2 - 0.717x^3$	0.694*	48.15	± 5.32
Duroc crosses	$3225.62 - 1101.44x + 126.001x^2 - 4.747x^3$	0.366	13.40	± 15.34
Reciprocal crosses	$-1178.93 + 455.414x - 53.301x^2 + 2.103x^3$	0.399	15.98	± 16.24
Total Lactation 1-8 weeks.				
LW + LR	$-532.858 + 328.834x - 51.974x^2 + 2.665x^3$	0.209	4.4	± 44.47
Local	$1666.70 - 512.259x + 53.855x^2 - 1.856x^3$	0.684*	4.70	± 12.26
Duroc crosses	$5479.38 - 1970.08x + 240.168x^2 - 9.648x^3$	0.313	9.8	± 34.34
Reciprocal crosses	$-3211.53 + 1268.70x - 156.917x^2 + 6.340x^3$	0.419	17.52	± 32.83

* $P < 0.05$

Despite the r = 0.50 for the indigenous breed, the coefficient of alienation is only = 0.14 which is too low for the accuracy expected in prediction figures.

Fitting least square polynomial regression curves on the milk yield and percent fat component (since this is one of the major constituents that is easily determined), came out with high correlation coefficients of r = 0.15 - 0.64 in the earlier four weeks of lactation, of r = 0.36 - 0.69 in later stages, and r = 0.21 - 0.68 for the overall lactation at the cubic level of regression analysis. The equations are given in Table 5.24 and the curves in Fig.5.11-5.13 as calculated from the regression equations.

5.4 Conclusions

The results of this study are of interest for the major reason that they have provided some information on the milk production and milk composition and the interaction between them. A knowledge of the chemical composition of milk of the sow at various stages of lactation is of obvious importance in studies on the nutrition and management of both the sow and her litter. Furthermore, since the secretion and letdown of milk in the sow differ markedly from similar processes in the dairy cow, it is possible that a comparison of the chemical composition of the milk of the two species may help to elucidate some aspects of the general physiology of milk formation and secretion.

The main trends in milk yield and milk composition associated with the stages of lactation in this investigation are in broad agreement with those that have been established by several investigators who have worked mainly with the exotic breeds under temperate conditions

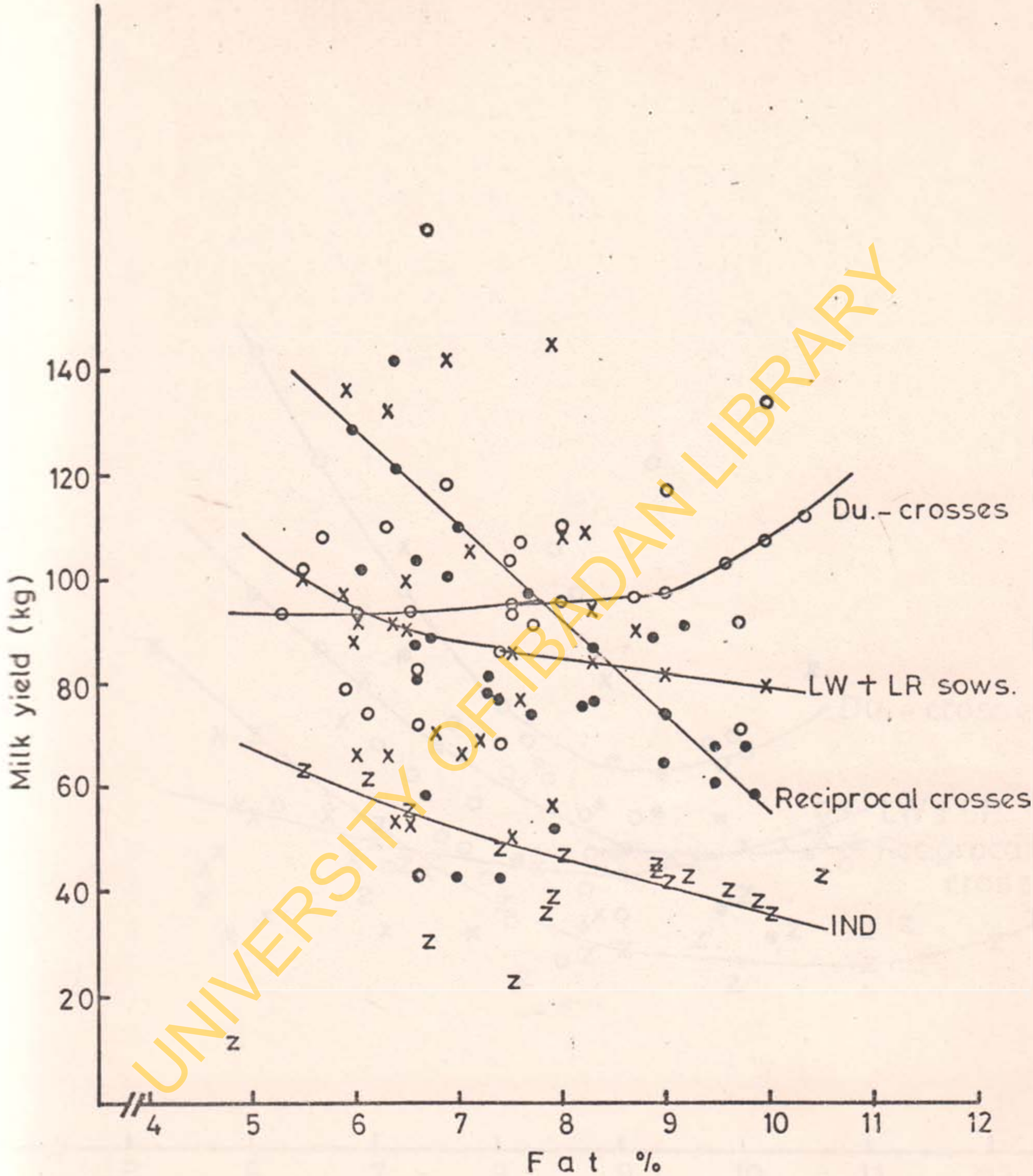

Fig. 5.11 Regression of milk yield on fat %, 1-4 weeks.

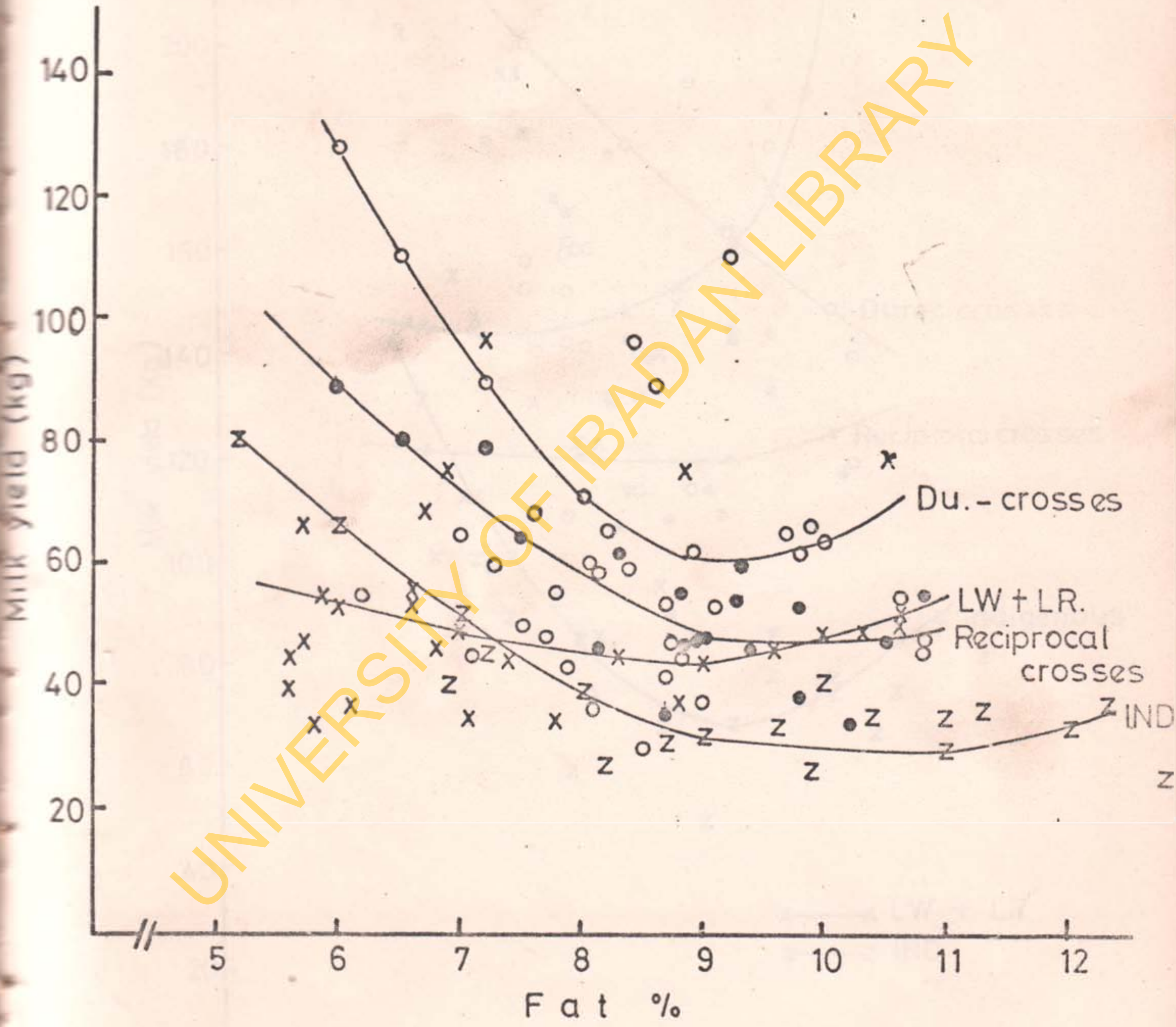

Fig. 5.12 Regression of milk yield on fat %, 5-8 weeks.

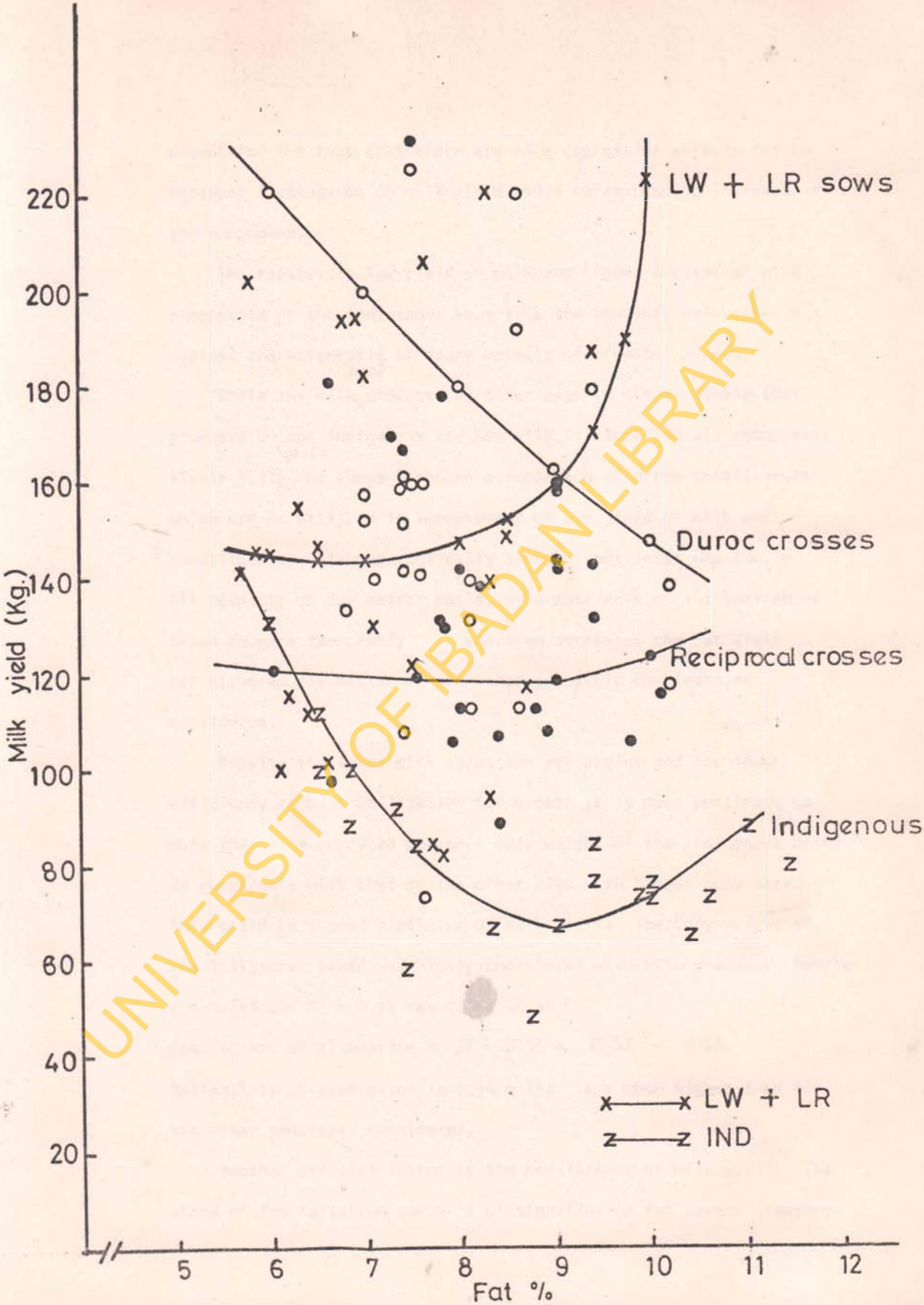

Fig. 5.13 Regression of milk yield on fat % 1-8 weeks

except for the fact that there are some depressive effects due to seasonal fluctuation on milk yield and a corresponding increase in the components.

The relatively low yield of milk and higher content of milk components of the indigenous sows like the tropical dairy cow is a typical characteristic of dairy animals of tropical origin.

While the milk yield produced by other pigs is almost double that produced by the indigenous sow her milk is richer in all components (Table 5.1D) page 160 and shows stronger association with the constituents which can be utilized in improvement of the yield of milk and constituents. Although the daily yield of nutrients was low in all respects on dry matter basis, milk nutrients of the indigenous breed compare favourably and even surpassed the fat yield per kilogram dry matter of the other genotypic combinations considered.

Despite the lower milk ingestion per piglet and the lower efficiency of milk utilization for growth it is more pertinent to note that milk produced per unit body weight of the indigenous breed is comparable with that of the other pigs with bigger body size. This could be a good predictor of milk yield. The body weight of the indigenous breed was highly correlated with milk produced, namely $r = 0.745$ and $R^2 = 0.56$ resulting in a

coefficient of alienation = $\sqrt{1 - 0.56} = \sqrt{0.44} = 0.66$.

Reliability of prediction is 0.34 = 34%, very much higher than for the other genotypes considered.

Another striking factor is the persistency of milk yield. The shape of the lactation curve is of significance for several reasons:

1. When feed is allocated according to yield, a sow having a flat lactation curve needs less feed during lactation than one with the same total yield but a steep lactation curve.

2. Very high yields at the beginning of lactation put a high physiological strain on the sow often leading to reproductive disorder or metabolic diseases, therefore a moderate initial yield combined with high persistency of lactation is preferable to a high initial yield.

3. When a moderate initial yield combined with high persistency is maintained then highly nutritious diet of high protein content 22-25% plus the addition of sweetners to stimulate feed intake is recommended from the second week of age for the piglets.

This characterises the indigenous sow into a separate class by themselves. They were more persistent in production and their lactation curve signifies a more or less natural pattern. In most cases the offspring do not readily take to creep feeding.

It might therefore be suggested that selection for higher milk production, early weaning (not less than five weeks of age) or crossbreeding are the major ways to improve the performance of the indigenous pigs.

CHAPTER VI

MILK PRODUCTION AND PERFORMANCE OF LITTERS AND DAMS IN SEVEN GENOTYPES OF SWINE.

6.1 Introduction

The weight of the litter at weaning is one of the most important economic traits in swine. It is dependent largely on the fertility of the sow and her level of milk production.

Fahmy and Bernard (1970) postulated that the ability of a sow to produce thrifty pigs at birth, referred to as prolificacy, and to raise these pigs to weaning, referred to as maternal nursing ability, are the main characters determining its productivity. Some other characters such as gestation length, number of teats, weight of dam at farrowing and weaning may have marked and direct effects. Similarly certain characters when considered individually, for example litter weight at weaning is usually regarded as the best estimate of productivity. It is a function of all pre-weaning effects, milk production of dam, environment provided for the dam and litter, thereby influencing the expression of the genetic make-up of the offspring.

In this chapter relationships of milk production as an expression of maternal provision in relation to the development of pigs and the whole litter will be examined. Attention will be drawn to the correlation(s) of milk yield of the dam to her own performance as measured by her weight (gain or loss).

Suggestions have been made as to the control of the shape of the lactation curve by feeding or management as a result of which intake of supplementary feed by the litter could be controlled. Feed intake of the litter and dams were therefore estimated to determine the efficiency of milk production and litter gain.

6.2 Materials and Methods

The same dams were used whose milk production and milk samples have been studied. Their weights were recorded shortly after farrow and when their litter was weaned. The feed intake of four sows of each genotype was recorded and that of their litter, both fed the rations described earlier (Chapter IV). Relationships between sow weights and litter weights and milk yield were investigated for the first three, the first five weeks and the entire lactation. These included individual weights of the piglets and size of litter at three, five and eight weeks.

Characters studied were litter size at birth and weaning, survival at weaning, average pig weights at birth and weaning, litter weights at birth, three, five and eight weeks, average preweaning gain, weight of dam at farrow and total weight loss during lactation.

The model used for the analysis of variance included breed, age and seasonal effects.

6.3 Results and Discussion

6.3.1 Milk Yield of Sow and Litter Performance

Table 6.1 shows means of the total milk yield of dams, number and weight of pigs at birth and weaning at eight weeks, as well as their gain in comparison with the dams' weight loss during lactation. Further included is the pigs milk utilization for the entire lactation (Appendix Table 6.1).

TABLE 6.1

MEAN MILK PRODUCTION AND LITTER PERFORMANCE

Characters	LW			LR			IND			DLW		
	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %
Milk, kg	137.68	42.20	30.65	133.39	44.18	33.13	73.99	17.51	23.67	148.32	34.02	22.94
Pigs born alive	7.33	1.96	26.74	5.15	1.84	35.73	5.28	1.90	35.98	8.44	1.97	23.34
Survival at weaning, %	91.50	10.78	11.78	92.12	13.49	14.64	85.88	19.47	22.67	90.29	11.88	1.32
No of pigs weaned	6.67	1.85	27.74	4.70	1.84	39.15	4.61	1.97	42.73	7.56	1.86	24.60
Litter birth weight (kg)	8.26	2.37	28.69	6.72	2.23	33.18	5.03	2.04	40.56	11.26	2.66	23.62
Litter weaning weight (kg)	39.65	12.87	32.46	35.77	12.12	33.88	21.31	12.89	60.49	61.68	26.95	43.69
Pig weaning weight (kg)	5.79	1.28	22.11	7.60	2.65	34.87	4.39	1.75	39.86	7.81	2.60	33.29
Pig preweaning gain (kg)	4.57	1.30	28.45	6.22	2.51	40.35	3.38	1.60	47.34	6.39	2.52	39.44
Litter preweaning gain (kg)	31.39	11.91	37.94	29.10	10.87	37.35	16.34	11.17	68.36	49.30	22.68	46.00
Weight of dam at farrow (kg)	140.96	31.34	22.23	130.61	34.50	25.07	60.46	25.92	42.87	128.34	22.98	17.91
Weight loss during lactation (kg)	28.15	13.12	46.61	33.12	22.97	67.52	22.04	12.14	55.08	33.09	14.53	43.91
Efficiency of milk utilization (kg gain/kg milk/pig)	4.79	2.03	42.38	4.89	1.74	35.58	5.93	3.38	57.00	3.32	1.30	39.16
N=		21			20			18			16	

Characters	DLR			LWR			LRW		
	Mean	SD	CV %	Mean	SD	CV %	Mean	SD	CV %
Milk, kg	133.21	39.65	25.88	129.18	33.31	25.79	144.64	39.36	27.27
Pigs born alive	8.07	2.20	27.26	6.92	3.19	46.52	7.50	3.50	46.67
Survival at weaning, %	87.76	13.21	15.05	90.97	10.80	11.87	93.04	7.86	8.45
No of pigs weaned	6.93	1.77	25/54	6.25	2.99	47.84	6.83	2.95	43.19
Litter birth weight (kg)	10.94	2.51	22.94	9.18	4.36	47.49	10.56	4.69	44.41
Litter weaning weight (kg)	57.43	22.52	39.21	57.06	25.62	44.90	63.07	30.93	49.04
Pig weaning weight (kg)	8.48	2.17	25.59	9.53	3.46	36.31	9.78	4.06	41.51
Pig preweaning gain (kg)	7.02	2.05	29.20	8.07	3.29	40.77	8.25	3.84	46.55
Litter preweaning gain (kg)	52.24	16.21	31.03	47.89	21.83	45.58	52.51	27.08	51.57
Weight of dam at farrow (kg)	138.44	32.32	23.35	133.33	31.30	23.48	138.26	35.74	25.85
Weight loss during lactation (kg)	34.20	12.40	33.97	28.77	13.09	45.91	26.31	13.74	52.22
Efficiency of milk utilization (kg gain/kg milk/pig)	2.97	0.53	17.85	3.01	0.67	22.26	3.11	0.96	30.87
N=		14			12			12	

Mean squares of the analysis of variance are presented in Table 6.2. There were highly significant breed effects ($P< 0.01$) in almost all the traits studied which included milk production, litter birth and weaning weight, individual weaning weight and preweaning weight gain of pig and litter. There was also a significant breed effect ($P< 0.05$) on the milk ingested per piglet, average litter size, individual birth weight and the efficiency of milk utilization.

There was a high significant seasonal effect on litter birth, weaning weight and weight gained and on the piglet birth and weaning weight ($P< 0.01$). The only significant seasonal effect ($P< 0.05$) observed was on pig birth weight and weight gained and milk production, but no seasonal variation in litter size, milk ingested per piglet, weight lost by the sow, and efficiency of milk utilization by the piglets could be detected.

The significance of milk yield and efficiency of milk utilization has been discussed in Chapter V.

6.3.2 Effect of Season

There was no seasonal fluctuation in the average litter size with values of 6.50 in the wet against 6.44 during the dry season (Table 6.3) and percent variation of 0.43% (Appendix Table 6.II). The litter birth weight, litter weaning weight and average preweaning weight gained during the 56 days were higher and significant during the wet season with 9.13, 51.45 and 42.34 kg respectively as compared to 7.96, 41.15 and 33.16 kg during the dry season (Table 6.3). Seasonal variation was correspondingly high in these litter variables and accounted for 34, 44 and 45% respectively of the variation in them.

TABLE 6.2

MEAN SQUARES OF ANALYSIS OF VARIANCE FOR EFFECT OF SEASON, GENOTYPE AND AGE OF DAM ON LITTER AND DAM PERFORMANCE

Source of Variation	Df	Total Milk	Milk/ Piglet	Average Litter Size	Litter birth wt	Litter weaning wt	WT. gained/ litter	Wt. gained /pig	Birth Wt./ pig	Weaning wt. pig	Wt. lost sow	Efficien-cy
Between season(s)	1	3277.72*	14.71	0.119	38.40**	2995.36**	2376.39**	33.41*	0.498*	47.79**	191.16	0.67
Among breeds (w/s)	12	9212.76**	156.36*	14.011*	49.36**	2854.19**	2177.68**	32.26**	0.210*	40.23**	426.66	16.37
" ages (w/b)	14	3250.72*	69.04	10.051*	19.64**	644.40*	467.40*	4.56	0.043	8.80	347.61	5.12
Within variables	85	1228.17	50.09	3.773	5.79	270.56	218.81	5.19	0.066	5.09	217.39	5.23

* P< 0.05

** P < 0.01

\+ Average litter size = no. of pigs after 1st week + no. of pigs after 7th week / 2

TABLE 6.3

MEAN OF MILK PRODUCTION AND LITTER PERFORMANCE ON THE BASIS OF SEASON, AGE AND GENOTYPE

Trait	Season		Age		Genotype							level of Significance
	Wet	Dry	Gilt	Sow	LW	LR	IND	D.LW	D.LR	LW.LR	LR.LW	
Milk yield (kg)	133.96	125.74*	121.32	137.76*	137.68^{b}	133.35^{e}	73.99^{abcdef}	148.32^{b}	153.21^{a}	129.18^{f}	144.64^{e}	**
"/W 0.73 (kg)	4.02	3.76	3.75	4.02*	3.71	3.68	3.88	4.26	4.24	3.63	3.99	
"/Piglet (kg)	22.06	21.34	21.48	21.92	20.10	27.71^{ab}	16.01^{abc}	18.75^{b}	20.34	24.85^{c}	24.34^{d}	*
Birth Wt/litter (kg)	9.13	7.96**	7.92	9.15**	8.26^{ci}	6.72^{be}	5.03^{adfghi}	11.25^{abc}	10.94^{de}	9.18^{h}	10.56^{fg}	**
Weaning Wt/litter (kg)	51.45	41.15**	42.24	50.32*	39.65^{cf}	35.77^{behj}	21.31^{adgi}	61.55^{gh}	64.25^{abc}	57.06^{jj}	63.07^{def}	**
Wt gained/litter (kg)	42.34	33.16**	34.32	41.17*	31.39^{cfi}	29.11^{beh}	16.35^{adgj}	50.23^{ghi}	53.24^{abc}	47.89^{j}	52.51^{def}	**
Birth wt/pig (kg)	1.41	1.27**	1.35	1.34	1.22^{b}	1.38	1.14^{ac}	1.40	1.41	1.46^{c}	1.54^{ab}	**
Weaning wt/pig (kg)	7.99	6.69	7.07	7.63	5.79^{bd}	7.60^{g}	4.39^{acefg}	7.79	8.48^{e}	9.91^{ab}	9.78^{cd}	**
Preweaning gain/pig (kg)	6.52	5.43*	5.66	6.30	4.58^{be}	6.22^{c}	3.38^{adfg}	6.39^{g}	7.03^{f}	8.07^{de}	8.25^{abc}	**
Efficiency of milk	4.30	4.25	4.45	4.13	4.79	4.66	6.62^{abcd}	3.52^{d}	2.97^{b}	2.92^{a}	3.14	**
Litter Size	6.50	6.44	5.96	6.92*	6.93	5.08^{bd}	4.83^{ac}	7.97^{ab}	7.68^{cd}	6.46	7.04	*
Weight lost Sow (kg)	28.30	30.57	30.57	28.34	28.15	33.12	22.04	33.09	34.30	28.77	26.31	

* $P < 0.05$

** $P < 0.01$

a - j Mean followed by similar constants are significantly different from each other.

This could be traced to the higher milk yield dealt with in the previous chapter and higher but insignificant efficiency of milk utilization. The same effect was noticeable in individual piglets. The pigs were bigger at birth and at weaning and had higher preweaning weight gains at the end of the 56 days lactation namely 1.41, 7.99 and 6.52 kg during the cooler months of the year as against 1.27, 6.69 and 5.43 kg during the hotter periods (Table 6.3), and 61, 47 and 44% of the variation in the pig weights at birth, weaning and preweaning gain was correspondingly accounted for by seasonal fluctuation.

Although the amount of weight lost in the sows was not significant, there was an accelerated depressing effect during the hotter months with 30.57 kg lost compared to 28.30 kg lost during the cooler months (Table 6.3), and 16% of the variation in weight loss was due to seasonal effect and another 18% was unaccounted for within the variables. From the 16% effect on lactational weight loss accounted for by seasonal variability and the fact that pigs were kept in confinement protected from rainfall and given adequate nutrition, other factors of possible influence on weight changes in sows might be the environmental temperature, disease level or further still qualitative nutrition of the sow. There might also be an indirect effect of litter size and postweaning gain. Indeed, Lodge and Macpherson (1961) suggested that weight loss during lactation may be influenced by the nutrients during pregnancy, and Lenkeit and Gutte (1955) demonstrated positive and negative nitrogen balances during pregnancy and lactation respectively. However, level of milk production might also be implicated.

Steinbach (1971) revealed the extent to which seasonal fluctuation affected weight loss in groups of Large White and Landrace sows in the tropics. He found a seasonal dependency of the postpartum weight and that sows farrowing during the hotter period of the year lost about 10 kg more weight than those that farrowed during the second half ot the year that corresponds to cooler months. A higher weight loss of 2 kg was found in this experiment which was statistically insignificant. A positive correlation (r = 0.33) between mean monthly lactational weight loss and the corresponding physiologically effective temperature was found. From the meterological data, average maximum and minimum temperatures were much lower during this period (21-31°C) compared to temperatures (22-34°C) during the period of Steinbach's (1971) experiment in 1968-69 and falls somewhat within the range of thermal comfort for these animals which might have accounted for the lower and insignificant difference in weight lost during the wet and cooler seasons.

The averages of season and parity effects on each trait and indication of their significant differences are summarized in Table 6.3.

Although a high and significant age effect was found on litter birth weight (P<0.01) and only a significant effect on total milk produced, litter size, litter weaning weight and litter weight gained, age had no pronounced effect on average milk ingested per piglet, birth weight, weaning weight, weight gained by the piglets, weight lost by the sows, and efficiency of milk utilization by the piglets.

6.3.3 Effect of Age (Parity)

Litter factors were highly influenced by the age of the sow and highly dependent on the size of the sow, uterine capacity reflecting birth weight and litter size and the level of milk production reflecting the weaning weight and the total preweaning gains. Recorded values were 6.92, 9.15, 50.32 and 41.17 kg for litter size, birth weight, weaning weight, and weight gained by litters from sows as against 5.96, 7.92, 42.24 and 34.32 kg from gilt litters. (Table 6.3) However the variance components were very low except for litter size with values of 35.96, 17.35, 9.53 and 8.91% respectively (Appendix Table 6.II) for litter size, litter birth weight, litter weaning weight and the overall weight gained.

Although there was no significant age effect on efficiency of milk utilization, there was quite an improvement in sow litter over gilt litters with values of 4.45 kg milk per kilogram live weight gained as against 4.13 kg for the litter from the gilts. Similarly, there was no significant differences in weight lost between the ages, yet the gilts lost about 2 kg more than the sows.

Further investigation revealed that there was no significant parity effect on either birth weight, weaning weight or average weight gained per piglet. There was however a decrease in average birth weight of piglets from sows with 1.34 kg versus 1.35 kg which might be traced to the significant increase in litter size of this group. Consequently the higher pig weaning weight of 7.63 and 7.07 kg of sows and gilts respectively and average total weight gained of 6.30 and 5.66 kg respectively at weaning might have been compensated for by the higher milk production of the sows. The two factors of growth rate and milk production together thereby constituted an improvement in the efficiency of milk utilization.

6.3.4 Genotype of Dam.

Apart from the two discussed factors above, the genotype of the dam seems to have the most extensive influence on milk production, litter size and performance of both the litter and individual piglets (Table 6.3) Appendix Table 6.111). There was a significant breed difference in average litter size ranging from 4.83 piglets in the indigenous to 7.97 piglets in the Duroc sired Large White (D.LW) dams. The others were 5.08 and 6.48 piglets for the Landrace (LR) and the reciprocal crossbred (LW.LR), where the LR was the dam likewise 6.93 and 7.04 for the Large White (LW) and the reciprocal crossbred (LR.LW) where the LW was the dam and 7.68 in the Duroc sired Landrace cross (D.LR). In all cases the influence of the bigger size of the Large White dam can be extrapolated from the increased litter size (Table 6.4).

The significant difference in litter size might have influenced the highly significant genotype effect on litter birth and weaning weight and weight gained at 56 days. This occurred in the range of 5.03 kg in the indigenous to 11.25 in the D.LW (Table 6.3). The litter birth weight of the crossbreds D.LW, D.LR, LR.LW were only significantly different from that of the LW.LR, while the litter birth weight of the purebreds were significantly different from that of the crossbreds but not from each other. Litter weaning weight bore similar significance, varying from 21.31 kg in the indigenous pigs to 64.25 kg in the D.LR and average values of 35.77, 39.65, 57.06

TABLE 6.4 GENOTYPIC COMPARISON BETWEEN LW AND LR DAMS

	Litter size		Litter birth weight (kg)		Litter weaning weight (kg)		Litter gain (kg)		ADG/pig (g)	
Dams genotype	LW	LR	LW	LR	LW	LR	LW	LR	LW	LR
Purebred	6.93	5.08	8.26	6.72	39.65	35.77	31.39	29.11	81.71	111.13
Duroc Crosses	7.97	7.68	11.25	10.94	61.55	64.25	50.23	53.24	114.18	125.47
Reciprocal "	7.04	6.46	10.56	9.18	63.07	57.06	52.51	47.89	144.18	147.26
Mean	7.58	6.41	10.02	8.95	54.76	52.37	44.71	43.41	113.36	127.95
Level of significance	*		**		**		NS		*	

* $P < 0.05$
** $P < 0.01$
NS not significant

61.55 and 63.07 kg for the litter of LR, LW, LWR, DLW and LR.LW respectively. The effect of the higher milking potential of the LW among the purebreds and the crossbred with a Large White dam was highly expressed (Table 6.4). This goes to confirm the belief that the Large White pigs are of outstanding performance. In some countries crossbreds have been developed with their performance rated alongside that of the Large White or the Yorkshire as it is widely known. In most cases it is used as the control line. However litter weights are inversely related to pigs weights. The litter weaning weights of the crossbreds were not significantly different from each other but different from that of the purebreds which might still be due to the carry-over effect of the dam.

The same trend was noticeable in the total litter weight gained during the 56 day lactation. Average daily gain per pig was highest for the reciprocal Large White-Landrace crosses with 144-147g per day and least for the indigenous pigs with 60.29g gain per pig per day. The others ranked between these two extreme values with 81.71 and 111.13g for the Large White and Landrace pigs and 114.18 and 125.47g per day for pigs from the Duroc sired crosses (D.LW and D.LR) respectively.

The genotype of the dams was the main factor constituting the variation of litter size and litter weight at birth and weaning. It had the most significant effect on litter size with 50.13% (Appendix Table 6.II). However the genotype effect on litter weight followed a decreasing trend as the animal ages from 43.61% of the variation at birth to 42.19% at weaning and overall 41.56% on the total weight gained in 56 days accounted for.

6.3.5 Individual Pig Performance

The litter weights were reduced to individual piglet basis by dividing the litter weights by the average litter size (Appendix Table 6.IV). The relative increases in birth, weaning and weight gained by each piglet within breed ranged from 1.14, 4.39 and 3.38 kg for piglets of indigenous origin among purebreds to 1.54, 9.78 and 8.25 kg of piglets born to the LR.LW sows (Table 6.5).

Table 6.5 BREED EFFECT ON PIGLET PERFORMANCE

Trait	Purebreds			Duroc Crosses		Reciprocal Crosses	
	LW	LR	IND	DLW	DLR	LW.LR	LR.LW
Pig birth weight (kg)**	1.22	1.38	1.14	1.40	1.41	1.46	1.54
Pig weaning weight (kg)**	5.79	7.60	4.39	7.79	8.48	9.91	9.78
Pig weight gained (kg)**	4.58	6.22	3.38	6.39	7.03	8.07	8.25

** = P<0.05

There were highly significant (P<0.01) breed differences in the weights of piglets born to the crossbreds and the purebreds.

A diagram of the average growth rate of the individual piglets is presented in Fig.6.1. The growth rate of the piglets born to purebred dams fell within the lower plane lowest is the indigenous breed. However the groups of the crossbreds seem to run parallel to each other. The purebreds were followed by the Duroc sired crosses. The reciprocal crosses appear to be the fastest growing of all. The higher growth rate by the Landrace and crossbred dams with Landrace genotype over that of Large White dam, was definitely

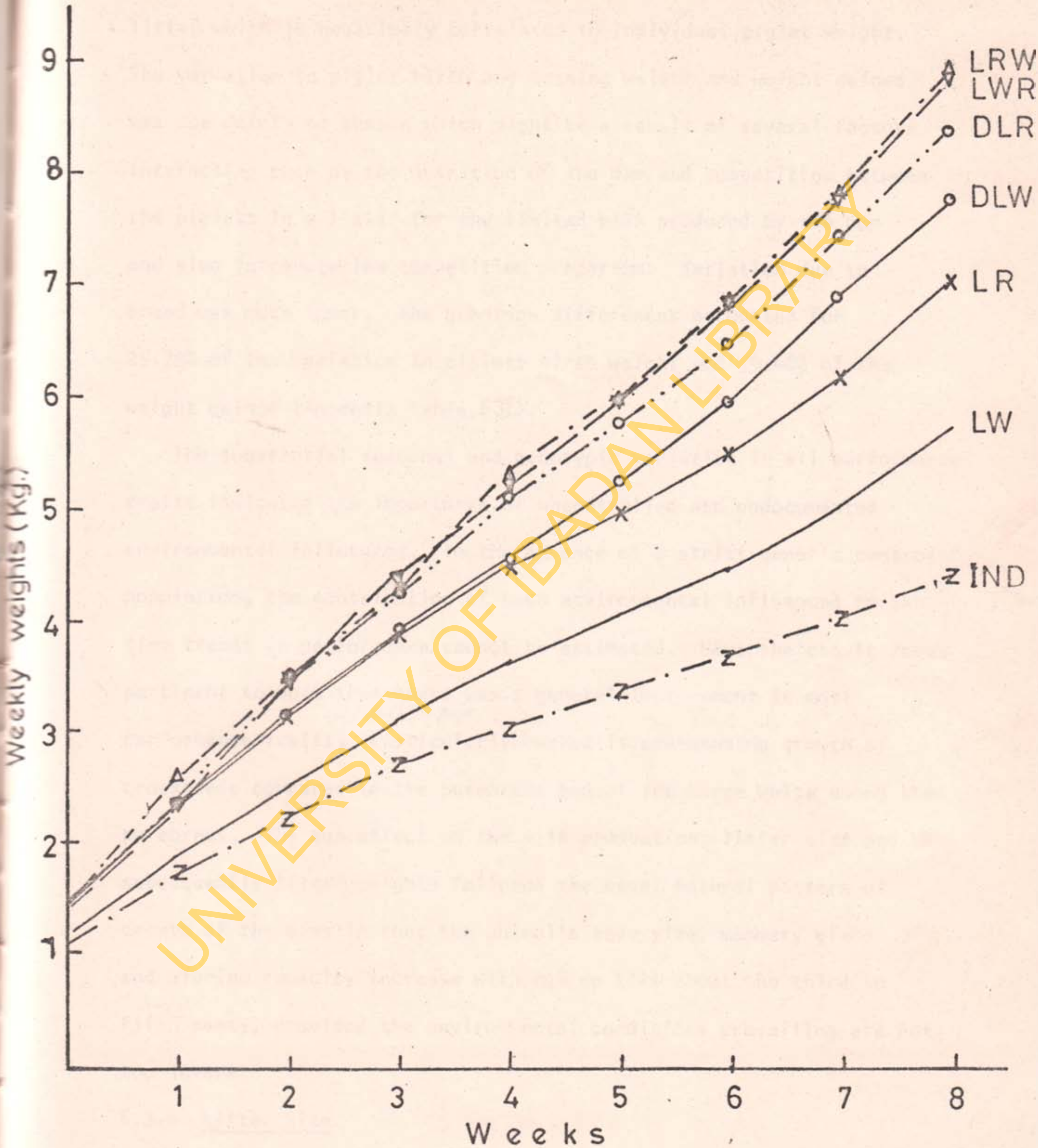

Fig. 6.1 Mean individual weights (kg) from birth to weaning by week and genotype.

associated with the reduced number of piglets born and weaned per litter which is negatively correlated to individual piglet weight. The variation in piglet birth and weaning weight and weight gained was due mainly to season which might be a result of several factors interacting such as the nutrition of the dam and competition between the piglets in a litter for the limited milk produced by the dam and also intra-uterine competition prepartum. Variation due to breed was much lower. The genotype differences accounted for 25.70% of the variation in piglets birth weight and 39.48% of the weight gained (Appendix Table 6.II).

The substantial seasonal and genotypic variation in all performance traits indicated the importance of uncontrolled and undocumented environmental influences. In the absence of a strict genetic control population, the contribution of such environmental influences to the time trends in performance cannot be estimated. Nevertheless it seems pertinent to note that there was a general improvement in most performance traits in crossbred pigs. Particularly marked is pre-weaning growth of crossbreds compared to the purebreds and of the Large White among the purebreds. The age effect on the milk production, litter size and subsequently litter weights followed the usual natural pattern of growth of the dams in that the animal's body size, mammary gland and uterine capacity increase with age up till about the third to fifth parity, provided the environmental conditions prevailing are not too severe.

6.3.6 Litter Size

Litter productivity for the different genotypes namely litter size, weights and mortality are given in Table 6.6.

Table 6.6 LITTER PRODUCTIVITY OF THE DIFFERENT BREEDS AND CROSSES.

Genotype	M.L.S. Birth	M.L.S. Weaning	M.L.W. Birth kg	M.L.W. Weaning kg	Pig Weights kg	% Loss	
LW	9.33	6.67	8.26	39.65	5.94	9.0)	
						)	8.85
LR	5.15	4.70	6.72	35.77	7.61	8.7)	
IND	5.28	4.61	5.03	21.31	4.62	12.7	
D.LW	8.44	7.56	11.26	61.68	8.16	10.4)	
						)	12.25
D.LR	8.07	6.93	10.94	57.43	8.29	14.1)	
LW.LR	6.92	6.25	9.18	57.06	9.13	9.7)	
						)	9.30
LR.LW	7.50	6.83	10.56	63.07	9.23	8.9)	

M.L.S. = Mean Litter Size
M.L.W. = Mean Litter Weight

The number of pigs born per litter varies from 5.15 to 8.44 pigs in the indigenous and the Duroc sired Large White, the standard deviation was in the range of 1.84 - 1.96 in the purebreds and 1.97 - 3.50 in the crossbreds (Table 6.1). However litter size of eight and above is the rule rather than exception among the Duroc crossbreds. The preweaning death losses were low with 8.85 and 9.30% for the purebred Large White and Landrace and their reciprocal crosses and higher with 12.25 for the Duroc crosses and 12.7% for the indigenous breed.

Genotype and parity differences in average litter size were significant ($P<0.05$) but seasonal variation was insignificant (Table 6.2). Average litter size at birth and at weaning were positively correlated with litter birth and weaning weights but were negatively correlated with pig birth and weaning weights. There was a highly significant positive correlation between litter size and litter birth weight of r = 0.52 - 0.93 (Table 6.7) for the Large White to the reciprocal crosses. The relative increase in birth weight per unit increase in litter size was however highest for the crossbreds and lowest for the Large White (655g) followed by the indigenous litters (873g).

Table 6.7 RELATIONSHIP BETWEEN LITTER SIZE AND LITTER WEIGHT AT BIRTH.

Genotype	r	$\hat{Y} = \bar{Y} + bx$	SE_b
LW	0.522*	3.69 + 0.655x	0.245
LR	0.875**	1.42 + 1.043x	0.136
IND	0.826**	0.81 + 0.873x	0.149
D.LW	0.861**	0.52 + 1.347x	0.213
D.LR	0.699**	1.84 + 1.185x	0.350
LW.LR	0.924**	0.48 + 1.347x	0.176
LR.LW	0.932**	0.68 + 1.401x	0.173

* = $P<0.05$
** = $P<0.01$

The number of pigs farrowed and weaned compared favourably with the results of Walker et al. (1972). For both pure-and crossbreds litter size was 7.06 and 8.94 at birth and 5.45 to 7.69 at weaning. But the number farrowed was very low when compared with reports by Omtvedt et al. (1966) and Wilson et al. (1961) with litter size of 11-14 and 10-11 piglets respectively. However the percentage losses in both studies were rather very much higher with 22% compared to only 8.7-12.7% obtained in this study. This confirms reports that the larger the litter size (7-8) the higher the mortality encountered. Large litter size was associated with increased pre-weaning death losses in data reported by Weaver and Bogart (1943) and Winters et al. (1947). Increased death loss among smaller pigs at birth has also been noted in other studies. It could therefore be concluded that birth weight had a greater influence on survival rate than did litter size. Survival rate was as closely associated with litter size at birth by r = -0.13 to -0.57 (Fig. 6.2) as it was with litter size at weaning by r = 0.02 - 0.61. Both indicate that the higher the litter size is at birth the lower is the survival rate, while a higher survival rate brings about higher litter size at weaning. Winters et al. (1947) also found survival rate to increase with an increase in weaning weight of the litter. The coefficientsof correlation in Fig. 6.2 thereby show that preweaning death losses had almost as important an influence on litter size at weaning as the number of pigs farrowed.

The pooled correlation between litter size at weaning and pig weaning weight was -0.09 to -0.58 for the indigenous and the reciprocal crosses. This negative relationship might be due primarily to the relationship between the number of pigs farrowed in the litter and their preweaning growth rate. Weaver and Bogart (1943) using litters varying in size from 2-10 pigs at weaning concluded that an increased number of pig weaned per litter did not necessarily lessen the average weight per pig at weaning which was exactly what happened in this study. Although within a breed there might be a reduction in pig weaning weight with increased litter size, between the breeds the crossbreds with larger litter sizes produced offspring with high pig weaning weight at 56 days.

Differences in 56 day pig weights were significant ($P<0.01$) for season and breeds but not for age of the dam (Table 6.2). Although number of pigs weaned per litter was similar in both wet and dry periods pigs raised during the wet season were 1.30 kg heavier than those raised during the dry season and those from sows were just 0.56 kg heavier than those from gilts (Table 6.3). Pig weaning weight was primarily a function of gain from birth to weaning rather than a reflection of birth weight.

Many studies of the inheritance of body weight in swine at birth and 56 days and growth rate between these ages have been reported in the literature (Blunn et al., 1953; Craig et al., 1956; El-Issawi and Rempel, 1961; and Vogt et al., 1963). However few reports (Craig et al., 1956; Lodge and Mcdonald, 1959; Lodge and Pratt, 1963; and Fahmy and Bernard, 1970) are available on weights at other ages. With the importance of early weaning at ages prior to 56 days further knowledge is needed of these parameters and environmental factors which affect weight at different ages and association between these weights.

6.3.7 Relationships Between Preweaning Traits

Correlations between litter size and birth weights are given by genotype in Table 6.7. It also contains linear equations to show regression values per unit increase in litter size.

Relationship among preweaning weights are given in Table 6.8 - 6.10.

TABLE 6.7

RELATIONSHIP BETWEEN LITTER SIZE AND LITTER WEIGHT AT BIRTH

Genotype	r	Y = Y + bx	SE_b
LW	0.522*	3.69 + 0.655x	0.245
LR	0.875**	1.42 + 1.043x	0.136
IND	0.826**	0.81 + 0.873x	0.149
DLW	0.861**	0.52 + 1.347x	0.213
D.LR	0.699**	1.84 + 1.185x	0.350
DW.LR	0.924**	0.48 + 1.347x	0.176
LR.LW	0.932**	0.68 + 1.401x	0.173

* $P < 0.05$

** $P < 0.01$

Table 6.8 LITTER SIZE AND THREE WEEK WEIGHT

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.571**	4.62 + 2.432x	0.245
LR	0.835**	1.96 + 3.474x	0.540
IND	0.732**	0.36 + 2.632x	0.506
D.LW	0.628**	3.74 + 3.458x	0.869
D.LR	0.675**	1.54 + 4.000x	1.262
LW.LR	0.860**	6.14 + 3.397x	0.636
LR.LW	0.775**	5.34 + 3.542x	0.913

* $P<0.05$
** $P<0.01$

Table 6.9 LITTER SIZE AND FIVE WEEK WEIGHT

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.531*	7.79 + 2.902x	1.063
LR	0.740**	6.65 + 3.648x	0.789
IND	0.718**	0.84 + 3.214x	0.670
D.LW	0.553*	3.08 + 4.853x	1.502
D.LR	0.603**	3.54 + 5.322x	1.556
LW.LR	0.792**	9.23 + 4.535x	1.106
LR.LW	0.684*	12.36 + 4.273x	1.444

* $P<0.05$
** $P<0.01$

Table 6.10 LITTER SIZE AND WEANING WEIGHT EIGHT WEEKS

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.530*	14.47 + 3.606x	1.324
LR	0.574*	16.87 + 3.720x	1.250
IND	0.649**	0.37 + 4.335x	1.109
D.LW	0.509*	10.55 + 6.399x	2.229
D.LR	0.578*	17.53 + 6.082x	2.644
LW.LR	0.761**	14.93 + 6.521x	1.753
LR.LW	0.652**	17.56 + 6.464x	2.376

* $P<0.05$
** $P<0.01$

There was a gradual decrease in correlation between the variables as the animals age from a value of 0.571 in the Large White at three weeks, 0.531 at five weeks to 0.530 at eight weeks to a high value of 0.860 at three weeks, 0.792 at five weeks and 0.761 at eight weeks in the reciprocal LW.LR.

The relative increase in weight per unit increase in litter size rises with the age of the animal from low values of 2.432 kg at three weeks in the Large White offspring to 2.902 kg at five weeks and 3.606 kg at eight weeks to a high value of 4.000 kg in the offspring of the D.LR at three weeks to 5.322 kg at five weeks and 6.082 at eight weeks. However they were surpassed by the increase in weight of offspring of D.LW, and reciprocals at eight weeks with values of 6.399, 6.521 and 6.464 kg respectively per unit increase in litter size (Table 6.10).

The relative increase in weight as the animal grows older can be related to the fact that competition for milk decreases and the animal tends to increase consumption of creep feed which supplements the declining milk production of the dam. Individual birth weights and levels of creep consumption might thereby be factors governing weight gains as the animals grow older.

The reduced effect of litter size on weaning weight as compared with birth weight suggests that weaning weight is controlled to a large degree by the mothering ability of the dam. A similar finding of a small effect of litter size on pig weaning weight in Poland China pigs was reported by Bywaters (1937). The negative correlation between litter size at birth and pig weaning weight and preweaning gain may be explained by the findings of Smith and Donald (1937) who reported a positive relation between litter size and milk production but noted that the increased production was not great enough to give each pig in a large litter the same amount of milk as one in a smaller litter.

The same principle could apply during prenatal development and may explain the negative association between litter size and pig birth weight. It could therefore be inferred that as litter size increases, both litter birth and weaning weight increase while mean piglet weight decreases, probably as a result of increased competition for the available nutrient supply from the dam. The reduced mean piglet weight is more than compensated for by larger litter size. However the diminishing correlation between litter size and litter weight as the animal ages confirms the lessening competition for the nutrient supply from the dam as the piglets increase their supplementary feed consumption.

The effect of litter birth weight on litter weight at different ages (three, five and eight weeks) are shown in tables 6.11-6.13. The correlations decrease with age of the animal and there is an upward trend in the relative increase in weight of the animals at three, five and eight weeks per unit increase in birth weight of the litter.

Table 6.11 RELATIONSHIP BETWEEN LITTER BIRTH WEIGHT AND LITTER WEIGHT AT THREE WEEKS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LR	0.471*	8.30 + 1.610x	0.686
LR	0.804**	0.76 + 2.805x	0.420
IND	0.733**	0.53 + 2.494x	0.297
D.LW	0.676**	4.32 + 2.379x	0.694
D.LR	0.678*	10.19 + 2.020x	0.824
LW.LR	0.940**	4.71 + 2.546x	0.293
LR.LW	0.938**	0.16 + 2.852x	0.335

* $P<0.05$

** $P<0.01$

Table 6.13

RELATIONSHIP BETWEEN LITTER BIRTH WEIGHT AND LITTER WEIGHT AT EIGHT WEEKS.

Genotype	r	$\hat{Y} = \bar{Y} + bx$	SE_b
LW	0.451*	19.43 + 2.447x	1.024
LR	0.631**	12.73 + 3.429x	0.994
IND	0.634**	1.26 + 3.987*	0.999
D.LW	0.510**	4.12 + 5.100x	1.770
D.LR	0.654*	1.43 + 4.829x	1.446
LW.LR	0.890**	9.05 + 5.230x	0.848
LR.LW	0.846**	4.16 + 5.579x	1.114

* $P < 0.05$

** $P < 0.01$

The correlation coefficients range from low values of r = 0.471 in the Large White to a high value of 0.940 in the LW.LR at three weeks of age through 0.458 to 0.913 at five weeks to 0.451 to 0.890 at eight weeks respectively. The relative increases in weight per unit increase in birth weight of the offspring varies from 1.61 kg at three weeks in the offspring of the Large White to 2.852 kg for the reciprocal LR.LW piglets through 1.996 to 3.653 kg at five weeks to 2.447 and 5.579 kg respectively at eight weeks.

Positive and highly significant correlations between litter weights at birth and weaning were reported by many workers including Weaver and Bogart (1943) and Omtvedt et al. (1966). To further investigate the influence of within litter competition on growth rate Lodge and Pratt (1963) obtained correlations between birth and three, five and eight weeks weight. The decreasing trend in correlations between litter birth weight and these litter weights in this study with values of 0.47 - 0.94 at three weeks, 0.46 - 0.91 and 0.45 - 0.89 at five and eight weeks respectively were within ranges obtained by Lodge and Pratt (1963) with values of r = 0.89, 0.52 and 0.45 respectively for the Landrace and values of r = 0.64 obtained by Omtvedt et al. (1966) for Duroc crosses and r = 0.69 for Yorkshire crosses by Fahmy and Bernard (1970) for eight weeks. The relation between litter weights at birth and weaning depends mainly on the common effect of litter size on both traits. These findings indicate that selection for litter size could be more important in improving litter weight at weaning than selection for heavier pigs, knowing that the heritability of both traits is relatively low ranging from 0.05 to 0.20. The crossbreds with higher litter size had higher increases in weight per unit increase in litter size and litter birth weight at the different ages. This was in line with results reported by Lodge and Pratt (1963). However the relative increments obtained per unit increase in birth weight were higher in this study than 0.795, 1.59 and 2.27 kg at three, five and eight weeks obtained by Lodge and Pratt (1963).

Since litter birth weight is greatly influenced by litter size, its association with weaning performance was similar to that noted for number farrowed. As litter birth weight increased, number weaned and litter weaning weight increased and so did the survival rate while pig weight decreased.

Relationships between preweaning performance traits are presented in Fig. 6.2. Correlation coefficients are given in the order of LW, LR, IND, D.LW, D.LR, LW.LR and LR.LW respectively. Litter size at birth and at weaning were positively correlated with litter birth and weaning weight respectively but were negatively correlated with pig birth weight and weaning weights respectively. However increased pig birth weight was associated with increased pig weaning weight. Correlation values of r = 0.03 to 0.90 were obtained for the Large White and the LR.LW reciprocal crosses respectively. The others fell within that range. Although the values were low and insignificant for the purebreds, they were highly significant for the crossbreds and they were higher than r = 0.54 reported by Omtvedt et al. (1966). Pig birth weight was associated with high survival rate of 0.42 - 0.62 for the purebreds and r = 0.17 - 0.28 for the crossbreds (Fig.6.2).

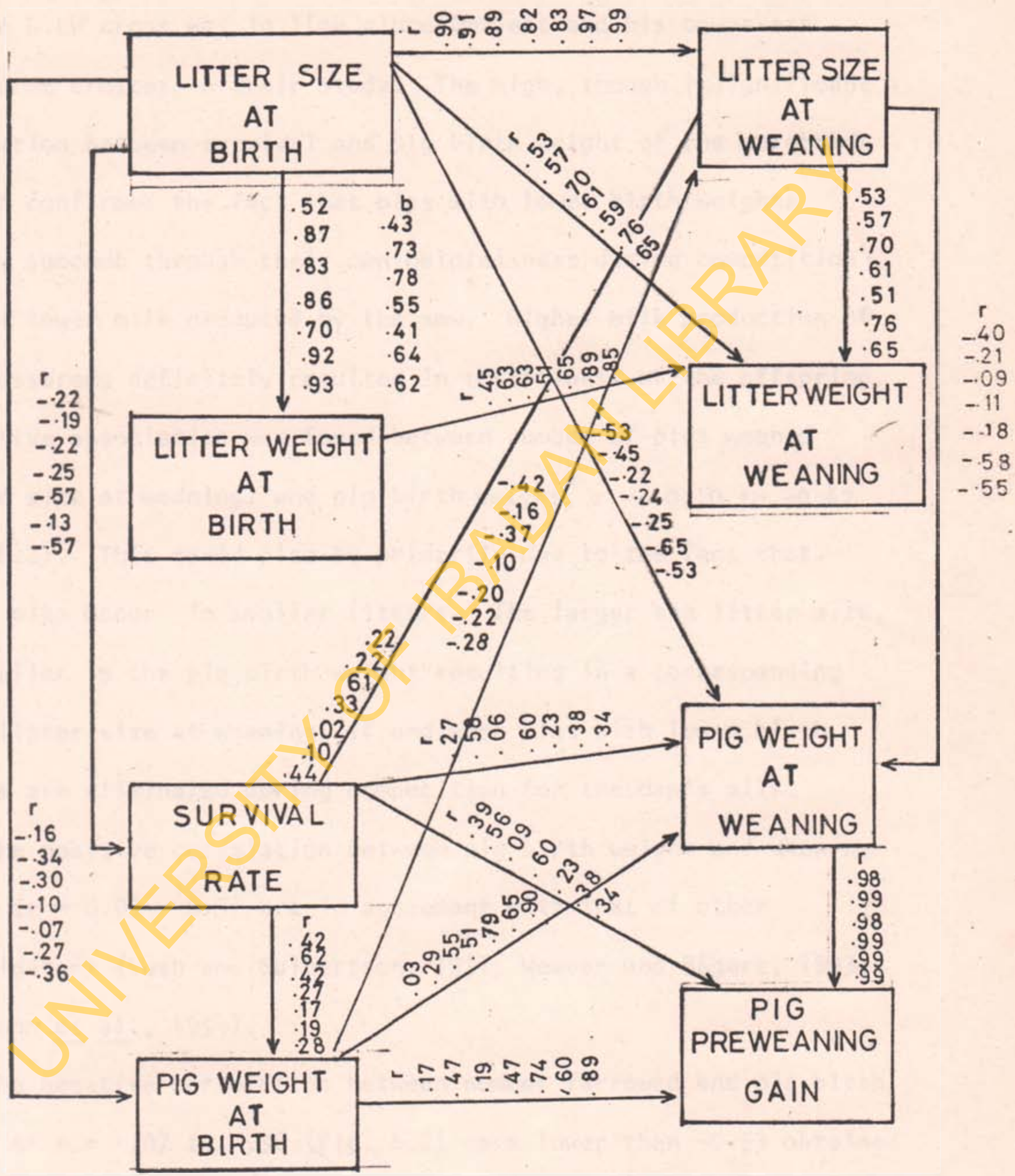

Fig. 6·2 Relationship between preweaning performance traits.
Legend: Correlation coefficients are given in the following order LW - LR - IND - DLW - DLR - LWLR - LRLW.

Although the other values appeared higher or lower than r = 0.28 obtained by Omtvedt et al. (1966) the r = 0.27 obtained for the D.LW cross was in line since Omtvedt and his coworkers used Duroc crosses in their study. The high, though insignificant correlation between survival and pig birth weight of the purebreds however confirmed the fact that pigs with lower birth weights readily succumb through their own helplessness during competition for the lower milk produced by the sow. Higher milk production of the crossbreds definitely resulted in thriftiness of the offspring. A negative association was found between number of pigs weaned (Litter size at weaning) and pig birth weight, r = -0.10 to -0.42 (Fig. 6.2). This could also be primarily due to the fact that larger pigs occur in smaller litters. The larger the litter size, the smaller is the pig birth weight resulting in a corresponding lower litter size at weaning, if and when pigs with lower birth weights are eliminated during competition for the dam's milk.

The positive correlation between pig birth weight and weaning weight (r = 0.03 - 0.9) are in agreement with that of other investigators (Lush and Culbertson, 1931; Weaver and Bogart, 1943; and Blunn et al., 1954).

The negative correlation between number farrowed and pig birth weight of r = -.07 to -.36 (Fig. 6.2) were lower than -0.53 obtained by Omtvedt et al. (1966) but they similarly indicate that heaviest pigs occur in small litters and this accounts for the fact that an increase in pig birth weight is associated with a decrease in total weaning weight.

Correlation coefficients of r = 0.52 - 0.93 and r =-0.07 to -0.36 for litter size and litter birth weight and litter size and pig birth weight are just below an average correlation reported by Omtvedt et al. (1966) but similar to those reported by Carmichael and Brice (1920), Lush et al. (1934), and Omtvedt et al. (1965).

An increase in number of pigs farrowed was associated with an increase in litter size at weaning (r = 0.82 - 0.99) and litter weaning weight (r = 0.53 - 0.76) and a decrease in survival rate (r = -0.13 to -0.57).

The regression coefficient of number of pigs weaned on number of pigs farrowed was 0.67 and 0.77 for the D. LR and D.LW crosses, 0.83 and 0.92 for the LR.LW and LW.LR, and 0.85, 0.91 and 0.92 for the Large White, Landrace and indigenous purebreds (Table 6.14).

These values were within the range of 0.77 obtained by Fahmy and Bernard (1970) who worked with the Yorkshire breed, but higher than 0.58 obtained by Omtvedt et al. (1966) for Duroc crosses. These regression values for the purebreds and the LW.LR crosses further strengthen the argument of greater survival of pigs from a small litter.

6.3.8 Sow Performance

The weight lost during the period of lactation varied from a low amount of 22.04 kg in the indigenous to 34.30 kg in the D.LR crosses. There was no significant difference between the different genotypes (Table 6.*l*) although there was about 12 kg difference between the lowest and highest values.

Table 6.14 RELATIONSHIP BETWEEN LITTER SIZE AT BIRTH AND WEANING.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LR	0.90**	0.44 + 0.85x	0.106
LR	0.91**	0.87 + 0.91x	0.095
IND	0.89**	1.32 + 0.92x	0.117
D.LW	0.82**	1.06 + 0.77x	0.144
D.LR	0.83**	1.52 + 0.67x	0.130
LW.LR	0.97**	0.54 + 0.92x	0.074
LR.LW	0.99**	0.60 + 0.83x	0.043

** $P<0.01$

A closer look at the percentage weight lost by the sows brings out the fact that the indigenous breed which seems to lose the least in body weight, lost the greater percentage of its weight at farrow with 36.45% of its body tissue catabolised during the process of lactation (Table 6.15). The Large White and the LR.LW cross lost the smallest percent of body tissue,namely 19.97 and 19.03%. However only 36% of the variation in weight lost was due to the difference in genotype.

6.3.9 <u>Litter Size and Body Weight Changes of Dam</u>

Relationships between the body weight of the dam and the average litter size farrowed were weak and not significant (Table 6.16) ranging from r = 0.004 to 0.455 for the LW.LR and the indigenous breed respectively. The regression of litter size on body weight with

Table 6.15 MEAN WEIGHT AT FARROW (kg), WEIGHT LOST DURING LACTATION (kg) AND PERCENTAGE WEIGHT LOSS.

	LW	LR	IND	D.LW	D.LR	LW.LR	LR.LW
Weight at farrow, kg.	140.96	137.61	60.46	128.34	138.44	133.33	138.26
	±7.01	±7.91	±6.29	±5.93	±8.96	±9.44	±10.78
Weight lost, kg	28.15	33.12	22.04	33.09	34.30	28.77	26.31
	±2.93	±5.48	±2.95	±3.75	±4.01	±4.64	±4.14
% Lost	19.97	24.06	36.45	25.75	24.78	21.58	19.03

Table 6.16 RELATIONSHIP BETWEEN LITTER SIZE AND DAM'S BODY WEIGHT AT FARROW.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LR	0.345	4.02 + 0.021x	0.013
LR	0.018	4.94 + 0.001x	0.013
IND	0.455*	2.77 + 0.034x	0.017
D.LW	0.028	7.71 + 0.002x	0.020
D.LR	0.247	6.16 + 0.011x	0.013
LW.LR	0.004	6.38 + 0.004x	0.032
LR.LW	0.117	4.27 + 0.020x	0.040

* $P<0.05$

litter size increments of 0.004 in the LW.LR to 0.034 pigs in the indigenous pigs per unit increase in body weight were rather too low and of little use in improving litter productivity. Only in the indigenous a significant correlation of 0.455 was found, but the increment by which litter size would increase per kilogram sow weight was less than 0.04.

Looking at the figures, litter size produced per average body weight was highest for the crossbreds and lowest for the indigenous breed, however the highest increase in litter size per unit increase in body weight was attained in the latter breed. This brings to mind the fact that indigenous pigs are generally small in size. Therefore any means of improving their body size which is closely correlated with increased litter size will be useful. This might be another factor to explore and improve the indigenous sow.

The association between litter size and lactational weight loss of the sow was positive with values ranging from 0.16 in the Large White to 0.595 in the indigenous sow (Table 6.17).

Table 6.17 RELATIONSHIP BETWEEN LACTATIONAL WEIGHT LOSS AND LITTER SIZE.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.161	20.35 + 1.118x	0.572
LR	0.255	29.33 + 0.747x	0.667
IND	0.595*	3.96 + 3.743x	1.267
D.LW	0.228	17.79 + 1.949x	1.214
D.LR	0.530*	20.58 + 1.791x	0.484
LW.LR	0.359	16.75 + 1.860x	1.520
LR.LW	0.591*	7.94 + 2.610x	1.112

* $P<0.05$

Table 6.18 RELATIONSHIP BETWEEN WEIGHT LOSS OF DAMS AND LITTER PREWEANING GAIN.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.458*	12.30 + 0.505x	0.224
LR	0.229	18.45 + 0.504x	0.506
IND	0.282	17.04 + 0.306x	0.260
D.LW	0.228	25.84 + 0.147x	0.166
D.LR	0.224	32.17 + 0.200x	0.249
LW.LR	0.567*	9.61 + 0.400x	0.079
LR.LW	0.259	19.48 + 0.130x	0.150

* $P < 0.05$

The purebred exotic and the crossbreds with exception of the LR.LW lost more weight than the indigenous pig when the litter effect was held constant. About 1.4 kg body weight loss was associated with each increase of one pig in litter size. (Table 6.17) Even though the indigenous pigs had the lowest loss in absolute values (3.96 kg) they lost nearly 4 kg per unit increase in litter size while the other pigs lost 1-2.2 kg (0.932 kg by the purebreds, 1.870 kg by the Duroc crosses and 2.235 kg by the reciprocal crosses).

The higher weight loss per unit increase in litter size of the indigenous emphasizes the fact that the indigenous sows though low milk producers tended to catabolise a greater part of their body tissue to meet nutrient requirement of the young. This could be the reason why they are difficult to rebreed after weaning and take a longer time to recover after weaning litters of five pigs and above.

Steinbach (1971) attempted to find reasons for lactational weight loss in sows. He indicated that weight loss may be affected indirectly by litter size and litter weight gain.

Table 6.18 shows the correlation between the amount of weight lost by the dams and the corresponding weight gained by the litters for the different genotypes. Although the correlations were positive and insignificant except for the Large White and the LW.LR, the average weight loss by all the sows cannot be overlooked, even when the litter effect was removed. This can be seen from the low regression values between weight lost and weight gained of 0.130 - 0.505 kg weight lost for every kilogram weight gained by the piglets during suckling. It can therefore be concluded that lactational weight loss is a general feature in swine although the amount lost varied from 2.27 kg (Adam and Hargreaves, 1970) to 70 kg (Wallace et al., 1934) and 22-34 kg in this study. For the means of the genotypes the range of 2-69 kg in this study were in line with the range of 1-50 kg obtained by Steinbach (1971).

6.3.10 Milk Production and Litter Performance

Relationships between milk production and litter performance are given in Tables 6.19-21. The correlation between milk yield and litter size was positive (Table 6.19) with values ranging from r = 0.37 in the Large White to 0.81 in the D.LW. Regression coefficients of milk on litter size were 7.23 - 16.21 kg per unit increase in litter size. Regression of milk on litter birth weight (Table 6.20) was 5.34 - 10.39 kg per kilogram increase in litter birth weight with high positive correlations ranging from r = 0.30 in the Large White to 0.88 in the LR.LW crosses.

Table 6.19 RELATIONSHIP BETWEEN MILK YIELD AND LITTER SIZE.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.370	77.75 + 8.304x	4.772
LR	0.686**	51.00 + 16.211x	4.053
IND	0.796**	39.09 + 7.226x	1.374
D.LW	0.806**	19.77 + 16.129x	3.161
D.LR	0.439*	62.89 + 11.761x	2.960
LW.LR	0.756**	74.77 + 8.422x	2.301
LR.LW	0.742**	78.78 + 9.360 x	2.670

* $P<0.05$
** $P<0.01$

Table 6.20 RELATIONSHIP BETWEEN MILK YIELD AND LITTER BIRTH WEIGHT.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.300	93.56 + 5.342x	3.871
LR	0.664**	14.93 + 13.158x	3.490
IND	0.736**	42.20 + 6.321x	1.453
D.LW	0.821**	31.38 + 10.385x	1.453
D.LR	0.592**	50.90 + 9.352x	3.667
LW.LR	0.875**	69.08 + 6.547x	1.242
LR.LW	0.883**	66.42 + 7.410x	1.240

* $P<0.05$
** $P<0.01$

Table 6.21 RELATIONSHIP BETWEEN MILK YIELD AND LITTER WEANING WEIGHT AT 56 DAYS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.672**	50.27 + 2.205x	0.557
LR	0.671**	45.86 + 2.446x	0.637
IND	0.808**	50.57 + 1.099x	0.200
D.LW	0.677**	95.07 + 0.866x	0.251
D.LR	0.838**	32.74 + 1.875x	0.352
LW.LR	0.945**	59.45 + 1.875x	0.133
LR.LW	0.854**	116.26 + 1.080x	0.210

** $P<0.01$

The regressions of litter weaning weight (Table 6.21) on milk produced were however striking in that the D.LW piglets which tended to stimulate greatest volume of milk per kilogram increase in litter birth weight appears most economic in production by utilizing 0.866 kg of milk per unit increase in litter weaning weight. The other values follow from over 1-2.4 kg milk per unit increase in litter gain.

Similarly, corresponding results were obtained for the regression of milk produced on litter preweaning weight gained in 56 days (Table 6.22).

Table 6.22 RELATIONSHIP BETWEEN MILK YIELD AND PREWEANING WEIGHT GAINED.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.666*	63.60 + 2.360x	0.607
LR	0.606*	94.12 + 1.348x	0.416
IND	0.786*	53.83 + 1.233x	0.243
D.LW	0.616*	102.77 + 0.942x	0.315
D.LR	0.831**	44.97 + 2.033x	0.394
LW.LR	0.938**	60.88 + 1.431x	0.167
LR.LW	0.822**	82.18 + 1.190x	0.260

* $P<0.05$
** $P<0.01$

Such high correlation coefficients of r = 0.61 to 0.94 between milk produced and litter weaning weight and litter preweaning gain (Table 6.21-22) show that pigs are bound to be heavier and gain more if there is more milk available.

The correlation between milk production and litter productivity agreed with reports of Smith and Donald (1937) who found a positive relationship between litter size and milk production, but they noted that the increased production was not large enough to give each pig in a large litter the same chance as one in a small litter. Similar high significant correlations of r = 0.8 - 0.9 were obtained by Lalevic (1953) between milk production and litter size and also with litter weight gains.

A high significant correlation between milk yield and litter weaning weight (r = 0.61 - 0.95) and litter weight gains (r = 0.67 - 0.94) could indicate that for a considerable portion of the lactation period, the pigs are entirely or largely dependent on the milk produced by the sow. Among the crossbreds the D.LR sows produced most milk and weaned heaviest litters while the LW.LR produced least milk and weaned small pigs at 56 days. In all cases the correlation was higher than values obtained by Allen et al. (1959) (r = 0.18 and 0.77) in the Landrace x Poland and the Polands but within the range of 0.64 reported for the Durocs and a little higher than 0.42 for the Landrace with regard to milk yield and weight of litters at six weeks of age. The increment of 0.866 - 2.446 kg milk per kilogram litter weight at weaning was also higher than 0.82 - 0.86 kg obtained by Allen et al. (1959). The milk production of their pigs was within the range obtained in this study but their animals weaned heavier litters at 42 days of age.

The relationships between milk yield and weight loss by genotype are shown in Table 6.23. The correlations and regressions were positive and significant for the indigenous and the purebred exotic, but small and insignificant for crossbred. It indicates that the larger the amount of milk produced, the greater is the amount of weight lost by the sows.

Table 6.23. RELATIONSHIP BETWEEN MILK PRODUCTION AND WEIGHT LOST DURING LACTATION.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.530*	89.68 + 1.705x	0.625
LR	0.521*	101.46 + 0.963x	0.372
IND	0.469*	59.07 + 0.677x	0.319
D.LW	0.112	132.19 + 0.262x	0.224
D.LR	0.170	137.26 + 0.465x	0.275
LW.LR	0.378	105.88 + 0.810x	0.630
LR.LW	0.315	120.99 + 0.900x	0.860

* $P<0.05$

The regression of milk yield on weight loss was 0.26-1.71 kg milk per kilogram weight lost with a mean of about 1.115 kg for the purebreds and 0.609 kg for the crossbreds. The fact that there is a limit to which each breed or cross produces before depression sets in was revealed by Steinbach (1971). He indicated that weight lost was highest during the earlier part of lactation and that the curve of weight loss against lactation length tended to level off after the fifth week in production. It could then be concluded that the animal catabolises its body weight at the initial stage of milk production so as to produce enough milk to meet the nutrient requirement of the young especially at the earlier stages when the pigs frequent the udder at short intervals.

However there is a limit to which the sow can be fed to reduce the amount of weight lost although some have been found which actually gained weight during lactation.

Despite the use of feeding levels calculated to maintain sows' live weight over the eight week lactation, there were considerable variations in live weight changes. Smith (1959a) found that the heavier the litter weight, the more weight was lost during suckling. This might have been influenced by weight change during previous lactations or by the duration of the suckling period as found by Smith (1960) and Lodge and Macpherson. (1961). Because of the many factors involved and the interrelationships between sow weight change at different stages of lactation, it would appear desirable to carry out trials with sows over subsequent parities.

6.3.11 Efficiency of Production of Sows of Different Genotypes

Another objective of this study was to determine whether sows of various genotypes differed in the efficiency with which they produced milk and gains in the pigs in their litters. Detailed data relative to this are given in (Appendix Table 6.Va and b).

For many years the recommended daily ration for lactating sows has been 2.72 kg (6 lbs.) per sow and 0.23 kg (1/2 lb.) per piglet suckled. Williamson and Payne (1965) also suggested that a sow suckling eight pigs should get 14 lb. ration daily (6.35 kg) when the feed contained 17% crude protein and the creep 20-25%.

Experiments on sow feeding by Smith (1959b) have shown that when a ration consists entirely of skim milk, the quantity of six units plus one unit feed per piglet suckled (6 lb. plus 1 lb. per piglet) often exceeded the appetite of the sow, especially in the case of first litter gilts and sows suckling more than six pigs. The problem is further accentuated in the summer months when a high environmental temperature depresses appetite which may be a factor under the tropical condition where exotic breeds are raised. This thereby stresses another aspect of this experiment to evaluate feed and creep intake of sows and piglets of different genotype and to compare the efficiency of pig production under the present farm feeding regime.

On the basis of weekly feed analyses the average content of

feed was for sows	87.67% dry matter,
	16.25% protein on dry matter basis, and
	4.19% ether extract on dry matter basis
and of the creep	90.27% dry matter,
	17.58% protein on dry matter basis and
	3.57% ether extract on dry matter basis.

Data relative to the efficiency of production are summarised in Table 6.24 and illustrated by histograms in Fig. 6.3 - 6.10.

A significant difference ($P<0.01$) (Table 6.25) was noted between genotypes in the amount of feed consumed during the eight week lactation (Appendix Table 6.VI). Average feed consumption varied

TABLE 6.24

EFFICIENCY OF PRODUCTION OF SOWS OF DIFFERENT GENOTYPES IN A LACTATION OF EIGHT WEEKS.

Characteristic	LW	LR	LND	DLW	DLR	LW.LR	LR.LW
Average feed consumed per sow kg**	e 112.19 ± 6.35	bi 95.75 ± 19.63	aefghi 54.34 ± 10.06	dg 109.44±9.82	ch 97.46±9.95	abcd 121.26±1.46	f 111.50±13.10
Average milk per sow (kg) **	ch 140.76 ± 22.15	be 119.98 ± 15.34	adfgh 79.42 ± 5.90	abc 176.45±17.72	g 149.10±5.98	f 153.16±18.94	de 170.98±20.67
Feed/Sow/Kg Milk (kg)	0.88 ± .19	0.91 ± 0.31	0.70 ± 0.16	0.62±0.09	0.65±0.09	0.82±0.09	0.65±0.11
Feed/Sow/Kg litter gain (kg)*	e 3.59 ± 0.52	fghi 3.83 ± 0.092	abcde 4.00 ± 0.57	di 2.22±0.89	bg 2.10±0.28	af 2.19±0.41	bg 2.17±0.37
Milk/litter/kg gain (kg)**	e 4.23 ± 0.29	fghi 4.82 ± 0.98	abcde 6.06 ± 0.63	di 3.24±0.94	bg 3.10±0.14	af 2.74±0.26	ch 3.17±0.21
Creep/kg litter gain (kg)*	b 0.24 ± 0.11	0.36 ± 0.08	abcd 0.56 ± 0.16	ae 0.16±0.02	c 0.29±0.09	d 0.33±0.08	e 0.44±0.12
Feed by sow and litter* per litter gain (kg)	e 3.83 ± 0.50	fgh 4.19 ± 0.89	abcde 4.56 ± 0.56	bg 2.37±0.89	af 2.34±0.36	ch 2.52±0.49	d 2.61±0.48
Weight lost (kg)	34.25 ± 10.45	23.23 ± 2.29	22.16 ± 5.56	40.56±8.05	44.18±4.82	37.42±9.71	33.21±8.09
N	4	4	4	4	4	4	4

* P < 0.05
** P < 0.01
a-i Mean followed by similar constants differ significantly from each other.

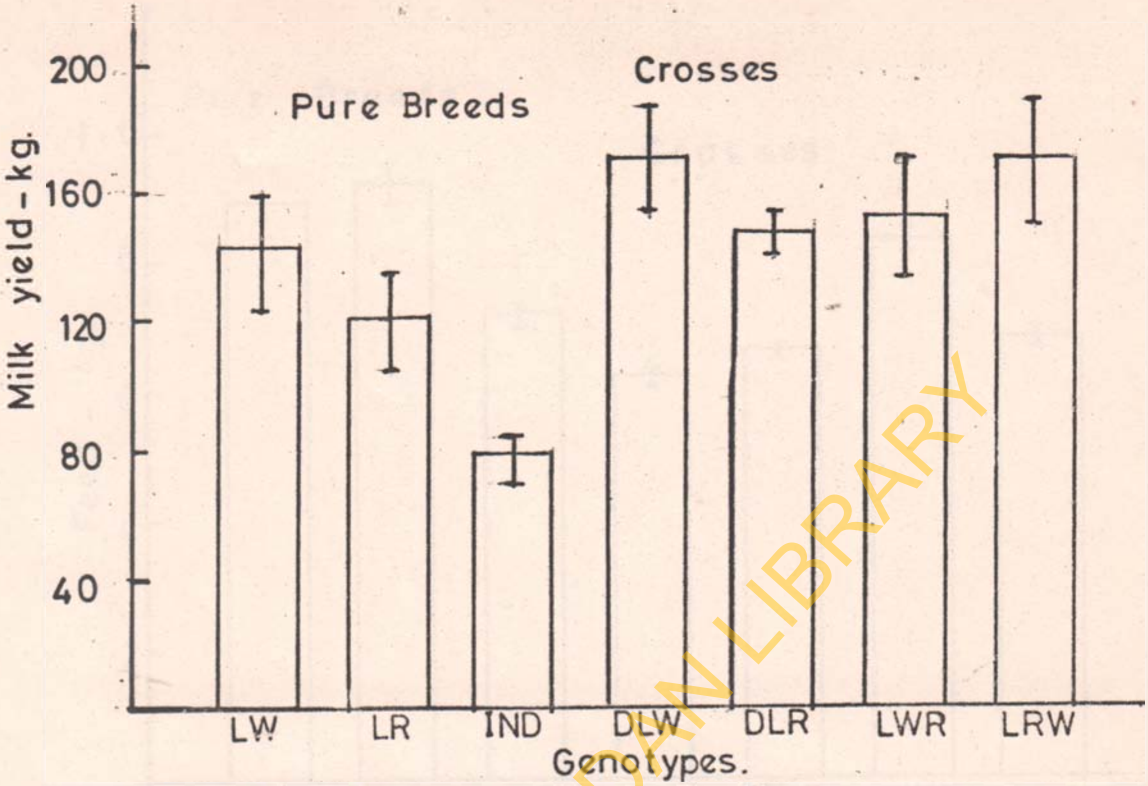

Fig. 6.4 Average milk production.

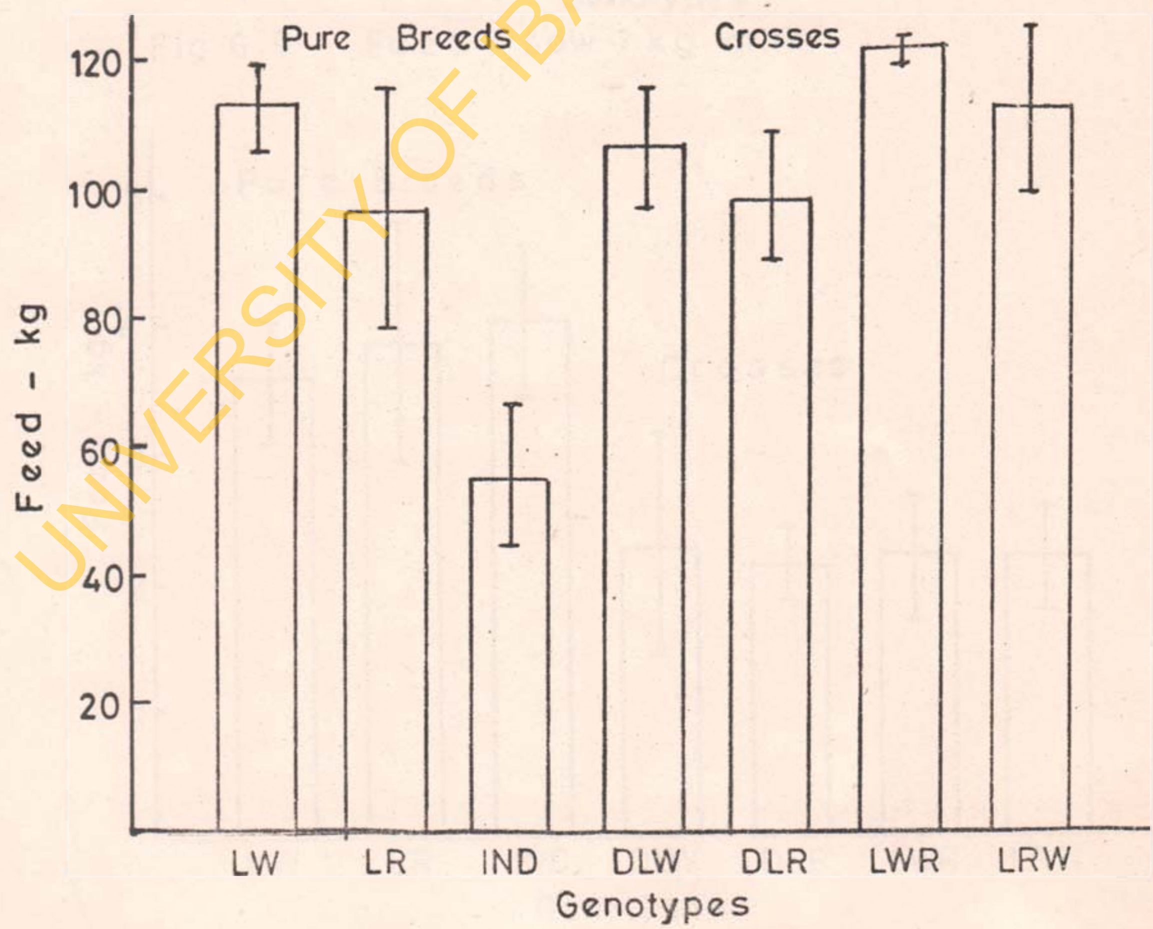

Fig. 6.3 Average feed consumption (kg)

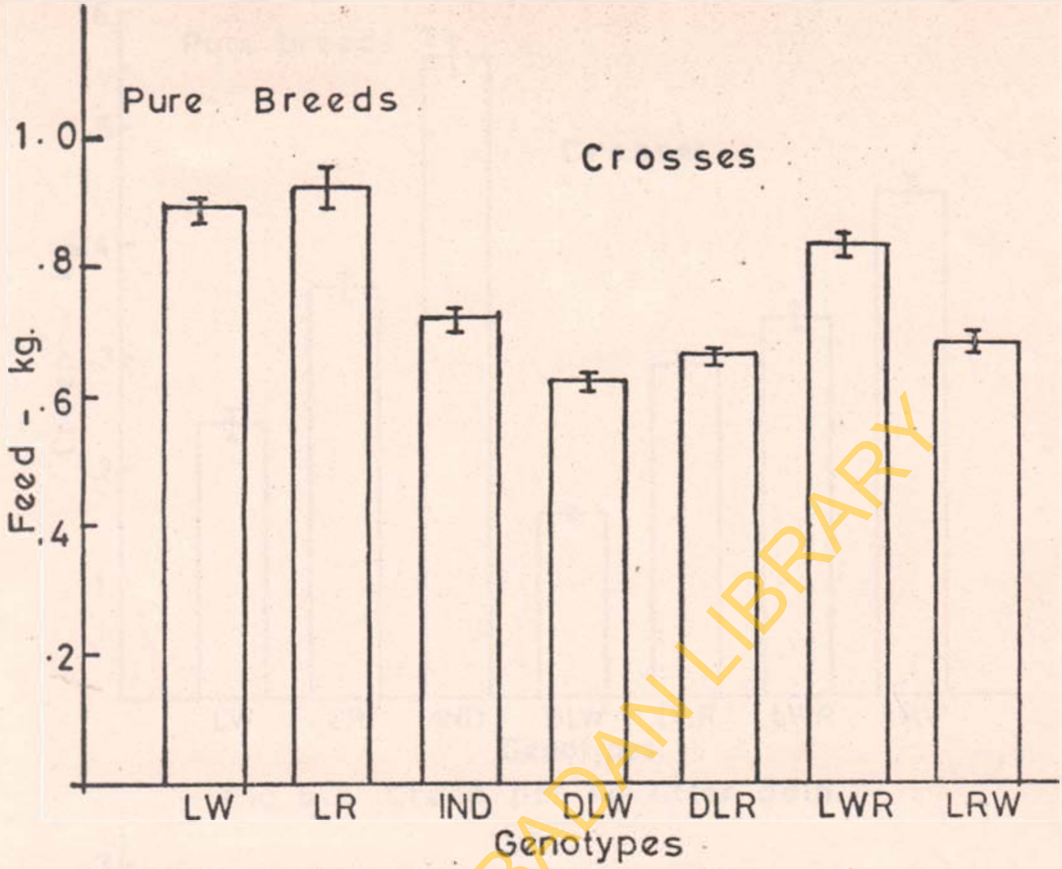

Fig. 6.5 Feed / sow / kg milk.

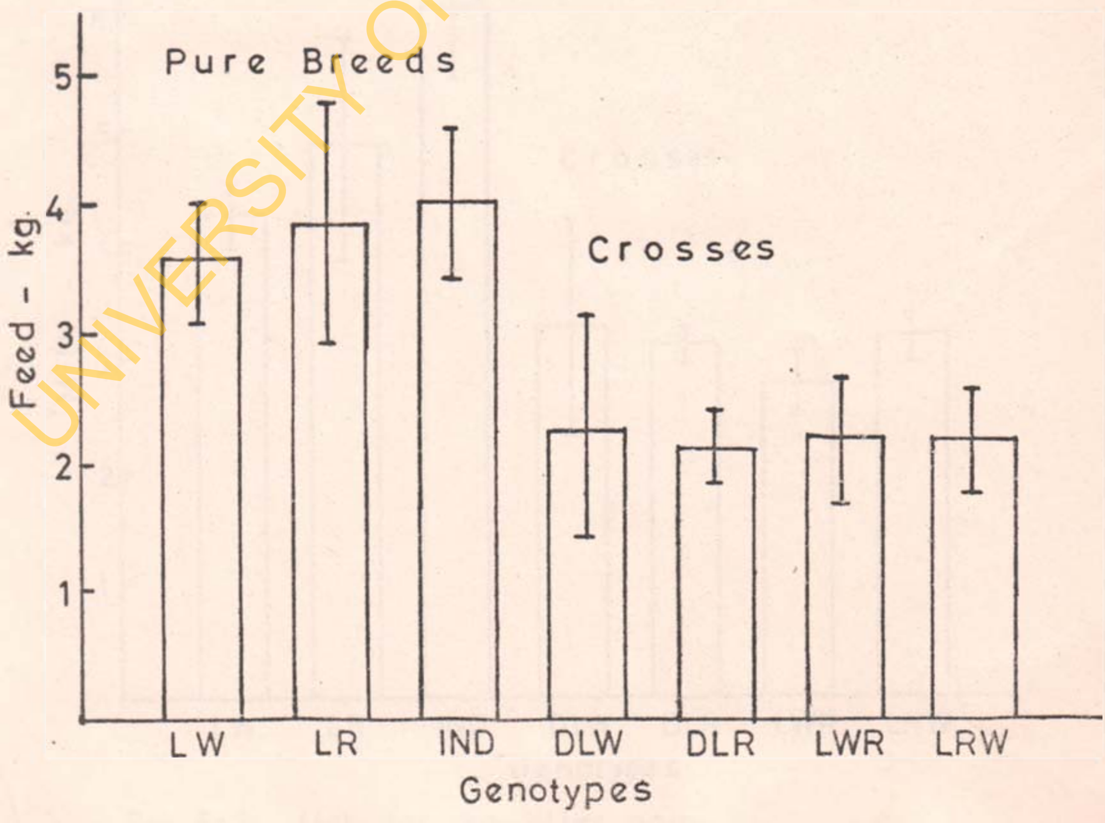

Fig: 6.6 Feed / sow / kg litter gain.

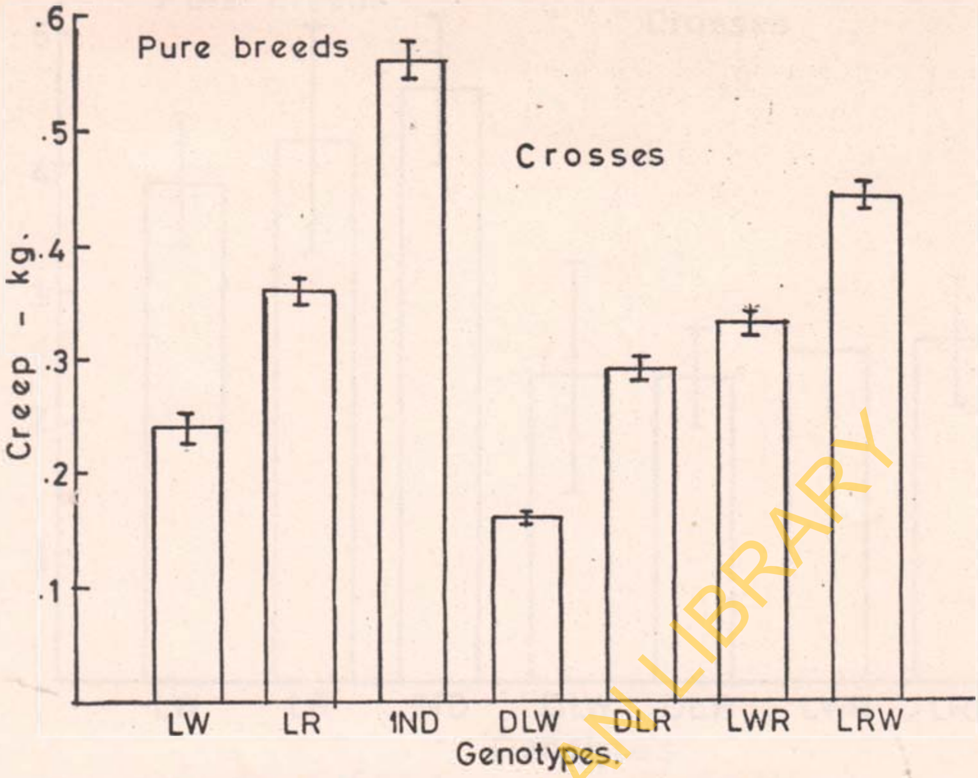

Fig. 6.8 Creep per kg litter gain.

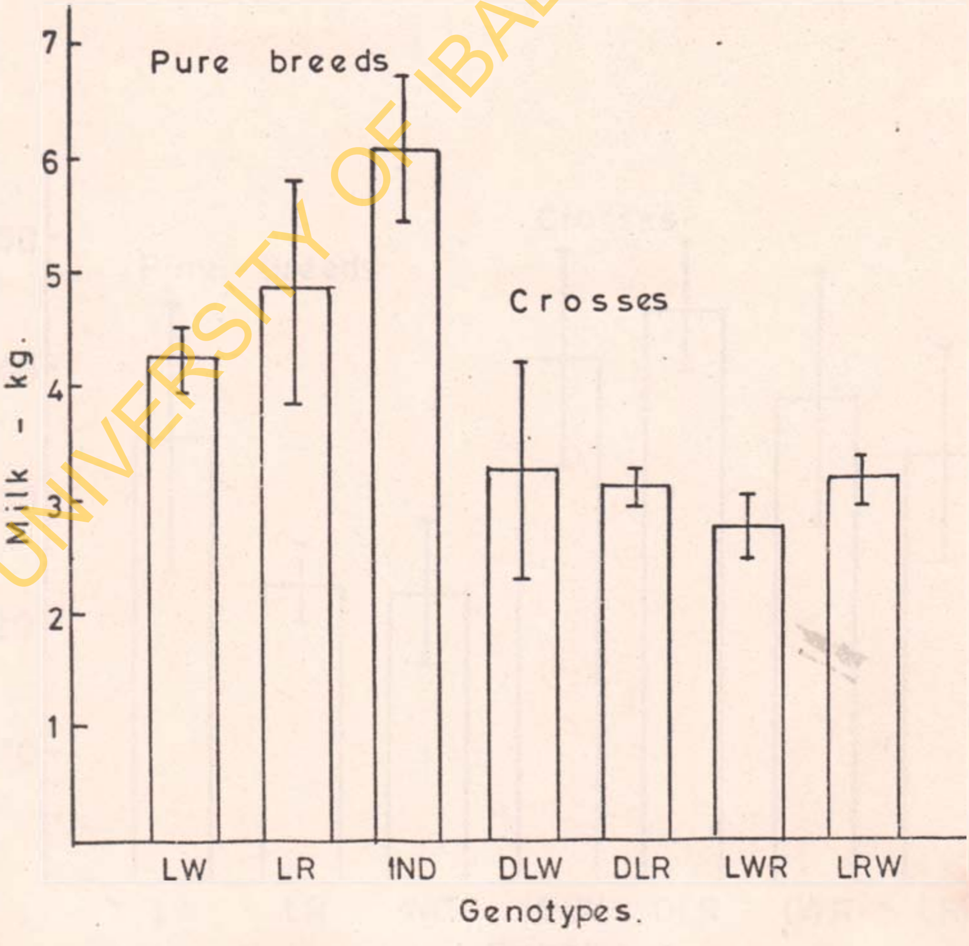

Fig. 6.7 Milk per kg. litter gain.

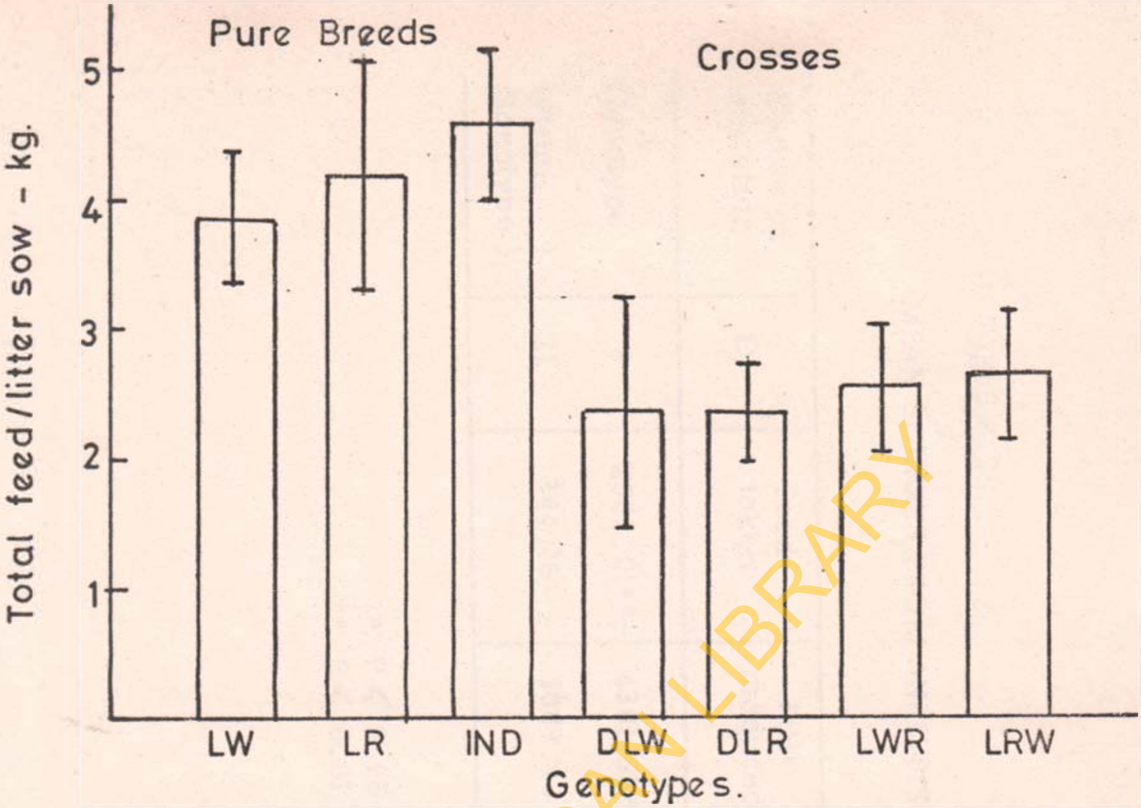

Fig. 6.9 Feed by sow and litter / kg litter gain.

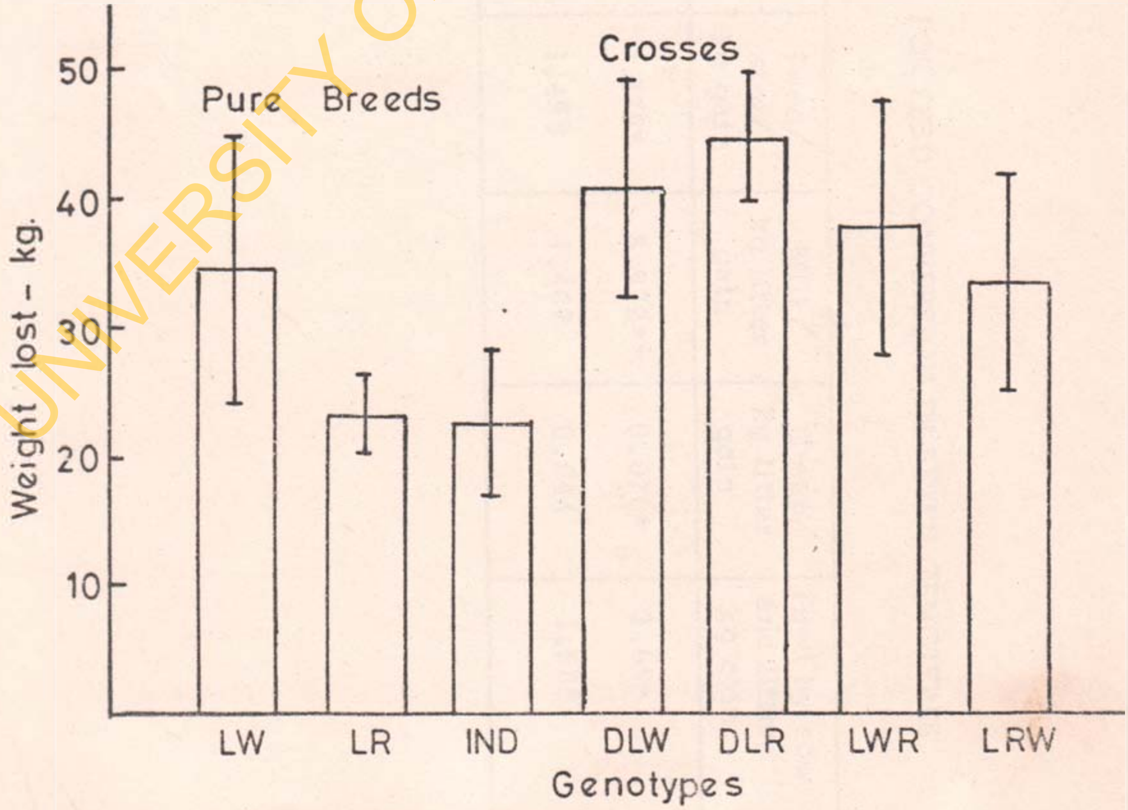

Fig. 6.10 Weight lost.

TABLE 6.25

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR FEED CONVERSION IN SEVEN GENOTYPES

Source of Variation	Df	Feed taken	Milk produced	Feed/ sow/kg milk	Feed/ sow/ kg gain	Milk/ kg litter gain	Creep/ kg litter gain	Feed by sow and litter/ kg gain
Genotype	6	2502.01**	4381.55*	0.054	3.178*	5.972**	0.070*	3.65*
Within Genotype	21	344.16	1089.43	0.143	1.498	1.407	0.044	1.588

* $P < 0.05$
** $P < 0.01$

from 54.34 kg in the indigenous to 121.26 kg in the exotic breeds (Table 6.24). The variation in feed consumption may be related to appetite since the indigenous pigs are by nature of their lack of domestication scavengers, and it may as well be due to the ratio of their body size and size of the gastrointestinal tract (Fig. 6.3). It is to be noted that the D.LW that produced the largest volume of milk (Fig. 6.4) was second to last in the amount of feed consumed among the crossbreds and third among all genotypes as a result they had the second highest body weight lost (Fig. 6.10)

Feed consumption by the sows for every kilogram of milk produced (Fig. 6.5) varied from a low of 0.62 kg in the D.LW to 0.91 in the Landrace sows, the others fell within this range but were not significantly different from each other (Table 6.25). The indigenous pigs ranked fourth in the efficiency of feed required for milk with 0.70 kg.

The amount of feed required by the sows to produce a kilogram gain in the litters varied from a low value of 2.10 kg in the D.LR to 4.00 kg in the indigenous pigs (Fig. 6.6). The breed differences were significant ($P<0.05$) between the crossbreds and the purebreds but not within the two groups except for the Large White and the indigenous pigs (Table 6.24).

The efficiency with which piglets made their gains during the nursing period is indicated by the amount of milk and creep consumed per kilogram gain (Fig. 6.7 and 6.8). The differences in milk required per kilogram of gain was highly significant ($P<0.01$) and significant ($P<0.05$) for the creep eaten per kilogram of pig gain. The crossbreds required 2.74 - 3.24 kg milk per kilogram of litter gain while the purebreds required 4-6 kg. The D.LW pigs needed least creep feed per kilogram of gain with 0.16 kg while the indigenous had the highest requirement 0.56 kg, significantly different from that of the others (Table 6.24). These data are of interest because they indicate that even the indigenous pigs were quite efficient in converting feed to milk and compared favourably with the others in the creep conversion to weight gains.

Another method used to determine the efficiency of production of sows and pigs was to evaluate the amount of feed consumed by both sow and litter per kilogram of pig gain (minus milk) (Fig. 6.9). Significant differences were observed among genotypes ($P<0.05$) in this respect. The indigenous and the Landrace were the least efficient with intakes of 4.56 and 4.19 kg respectively followed by the Large White. The crossbreds were the most efficient with intakes of 2.3 - 2.6 kg and no significant difference between these values (Table 6.24). This indicates a difference among the pure-and cross-breds in the efficiency of pig production.

The efficiency of conversion of feed nutrients to milk nutrients is shown in Table 6.26. Nutrients determined were protein, fat, dry matter and ash of both milk and ration of the sows (Appendix Table 6.VII). The efficiency of conversion of dry matter in the feed to total solids in the milk varied from 27% in the purebred exotic pigs to the Duroc crosses with 37%, the indigenous with 37% and 32% for the reciprocal crosses. The conversion of feed ash to milk ash was very low from 15-24% for the exotic pigs and 40% for the indigenous breed while the conversion of feed protein to milk

Table 2.26 EFFICIENCY OF CONVERSION OF FEED NUTRIENTS TO MILK NUTRIENTS (%).

Genotype	Total Solids		Ash	Protein	Fat
LW	26.93)	) 27.38	15.28	47.01	241.28
LR	27.59)		15.30	47.49	213.72
IND	36.82		40.37	62.97	316.67
D.LW	38.35)	) 37.48	18.77	64.10	304.52
D.LR	36.60)		20.31	60.41	304.41
LW.LR	30.21)	) 32.73	17.70	54.52	251.18
LR.LW	35.26)		24.19	63.58	303.85

protein was very high with 47% for the purebred exotic, 63% in the indigenous, 62% for the Duroc crosses and 59% for the reciprocal crosses.

The most striking of these figures was the efficiency of conversion of feed ether extract to milk fat. While the fat content of the ration was very low and fat intakes were 2.28-5.1 kg (Appendix Table 6.VII) fat yield in the milk varied from 7-14 kg resulting in ratios of milk fat yield of 2-3 times the amount offered in the feed. This brings to mind the relative body weight lost in these pigs. It means that the animals might have all the time been catabolizing their body fat into milk fat. It has been generally accepted that inadequate intake of fat or other nutrients does not seem to limit milk production because the impulse to secrete causes the body reserves to be called upon. The amount of the diet consumed and the changes in body weight during lactation depend on the obesity of the sow at the beginning of the lactation. Obese sows tend to consume less feed during lactation and lose more weight than thin sows. The energetic efficiency of lactation is higher when milk is produced by current energy intake than by dependence on body fat depots. Therefore in practical feeding, the greatest efficiency of energy utilization is achieved by controlled energy intake during gestation to minimize fattening and by feeding higher energy during lactation to minimize mobilization of depot fat for milk production.

Willett and Maruyama (1946) have shown that an increase in fat intake by the sow results in an increased milk fat content and it appears likely that the utilization of body fat by the sow has a similar result in terms of the milk constituents. Similarly Brody (1945) reported that in the rather extreme case of fasting dairy cows the fat percentage of the milk rose and the lactose content fell while the total yield of milk and kilogram yield of milk fat also fell. Gross efficiency of conversion of dietary protein to milk protein when adequate energy was provided was put at 33% (ARC, 1967) which is just about half the efficiency of protein utilization reported in this study. It might therefore be necessary to modify the feed energy in a way to reduce the rate at which body fat was catabolised during lactation.

The above results show that quantity of milk consumed is certainly not the only or even the predominant factor involved in efficiency of pig production. There are differences in milk composition between genotypes as related in Chapter V and even variations between teats of the same sow as indicated by Smith (1960), but it is unlikely that these differences are sufficiently large to exert much influence on growth rate. Genetic factors may very well be of first importance in which case weight of the animals at lower ages could provide a useful criterion on which selection can be based.

Repeatability estimates for feed consumption (Appendix Table 6.VIII) and milk production were 0.68 and 0.43. While the repeatabilities of conversion of feed to milk and milk to litter gain were high with 0.42 and 0.45 respectively, the repeatabilities of conversion of sow feed or pig creep to gain were low with 0.22 and 0.17 respectively. The repeatability of conversion of both feed and creep to litter gain was correspondingly low (0.24). Heritability estimates of these production factors have not been reported in swine but in mice heritability estimates for gain were found to vary from 0.12-0.22 and for feed intake from 0.14 to 0.24 and 0.17 for milk yield (Jara-Almonte and White, 1973). For economy of gain in pigs heritability ranges from 0.08 to 0 .72 with an average of 0.32 (Craft, 1954).

The between litter analysis shows that considerable variability in weaning weight between piglets of the same litter arises from differences in birth weight and milk consumption. Reduction of this variable could be of practical and experimental value. But it is uncertain what steps should be taken to produce more uniform litters at weaning. Probably by manipulating qualitatively the feed supplied so that pigs are induced to take more supplementary feed could be suggested or by selection of sows on the basis of three weeks weight of piglets which would be an indicator of her milk supply. Three weeks is perhaps preferable because it is at peak milk production, at five weeks there may be already a decline.

The overall problem which remains to be answered therefore is, what sequence of feeding during pregnancy, lactation and the period between weaning of the litter and remating may be expected to result in optimum economic reproductive performance. It is not known in what tissues of the sows the loss in weight occurs, what part their breakdown actually plays in maintenance of milk yield, and to what extent the shape of the lactation curve may be controlled by variation in feed intake. In any attempt to raise the average weaning weight in a herd, attention should be paid to mean weights at three and five weeks rather than to birth weights. This would mean much earlier selection of animals of higher weights and increases in the economy of production.

A closer look at the milk production at three and five weeks and the weights of the litter at these ages reveals significant positive correlations between milk yield and corresponding weights at these ages to the tune of r = 0.43 - 0.87 at three weeks and r = 0.43 - 0.86 at five weeks (Tables 6.27 and 6.28). Regression coefficients of 0.63 - 2.47 kg at three weeks and of 0.66 - 3.19 kilogram milk per unit increase in litter weight at these weeks were obtained.

These values could be used as better predictors of milk production at these periods. From the coefficients of correlation of r = 0.43 - 0.87 the coefficient of alienation is very high and varies from 41-73%. This would give good predictors at these ages

Table 6.27 RELATIONSHIP BETWEEN MILK AND LITTER WEIGHTS AT THREE WEEKS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.651**	30.89 + 1.519x	0.406
LR	0.747**	13.53 + 2.468x	0.517
IND	0.811**	15.34 + 1.164x	0.210
D.LW	0.433**	42.20 + 0.689x	0.383
D.LR	0.576*	20.81 + 1.595x	0.654
LR.LW	0.569*	36.64 + 0.630x	0.290
LW.LR	0.874**	19.13 + 1.260x	0.220

* $P<0.05$
** $P<0.01$

Table 6.28 RELATIONSHIP BETWEEN MILK AND LITTER WEIGHTS AT FIVE WEEKS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.696**	47.33 + 2.030x	0.480
LR	0.825**	23.28 + 3.189x	0.515
IND	0.828**	32.53 + 1.290x	0.218
D.LW	0.429*	82.18 + 0.664x	0.373
D.LR	0.720**	31.67 + 1.961x	0.141
LR.LW	0.862**	51.07 + 1.070x	0.200
LW.LR	0.775**	51.59 + 1.260x	0.320

* $P<0.05$
** $P<0.01$

in making adequate selection programmes for the dams. Similarly are the litter weights at these ages.

Regressions of litter weight at three weeks on five and on eight weeks weight reveal a highly significant correlation of r = 0.8 - 0.99 (Table 6.29 - 6.30) coupled with high increments in weight of 1.16 - 1.36 kg at five weeks per kilogram increase in weight at three weeks and of 1.31 to 2.00 kg increase in weight at eight weeks.

Donald (1939) has postulated that where competition existed (e.g. within litter) initial weight was important in influencing the final weight but where there was no competition (e.g. between litters) the degree of importance of initial weight depended on the correlation between it and milk supply. Birth weights and amount of milk consumed had considerable influence upon the relative weights of litter mate piglets at three weeks of age. But the relative mean weights of different litters at other ages were apparently governed largely by factors such as genetic influences, climatic effects and differences in feed value between milk and creep consumption. It must not be assumed that birth weight and milk consumption are not important, but that three week weight could be a better indicator of weaning weight than birth weight or milk consumption in that one kg difference in weight at three weeks was revealed to have yielded 1.2 - 1.4 kg difference in weight at five weeks and 1.3 - 2.0 kg at eight weeks.

This finding is in close agreement with the work of Lodge and Mcdonald (1959) in which they obtained 2-3 kg difference at eight

Table 6.29 RELATIONSHIP BETWEEN LITTER WEIGHT AT THREE AND FIVE WEEKS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.931***	2.22 + 1.196x	0.107
LR	0.966***	2.69 + 1.156x	0.072
IND	0.990***	0.24 + 1.233x	0.044
D.LW	0.954***	0.54 + 1.317x	0.111
D.LR	0.970***	2.73 + 1.291x	0.091
LR.LW	0.959***	0.21 + 1.365x	0.128
LW.LR	0.976***	2.05 + 1.334	0.094

*** $P<0.001$

Table 6.30 RELATIONSHIP BETWEEN LITTER WEIGHT AT THREE AND EIGHT WEEKS.

Genotype	r	$\hat{y} = \bar{y} + bx$	SE_b
LW	0.974***	6.16 + 1.550x	0.083
LR	0.838**	10.18 + 1.305x	0.200
IND	0.937***	0.33 + 1.605x	0.149
D.LW	0.890**	4.11 + 1.835x	0.251
D.LR	0.796**	12.33 + 1.608x	0.354
LW.LR	0.921**	1.00 + 1.998x	0.268
LR.LW	0.914**	3.06 + 1.982x	0.228

** $P<0.01$
*** $P<0.001$

weeks, and of Teter and Hanson (1959) who studied pigs weaned at three weeks and found an average increase in eight weeks weight of 1.8 - 3.6 kg for every kilogram increase in three week weight.

There was a significant tendency for creep feed consumption to be greater for litters which were heavier at three weeks, and creep feed consumption was itself of great importance in determining mean weaning weight. Similar evidence was given by Teague and Wilson (1957) who found that growth rate and vigour of piglets during the first three or four weeks of life greatly influenced subsequent creep feed consumption and rate of gain.

Since milk production of sows is only utilized by piglets, its association with weight gained by the litter during the suckling period was further examined to evaluate the dependence of the litter on the milk of the sow. Least square polynomial regression curves fitted to the data (Table 6.31) revealed that the association between weight gained and milk production, although high and significant in separated linear regression analyses, is of a curvilinear nature. The regression coefficient revealed that 38-57% of the variation in litter weight gained by the exotic purebreds was due to milk ingested while this association accounted for 72% of the variation in the indigenous pigs and 71-89% in the crossbreds. The residual might be due to variation in creep feed consumption, nutritive value and palatability of the creep offered.

From the curves (Fig.6.11 & 12) it can be deduced that the weight gained in relation to milk production of the purebreds increased to a maximum of about 50 kg in the offspring of the

Table 6.31

RELATIONSHIP BETWEEN MILK YIELD AND WEIGHT GAINED

Genotype	$\hat{Y} = \bar{Y} + b_1x + b_2x^2 + b_3x^3$	R	% variation due to regression	SE of estimate $\hat{Y}$
LW	$28.73 - 21.851x + 0.807x^2 - 0.0082x^3$	0.756*	57.1	± 29.98
LR	$90.04 + 0.56x + 0.0265x^2 - 0.000041x^3$	0.614*	37.8	± 37.99
IND	$28.80 + 6.049x - 0.232x^2 + 0.00312x^3$	0.847*	71.7	± 10.27
D.LW	$218.79 - 5.357x + 0.096x^2 - 0.000432x^3$	0.721*	71.0	± 26.34
D.LR	$268.59 - 12.335x + 0.285x^2 - 0.00177x^3$	0.858*	73.6	± 23.24
LW.LR	$94.92 - 0.136x + 0.019x^2 - 0.0000604x^3$	0.946*	89.4	± 12.70
LR.LW	$165.061 - 5.240x + 0.141x^2 - 0.00088x^3$	0.889*	79.1	± 21.11

* $P < 0.05$

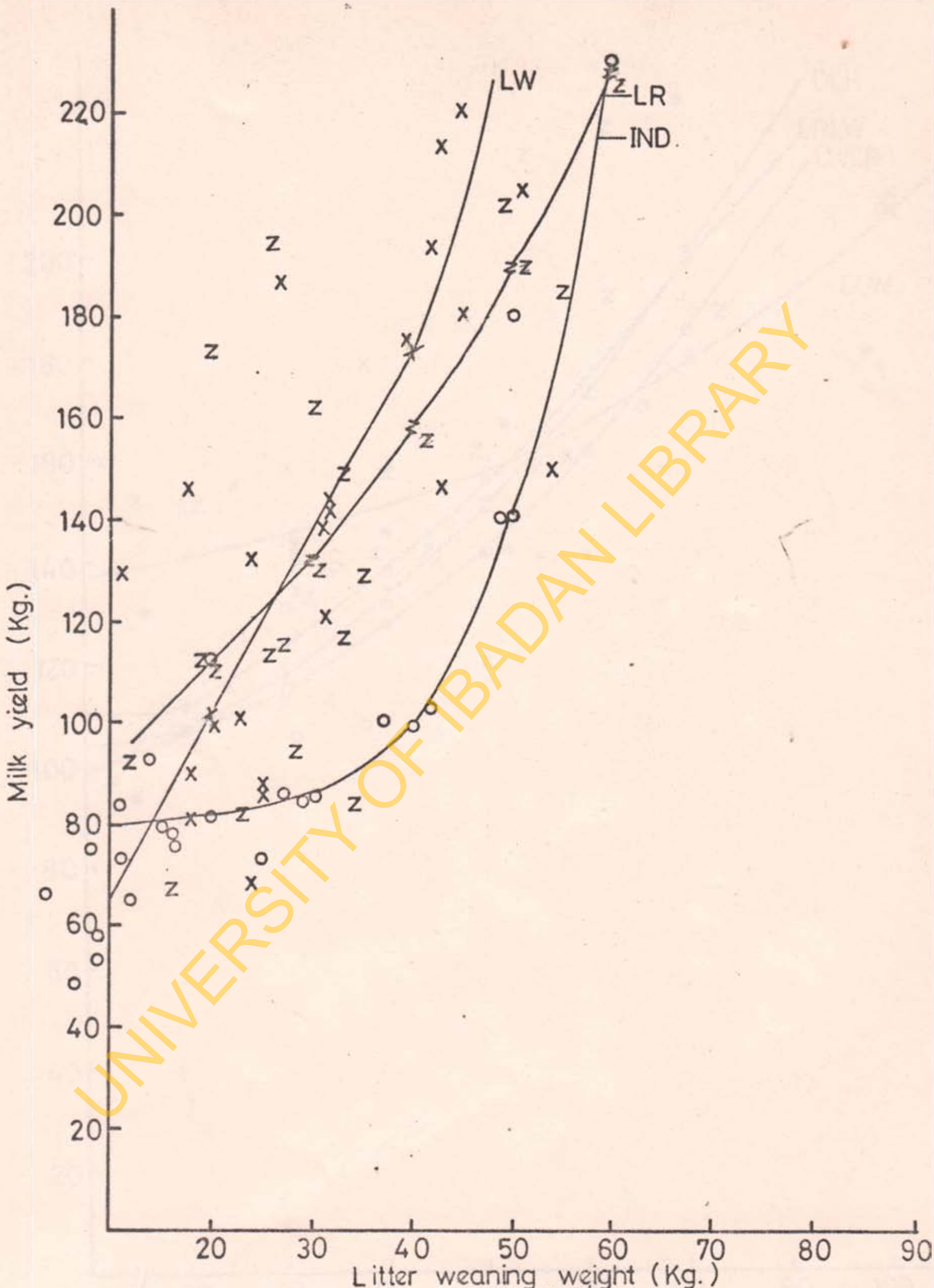

Fig. 6.1 Regression of milk yield on weight gained by litters - pure breeds.

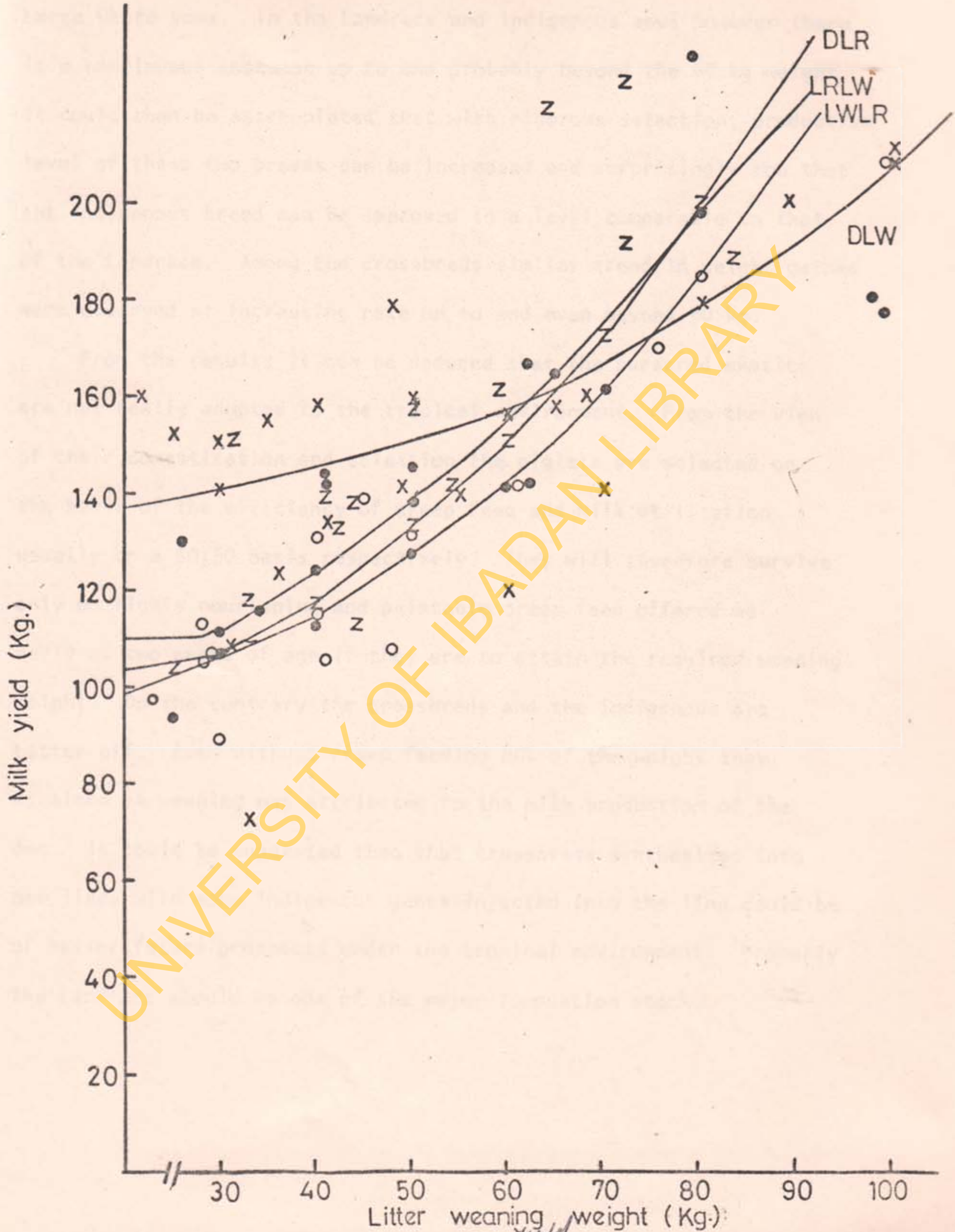

Fig. 6.12 Regression of milk yield on weight gained by litters - crossbreds

Large White sows. In the Landrace and indigenous sows however there is a continuous increase up to and probably beyond the 60 kg weight. It could then be extrapolated that with rigorous selection, productive level of these two breeds can be increased and surprisingly too that the indigenous breed can be improved to a level comparable to that of the Landrace. Among the crossbreds similar trend in weight gained were observed at increasing rate up to and even beyond 90 kg.

From the results it can be deduced that the purebred exotics are not really adqpted to the tropical environment. From the view of their domestication and selection the piglets are selected on the basis of the efficiency of creep feed and milk utilization usually on a 50:50 basis respectively. They will therefore survive only on highly nourishing and palatable creep feed offered as early as two weeks of age if they are to attain the required weaning weight. On the contrary the crossbreds and the indigenous are better off. Even without creep feeding 80% of the weight they attained at weaning was attributed to the milk production of the dam. It could be suggested then that crossbreds synthesized into new lines with some indigenous genes injected into the line could be of better future prospects under the tropical environment. Probably the Landrace should be one of the major foundation stock.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This chapter is an attempt to summarize findings of this study with specific attention paid to differences in performance of exotic breeds of swine raised pure (Large White and Landrace), and crossbreds among imported stock namely the two kinds of Duroc sired crosses of the Large White and Duroc x Landrace) and reciprocal crosses of the Large White and Landrace (Large White x Landrace and Landrace x Large White). In all crosses the first named breed is the sire. Finally an appraisal is made of the indigenous pig of Southern Nigeria.

7.1 Superiority of Crossbreds

Many studies have been made by geneticists seeking explanations for hybrid vigor arising from crosses. Attempts to explain hybrid vigor and also the depressing effects of inbreeding are based on two theories.

First, the dominance theory was based on the observed association between recessiveness and detrimental effect which assign the increased vigor of crossbreds to complementary effects of favourable dominant genes brought into the cross from each parent. Inbreeding uncovers recessives and thereby results in deterioration but crossing hides the effect of bad genes. Thus in the crossbred some of the detrimental recessives coming from one parent are hidden by their dominant alleles coming from the other parent, and an increase in vigor is the result. Since number of genes for most of the important traits in swine is large and linkage of desirable and less desirable genes is possible, the probability of a single breed or an inbred line becoming homozygous for only the dominant or beneficial genes is remote.

The second theory is that of hybridity which in itself contributes to vigor. In Mendelian terms there would be loci at which the heterozygote is superior to either homozygotes and the increased vigor is in proportion to the number of such loci. In both cases vigor decreases with inbreeding and increases with crossbreeding.

Most of the present day swine breeds have evolved from crossbred foundations. In 1935 the United States Department of Agriculture initiated development of new lines from crossbred foundations as a way of combining desirable traits of two different breeds. One of the foundation stocks was the Danish Landrace imported in 1934, and later other breeds were introduced. From crossing the Danish Landrace with other breeds new lines were developed and have since been recognised as new breeds, such as Montana No.1, Maryland No. 1, Beltsville No. 1 and 2, the Minnesota No. 1, the Palouse and the Lacombe. Other new breeds without the Landrace were the Minnesota Nos. 2 and 3 and 4 with traces through other breeds. Details relating to the development of the Minnesota lines were reported by Winters et al. (1948), Roubicek et al. (1951), and Sumption et al. (1957).

Similar efforts were made in Europe. The Piétrain, developed in Belgium is now in more prominence because of its outstanding meat quality. While all these breeds were developed for improved commercial traits, new breeds of laboratory pigs of small size evolved for use in biomedical research. Examples are the Minnesota Miniature pig, (Dettmers et al., 1965) , the Labco and the Göttingen strain (Haring et al., 1966 and 1967).

Crossbreeding in pigs for better litter size, survival and gain is so well known and widely practised that it is surprising that in several of the commercial piggeries in Nigeria purebred pigs are still raised, preferably Large White because they are considered the best adapted and therefore the most economical.

Dettmers (1976) reported some results of crossbreeding among the Large White, Landrace and Saddleback carried out in Nigeria and between the Large White and Local Black of Ghana.

In the present study comparative results from purebreds and crosses as to litter size and weights at different ages are shown in Table 7.1 and Appendix Table 6.II. In these cases the dams are purebreds or single crosses as designated. The piglets are offspring of the single cross dams mated to one of the parent breeds as a crisscross design.

From above results the crossbreds are superior to purebreds in all traits studied except in milk production of the LWxLR. Superiority ranges from 11-58% for the LW. LR and 20-74% for the LR x LW for litter size, litter weights at birth, 21, 42 and 56 days and the average daily litter gain. There was no superiority encountered in milk production of the LW x LR over the purebred but the depression was not significant while the LR x LW showed 7% heterosis over the purebred.

Comparing the two kinds of crossbreds, it is very obvious that crosses between the Landrace sire and Large White dams produced a greater heterotic effect than the other way round (Landrace dam). The Large White dams are well known for their growthiness and high milking potential. They therefore scored higher with 20% heterosis in litter size, 41-67% heterosis for litter weights and 74% on daily litter gain.

Table 7.1 SUPERIORITY OF CROSSBREDS OVER PUREBRED LARGE WHITE AND LANDRACE SOWS.

Genotype of dams	Litter size	Litter Weights (kg)/days 0	21	42	56	Litter Daily Gain (g)	Milk Yield (kg)
LW	7.33	8.26	21.60	28.05	39.65	560.5	137.68
LR	5.15	6.72	19.61	25.36	35.77	519.6	133.35
Average	6.24	7.49	20.61	26.71	37.71	540.1	135.52
Crossbreds							
LW x LR	6.92	9.18	28.08	38.53	57.06	855.2	129.18
LR x LW	7.50	10.56	30.28	42.44	63.07	937.7	144.64
Heterosis							
LW x LR	+0.68	+1.69	+7.47	+11.82	+19.35	+315.1	- 6.34
%	10.90	22.56	36.24	44.24	51.31	58.34	
LR x LW	+1.26	+3.07	+9.67	+15.73	+25.36	+397.6	+ 9.12
%	20.19	40.99	46.92	58.89	67.25	73.62	6.73
Duroc Crosses							
DU x LW	8.44	11.26	31.30	41.76	61.68	880.4	148.32
DU x LR	8.07	10.94	32.29	44.42	57.33	932.9	153.21
Heterosis							
DU x LW	+2.20	+3.77	+10.69	+15.05	+23.97	+340.3	+12.80
%	35.25	50.33	51.87	56.35	63.56	63.01	9.45
DU x LR	+1.29	+3.45	+11.68	+17.71	+19.62	+392.8	+17.69
%	20.73	46.06	56.67	66.30	52.03	72.73	13.05

In comparison, the D.LW crosses had 35% heterosis for litter size, 50-64% on litter weights and 9% for milk production while the D.LR showed 21% heterosis for litter size, 46-73% on litter weights and 13% for milk production. Here the Landrace as the dam seemed better off in litter and milk productivity than the Large White combination although the litter size was lower.

When the Duroc crosses were compared to the average of the reciprocal crosses (Table 7.2) superiority was recorded for litter traits up till 42 days of age and also for milking capacity. Here the Duroc x Landrace crosses appeared superior to their counterparts. This then brings to mind the theory of nicking or combining ability. Despite the superiority of the Large White-Landrace reciprocals over the Large White and Landrace purebreds, they were surpassed by the Duroc crosses especially by the D,LR cross except in litter weaning weight. It can then be inferred that the Duroc and Landrace combinations had greater nicking quality than even the Landrace x Large White combinations which were superior to the Large White x Landrace combinations and the purebreds.

In comparison with other results, for example Skarman (1965) (according to Cole, 1971) confirmed in his experiment on comparison of reciprocal crossing between Large White and Landrace pigs with purebreeding the production of large litters at birth, a higher survival rate to weaning and heavier piglet and litter weight at three and eight weeks of age of the Landrace x Large White sows. In contrast, a large scale experiment at Oklahoma involving the Beltsville No. 1 and Duroc breeds (Cunningham, Omtvedt and Whatley, 1967) did not show an increase in

Table 7.2 COMPARISON OF DUROC AND LW.LR RECIPROCAL CROSSES.

Genotype	Litter size	0	21	42	56	Daily Litter Gain(g)	Milk Production (kg)
LW + LR	6.92	9.18	28.08	38.53	57.06	855.2	129.18
LR + LW	7.50	10.56	30.28	42.44	63.07	937.7	144.64
Average	7.21	9.87	29.18	40.49	60.07	896.5	136.91
DU + LW	8.44	11.26	31.30	41.76	61.68	880.4	148.32
DU + LR	8.07	10.94	32.29	44.42	57.33	932.9	153.21
Superiority							
DU + LW	+1.23	+1.39	+2.12	+1.27	+1.61	-16.01	+11.41
%	17.06	14.08	7.27	3.14	2.68		8.33
DU + LR	+0.86	+1.07	+3.11	+3.93	-2.74	+36.4	+16.30
%	11.93	10.84	10.66	9.71		4.06	11.91

survival rate and total litter weight at weaning. The analysis of an extensive set of British field data by Smith and King (1964) again demonstrated the crossbreds' advantage.

These data have all referred to gains arising from the extra vigor possessed by crossbred piglets born to purebred dams. Further gain was however expected from the use of crossbred dams through heterosis in the component traits of the reproductive process. Results of Hazel (1958) indicated 28% heterosis in the weaning weight of litters from two breed crosses compared to purebred pigs, While Dettmers (1976) showed 8% superiority of the single crosses to purebreds and 26% in the three way crosses between Large White, Landrace and Saddleback over purebreds. Most improvement could have been due to lower mortality in the crossbred pigs between birth and weaning and some to their slightly heavier weaning weights.

Crossbred pigs have also been shown to make faster gains from weaning to market weight but there was little or no difference in amount of feed required per unit of gain (Lesley 1972). Crossbred litters were less variable in body weights than purebreds, this despite the known tendency for increased litter size to be associated with increased variability. Reproductive disorders appear to be reduced in crossbred females (Smith and King, 1964; Skarman, 1966) and crossbred progeny have a lower incidence of disease defects (Skarman, 1965).

Similar observations were found during this study. Most of the purebred progeny suffered from diarrhoea (piglet scours) which seemed to be rampant among the stock. The rate of scours was however very much reduced among the crossbred pigs. Considering the economy of bringing up these pigs in the type of hygienic surrounding provided and the cost of adding antibiotics to the water and creep feed of the purebreds, they are less profitable. Most of the advantages of crossbred piglets are evident by the time the pigs are weaned. The average of 51-67% superiority of the crossbreds' litter weights at weaning is large enough to be of great value in commercial pork production in Nigeria.

In assessing the superiority of crossbreeding over purebreeding, breeds might have to be ranked with respect to their reproductivity. Breeders are sometimes interested in selection for improvement of a single trait. Usually they are interested in improving more than one and those traits which are of greatest economic importance such as litter weaning weight.

A selection index for the purpose of selecting for sow performance was developed by Dickerson et al. (1954). They recommended:

$$\text{Index} = 2(N_b + 2N_w + \frac{2T_w}{30})$$

where N_b = Number of pigs born,

N_w = Number of pigs weaned,

T_w = Total litter weight at weaning.

The purpose of selection is to improve the average genetic worth of the population. Since genetic values cannot be observed directly phenotypic values must serve as estimates of breeding values. A linear function of phenotypic values is used to obtain an index which is the basis for selection.

Individual selection indexes for the animals of this study are reported in Appendix Table 7.1 and means of the selection indexes for each genotype studied are shown in Table 7.3. Selection index for each genotype varied from 31.8 in the indigenous to 56.1 for the Duroc sired Large White. The mean index of all animals studied was 44.9, and 53 animals attained values above this mean for the population (Fig 7.2) while a total of 59 animals could have been selected on the basis of their own group average (Table 7.3). The reduction in number selected was due to the smaller number of animals that ranked above the population mean among the Landrace and indigenous pigs.

Selection indices by genotype are represented graphically in Fig. 7.1 and 2. When different selection pressures were applied the resulting expected genetic change for each genotype are given in Table 7.4. When the top 20-25% were selected (assuming average

Table 7.3 AVERAGE SELECTION FOR SOW PRODUCTIVITY.

Genotype	N	Selection index for each genotype	No selected	% of genotypes selected	Selection index for the population	No. of animals selected
LW	21	47.0	10	47.6	44.9	10
LR	20	34.9	9	45.0		4
IND	18	31.8	10	55.5		3
D.LW	16	56.1	10	62.5		12
D.LR	14	53.7	9	64.3		11
LW.LR	12	50.4	6	50.0		17
LR.LW	12	46.6	5	41.8		6
TOTAL	113		59			53

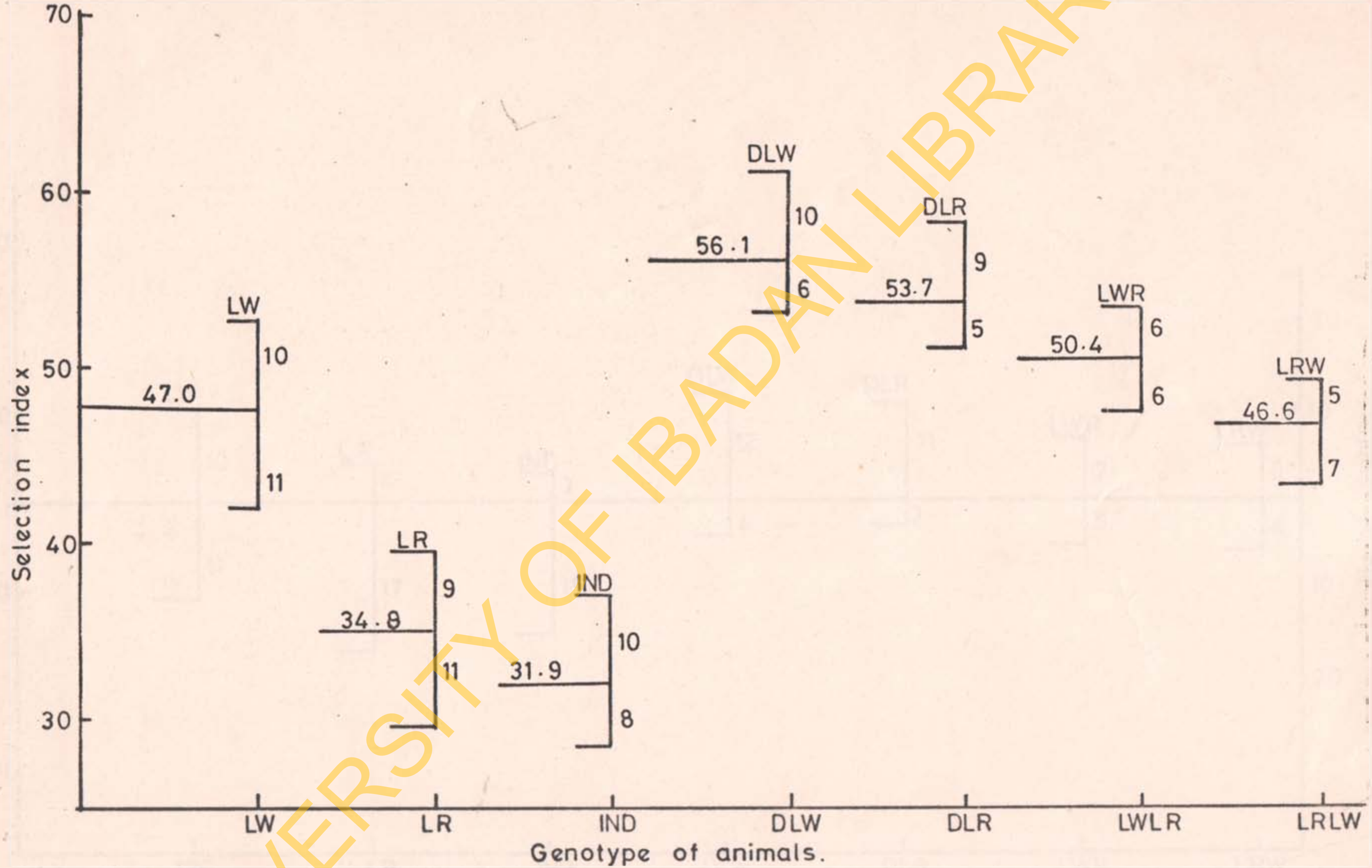

Fig. 7.1 Average selection of each genotype.

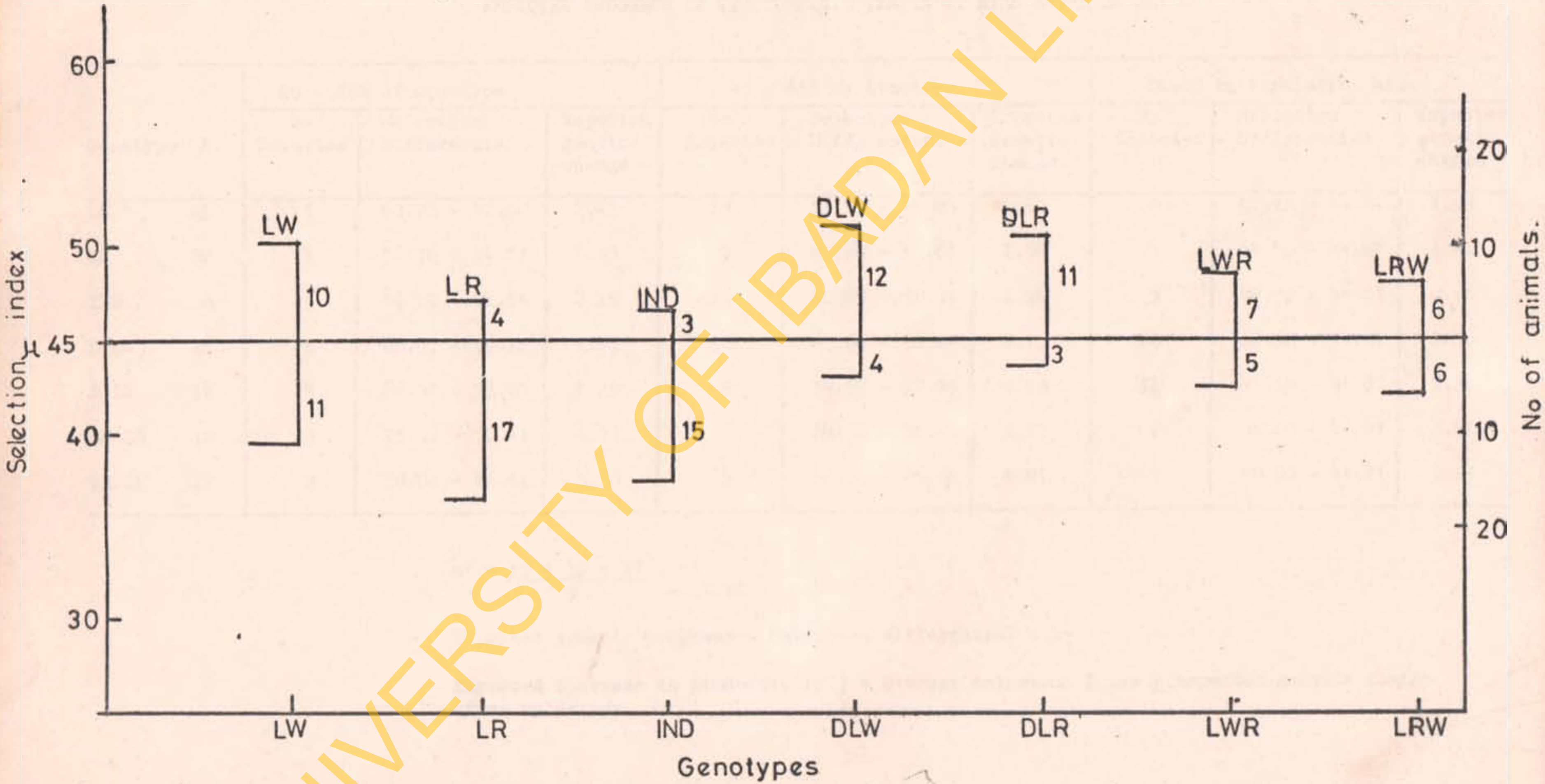

Fig. 7.2 Average selection based on population mean.

TABLE 7.4

EXPECTED PROGRESS IN THE COMBINED TRAITS STUDIED AFTER SELECTION

Genotype	N.	20 - 25% of Genotype			45 - 65% of Genotype			Based on Population mean		
		No Selected	Selection Differential	Expected genetic change	No Selected	Selection Differential	Expected genetic change	No Selected	Selection Differential	Expected genetic change
LW	21	5	63.23 - 47.00	2.43	10	57.73 - 47.00	1.61	10	57.73 - 44.87	1.93
LR	20	5	51.76 - 34.87	2.53	9	45.40 - 34.87	1.58	4	54.26 - 44.87	1.41
IND	18	5	46.19 - 31.84	2.15	10	40.89 - 31.84	1.36	3	49.29 - 44.87	0.66
D.LW	16	5	68.81 - 56.11	1.91	10	63.64 - 56.11	1.13	12	61.52 - 44.87	2.50
D.LR	14	5	62.92 - 53.65	1.39	9	59.87 - 53.65	0.93	11	47.16 - 44.87	0.34
LW.LR	12	3	75.12 - 50.41	3.13	6	69.56 - 50.41	2.87	7	66.00 - 44.87	3.17
LR.LW	12	3	70.61 - 46.61	3.60	5	66.01 - 46.61	2.91	7	60.03 - 44.87	2.27

$$h^2 = \frac{15 + 12 + 17}{3} = 14.7\%$$

Expected genetic progress = Selection differential x h^2

Expected increase in productivity after selection) = Average selection Index $\pm$ Expected genetic change heritability of 15% for litter size at birth and at weaning and for litter weaning weight) expected genetic change in sow performance varied from 1.39 in the Duroc sired Landrace to 3.60 in the LR.LW. Whereas when the total number of animals taken on the basis of genotypic average was selected, the expected genetic change was 0.93 in the Duroc sired Landrace to 2.91 in the LR.LW sows. When selected on the mean of the population index the expected change was 0.34 in the Duroc sired Landrace to 3.17 in the LW.LR crosses.

From the above table it became obvious that while selection based on the population mean increased the productivity of the Landrace and the indigenous pigs to 44.87 $\pm$ 1.41 and 0.66 compared to 34.87 $\pm$ 2.53 and 31.84 $\pm$ 2.15 respectively, on the other hand it lowered that of the other pigs, 44.87 compared to 46.61 to 56.11. Strict selection based on the genotypic average with few animals selected (20-25%) had a stronger impact on the productivity of the Large White and the other crossbreds.

The usefulness of a selection index in terms of genetic progress depends on the degree of heritability of the traits chosen for inclusion in the index and also on the selection differential and proportion of potential breeding stock that is saved for breeding. The more rigid the culling is the more rapid will be the expected progress, but the decision as to what proportion of potential breeding stock to save for breeding must be based on the number needed to maintain the size of the breeding herd. A more realistic approach would be to save that proportion for herd replacements which show promise of improving the production efficiency of the herd on the basis of performance information.

Thus it is clear that a selection index serves to rank individuals according to a predetermined set of performance traits and that the ranking depends on the weight placed on the traits.

7.2 The Indigenous Sow

Despite the ancient cultural and religious taboos forbidding the consumption of pork, the domestication of the pig as a source of human food had persisted and the continued increase in numbers of swine throughout the world up to the present time provides evidence of the contribution of the pig to human nutrition through the ages. The pig has traditionally been a scavenger and in early domestication it was raised as a means of utilizing food wastes of man. In many parts of the world especially in developing countries the pig still performs this function as a backyard inhabitant. The efficiency of utilization of feed for pork production depends on the provision of a balanced diet, on husbandry conditions and genetic selection conducive to high efficiency. The low efficiency of swine production in many developing countries reflects the need to improve its economy for as efficiency rises unit cost of production declines. The low efficiency is probably due to a variety of factors, but it seems clear that significant improvements can be made in most cases by appropriate adjustments in feeding, breeding and management.

The domestic pig has evolved by natural selection and hybridization and more recently by the application of the principles of population genetics by animal breeders. While there are currently some 87 recognized breeds (Mason, 1969) of domestic swine in the world, most of them in Europe and North America, there are in addition another 225 varieties of pigs not recognized as breeds, but each having unique characteristics, appearance or are suitable to a specific (ecological niche) geographical location.

The indigenous pigs of Nigeria can be characterized as one of those breeds whose productive potential has not been fully exploited. Comparing them with other breeds they rank low, they are of relatively small size, have small litter size and low weights, produce less milk which is relatively richer in all constituents, especially in fat (energy content) and is more evenly distributed throughout the lactation. This might be related to adaptation during its evolution. Analysis of the association between the milk and the components revealed high significant correlations of 0.4 - 0.7 between the milk and the components in contrast to low correlations of the exotic pure and crossbred pigs. Similarly, relationships between the milk and litter performance indicated a high level of dependence of the weight gained by piglets on the level of milk secretion of the dam.

While the European breeds have been domesticated and selected for high litter performance and their offspring has been introduced to creep feeding at early ages, the indigenous pigs have always scavenged. Therefore their offspring might not have been able to utilize garbage at such an early age and so have remained very much dependent on milk production of the sow alone, probably for the first six to eight weeks of their life when they begin only to nibble at waste foods.

Their relatively slow rate of growth was shown on the lower part of the graph (Fig. 6.11) in proportion to milk production of the dam. But from the degree of relationship and the regression coefficients high milk production has been found to induce higher weight gains in the piglets comparable to the rate of gain in piglets of the Landrace sows. Probably it could be stressed that when these animals are intensively managed in confinement, efficiency of production will be maximized if their management is coupled with very rigid selection procedures during postnatal and growth phases after weaning.

They will surely have something to contribute if and when new lines of pigs are to be synthesized for production under the tropical environment. They are more economical by way of their feed intake and comparable to the other breeds in the efficiency of utilization of feed for milk.

7.3 Conclusions and Recommendations

From the summary of the results it is quite obvious that the exotic purebreds in the tropics produce at a much lower rate than under the temperature conditions. However crossbreeding has been concluded to be a way of upgrading the production capacity of these breeds under the tropical conditions. Their reduced reproductive performance in almost all cases has been connected with depressive effects of tropical temperature which is confirmed by the significant seasonal effect on almost all traits studied.

However crossbred dams perform even better under poor conditions, if the animals have been bred and selected in the environment where they are expected to perform.

This might be a way to solve the problem of reduced performance of swine in this country and boost the much profound protein shortages.

Crossbreeding in most swine producing countries has been the main tool utilized by the breeder in developing new lines. We might not be out of context if we decide to explore and utilize productive genes in the breeds we have presently to a high profit level whereby a new breed might be synthesized. This might be much called for in the case of the indigenous breed before they become extinct in the swine kingdom.

In conclusion it is quite obvious that lack of adequate selection procedure has contributed immensely to the poor performance of our animals in developing countries. It might be suggested that:

1. We develop practical selection indexes based on two or more traits for the overall appraisal of individual animals and increase population of animals in order to ensure adequate evaluation and effectiveness of selection.
2. To identify through blood grouping, the cellular antigens, their genetic nature and association if any with the expression of economically important traits.
3. To change sizes of farms, increase application of technology in order to encourage increased specialization both in production of breeding stock and market hogs.

Shift in the numbers of some of the purebreds during recent years are reflections of the alertness of commercial hog producers to the strong and weak points of a particular breed and the change to what the market prefers. It is therefore time for us to start utilizing the few purebreeds we have in crossing to develop new lines and especially explore the possibility of improving our indigenous stock by crossing or upgrading and strict selection, before they are totally wiped out into oblivion.

7.4 Summary

The major advantage of this study was that several breeds were compared under similar management and environmental conditions. The aim of the investigation was to solve the much pressing problem of milk production of sows in relation to their performance and growth of the litter as well as the nourishment derived from the milk. Included are also data collected on indigenous pigs of Southern Nigeria. The study involved 100 sows belonging to the LW, LR, IND, D.LW, D.LR, LW.LR and LR.LW.

1. From the nursing behaviour of the piglets it was quite evident that during the early part of lactation the piglets frequented the udder twice as often during the first four weeks as compared to the latter weeks (40Vs 75 minutes suckling interval), while the suckling period increased to the third week of lactations (59-84 secs.) followed by a decrease to 32 seconds.

2. To secure enough milk from the sow's udder, letdown of milk was stimulated by oxytocin injection. About 2-3 ml sufficed to completely evacuate the udder by hand stripping.

3. Milk yield over an eight week lactation was lowest in the indigenous breed with average of 74 kg yield in

56 days as against 133-137kg of the exotic purebred and 129-153 kg in the crossbreds. The variability was however less 22-27% in the indigenous and crossbreds compared to 30-33% variation in the exotic purebreds.

4. Lactation curves revealed peak production in the third week by the Large White, Duroc sired crosses and the Large White x Landrace crosses, fourth week in the Landrace and the Landrace x Large White while the rate of decline was very negligible till the fifth week in the indigenous breed.

5. Milk produced was 7% higher during the wet than dry season and 13% greater in the sows than the gilts.

6. Milk ingested per piglet decreases with increased litter size among the exotics (pure & crossed) however the crossbreds were the most efficient utilizers of milk for growth.

7. Differences in milk components were associated with season and genotypes. In all cases both colostrum and milk components of the indigenous sows were richer than that of their exotic counterparts. The constituents of milk produced during the dry season were also richer in comparison to the wet season. On the whole milk produced in the tropics was higher in major constituents than that obtained from the literature for the different breeds under the temperate conditions.

8. While the percentage of components in the milk was highest in the indigenous pigs, due to low milk yield, the total yield was less and correspondingly average nutrient intake by a piglet was also lower.

9. The relationship between milk yield and fat content was higher than that between milk and the other constituents when least square polynomial curves were fitted at the cubic level.

10. In the sows productive performance, there were striking seasonal differences in all variables studied except litter size and efficiency of milk utilization. Breed differenceswere also observed in all traits studied. This comprises milk production, litter size, litter weights, pig weights and preweaning weight gains, sows weight loss and efficiency of milk utilization.

11. Correlation coefficients between most of the production traits were high and significant. All variables were positively correlated with litter weight and negatively with individual pig weight at birth and weaning.

12. Production evidences show that feed consumption during lactation by the exotics was higher and almost double the amount of feed required for milk production by the indigenous sows. However feed intake per kilogram milk was not significantly different among the genotypes. Similarly is the amount of creep feed taken per kilogram litter gain.

13. The reciprocal Large White Landrace crosses were superior to the Large White and Landrace purebreds for all traits studied except milk production of the Landrace sired crossbred while the Duroc crosses outweigh their reciprocal counterparts in litter size, litter weights at birth, three and five weeks as well as in milk production.

14. To evaluate sow productivity, the Dickersons selection index was used. On the individual breed average, 52% of the animals qualified for selection but on the average of all groups together only 47% fell within the range. While 55% of the indigenous pigs fell within the range of values for selection on their genotypic average, only 17% of them qualified on the group average.

The fact that some of them ranked high compared to the exotic pigs might generate an impulse to improve the productive level of this breed. It is still a stern belief of this author that the local breed of pigs will be a source of animal protein in the rural areas of Nigeria where they are maintained on suboptimal level of feed intake.

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APPENDIX TABLE 3.1

MEAN DAILY TEMPERATURES

LATITUDE 07° 20'N
LONGTITUDE 03° 50'E
ALTITUDE 700'

MAXIMUM °F

	1970	1971	1972	1973	1974	1975
JAN	91	92	93	94	90	93
FEB	96	93	95	98	94	93
MAR	93	92	93	96	95	93
APR	91	91	90	92	90	90
MAY	89	91	89	91	88	88
JUNE	87	86	86	88	86	87
JULY	83	83	84	84	83	83
AUG	81	81	83	85	84	81
SEPT	83	83	84	85	83	80
OCTO	87	87	87	88	85	86
NOV	91	92	92	91	90	89
DEC	92	90	93	90	91	-

MINIMUM °F

	1970	1971	1972	1973	1974	1975
JAN	70	68	70	72	67	63
FEB	73	72	73	76	72	70
MAR	74	72	73	74	74	73
APR	73	72	72	74	72	72
MAY	72	72	73	72	72	72
JUNE	71	70	70	71	70	72
JULY	70	70	72	71	70	71
AUG	70	69	70	73	73	70
SEPT	71	69	70	71	70	69
OCT	71	70	72	71	71	69
NOV	71	71	71	69	71	70
DEC	67	65	69	72	67	-

APPENDIX TABLE 3.2

MEAN RELATIVE HUMIDITY %

	1970	1971	1972	1973	1974	1975
JAN	77	55.5	59.5	60.5	55.5	40.5
FEB	58.5	63	60	66.5	55.5	59.5
MAR	67.5	69	63	55	61.5	66.5
APR	73.5	71	73.5	71.5	74.5	73
MAY	76.0	69	74.5	76	74.5	82.5
JUNE	78	78	79	77	78.5	83.5
JULY	78	81	81.0	80	82.5	87
AUG	84.5	89.5	81.5	82	80.5	87
SEPT	85.5	82	81.0	81	81.5	86
OCT	78.5	73.5	77.5	76.5	79	83
NOV	65.5	61.5	62.5	74	67	78
DEC	58.0	54.5	58	69.5	53.5	-

TOTAL PRECIPITATION MM.

	1970	1971	1972	1973	1974	1975
JAN	3.6	-	-	-	-	-
FEB	-	37.6	38.9	-	-	71.0
MAR	129	181.3	54.4	52.0	79.6	132.9
APR	156	82.2	141.0	109.1	211.8	222.1
MAY	224.5	93.2	161.7	89.4	104.0	161.75
JUNE	176	112.8	227.3	172.4	221.7	125.25
JULY	40.4	202.7	157.4	148.0	245.9	125.00
AUG	51.0	41.0	29.5	260.5	26.7	91.00
SEPT	311.4	234.9	203.5	302.8	130.0	102.00
OCT	163.1	86.3	59.9	198.5	128.1	188.00
NOV	21.3	7.6	-	-	15.8	21.50
DEC	-	18.8	15.8	52.6	-	-

APPENDIX TABLE 4.1

SUCKLING INTERVALS - MINUTES

Animal NO.	Litter Size	1-2 Weeks		2-3 Weeks		3-4 Weeks		4-5 Weeks		5-6 Weeks		6-7 Weeks		7-8 Weeks	
		a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
LD 1697	6	37.7	36.6	35.8	38.3	39.8	49.5	43.1	49.0	53.6	66.0	44.3	59.7	53.8	57.8
134	3	42.7	39.9	43.6	38.0	74.6	109.5	67.6	102.0	62.8	107.8	142.0	89.8	111.2	159.6
LW A104	9	39.9	37.3	38.6	37.9	54.8	55.3	47.6	60.4	56.6	69.4	81.7	71.0	86.9	69.9
A 227	9	40.8	36.4	37.8	38.3	47.7	54.9	58.9	65.4	53.9	63.0	63.0	78.9	67.4	62.2
4564	9	45.3	38.1	43.4	38.2	50.1	64.8	49.6	73.3	52.4	61.5	68.6	73.0	56.3	75.3
759	8	43.1	38.4	42.1	38.2	50.0	63.8	46.7	76.0	56.1	61.5	68.6	94.4	80.6	60.3
A 105	5	42.8	36.3	38.5	38.2	52.1	64.3	87.2	71.7	63.7	86.7	73.5	118.3	67.4	65.6
158	7	42.1	36.1	38.4	46.5	42.1	61.3	50.6	77.8	52.4	69.4	71.0	75.5	74.6	66.5
A 505	6	43.6	36.4	39.4	38.3	44.3	59.4	53.9	63.6	41.2	56.4	41.2	69.1	52.6	51.1
293	5	40.7	36.1	39.1	38.6	90.3	79.6	74.2	103.0	62.9	166.5	79.3	182.5	83.8	62.8
Mean (Minutes)		41.9	37.2	39.7	39.1	54.6	66.2	57.5	70.8	55.1	70.5	71.0	80.0	73.4	73.1

APPENDIX TABLE 4.11

NURSING BEHAVIOUR - SECONDS

Animal NO.	L.S.	1-2 Weeks			2-3 Weeks			3-4 Weeks			4-5 Weeks			5-6 Weeks			6-7 Weeks			7-8 Weeks		
		PRE	NUR-SING	POST	PRE	NUR-SING	POST	PRE	NUR-SING	POST	PRE	NUR-SING	POST	PRE	NUR-SING	POST	PRE	NUR-SING	POST	PRE	NUR-SING	POST
995	7.0	95	20	90	60	70	12	30	60	10	125	45	15	45	60	38	30	40	40	90	50	90
11	10.0	75	65	40	70	55	70	75	63	-	65	45	15	125	45	60	50	45	40	10	45	38
136	4.0	62	105	10	45	80	62	65	65	20	80	60	-	60	50	-	80	45	-	90	40	140
893	5.5	20	75	20	28	60	65	70	30	90	50	80	3	93	45	24	157	37	35	60	38	20
38	9.0	30	35	20	40	50	40	20	110	-	37	67	30	85	50	25	90	38	35	100	25	-
306	10.5	75	50	35	70	70	35	48	80	-	90	80	10	72	47	10	100	45	26	120	15	-
726	5.0	50	70	15	75	70	35	60	120	2	75	70	5	95	40	10	120	48	30	70	42	3
Mean (secs.)		76.0	42.5	41.2	86.4	54.3	55.0	65.3	45.8	44.3	75.3	44.5	15.2	96.6	46.2	21.4	81.8	41.0	37.5	70.0	45.0	102.6

TABLE 4.3

EFFECT OF BREED AND AGE ON MILK PRODUCTION

Breed	N	Age	Average Yield (ml)	SD	CV	Range	K Value
LW	12	all	288.67	220.42	76.36	34 - 574	1.09 MS
LB	8	all	374.50	150.96	40.31	206 - 659	
LW	5	Gilts	182.00	222.01	121.98	34 - 574	1.001 MS
LR	3		276.33	66.83	24.18	206-339	
LW	7	sows	364.86	199.89	54.79	62 - 574	0.72 MS
LR	5		433.40	161.50	37.26	252 - 659	
LW	5	gilts	182.00	222.01	121.98	34 - 574	1.62 MS
	7	sows	364.86	199.89	54.79	62 - 574	
LR	3	gilts	276.33	66.83	24.18	206 - 339	2.19*
	5	sows	433.40	161.50	37.26	252 - 659	
Both Breed	8	gilts	217.38	178.40	82.07	34 - 574	2.28*
	12	sows	393.42	180.34	45.84	62 - 659	

$$K = \frac{\bar{x} - \bar{y}}{\sqrt{Se_x \times Se_y}}$$ after Treloar 1951

* Significant at 5%

TABLE 4.4

EFFECT OF TIME OF MILKING ON YIELD

Breed	N	Period	Average yield ml	SD	CV	Range	K Value
All sows	12	AM	4.09	0.69	11.87	0.25 - 9.49	1.69 AS
		PM	2.39	1.08	45.19	51 - 4.44	
All gilts	8	AM	3.13	1.78	56.87	1.18 - 6.98	0.0041 AS
		PM	3.19	3.20	100.31	0.32 - 894	
Sows	12	AM	4.09	0.69	16.87	0.25 - 9.49	1.46 AS
Gilts	8	AM	3.13	1.78	56.87	1.18 - 6.98	
Sows	12	PM	2.39	1.08	45.19	0.51 - 4.44	0.53 AS
gilts	8	PM	3.19	3.20	100.31	0.32 - 8.94	

TABLE 4.5

EFFECT OF BREED AND AGE ON MILK PRODUCED PER UNIT VOLUME OF OXYTOCIN

Breed	Age	N	Average yield/ UniteVol Oxytocin	SD	CV	Range	K Values
Both	Sows	12	46.58	19.94	42.81	5.64 - 73.72	0.009 AS
Breeds	gilts	8	46.47	32.23	69.36	8.50 - 95.67	
LW	gilts	5	32.90	32.56	98.97	8.50 - 95.67	2.19*
LR		3	69.08	23.66	19.77	51.50 - 84.75	
LW	Sows	7	44.16	22.49	50.93	5.64 - 66.70	0.54 AS
LR		5	49.97	15.05	30.12	36.56 - 73.72	

APPENDIX TABLE 4.5

TIME LAPSE OF MILK LET DOWN IN SOWS AFTER INJECTION OF OXYTOCIN (Minutes)

Animal No	1	2	3	4	5	6	7	8
LW 757	2	1*			4	3		
745	8*	8*			4	10		
39	2*	2			1	2		
814	2	3			2*	22		
844	4	4			3	24		
3997	2	2	2	5	2	2	10	2
4270	2	2	2	3	15	5	4	-
334	5	10	12	8	10	3	2	4
4	12	-	5	7	2	25	3	5*
137	5	8	5	2	2	5	1	1
3929	2	7	1	1	1	1	2	1*
4103	4	4	4	3	1	22	2	2
LR 774	6	1			1	1		
762	4	7			4	5		
66	2	4			2	1		
2127	1	2	1	15	2	3	2	4
89	2	13	2	5	2	2	2	4
97	3	1	3	2	3	2	3	2
98	3	4	2	3	4	3	2	2
1697	5	2	4	3	2	3	2	6

- No let down

* Period of let down after 2nd dose

APPENDIX TABLE 4.6

TOTAL YIELD OF MILK SAMPLES, TIME AND VOLUME OF OXYTOCIN

Animal No	Yield of Milk (ml)	Vol of Oxytocin (ml.)	Length of Withdrawal (minutes)	Yield/ Unit time	Yield/ Unit vol of oxytocin
LW 757	99	5.5	72	1.38	18.00
745	72	7.5	142	0.51	9.60
39	574	6.0	70	8.20	95.67
814	131	4.0	37	5.41	32.75
844	34	4.0	32	1.06	8.50
3997	534	8.0	157	3.40	66.70
4270	114	8.0	136	0.84	14.25
334	385	8.0	195	1.97	48.13
4	62	11.0	105	0.59	5.64
137	431	8.0	142	3.04	53.88
3929	574	9.0	110	5.22	63.77
4103	454	8.0	104	4.37	56.75
LR 774	284	4.0	73	3.89	71.00
762	206	4.0	65	3.17	51.50
66	339	4.0	47	7.21	84.75
2127	657	9.0	123	5.34	73.22
89	329	9.0	107	3.08	36.58
97	526	9.0	104	5.06	58.44
98	401	8.0	140	2.86	50.13
1697	252	8.0	96	2.63	31.50

APPENDIX TABLE 5.1

LACTATION TREND IN MILK PRODUCTION

Animal NO	Litter SIZE	WEEKLY PRODUCTION (Kg) 1	2	3	4	5	6	7	8	TOTAL YIELD
LW										
104	6.0	9.66	15.54	25.20	26.46	20.86	9.66	6.86	6.58	120.82
844	6.0	13.10	26.23	30.68	21.12	16.05	16.37	13.05	10.59	147.19
865	9.0	13.72	28.00	36.54	21.56	16.66	12.60	10.92	8.68	148.68
158	10.0	18.48	22.40	37.80	24.78	16.94	13.16	9.66	7.14	150.36
401	7.5	22.68	38.92	22.12	10.64	11.76	12.04	7.84	6.44	132.44
3933	8.0	16.84	26.06	29.56	32.75	26.06	17.97	16.06	15.42	180.67
3469	8.0	15.57	24.15	33.90	35.30	20.34	10.80	27.01	20.34	187.41
453	6.0	10.64	12.60	14.28	15.12	12.88	8.40	7.28	6.44	87.64
453	8.0	21.50	22.70	38.80	37.50	22.88	27.50	26.70	16.53	214.11
7016	6.0	16.52	20.16	27.58	23.80	13.72	12.04	7.56	7.84	129.22
7026	9.0	10.43	25.76	33.39	39.28	33.86	26.87	18.31	17.97	204.87
893	5.5	12.74	26.60	27.44	27.44	16.52	12.32	8.54	7.00	138.60
464	5.0	14.00	16.80	19.60	15.12	10.08	7.84	8.96	7.56	99.96
517	3.0	11.76	13.44	15.96	15.40	11.76	8.40	4.76	8.68	90.16
3929	7.0	25.20	16.38	21.70	29.54	21.00	14.00	10.92	7.70	146.44
4567	7.0	21.98	26.18	21.70	27.02	16.24	11.90	8.12	7.84	140.98
293	10.5	20.68	27.84	37.84	44.20	22.84	16.24	13.58	10.64	193.86
4509	6.0	12.88	15.12	10.64	17.36	8.40	7.28	5.04	4.76	81.48
844	8.0	17.64	38.08	36.12	14.00	11.20	10.08	7.28	8.40	142.80
455	4.0	7.28	7.28	7.28	10.92	8.12	11.48	8.96	6.72	68.14
893	6.0	15.12	17.36	13.44	12.32	11.20	6.72	5.32	3.92	85.40
LR										
795	8.0	22.90	36.00	42.30	44.20	14.94	21.61	19.24	18.75	219.94
797	3.0	5.40	13.69	18.60	28.14	14.94	8.26	6.48	6.86	102.27
764	5.0	17.08	14.84	19.88	14.00	17.08	9.80	10.92	8.40	112.00
547	4.5	12.88	13.16	12.88	19.32	9.80	7.28	7.84	8.40	91.56
1863	5.0	18.88	37.10	44.80	40.04	16.53	16.53	11.44	8.58	193.90
764	6.0	16.21	19.06	18.43	34.32	12.08	17.16	24.79	13.35	155.40
797	5.0	10.22	10.64	13.86	18.06	13.16	6.02	5.46	4.48	81.90
357	2.0	7.28	10.22	9.94	8.96	9.34	7.14	7.14	6.86	66.88
16	3.0	15.68	22.12	17.64	20.44	19.04	12.60	6.44	5.88	119.84
726	5.0	13.72	40.04	32.20	42.28	19.88	14.28	11.48	10.64	184.52
357	3.0	5.21	9.53	14.70	20.34	18.43	7.63	5.47	2.35	83.66
16	8.0	15.91	33.56	39.75	46.74	27.58	12.74	14.98	10.92	202.18
796	5.5	10.08	17.64	21.98	19.32	18.06	13.30	8.68	7.98	117.04

384	5.0	20.72	38.14	35.42	20.02	15.96	10.64	12.32	8.54	161.76
283	6.5	24.96	38.48	43.84	21.98	18.34	10.92	9.52	5.32	173.36
234	8.0	19.32	22.96	26.88	35.00	12.88	11.76	10.92	9.24	148.96
773	8.0	16.10	21.98	26.46	25.06	23.80	12.88	12.04	9.66	128.95
882	4.0	9.52	14.28	18.20	15.12	14.42	7.42	8.96	6.02	93.94
2158	3.0	7.42	18.90	24.36	18.90	17.22	13.02	9.38	6.02	115.22
2158	4.0	12.88	22.68	19.04	26.88	11.76	7.84	5.60	7.00	113.68
INDIGENOUS										
92	5.0	6.80	10.34	12.14	13.30	13.30	14.15	13.35	9.53	79.61
3	2.0	3.80	4.28	6.74	7.82	8.52	8.17	6.58	2.28	48.19
4	6.0	8.48	10.98	12.52	11.90	9.24	7.28	6.30	6.30	73.00
914	5.0	8.82	11.06	12.26	13.40	10.08	10.08	7.14	6.02	78.86
182	5.0	8.96	11.88	13.12	10.36	12.08	13.16	7.56	7.28	84.40
173	7.0	8.20	10.84	12.96	10.92	10.36	7.28	8.52	7.00	76.08
174	4.0	6.92	7.56	11.48	11.77	12.04	8.92	7.28	7.28	73.24
182	4.0	5.14	8.66	12.70	13.50	12.88	8.40	8.54	4.90	74.72
173	3.0	5.20	8.54	10.30	12.00	13.30	7.42	5.68	3.22	65.66
174	3.0	4.76	6.30	9.30	10.50	8.40	7.84	5.88	4.72	57.70
183	1.5	2.98	4.95	7.30	5.90	6.90	4.30	3.88	-	36.21
172	3.0	5.94	8.50	9.18	10.42	6.48	5.60	3.42	3.93	53.47
1	7.5	9.20	12.52	10.42	15.48	16.06	13.72	9.24	5.74	92.38
11	6.5	6.76	10.40	12.24	10.12	12.12	6.72	6.44	6.44	64.80
2	8.5	10.48	16.88	18.62	14.56	14.84	11.06	7.56	6.30	100.30
6	4.0	12.04	11.20	17.08	13.72	11.76	7.84	6.16	4.48	84.28
7	6.0	17.64	18.48	18.16	11.20	13.44	8.96	7.56	7.28	102.72
263	6.0	9.52	13.44	14.84	12.04	14.84	7.84	6.44	7.28	86.24
DLW										
457	8.0	19.74	19.74	22.96	28.70	24.92	1834	9.94	7.70	152.04
85	6.0	8.40	10.50	12.46	11.48	9.24	7.56	6.86	6.72	73.22
661	6.5	12.74	17.36	21.14	21.00	20.16	13.44	8.12	7.14	108.36
27	7.0	11.42	19.26	29.54	30.66	22.96	13.10	12.82	10.86	140.62
184	9.0	18.76	23.24	28.28	36.68	20.16	8.82	7.84	8.12	151.90
557	8.5	12.18	16.94	21.84	23.52	28.56	15.12	11.76	9.94	139.86
26	5.5	9.52	11.22	26.46	16.52	13.16	17.08	14.00	14.84	122.80
195	7.0	11.70	19.41	23.56	24.47	19.16	15.12	10.64	9.80	133.86

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175	9.0	23.69	25.76	37.84	29.26	25.48	12.36	12.18	12.32	178.89
394	9.0	14.98	26.54	32.42	33.88	18.06	14.00	11.48	8.96	160.32
411	5.0	15.40	14.28	25.68	23.44	16.86	8.12	8.40	7.84	120.00
21	7.5	14.94	27.97	33.05	25.76	21.98	12.74	12.60	11.20	160.24
24	9.5	22.96	30.52	30.52	18.76	17.46	15.12	11.48	11.20	158.20
11	10.0	18.76	18.76	31.08	26.60	17.36	16.80	17.92	12.32	159.60
15	9.0	21.28	28.00	29.12	28.80	32.20	35.00	12.88	14.56	201.32
49	11.0	16.24	27.64	24.56	25.40	25.96	29.88	31.84	30.44	211.96
DLR										
98	7.5	15.40	19.04	19.32	17.78	16.52	10.92	9.32	9.24	117.54
97	8.5	16.80	16.52	22.20	27.44	20.72	16.24	12.32	10.08	142.32
126	7.5	10.80	16.32	23.88	17.38	15.00	12.96	9.66	7.14	113.14
49	5.5	10.78	12.32	23.24	16.94	17.22	9.52	7.14	6.58	103.74
38	8.5	17.92	23.24	25.06	26.74	20.30	10.08	10.36	6.16	139.86
249	8.0	21.98	28.56	32.90	26.46	24.22	9.24	8.40	6.44	1 8.20
226	9.0	18.76	25.20	34.44	39.48	14.56	11.62	9.52	7.00	160.58
626	4.0	11.76	22.12	19.60	22.96	11.76	8.68	8.68	7.56	113.12
406	9.5	21.56	20.44	22.60	21.28	18.48	8.96	10.36	8.12	132.15
425	8.0	21.20	23.44	31. 20	34.00	36.52	24.56	24.84	24.28	220.0
34	7.0	23.80	26.60	20.72	20.44	13.44	12.04	11.76	8.96	137.76
212	8.5	22.68	58.80	60.20	24.92	22.40	13.44	16.52	6.16	225.12
37	7.0	23.52	29.68	40.32	40.04	22.96	13.72	13.44	8.40	192.08
58	9.0	17.36	28.76	31.00	37.36	23.16	21.20	19.24	11.20	189.28
LWLR										
367	6.0	8.68	19.46	24.50	15.12	11.90	9.80	8.54	7.70	105.70
613	6.5	9.32	22.72	25.56	19.40	21.28	15.96	12.52	11.76	138.52
995	7.0	13.52	24.64	24.08	15.68	14.00	8.96	5.32	6.72	112.92
74	9.5	13.30	15.40	14.98	21.14	26.18	15.82	13.16	10.64	130.62
75	8.0	9.38	21.48	26.94	30.44	20.02	18.34	8.82	6.58	142.00
706	2.0	10.36	14.28	15.68	12.04	14.28	15.68	11.48	13.44	107.24
990	3.5	6.30	10.64	13.02	12.74	16.94	12.04	9.94	7.42	89.4
136	4.0	13.72	20.16	22.96	17.64	8.12	10.08	8.12	7.56	108.36
203	2.0	10.36	15.40	17.08	16.24	16.24	10.64	12.04	8.12	106.12
205	9.0	16.10	22.54	29.40	21.14	13.16	10.36	9.24	8.68	130.62
990	10.0	19.28	24.92	31.36	25.76	22.96	21.84	12.32	11.20	169.64
618	10.0	16.80	22.68	24.92	30.52	32.68	29.60	25.12	27.08	209.40

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LR.LW

66	6.5	16.66	16.38	16.80	17.92	13.86	12.88	10.22	8.54	113.26
68	6.0	15.12	19.32	25.48	22.12	19.88	10.64	9.80	8.12	130.48
197	4.4	6.86	7.84	10.36	17.64	20.58	15.26	10.78	8.68	98.00
62	2.0	8.54	10.92	12.88	17.36	19.60	9.66	8.82	5.88	93.66
681	11.00	14.14	21.98	20.30	34.16	20.30	14.42	10.92	7.70	143.92
376	9.0	16.80	23.94	22.12	26.32	24.22	13.16	8.26	7.70	142.52
914	8.5	23.32	20.32	26.96	33.40	20.72	15.68	13.76	12.60	166.76
306	10.5	21.00	27.16	28.00	25.12	27.08	22.88	16.16	13.16	180.56
58	8.5	13.44	17.64	23.72	26.52	24.56	24.56	25.68	21.48	177.60
66	3.0	10.36	15.40	18.48	17.08	20.72	16.24	8.40	9.80	116.48
685	10.0	37.24	38.08	28.28	38.36	39.20	24.64	12.60	12.32	230.72
62	4.0	10.64	14.28	26.52	25.68	18.40	18.96	18.68	8.96	142.12

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APENDIX TABLE 5.11

WEEKLY LITTER PERFORMANCE

ANI-MAL NO	LIT. SIZE	LIT. B.WT	WEEKS 1	2	3	4	5	6	7	8	WT GND	WT. LOST SOW	MILK YIELD
LW 104	6.0	5.45	10.28	14.25	18.61	22.36	25.73	28.83	31.88	36.26	30.81	39.00	120.82
844	6.0	6.54	12.70	17.72	23.04	27.83	31.23	33.82	42.04	49.94	43.40	32.00	147.19
865	9.0	9.00	18.78	25.35	31.79	36.15	40.96	44.38	49.28	51.95	42.95	29.00	148.68
158	10.0	12.25	17.77	23.19	36.15	44.62	51.62	58.53	63.28	66.45	54.20	23.15	150.36
401	7.5	12.25	17.48	20.65	24.24	27.34	27.03	29.04	33.71	36.29	24.04	40.00	132.44
3933	8.0	8.00	13.68	25.35	27.28	31.14	35.68	38.59	44.88	53.09	45.09	38.50	180.67
3469	8.0	8.30	13.43	17.20	18.58	19.30	22.47	25.92	30.28	35.37	27.07	41.00	187.41
453	6.0	5.85	10.16	14.26	17.53	20.13	21.46	23.78	26.28	30.44	24.59	29.00	67.61
453	8.0	8.00	20.13	26.00	32.28	34.73	38.61	40.27	43.68	50.83	42.83	34.00	214.11
70x	6.0	5.30	9.38	10.74	11.35	12.88	14.13	14.68	14.43	16.24	10.74	14.00	129.22
70x	9.0	7.50	17.41	25.97	34.96	40.41	42.90	47.67	55.48	58.11	50.51	36.50	204.87
893	5.5	8.00	9.80	14.47	19.2	22.83	27.34	30.76	34.44	39.36	31.36	17.00	138.60
464	5.0	6.50	8.88	12.43	16.53	19.67	21.74	22.18	25.25	29.16	22.66	24.00	99.96
517	3.0	4.00	6.90	8.60	10.26	14.20	16.06	18.58	19.21	21.70	17.70	23.00	90 6
3929	7.0	9.50	10.52	11.25	13.88	16.05	16.90	19.18	23.38	27.88	18.38	9.00	146.44
4567	7.0	10.60	11.60	14.92	20.01	24.75	28.75	32.66	38.06	42.20	31.60	23.00	140.98
293	10.5	10.50	19.34	26.74	32.92	37.50	41.25	42.66	47.13	52.38	41.88	64.00	193.86
4509	6.0	10.25	12.58	15.25	14.75	16.86	17.32	20.13	24.05	28.43	18.18	19.00	81.48
844	8.0	11.20	15.43	12.80	18.54	21.72	27.10	33.31	39.08	43.30	32.10	17.00	142.80
455	4.0	5.50	7.02	8.73	11.67	14.34	16.95	20.06	24.63	29.12	23.68	6.00	68.41
893	6.0	9.00	15.05	18.72	19.96	21.97	23.83	26.03	29.78	34.23	25.23	33.00	85.40
LR													
795	8.0	8.4	17.95	25.93	31.35	33.54	40.22	41.75	45.45	53.07	44.67	40.00	219.94
797	3.0	5.09	6.83	8.83	11.44	14.44	17.47	18.48	21.79	26.33	21.24	37.00	102.27
764	5.0	6.50	10.45	9.82	13.65	14.63	16.16	18.28	19.65	25.10	18.60	2.00	112.00
547	4.5	6.75	9.24	11.14	9.98	12.28	13.34	15.03	16.35	18.64	11.89	16.00	91.56
1863	5.0	6.40	10.53	14.90	19.20	21.51	24.81	26.67	26.76	32.80	26.40	64.00	193.90
764	6.0	5.60	10.25	13.45	16.33	18.16	19.89	20.43	21.91	25.76	20.16	18.50	155.40
797	5.0	6.00	9.75	12.49	14.13	17.08	19.61	22.54	24.15	29.24	23.24	28.00	81.90
357	2.0	3.60	6.28	8.15	9.28	11.20	12.18	13.88	16.95	19.54	15.94	7.00	66.88
16	3.0	5.60	9.65	12.20	15.34	17.95	20.89	23.38	27.11	35.43	29.83	20.00	119.84
726	5.0	7.25	12.96	18.78	26.40	35.16	40.59	47.69	54.58	61.78	54.53	41.00	184.52

CONTINUE →

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357	3.0	4.18	9.85	15.05	19.67	22.47	26.65	29.90	35.41	37.09	32.91	37.00	83.66
16	8.0	12.30	22.38	29.06	35.28	39.57	44.15	50.00	56.15	61.33	49.03	37.80	202.18
796	5.5	5.90	10.31	14.98	18.24	22.85	25.33	27.41	33.16	38.60	32.70	42.00	117.04
384	5.0	7.00	12.90	18.48	23.53	26.37	29.33	30.58	33.53	37.36	30.36	99.00	161.76
283	6.5	8.50	15.21	20.93	26.53	30.48	29.94	31.58	29.29	28.12	19.62	74.00	173.36
234	8.0	10.95	19.31	25.87	29.93	34.92	35.17	39.82	42.28	44.07	33.12	25.00	148.96
773	8.0	9.10	16.33	24.63	29.49	32.24	32.85	35.78	39.58	44.33	35.23	26.00	128.95
882	4.0	4.09	7.60	10.30	13.50	16.81	19.86	23.85	28.50	32.52	28.43	23.00	93.94
2158	3.0	4.75	7.00	10.87	14.75	16.88	19.55	23.41	27.93	31.92	27.17	23.00	115.22
2158	4.0	6.50	8.30	11.35	14.16	16.99	19.29	22.75	27.63	32.40	25.90	20.00	113.68
IND													
92	5.0	4.68	7.79	9.76	11.33	12.60	13.53	15.03	16.84	1920	14.52	28.00	79.61
3	2.0	3.10	3 .73	6.29	8.30	9.13	9.90	10.63	9.04	9.90	6.80	19.70	48.19
4	6.0	8.00	12.83	17.62	21.46	25.13	25.73	27.87	29.92	32.58	24.58	33.14	73.00
914	5.0	4.00	7.29	9.92	12.24	13.66	15.83	16.90	18.75	20.28	16.28	36.00	78.86
182	5.0	4.00	6.53	9.54	10.65	11.34	12.13	13.31	13.88	15.01	11.01	19.00	84.40
173	7.0	4.40	7.80	9.56	10.92	13.16	14.60	16.41	18.53	20.32	15.92	16.00	76.08
174	4.0	4.80	7.76	8.31	9.85	10.09	12.26	13.12	14.39	16.06	11.26	26.00	73.24
182	4.0	3.00	5.01	6.25	8.22	9.20	9.60	9.77	10.23	11.20	8.20	20.00	74.72
173	3.0	3.60	4.05	2.72	3.78	4.45	5.75	6.15	6.55	7.50	3.90	16.00	65.66
174	3.0	3.50	4.52	6.45	8.70	9.78	10.42	11.20	11.60	12.30	8.80	11.50	57.70
183	1.5	2.00	2.28	3.23	3.68	3.63	4.55	3.25	3.28	3.80	2.80	4.50	36.21
172	3.0	3.50	4.53	6.68	8.00	9.20	10.55	10.35	11.69	12.13	8.63	18.50	53.47
1	7.5	8.00	13.35	15.12	17.08	18.64	19.95	22.29	23.46	22.43	14.43	38.63	92.38
11	6.5	5.20	8.88	10.28	12.55	13.79	15.28	16.58	16.78	17.23	12.03	15.00	64.80
2	8.5	9.52	18.25	25.31	30.43	32.68	35.95	38.48	42.92	46.35	36.83	53.00	100.30
6	4.0	5.70	9.73	10.66	15.59	19.48	21.09	25.43	29.25	34.25	28.55	13.62	84.28
7	6.0	6.20	13.50	17.34	21.57	24.60	29.70	35.18	42.44	48.45	42.25	5.90	102.72
263	6.0	7.25	12.64	17.33	20.88	24.02	27.66	29.78	31.87	34.67	27.42	22.24	86.24

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ANIMAL NO	Ls	Litter Birth wt.	1	2	3	4	5	6	7	8	wt. gained T	wt. lost sow	Milk Yield
DLW													
457	8.0	11.50	19.58	26.48	31.87	32.72	34.70	36.83	39.55	42.15	30.65	48.00	152.04
85	6.0	6.75	10.28	14.00	18.33	22.46	26.00	29.31	34.70	39.26	32.51	56.00	73.22
661	6.5	8.65	14.46	19.20	24.60	28.05	28.26	30.76	34.84	39.47	30.82	59.96	108.36
27	7.0	10.80	18.66	28.65	35.57	41.31	46.33	51.46	55.93	60.23	49.40	63.00	140.62
184	9.0	10.00	19.51	23.44	27.75	32.75	32.18	30.75	32.63	35.37	25.37	26.80	151.90
557	8.5	11.29	19.95	26.65	32.83	39.73	45.38	51.74	60.24	66.18	54.93	19.00	139.86
26	5.5	8.00	9.85	14.12	19.35	23.68	28.61	32.24	37.67	44.20	36.20	22.13	122.80
195	7.0	9.70	17.25	22.97	27.10	30.33	34.29	38.13	49.16	50.60	40.90	27.80	133.86
175	9.0	14.00	21.61	23.88	29.90	34.52	40.22	48.90	57.81	62.17	48.17	28.30	178.89
394	9.0	11.25	18.95	25.20	34.05	40.12	42.27	45.73	49.68	53.53	42.28	31.00	160.32
411	5.0	8.50	15.34	22.49	29.25	36.78	44.08	50.49	58.39	68.23	59.73	24.51	120.00
21	7.5	13.00	16.07	20.61	23.29	22.12	22.80	24.10	27.12	30.44	17.44	39.79	160.24
24	9.5	14.25	20.90	27.38	31.78	39.55	50.12	55.24	65.55	79.02	64.77	22.02	158.20
11	10.0	15.25	23.29	30.44	35.52	45.01	48.43	59.91	72.70	82.85	67.60	8.63	159.60
15	9.0	11.35	20.57	30.75	41.97	50.98	62.29	76.10	87.70	100.61	89.26	31.33	201.32
49	11.0	15.85	31.01	43.24	57.68	65.97	81.83	95.75	112.38	130.54	14.69	41.09	211.96
DLR													
98	7.5	9.50	15.16	23.67	32.19	35.58	40.26	42.89	40.26	42.80	33.30	30.87	117.54
97	8.5	11.50	15.62	18.90	25.25	31.05	37.45	34.88	55.00	65.67	54.17	29.96	142.32
126	7.5	9.60	14.66	23.40	30.49	38.08	41.17	46.33	49.00	52.06	42.46	41.00	113.32
49	5.5	6.25	10.49	16.76	19.24	22.38	24.60	26.47	28.94	32.54	25.29	15.88	103.74
38	8.5	10.50	14.85	19.90	24.64	29.72	35.41	39.63	45.35	51.92	41.42	50.85	139.86
249	8.0	11.25	20.58	31.82	34.23	38.90	44.49	47.60	51.94	60.85	49.60	46.53	158.20
226	9.0	9.75	14.58	29.82	38.17	49.63	52.66	56.48	61.34	68.93	59.18	49.37	160.58
626	4.0	6.75	12.64	19.00	24.12	29.80	32.57	37.50	43.71	50.45	43.70	5.79	113.12
406	9.5	14.00	24.88	38.26	47.71	56.32	60.99	64.34	66.96	74.96	60.96	51.08	132.16
425	8.0	12.50	25.51	32.18	35.14	42.88	50.83	57.35	65.89	76.67	64.17	17.25	220.04
34	7.0	14.25	20.05	27.88	21.84	29.25	35.77	38.35	50.33	58.49	44.24	29.97	137.76
212	8.0	14.30	23.17	33.15	43.47	47.57	61.13	67.62	81.87	86.44	72.14	46.99	225.12
37	7.0	10.50	17.79	27.10	34.86	43.65	48.50	60.19	72.81	82.30	71.80	38.82	192.08
58.	9.0	12.50	23.70	32.54	43.24	51.51	60.69	70.86	82.75	95.39	82.89	25.87	189.28

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LITTER PERFORMANCE

ANIMAL NO	Litter Size	Litter birth	1	2	3	4	5	6	7	8	Litter wt gained	wt lost sow	Milk Yield.
LWLR													
367	6.0	10.80	13.83	21.68	28.76	33.96	40.38	46.26	49.28	51.89	41.09	33.26	105.70
613	6.5	8.00	12.63	19.10	27.06	32.25	37.00	41.29	46.38	53.39	45.39	24.51	138.52
995	7.0	9.30	18.03	26.48	26.29	24.90	25.45	26.83	31.25	37.72	27.92	17.71	112.92
74	9.5	11.25	20.57	31.57	36.61	39.73	43.97	49.58	54.84	61.28	50.03	52.37	130.62
75	8.0	10.85	20.92	31.64	39.59	45.71	51.53	59.24	66.78	71.53	60.68	28.30	142.00
706	2.0	3.25	6.08	9.40	12.06	15.38	17.67	21.09	27.37	32.39	29.14	2.27	107.24
990	3.5	3.75	8.03	11.46	16.10	20.45	24.43	28.16	33.52	33.58	29.83	28.00	89.04
136	4.0	6.30	12.50	17.87	21.95	27.44	32.50	40.27	46.55	54.22	47.92	44.00	108.36
203	2.0	3.85	6.36	10.22	14.41	17.88	21.31	23.99	25.90	31.23	27.38	25.85	106.12
205	9.0	10.50	1407	19.36	25.13	28.75	33.48	37.09	43.14	50.11	39.61	14.07	130.62
990	10.0	14.25	23.46	30.58	35.75	48.88	57.21	64.42	72.68	90.62	76.37	19.98	169.64
618	10.0	17.50	25.59	40.87	53.23	66.96	77.31	89.11	100.51	116.79	99.29	54.93	209.40
LRLW													
66	6.5	1025	15.56	24.88	32.34	38.71	43.85	43.87	46.94	50.12	39.87	17.95	113.26
68	6.0	7.50	12.06	16.93	24.00	28.34	29.29	30.46	31.90	33.92	26.42	31.70	130.48
197	4.5	5.85	9.79	10.45	12.05	15.38	20.62	24.90	26.77	29.25	23.40	29.00	98.00
62	2.0	3.50	6.30	8.56	10.08	14.66	18.98	21.57	24.75	28.93	25.43	12.72	93.66
681	11.0	13.25	18.31	23.63	26.38	31.29	32.05	37.28	45.34	53.97	40.72	21.18	143.92
376	9.0	11.25	16.88	24.26	28.52	32.94	36.50	41.02	45.36	51.76	40.51	56.71	142.52
914	9.5	13.99	24.02	34.05	37.24	44.91	50.42	55.94	64.29	76.25	62.21	30.88	166.76
306	10.5	17.62	2893	42.68	50.99	63.61	69.95	84.58	99.35	115.22	97.60	37.00	180.56
58	8.5	13.30	24.25	35.03	43.79	62.15	70.45	83.34	98.42	111.93	98.63	36.32	177.60
66	3.0	4.80	8.26	13.43	16.97	19.69	24.50	28.82	32.88	39.17	34.37	7.94	116.48
685	10.0	17.25	32.47	46.06	54.46	63.65	72.46	77.95	85.76	95.98	78.73	24.06	230.72
62	4.0	8.20	15.23	20.08	26.56	33.68	40.18	51.18	61.23	70.33	62.13	10.31	142.12

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APPENDIX TABLE 5.111

MILK PRODUCTION

Genotypes	PARITY		SEASON	
	Gilts	Sows	Wet	Dry
LW	137.01	138.18	126.61	149.85
LR	139.27	125.42	131.88	132.82
IND	63.05	67.63	74.41	51.08
D.LW	132.28	160.72	164.93	126.97
D.LR	134.58	171.84	172.79	133.63
LW.LR	110.91	142.23	136.36	122.83
LR.LW	132.26	157.09	169.50	126.94
Mean	120.94	135.14	133.64	122.85

APPENDIX TABLE 5.IV

MULTIPLE RANGE TEST FOR BREED DIFFERENCE IN MILK PRODUCTION

(a) Milk Yield:							
Significant Range	2.83	2.98	3.08	3.14	3.20	3.24	
Standard error of mean	4.307						
Rp	40.49^{a}	42.64^{b}	44.07^{c}	44.93^{d}	45.79^{e}	46.36^{f}	g
Mean	153.21	148.32	144.69	137.68	133.35	129.18	73.99
Differences	79.72^{a-g}	74.33^{b-g}	70.70^{c-g}	63.69^{d-g}	59.36^{e-g}	55.19^{f-g}	
(b) Milk per Piglet:							
Standard error of mean	2.889						
Rp	8.18	8.61	8.90	9.07	9.25	9.36	
Mean	27.71	24.85	24.34	20.34	20.14	18.75	16.01
Differences	11.70^{a-g}	8.84^{b-g}	-	-	-	-	
	8.96^{a-f}	-	-	-	-	-	
	-	-	-	-	-	-	
(c) Efficiency of Milk Utilization:							
Standard error of mean	0.934						
Rp	2.64	2.78	2.88	2.93	2.99	3.03	
Mean	5.93	4.79	4.66	3.52	3.14	2.97	2.92
Differences	3.01^{a-g}	-	-	-	-	-	-
	2.96^{b-g}	-	-	-	-	-	-
	2.79^{c-g}	-	-	-	-	-	-

APPENDIX TABLE 5.V

MILK INTAKE PER PIGLET

Genotype	PARITY		SEASON	
	Gilts	Sows	Wet	Dry
LW	21.32	19.18	20.02	20.28
LR	25.64	29.78	25.85	29.30
IND	18.87	14.75	17.13	16.29
D.LW	18.34	19.04	19.60	17.66
D.LR	19.44	21.44	23.48	17.20
LW.LR	21.52	27.23	26.33	23.36
LR.LW	24.68	23.98	27.10	22.04
MEAN	21.48	21.92	22.06	21.34

APPENDIX TABLE 5.VI

EFFICIENCY OF MILK UTILIZATION

Genotype	PARITY		SEASON	
	Gilts	Sows	Wet	Dry
LW	4.00	5.30	4.48	5.04
LR	5.24	4.55	4.45	5.34
IND	7.47	4.40	6.40	5.19
D.LW	3.36	3.29	3.07	3.64
D.LR	3.02	2.92	2.77	3.17
LW.LR	3.26	2.88	3.02	3.05
LR.LW	3.22	3.05	2.45	3.62
MEAN	4.46	3.95	4.09	4.29

APPENDIX TABLE 5.VII

Animal No	Milk 1-8	% CONSTITUENTS Prot	Fat	Lact	Ash	TS	G	P	KG CONSTITUENTS Prot	Fat	Lact	Ash	TS
LW													
104	120.82	6.84	7.50	5.44	0.71	20.49	0.28	0.117	8.26	9.06	6.57	0.86	24.76
844	147.19	6.35	6.49	6.09	0.81	19.87	0.30	0.104	9.35	9.55	8.96	1.19	29.25
865	148.68	5.95	8.52	4.66	0.73	19.75	0.31	0.137	8.85	12.67	6.93	1.09	29.36
3933	180.67	5.32	7.00	4.22	0.75	17.27	0.22	0.122	9.61	12.65	7.62	1.36	31.20
3469	187.41	6.50	9.38	4.18	0.77	20.83	0.33	0.129	12.18	17.58	7.83	1.44	39.04
453	87.64	5.32	6.76	4.53	0.75	17.31	0.30	0.111	4.66	5.92	3.97	0.66	15.17
70x	204.87	5.21	7.58	6.29	0.72	19.81	0.24	0.168	10.67	15.53	12.88	1.48	40.58
893	138.60	5.80	8.29	5.67	0.69	20.54	0.28	0.163	8.04	11.49	7.86	0.96	28.47
464	99.96	6.95	5.97	4.22	0.78	17.53	0.34	0.136	6.95	5.97	4.22	0.78	17.52
3929	146.44	5.68	5.94	3.99	0.64	16.37	0.28	0.197	8.32	8.70	5.84	0.94	23.97
4567	140.98	6.74	5.74	5.17	0.71	18.41	0.22	0.154	9.50	8.09	7.29	1.00	25.95
293	193.86	6.45	6.93	4.60	0.74	18.72	0.33	0.138	12.50	13.43	8.92	1.43	36.29
LR													
795	219.94	5.75	8.31	4.53	0.76	19.05	0.25	0.129	12.65	18.28	9.30	1.67	41.90
797	102.27	5.85	6.55	5.41	0.74	18.56	0.24	0.159	5.98	6.70	5.53	0.76	18.98
764	112.00	5.22	6.39	4.68	0.67	17.05	0.29	0.133	5.85	7.16	5.24	0.75	19.10
1863	193.90	6.08	6.77	5.01	0.71	18.59	0.36	0.141	11.78	13.13	9.71	1.38	36.05
764	155.40	6.62	6.33	5.43	0.78	19.19	0.28	0.119	10.29	9.84	8.44	1.21	29.82
797	81.90	5.93	7.76	5.40	0.65	19.81	0.26	0.146	4.86	6.36	4.42	0.53	16.22
357	83.66	6.07	7.65	6.72	0.71	21.14	0.25	0.178	5.08	6.40	5.62	0.59	17.69
16	202.18	6.66	5.75	4.52	0.81	17.50	0.25	0.169	13.47	11.63	9.14	1.64	35.38
796	117.04	6.88	8.70	6.290	0.66	22.54	0.28	0.153	8.05	10.18	7.36	0.77	26.38
773	128.95	5.99	7.10	6.12	0.70	19.90	0.24	0.139	7.72	9.16	7.89	0.90	25.66
882	93.94	5.76	8.31	4.23	0.73	18.91	0.25	0.144	5.41	7.81	3.97	0.69	17.76
2158	115.22	6.96	6.21	6.02	0.79	19.97	0.28	0.148	8.02	7.16	6.94	0.91	23.01
IND													
92	79.61	9.02	11.39	5.10	1.07	26.20	0.43	0.224	7.18	9.07	4.06	0.85	20.86
3	48.19	7.01	8.69	5.44	0.77	21.91	0.31	0.151	3.38	4.19	2.62	0.37	10.56
4	73.00	7.26	9.92	5.05	0.86	23.59	0.25	0.207	5.30	7.24	3.69	0.63	17.22
182	84.40	8.07	9.42	5.85	0.83	24.17	0.30	0.203	6.81	7.95	4.94	0.70	20.40
173	76.03	6.41	9.40	5.11	0.87	21.63	0.42	0.165	4.88	7.15	3.89	0.66	16.46
174	73.24	6.91	10.58	5.10	0.86	23.43	0.38	0.245	5.06	7.775	3.74	0.63	17.16

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Animal	% CONSTITUENTS Milk	Prot	fat	Lact	Ash	7s	G	P	KG CONSTITUENTS Prot	fat	lact	Ash	Ts
182	74.72	8.64	9.97	5.78	0.92	25.24	0.21	0.203	6.46	7.45	4.32	0.69	18.86
173	65.66	6.21	8.27	4.55	0.79	19.72	0.37	0.199	4.08	5.43	2.99	0.52	12.95
174	5770	5.92	7.43	4.33	0.92	18.61	0.34	0.198	3.42	4.29	2.50	0.53	10.74
1	92.38	5.91	7.26	4.94	0.77	19.00	0.35	0.208	5.46	6.71	4.56	0.71	17.55
11	64.80	6.76	10.35	5.79	0.78	23.67	0.41	0.163	4.38	6.70	3.75	0.51	15.34
2	100.30	5.68	6.52	4.36	0.86	17.71	0.32	0.187	5.70	6.54	4.37	0.86	17.76
DL W													
457	152.04	5.70	6.79	5.41	0.80	18.94	0.31	0.158	8.67	10.32	8.23	1.22	28.80
85	73.22	6.93	7.58	5.09	0.78	20.38	0.40	0.186	5.07	5.55	3.73	0.57	14.92
661	108.36	6.79	7.37	5.55	0.74	20.44	0.21	0.117	7.36	7.99	6.01	0.80	2215
27	140.62	6.13	7.58	6.44	0.68	20.83	0.31	0.126	8.62	10.66	9.06	0.96	29.29
184	151.90	5.91	7.39	5.19	0.72	19.33	0.34	0.208	8.98	11.23	7.88	1.09	29.36
557	139.86	7.42	7.16	5.71	0.73	20.66	0.32	0.170	10.38	10.01	7.99	1.02	28.90
195	133.86	6.13	6.83	5.02	0.77	18.76	0.33	0.169	8.21	9.14	6.72	1.03	25.11
175	178.89	5.74	9.39	5.70	0.73	21.56	0.31	0.125	10.27	16.80	10.20	1.31	38.57
394	160.32	5.74	7.36	5.64	0.87	19.47	0.33	0.159	9.20	11.80	9.04	1.39	31.21
21	160.24	5.557	7.42	5.65	0.78	19.41	0.33	0.159	8.93	11.89	9.05	1.25	31.10
15	158.20	6.42	9.03	4.71	0.73	20.59	0.33	0.122	10.16	14.29	7.45	1.15	32.57
24	159.60	6.13	7.46	6.44	0.72	20.75	0.31	0.126	9.78	11.91	10.28	1.15	33.12
DL R													
98	117.54	6.07	10.24	5.14	0.72	22.05	0.29	0.160	7.13	12.04	6.04	0.85	25.92
97	142.32	6.15	7.37	5.08	0.88	19.48	0.46	0.150	8.75	10.49	7.23	1.25	27.73
126	113.14	6.89	8.08	6.31	0.74	21.87	0.28	0.152	7.80	9.14	7.14	0.84	24.74
38	139.86	6.74	8.09	5.13	0.78	20.73	0.33	0.165	9.43	11.31	7.17	1.09	28.99
249	158.20	6.42	7.00	5.18	0.76	19.49	0.40	0.110	10.16	11.07	8.19	1.20	30.83
226	160.58	7.12	7.40	5.31	0.85	20.68	0.27	0.183	11.43	11.88	8.53	1.36	33.21
626	113.12	5.73	8.58	5.19	0.86	20.36	0.28	0.129	6.48	9.71	5.87	0.97	23.03
121	132.16	5.89	8.08	6.06	0.80	21.94	0.28	0.152	7.78	10.68	8.01	1.06	29.00
406	220.04	6.42	8.60	4.48	0.87	20.36	0.22	0.165	14.13	18.92	9.86	1.91	44.80
34	137.76	6.07	10.24	5.14	0.81	22.13	0.29	0.161	8.36	14.11	7.08	1.12	30.49
37	225.12	6.60	7.53	5.59	0.76	20.49	0.31	0.163	14.86	16.95	12.58	1.71	46.13
212	192.08	5.91	8.64	6.80	0.78	22.12	0.27	0.131	11.35	16.60	13.06	1.50	42.49

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ANIMAL No	Milk 1-8	% CONSTITUENTS Prot	fat	Lact	Ash	Ts	G	P	KG CONSTITUENTS Prot	Lat	Lact	Ash	Ts
LW&LR													
367	105.70	6.31	9.81	4.46	0.82	21.52	0.30	0.152	6.67	10.37	4.71	0.87	22.75
613	138.52	7.33	8.15	5.03	0.89	21.27	0.44	0.234	10.15	11.29	6.97	1.23	29.46
995	112.92	6.86	7.99	5.65	0.90	21.66	0.26	0.137	7.75	9.02	6.38	1.02	24.46
74	130.62	6.43	9.42	4.73	0.78	21.23	0.28	0.112	8.40	12.30	6.18	1.02	27.73
75	142.00	6.35	7.98	6.37	0.74	21.04	0.40	0.192	9.02	11.33	9.05	1.05	29.38
706	107.24	7.74	8.35	5.43	0.87	22.37	0.27	0.139	8.30	8.95	5.82	0.93	23.99
990	89.04	6.46	8.39	4.99	0.71	20.53	0.29	0.195	5.75	7.47	4.44	0.63	18.28
136	108.36	6.31	8.91	5.39	0.85	21.58	0.25	0.146	6.84	9.65	5.84	0.92	23.38
203	106.12	6.19	7.76	4.69	0.68	19.47	0.31	0.174	6.57	8.23	4.98	0.72	20.66
618	130.62	6.82	7.70	5.49	0.71	20.80	0.32	0.159	8.91	10.06	7.17	0.93	27.17
205	169.64	6.78	7.25	4.38	0.85	19.27	0.29	0.123	11.50	12.30	7.43	1.44	32.69
LR&W													
66	113.26	5.11	8.75	5.14	0.74	21.11	0.28	0.134	5.79	9.91	5.82	0.84	23.91
68	130.48	6.66	7.80	4.99	0.73	20.05	0.28	0.141	8.69	10.18	6.51	0.95	26.16
197	98.00	6.84	6.58	6.02	0.79	20.25	0.27	0.144	6.70	6. 45	5.90	0.77	19.85
681	143.92	6.02	8.96	5.47	0.89	20.94	0.29	0.123	8.66	12.90	7.87	1.28	30.14
376	142.52	6.31	9.35	5.31	0.76	21.72	0.28	0.112	8.99	13.33	7.57	1.08	30.96
914	166.76	7.86	7.43	5.84	0.69	21.81	0.30	0.147	13.11	12.39	9.74	1.15	36.37
58	180.56	5.90	6.66	4.80	0.85	18.03	0.29	0.140	10.65	11.94	8.67	1.53	32.56
306	177.60	7.35	7.81	4.86	0.93	20.95	0.31	0.139	13.05	13.87	8.63	1.65	37.21
66	116.48	5.11	10.13	5.14	0.74	21.11	0.28	0.134	5.95	11.80	5.99	0.86	24.59
62	230.72	6.68	7.49	4.55	0.86	19.83	0.33	0.172	15.41	17.28	10.50	1.98	45.75
685	142.12	6.74	9.01	4.37	0.78	20.90	0.38	0.176	9.58	12.81	6.21	1.11	29.70

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Appendix Table 5.VIII

MULTIPLE RANGE TEST FOR BREED DIFFERENCE IN COLOSTRUM COMPOSITION

S.n.f.							
Standard error of mean	0.755						
Rp	2.14^{a}	2.25^{b}	2.33^{c}	2.37^{d}	2.42^{e}	2.45^{f}	g
Mean	14.69	14.71	14.12	13.94	13.83	13.62	12.35
Differences	2.34^{a-g}	2.36^{b-g}	-	-	-	-	-
Total Solids:							
Standard error of mean	0.982						
Rp	2.78	2.93	3.03	3.08	3.14	3.18	
Mean	22.84	22.66	22.65	21.92	21.86	21.72	19.62
Differences	3.22^{a-g}	3.04^{b-g}	3.031^{c-g}	-	-	-	-
Protein:							
Standard error of mean	0.632						
Rp	1.79	1.88	1.95	1.98	2.02	2.05	
Mean	8.93	8.70	8.44	7.81	7.53	7.38	6.97
Differences	1.96^{a-g}	-	-	-	-	-	-
Lactose:							
Standard error of mean	0.332						
Rp	0.94	0.99	1.02	1.04	1.06	1.08	
Mean	6.02	5.31	5.28	5.18	4.85	4.75	4.66
Differences	1.36^{a-g}	-	-	-	-	-	-
	1.27^{a-f}	-	-	-	-	-	-
	1.17^{a-e}	-	-	-	-	-	-
Phosphorus:							
Standard error of mean	0.018						
Rp	.051	.054	.055	.057	.058	.058	
Mean	.168	.157	.138	.128	.119	.117	.110
Difference	$.058^{a-g}$	-	-	-	-	-	-

\- Not significantly different from each other.

APPENDIX TABLE 5.IX

AGE AND SEASONAL VARIATION IN COLOSTRUM CONTENTS

	Genotypes							
	LW	LR	IND	D.LW	D.LR	LW.LR	LR.LW	MEAN
Total Solids:								
Gilts	20.01	21.06	22.49	20.86	22.51	21.30	22.16	21.46
Sows	19.23	22.68	23.19	22.98	22.81	22.07	23.06	22.29
Wet	17.52	21.86	20.52	22.66	23.77	20.57	22.16	21.29
Dry	21.72	21.88	25.16	21.18	21.55	22.67	23.06	22.46
Fat:								
Gilts	7.08	8.16	9.26	7.56	8.13	8.12	8.11	8.06
Sows	7.48	8.05	9.18	7.70	7.75	7.32	7.92	7.91
Wet	6.48	8.54	8.09	8.03	7.20	5.78	6.43	7.28
Dry	8.08	7.67	10.35	7.23	8.68	9.27	9.32	8.66
S.n.f.								
Gilts	12.94	12.97	13.24	13.30	14.38	13.18	14.15	13.44
Sows	11.76	14.68	14.01	14.95	15.06	14.58	15.15	14.31
Wet	11.05	13.31	12.43	14.30	16.56	14.79	15.73	13.96
Dry	13.65	14.34	14.81	13.95	12.87	13.24	13.83	13.81
Protein:								
Gilts	7.02	7.24	7.43	6.89	8.85	7.59	8.55	7.63
Sows	6.91	8.39	7.62	7.87	8.56	8.63	9.24	8.17
Wet	6.33	7.81	6.57	7.52	10.34	9.22	10.29	8.22
Dry	7.61	7.82	8.49	7.23	7.07	7.28	7.79	7.61
Lactose:								
Gilts	5.22	5.04	5.07	5.67	4.70	4.75	4.55	5.02
Sow	4.10	5.51	5.56	6.37	5.66	5.17	4.92	5.33
Wet	4.02	4.82	5.11	6.00	5.39	4.77	4.57	4.97
Dry	5.30	5.74	5.52	6.04	4.97	5.16	4.91	5.37
Ash:								
Gilts	0.677	0.695	0.745	0.787	0.823	0.832	0.844	0.732
Sows	0.750	0.733	0.817	0.712	0.835	0.787	0.818	0.779
Wet	0.672	0.693	0.755	0.785	0.837	0.798	0.864	0.769
Dry	0.755	0.735	0.807	0.713	0.822	0.807	0.802	0.778

APPENDIX TABLE 5.X

MULTIPLE RANGE TEST FOR BREED DIFFERENCES IN MILK CONSTITUENTS

Total Solids							
Significant Range	2.83	2.98	3.08	3.14	3.20	3.24	
Standard error of Mean	0.926						
R_p	2.62	2.76	2.85	2.91	2.96	3.00	
Mean	22.09	20.97	20.97	20.61	20.09	19.30	18.82
Differences	3.27	2.15	-	-	-	-	-
	2.79	-	-	-	-	-	-
Fat							
Standard error of Mean	0.657						
R_p	2.85	1.96	2.02	2.06	2.10	2.13	
Mean	9.09	8.33	8.33	8.30	7.63	7.18	7.15
Differences	1.94	-	-	-	-	-	-
	1.91	-	-	-	-	-	-
Ash							
Standard error of Mean	0.037						
R_p	.104	.110	.114				
Mean	0.86	0.84	0.83	0.80	0.75	0.73	0.73
Differences	0.13	0.11	-	-	-	-	-
	0.11	-	-	-	-	-	-
Calicium							
Standard error of Mean	0.029						
R_p	0.08	0.086					
Mean	0.35	0.32	0.31	0.31	0.30	0.29	0.27
Differences	0.08	0.05	-	-	-	-	-
Phosphorus							
Standard error of Mean	0.012						
R_p	.034	0.036					
Mean	.196	.160	.151	.147	.146	.141	.139
Differences	.057	.021	-	-	-	-	-
	.055	-	-	-	-	-	-
	.050	-	-	-	-	-	-
	.049	-	-	-	-	-	-
	.045	-	-	-	-	-	-
	.036	-	-	-	-	-	-

APPENDIX TABLE 5.XI

MULTIPLE RANGE TEST - WEEKLY DIFFERENCES IN MILK COMPONENT

Total Solids								
Standard error of Mean		0.926						
R_p	2.62	2.76	2.85	2.91	2.96	3.00		
Mean	22.02	21.36	21.25	20.26	19.95	19.70	19.22	19.19
Differences	2.83	2.17	-	-	-	-	-	-
	2.80	-	-	-	-	-	-	-
Fat								
Standard error of Mean	0.657							
R_p	1.85	1.96	2.02	2.06	2.10	2.13		
Mean	8.88	8.58	8.56	8.09	7.90	7.60	7.20	7.13
Differences	1.75	-	-	-	-	-	-	-
Ash								
Standard error of Mean	0.037							
R_p	0.104	0.110	0.114					
Mean	0.86	0.85	0.81	0.79	0.76	0.73	0.73	0.72
Differences	0.14	0.13	0.09	-	-	-	-	-
	0.13	0.12	-	-	-	-	-	-
	0.13	0.12	-	-	-	-	-	-
	0.10	-	-	-	-	-	-	-
Calcium								
Standard error of Mean	0.029							
R_p	0.08	0.086	0.089	0.091				
Mean	.352	.344	.328	.319	.294	.292	.262	.250
Differences	.102	.094	-	-	-	-	-	-
	.090	.082	-	-	-	-	-	-
Phosphorus								
Standard error of Mean	.012							
R_p	.034	.036	0.37	.038	.038	.039		
Mean	.178	.167	.160	.153	.151	.144	.142	.140
Differences	.038	.027	-	-	-	-	-	-
	.036	-	-	-	-	-	-	-
	.034	-	-	-	-	-	-	-

APPENDIX TABLE 5.XII

SEASONAL VARIATION IN YIELD OF MILK COMPONENTS OF THE INDIGENOUS SOW

	Wet	Dry
Total Solids	20.69	23.49
Fat	8.30	9.86
Lactose	5.01	5.28
Ash	0.87	0.85
Solids not fat	12.36	13.60
Protein	6.56	7.45
Calcium	0.350	0.349
Phosphorus	0.193	0.199

APPENDIX TABLE 5.XIII

MULTIPLE RANGE TEST - YIELD OF MILK COMPONENT

Total Solids							
Standard error of Mean	2.74						
R_p	7.75	8.17	8.45	8.60	8.77	8.88	
Mean	32.28	30.65	28.76	25.66	25.50	24.46	16.32
Differences	15.96	14.33	12.44	9.34	9.18	8.14	-
	7.82	-	-	-	-	-	-
Lactose							
Standard error of Mean	0.781						
R_p	2.21	2.33	2.41	2.45	2.50	2.53	
Mean	8.40	7.97	7.58	7.41	6.96	6.27	3.29
Differences	5.05	4.18	3.79	3.62	3.17	2.48	-
	2.13	-	-	-	-	-	-
Protein							
Standard error of Mean	0.944						
R_p	2.67	2.81	2.91	2.96	3.02	3.06	
Mean	9.81	9.67	9.07	8.80	8.26	8.17	5.18
Differences	4.63	4.49	3.89	3.62	3.08	2.99	-
	1.64	-	-	-	-	-	-
Fat							
Standard error of Mean	1.160						
R_p	3.28	3.46	3.57	3.64	3.71	3.76	
Mean	12.74	12.08	10.97	10.89	10.09	9.48	6.71
Differences	6.03	5.37	4.28	4.18	3.48	-	-
	3.26	-	-	-	-	-	-
Ash							
Standard error of Mean	0.120						
R_p	0.339	0.358	0.370	0.377	0.384	0.389	
Mean	1.24	1.20	1.10	1.08	0.98	0.98	0.64
Differences	0.60	0.56	0.46	0.44	0.34	0.34	-
	0.26	-	-	-	-	-	-

APPENDIX TABLE 5.XIV

MULTIPLE RANGE TEST - INTAKE OF MILK COMPONENT PER PIGLET

Total Solids							
Standard error of Mean	0.0112						
R_p	0.0317	0.0334	0.0345	0.0352	0.0358	0.0363	
Mean	.0944	.0911	.0814	.0762	.0704	.0633	.0626
Differences	.0318	.0285	-	-	-	-	-
	.0311	-	-	-	-	-	-
Fat							
Standard error of Mean	.00458						
R_p	.01296	.0136	.0141	.00144	.0147	.0148	
Mean	.0373	.0334	.0328	.0303	.0275	.0260	.0240
Differences	0.0133	.0094	-	-	-	-	-
	0.0113	-	-	-	-	-	-
Protein							
Standard error of Mean	.00374						
R_p	.0106	.0112	.0115	.0117	.0120	.0120	
Mean	.0304	.0292	.0251	.0233	.0227	.0201	.0195
Differences	.0109	.0097	-	-	-	-	-
	.0103	-	-	-	-	-	-
Lactose							
Standard error of Mean	2.966						
R_p	8.39	8.84	9.14	9.31	9.49	9.61	
Mean	24.48	19.52	19.23	19.10	17.86	16.09	14.08
Differences	10.48	5.52	-	-	-	-	-
	8.39	-	-	-	-	-	-
Ash							
Standard error of Mean	0.430						
R_p	1.02	1.28	1.32	1.35	1.38	1.39	
Mean	3.46	3.04	2.88	2.83	2.51	2.42	2.36
Differences	1.10	-	-	-	-	-	-
	-	-	-	-	-	-	-

APPENDIX TABLE 5.XV

MILK PRODUCTION/$W_{kg}^{0.734}$

Genotype	Gilts	Sows	Wet	Dry
LW	4.35	2.23	3.34	3.92
LR	3.98	3.38	3.66	3.70
IND	3.63	4.13	3.87	3.89
D.LW	3.63	4.75	4.76	3.61
D.LR	3.68	4.80	4.48	4.00
LW.LR	3.08	4.02	3.81	3.44
LR.LW	3.44	4.55	4.40	3.71
Mean	3.75	4.02	4.02	3.76

APPENDIX TABLE 5.XVI

MULTIPLE REGRESSION EQUATION FOR MILK AND PERCENT FRESH CONTITUENTS (Y)

N = 82 r = .20 + Significant for exotics N = 22 - 24

r = .40 + " " Indigenous N = 12

1 - 4 Weeks

	N			Protein	Fat	Lactose	Ash	TS		
LW+LR	24	ŷ	= 0.774	+ 1.46	+ 2.10	- 0.51	+ 11.79	- 1.38	.15	NS
IND	12	ŷ	= 2.36	- 3.58	- 2.06	- 2.93	+ 6.32	- 1.80	.43	*
DLWLR	24	ŷ	=27.26	- 2.73	+ 0.86	- 2.43	+ 5.91	- 1.16	.20	*
LW&LR	22	ŷ	= 7.91	+ 0.30	- 0.93	- 0.47	+ 8.03	+ 0.26	.26	*
5 - 8 Weeks										
LW+LR		ŷ	= -2.73	- 3.70	+ 3.39	- 3.58	+ 6.58	- 3.55	.24	*
IND		ŷ	= 2.08	- 0.52	- 0.70	- 0.44	+ 2.23	- 0.27	.50	*
DLWLR		ŷ	= 8.22	- 1.88	+ 2.07	- 1.99	+ 3.67	- 2.19	.04	ns
LW&LR		ŷ	= 1.54	- 1.02	- 0.13	- 0.50	+ 2.27	- 0.78	.39	*
ESTIMATED YIELD PER TOTAL LACTATION - 8 WEEKS										
LW&LR		ŷ	= -10.65	- 13.29	+12.60	- 14.90	+ 28.13	- 13.19	.25	*
IND		ŷ	= -1 .28	- 2.05	- 2.35	- 0.77	+ 8.44	- 1.86	.21	ns
DLWLR		ŷ	= 12.82	- 0.50	+ 1.76	- 2.44	+ 11.96	- 1.84	.06	ns
LW&LR		ŷ	= 28.98	- 1.28	- 0.01	- 0.55	+ 11.75	- 1.46	.33	*

$r = 0.50$ $r^2 = 0.25$ Coefficient of alienation = $\sqrt{1-.25}$

= 0.86

predictive value = 1-0.86 = 0.14

APPENDIX TABLE 6.1

PERCENT - VARIATION IN LITTER AND SOW PERFORMANCE

Source of variation	Milk Produced	Milk/ Pig	Litter Size	Litter Birth Weight	Litter Weaning Weight	Weight Gained	Weight Gained/ Pig	Birth weight/ Pig	Weaning weight/ Pig	Weight Lost/ Sow	Efficiency of milk utilization
Season	19.32	5.07	0.43	33.93	44.28	45.35	44.31	60.95	46.89	16.16	2.45
Breed	54.29	53.88	50.13	43.61	42.19	41.56	42.79	25.70	39.48	36.07	.59.77
Age	19.16	23.79	35.96	17.35	9.53	8.91	6.05	5.26	8.64	29.39	18.69
Unaccounted	7.24	17.26	13.49	5.12	4.00	4.18	6.88	8.08	4.99	18.38	19.09

$$\% \text{ variation} = 100 - \left(\frac{MS_{Total} - MS_f}{MS_{Total}}\right)$$

APPENDIX TABLE 6.1 **LITTER PERFORMANCE** - weights in kilogram

Animal No.	Milk 3 weeks	Milk 5 wks	Total Yield	Average L.S.	Litter Birth weight	Litter weight 3 wks	Litter weight 5 wks	Litter weight wearing	Weight gained	Body weight Farrow	Weight lost	Litter size	Litter size wearing	% Survival
LW 104	50.40	97.72	120.82	6.0	5.45	18.61	25.73	36.26	30.81	141.00	39.00	6.0	6.0	100
844	70.01	107.17	147.19	6.0	6.54	23.04	31.23	49.94	43.40	175.00	32.00	6.0	6.0	100
865	78.26	116.48	148.68	9.0	9.00	31.79	40.96	51.95	42.95	131.00	29.00	9.0	9.0	100
158	78.68	120.40	150.36	10.0	12.25	36.15	51.62	66.45	54.20	106.69	23.15	10.0	10.0	100
401	83.72	106.12	132.44	7.5	12.25	24.24	27.03	36.29	24.04	106.00	40.00	8.0	7.0	87.5
3933	72.46	131.26	180.67	8.0	8.00	27.28	35.68	53.09	45.09	179.50	38.50	8.0	8.0	100
3469	73.62	129.26	187.41	8.0	8.30	18.58	22.47	35.37	27.07	190.00	41.00	9.0	7.0	77.8
453	37.52	65.52	87.64	6.0	5.85	17.53	21.46	30.44	24.59	120.00	29.00	6.0	6.0	100
453	83.00	143.38	214.11	8.0	8.00	32.28	38.61	50.83	42.83	163.00	34.00	8.0	8.0	100
70X	64.26	101.78	129.22	6.0	5.30	11.35	14.13	16.24	10.94	118.00	14.00	6.0	6.0	100
70X	69.58	142.72	204.87	9.0	7.50	34.96	42.90	58.11	50.51	144.00	36.50	9.0	9.0	100
893	66.78	110.74	138.60	5.5	8.00	19.24	27.34	39.36	31.36	139.00	17.00	6.0	5.0	83.3
464	50.40	75.60	99.96	5.0	6.50	16.53	21.74	29.16	22.66	96.00	24.00	5.0	5.0	100
517	41.16	68.32	90.16	3.0	4.00	10.26	16.06	21.70	17.70	102.00	23.00	3.0	3.0	100
3929	63.28	113.82	146.44	7.0	9.50	13.88	16.90	27.88	18.38	136.00	9.00	8.0	6.0	75.0
4567	69.86	113.12	140.98	7.0	10.60	20.01	28.75	42.20	31.60	165.00	23.00	9.0	7.0	77.8

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293	86.36	154.40	193.86	10.5	10.50	32.92	41.25	52.38	41.88	154.00	64.00	11.0	10.0	90.9
4509	38.64	64.40	81.48	6.0	10.25	14.75	17.32	28.43	18.18	195.00	19.00	7.0	5.0	71.4
844	91.84	117.04	142.80	8.0	11.20	18.54	27.10	43.30	32.10	143.00	17.00	9.0	7.0	77.8
455	21.84	40.88	68.14	4.0	5.50	11.67	16.95	29.12	23.62	100.00	6.00	5.0	4.0	80.0
893	45.92	69.44	85.40	6.0	9.00	19.96	23.83	34.23	25.23	138.00	33.00	6.0	6.0	100
LR														
795	101.20	160.34	219.94	8.0	8.40	31.35	40.22	53.07	44.67	160.00	40.00	8.0	8.0	100
797	37.69	80.77	102.27	3.0	5.09	11.44	17.47	26.33	21.24	178.00	37.00	3.0	3.0	100
764	52.80	83.88	112.00	5.0	6.50	13.65	16.16	25.10	18.60	91.00	2.00	6.0	4.0	66.7
547	38.92	68.04	91.56	4.5	6.75	9.98	13.34	18.64	11.89	73.00	16.00	5.0	4.0	80.0
1863	100.78	157.35	193.90	5.0	6.40	19.20	24.81	32.80	26.40	160.00	64.00	5.0	5.0	100
764	53.70	100.10	155.40	6.0	5.60	16.33	19.89	25.76	20.16	105.50	18.50	6.0	6.0	100
797	34.72	65.94	81.90	5.0	6.00	14.13	19.61	29.24	23.24	143.00	28.00	5.0	5.0	100
357	27.44	45.74	66.88	2.0	3.60	9.28	12.18	19.54	15.94	138.00	7.00	2.0	2.0	100
16	55.44	94.92	119.84	3.0	5.60	15.34	20.89	35.45	29.83	104.00	2.00	3.0	3.0	100
726	85.96	148.21	184.52	5.0	7.25	26.40	40.59	61.78	54.53	205.00	41.00	5.0	5.0	100
357	29.44	68.21	83.66	3.0	4.18	19.67	26.65	37.09	33.91	165.00	37.00	3.0	3.0	100

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IND.															
92	29.28	55.88	79.61	5.0	4.68	11.33	13.53	19.20	14.52	57.00	28.00	5.0	5.0	100
3	14.82	31.16	48.19	2.0	3.10	8.30	9.90	6.80	69.80	69.80	19.70	3.0	2.0	66.7
4	31.98	53.12	73.00	6.0	8.00	21.46	25.73	32.58	24.58	76.27	33.14	6.0	6.0	100
914	32.14	55.62	78.86	5.0	4.00	12.24	15.83	20.28	16.28	98.00	36.00	5.0	5.0	100
182	33.96	56.40	84.40	5.0	4.00	10.65	12.13	15.01	11.01	39.00	19.00	5.0	5.0	100
173	32.00	53.28	76.08	7.0	4.40	10.92	14.60	20.32	15.92	38.00	16.00	7.0	7.0	100
174	25.96	49.76	73.24	4.0	4.80	9.85	12.26	16.06	11.26	48.00	26.00	5.0	3.0	60.0
182	26.50	52.88	74.72	4.0	3.00	8.22	9.60	11.20	8.20	39.00	20.00	4.0	4.0	100
173	24.04	49.34	65.66	3.0	3.60	3.78	5.75	7.50	3.90	44.00	16.00	4.0	2.0	50.0
174	20.36	39.26	57.70	3.0	3.50	8.70	10.42	12.30	8.80	31.50	11.50	3.0	3.0	100
183	15.23	28.03	36.21	1.5	2.00	3.68	4.55	3.80	2.80	27.00	4.50	2.0	1.0	50.0
172	23.62	40.52	53.47	3.0	3.50	8.00	10.55	12.13	8.63	38.00	18.50	3.0	3.0	100
1	32.14	63.68	92.38	7.5	8.00	17.08	19.95	22.43	14.43	88.00	38.63	8.0	7.0	87.5
11	29.40	51.64	64.80	6.5	5.20	12.55	15.28	17.23	12.03	48.00	15.00	7.0	6.0	85.7
2	45.98	75.38	100.30	8.5	9.52	30.43	35.95	46.35	36.83	98.00	53.00	9.0	8.0	88.90
6	40.32	65.80	84.28	4.0	5.70	15.59	21.09	34.25	28.55	106.24	13.62	7.0	4.0	57.10
7	54.28	78.92	102.72	6.0	6.20	21.57	29.70	48.45	42.25	89.89	5.90	6.0	6.0	100
263	37.80	64.68	86.24	6.0	7.25	20.88	27.66	34.67	27.42	52.66	22.24	6.0	6.0	100
DLW														
457	62.44	116.06	152.04	8.0	11.50	31.87	34.70	42.15	30.65	182.00	48.00	10.00	8.0	80.0
85	31.36	52.08	73.22	6.0	6.75	18.33	26.00	39.26	32.51	98.00	36.00	6.0	6.0	100
661	51.24	92.40	108.36	6.5	8.65	24.60	28.26	39.47	30.82	120.00	59.96	7.0	6.0	85.7
27	60.22	113.84	140.62	7.0	10.80	35.57	46.33	60.23	49.40	165.00	63.00	7.0	7.0	100

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184	70.28	127.12	151.90	9.0	10.00	27.75	32.48	35.37	25.37	122.00	26.80	10.00	8.00	80.00
557	50.96	103.04	139.86	8.5	11.29	32.83	45.38	66.18	54.93	112.00	19.00	9.00	8.00	88.9
26	47.20	76 .88	122.80	4.4	8.00	19.35	28.61	44.20	36.20	116.22	22.13	5.00	4.00	80.0
195	54.67	98.30	133.86	7.0	9.70	27.10	34.29	50.60	40.90	130.30	27.80	7.00	7.00	100
175	87.29	142.03	178.89	9.0	14.00	29.90	40.22	62.17	48.17	136.80	28.30	10.00	8.00	80.0
394	73.94	125.88	160.32	9.0	11.25	34.05	42.27	53.53	41.28	127.00	31.00	9.0	9.0	100
411	55.36	95.66	120.00	5.0	8.50	29.25	44.08	68.23	59.73	144.37	24.51	5.0	5.0	100
21	75.96	123.70	160.24	7.5	13.00	23.29	22.80	30.44	17.44	108.00	39.79	10.0	6.0	60.0
24	84.00	120.40	158.20	9.5	14.25	31.78	50.12	79.02	64.77	106.69	22.02	10.0	9.0	90.0
11	68.60	112.56	159.60	10.0	15.25	35.52	48.43	82.85	67.60	102.15	8.63	10.0	10.0	100
15	78.40	138.88	201.32	9.0	11.35	41.97	62.29	100.61	89.26	143.01	31.33	9.0	9.0	100
49	68.44	119.80	211.96	11.0	15.85	57.68	81.83	13054	99.69	139.83	41.09	11.0	11.0	100
DLR														
98	53.76	88.06	117.54	7.5	9.50	29.62	35.58	45.80	33.30	123.94	30.87	8.0	7.0	87.5
97	55.52	103.68	142.32	8.5	11.50	25.25	37.45	65.67	54.17	120.76	29.96	10.0	8.0	80.0
126	51.00	83.38	113.14	7.5	9.60	30.49	41.17	52.06	42.46	210.00	41.00	10.0	7.0	70.0
49	46.34	8 0.50	103.74	5.0	6.25	19.24	24.60	32.54	25.29	69.01	15.88	5.0	5.0	100
38	66.22	113.26	139.86	8. 5	10.50	24.64	35.41	51.92	41.42	109.87	50.85	9.0	8.0	88.9
249	83.44	134.12	158.20	8.0	11.25	34.23	44.49	60.85	49.60	128.48	46.53	8.0	8.0	100
226	78.40	132.44	160.58	9.0	9.75	38.17	52.66	68.93	59.18	151.18	49.37	9 .0	9.0	100

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626	53.48	88.20	113.12	4.0	6.75	24.12	32.57	40.45	43.70	146.07	5.79	4.0	4.0	100
406	64.96	104.72	132.16	9.5	14.00	47.71	60.99	74.96	60.96	166.62	51.08	10.0	9.0	90
425	75.84	146.36	220.04	8.0	12.50	35.14	50.83	76.67	64.17	163.44	17.25	9.0	7.0	77.8
34	71.12	105.00	137.76	7.0	14.25	21.89	35.77	58.49	44.24	118.95	29.97	9.0	5.0	555.6
212	141.68	189.00	225.12	8.5	14.30	43.47	61.13	86.44	72.14	151.64	46.99	99.0	8.0	88.9
37	93.52	156.52	192.08	7.0	10.50	34.86	48.50	82.30	71.80	144.15	38.82	7.0	7.0	10.0
58	77.12	137.64	189.28	9.0	12.50	43.24	60.69	95.39	82.89	128.03	25.87	10.0	9.0	90.0
LW.LR														
367	52.64	79.66	105.70	6.0	10.80	28.76	40.38	51.89	41.09	122.34	33.26	8.0	6.0	75.0
613	57.60	98.28	138.52	6.5	8.00	27.06	37.00	53.39	45.39	148.91	24.51	7.0	6.0	85.7
995	62.24	91.92	112.92	7.0	9.80	26.29	25.45	37.72	27.92	103.97	17.71	8.0	6.0	75.0
74	43.68	91.00	130.62	9.5	11.25	36.67	43.97	61.28	50.03	135.00	52.37	10.0	9.0	90.0
75	57.80	108.26	142.00	8.0	10.85	39.59	51.53	71.53	60.68	126.36	28.30	8.0	8.0	100

706	40.32	66.64	107.24	2.0	3.25	12.06	17.67	32.39	29.14	154.36	2.27	2.0	2.0	100
990	29.96	59.64	89.04	3.5	3.75	16.10	24.43	33.58	29.83	129.00	28.00	4.0	3.0	75.0
136	56.84	82.60	108.36	4.0	6.30	21.95	32.50	54.22	47.92	169.00	44.00	4.0	4.0	100
203	42.84	75.32	106.12	2.0	3.85	14.41	21.31	31.23	27.38	103.51	25.85	2.0	2.0	100
205	68.04	102.34	130.62	9.0	10.50	25.13	33.48	50.11	39.61	104.19	14.07	9.0	9.0	100
618	75.56	124.28	169.64	10.0	14.25	35.75	57.21	90.62	76.37	99.88	19.98	10.0	10.0	100
990	64.40	127.60	209.40	10.0	17.50	53.23	77.37	116.79	99.29	203.39	54.93	11.0	10.0	90.9
IR-LW														
66	49.84	81.62	113.26	6.5	10.25	32.34	43.85	50.12	39.87	130.75	17.95	7.0	6.0	85.7
68	59.92	101.92	130.48	6.0	7.50	24.00	29.29	33.92	26.42	122.58	31.70	6.0	6.0	100
197	25.06	63.28	98.00	4.5	5.85	12.05	20.62	29.25	23.40	137.00	29.00	5.0	4.0	80.0
62	32.34	69.30	93.66	2.0	3.50	10.08	18.98	28.93	25.43	103.97	12.72	2.0	2.0	100
681	56.42	110.88	143.92	11.0	13.25	26.38	32.05	53.97	40.72	87.74	21.18	12.0	10.0	83.3
376	62.86	113.40	142.52	9.0	11.25	28.52	36.50	51.76	40.51	118.00	56.71	9.0	9.0	100
914	70.60	124.72	166.76	9.5	13.99	37.24	50.42	76.25	62.26	192.50	30.88	10.0	9.0	90.0
306	76.18	128.36	180.56	10.5	17.62	50.99	69.95	115.22	97.60	203.85	37.00	11.0	10.0	90.0
58	54.80	105.88	177.60	8.5	13.30	43.79	70.45	111.93	98.63	160.49	36.32	9.0	8.0	88.9
66	44.24	82.04	116.48	3.0	4.80	16.97	24.50	39.17	34.37	127.12	7.94	3.0	3.0	100
685	103.60	181.16	230.72	10.0	17.25	54.46	72.46	95.98	78.73	108.05	24.06	12.0	10.0	83.3
62	51.44	95.52	142.12	4.0	8.20	26.56	40.18	70.33	62.13	167.07	10.31	4.0	4.0	100

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APPENDIX TABLE 6.111

MULTIPLE RANGE TEST FOR BREED DIFFERENCE IN REPRODUCTIVE PERFORMANCE

Milk/Piglet							
Standard error of Mean	2.889						
R_p	8.12	8.55	8.84	9.04	9.19	10.43	
Mean	27.71	24.85	24.34	20.34	20.10	18.75	16.01
Difference	11.70	8.84	-	-	-	-	-
	8.96	-	-	-	-	-	-
Birth weight/piglet							
Standard error of Mean	0.105						
R_p	0.295	0.311	0.321	0.329	0.334	0.339	
Mean	1.54	1.46	1.41	1.40	1.38	1.22	1.14
Difference	0.40	0.32	-	-	-	-	-
	0.32	-	-	-	-	-	-
Birth weight/litter							
Standard error of Mean	0.982						
R_p	2.76	2.91	3.00	3.07	3.12	3.17	
Mean	11.25	10.94	10.56	9.18	8.26	6.72	5.03
Difference	6.22	5.91	5.53	4.15	3.23	-	-
	5.91	4.22	3.84	-	-	-	-
	2.99	-	-	-	-	-	-
Weight gained /litter							
Standard error of Mean	6.04						
R_p	16.97	17.88	18.48	18.91	19.21	19.51	
Mean	53.24	52.51	50.23	47.89	31.39	29.11	16.35
Difference	36.89	36.16	33.88	31.54	-	-	-
	24.13	23.40	21.12	-	-	-	-
	21.85	21.12	18.84	-	-	-	-
Weight gained/piglet							
Standard error of Mean	0.930						
R_p	2.61	2.75	2.85	2.91	2.96	3.00	
Mean	8.25	8.07	7.03	6.39	6.22	4.58	3.38
Difference	4.87	4.69	3.65	3.01	-	-	-
	3.67	3.49	-	-	-	-	-

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Weaning weight/litter							
Standard error of Mean	6.72						
R_p	18.88	19.89	20.56	21.03	21.37	21.71	
Mean	64.25	63.07	61.55	57.06	39.65	37.77	21.31
Difference	42.94	41.76	40.24	35.75	-	-	-
	28.48	27.30	25.78	21.29	-	-	-
	24.60	23.42	-	-	-	-	-
Weaning weight/piglet							
Standard error of Mean	0.921						
R_p	2.59	2.73	2.82	2.88	2.93	2.97	
Mean	9.91	9.78	8.48	7.79	7.60	5.79	4.39
Difference	5.52	5.39	4.09	3.40	3.21	-	-
	4.12	3.99	-	-	-	-	-
Efficiency of Milk Utilization							
Standard error of Mean	0.934						
R_p	2.62	2.76	2.86	2.92	2.97	3.01	
Mean	6.62	4.79	4.66	3.52	3.14	2.97	2.92
Difference	3.70	-	-	-	-	-	-
	3.65	-	-	-	-	-	-
	3.48	-	-	-	-	-	-
	3.10	-	-	-	-	-	-
Litter Size							
Standard error of Mean	0.793						
R_p	2.23	2.35	2.43	2.48	2.52	2.56	
Mean	7.97	7.68	7.04	6.93	6.46	5.08	4.83
Difference	3.14	2.85	-	-	-	-	-
	2.89	2.60	-	-	-	-	-

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APPENDIX TABLE 6-IV

Piglets Performance

ANI-MAL NO	MILK IN-TAKE	Birth wt	Wean-ing wt	Wt gained	Effici-ency	ANI-MAL NO	MILK IN-TAKE	Birth wt	Wean-ing wt	Wt gain-ed	Effici-ency
LW											
104	20.14	0.91	6.04	5.135	3.92	16	25.27	1.54	7.67	6.13	4.12
844	24.53	1.09	8.32	7.23	3.39	796	21.28	1.07	7.02	5.95	3.58
865	16.52	1.00	5.77	4.77	3.46	384	32.35	1.40	7.47	6.07	5.33
158	15.04	1.23	6.65	5.42	2.77	283	26.07	1.31	4.33	3.02	8.83
401	17.66	1.65	4.84	3.205	5.51	234	18.62	1.37	5.51	4.14	4.50
3933	22.58	1.00	6.64	5.64	4.01	773	16.12	1.14	5.54	4.40	3.06
3469	23.43	1.04	4.42	3.38	6.92	882	23.49	1.02	8.13	7.11	3.30
453	14.61	0.98	5.07	4.10	3.56	2158	38.41	1.58	10.64	9.06	4.24
453	26.76	1.00	6.35	5.35	5.00	21588	28.42	1.63	8.10	6.48	4.59
70x	21.54	0.88	2.70	1.82	11.81	IND					
70x	22.76	0.83	6.46	5.61	4.06	92	15.92	0.94	3.84	2.90	5.49
893	25.20	1.45	7.16	5.70	4.42	3	24.10	1.55	4.93	3.40	7.09
464	19.99	1.30	5.83	4.53	4.41	4	12.17	1.33	3.43	4.10	2.57
517	30.05	1.33	7.23	5.9	5.09	914	13.77	0.80	4.06	3.26	4.84
3929	20.92	1.36	3.98	2.63	7.97	182	16.88	6.96	3.06	3.21	5.26
4567	20.14	1.51	6.03	4.51	4.46	173	10.87	0.63	2.90	2.27	4.79
293	18.46	1.01	4.99	3.99	4.63	174	18.31	1.20	4.02	2.82	6.49
4509	13.58	1.71	4.74	3.03	4.68	182	18.68	0.75	2.80	2.05	9.11
844	17.85	1.40	5.41	4.01	4.45	173	21.89	1.26	2.50	1.30	16.84
455	17.035	1.58	7.280	5.905	2.885	174	19.23	1.27	4.16	2.93	6.56
893	14.23	1.56	5.705	4.205	3.38	183	24.14	2.25	3.86	2.80	8.62
LR											
795	27.49	1.05	6.63	5.58	4.92	1	12.32	1.07	3.99	1.92	6.42
797	34.09	1.70	8.78	7.08	4.81	11	19.97	0.80	2.65	1.85	5.39
764	22.40	1.30	5.02	3.72	6.02	2	11.86	1.12	5.45	4.33	2.73
547	20.35	1.50	4.14	2.64	7.71	6	21.07	1.42	8.56	7.14	2.95
1863	38.78	1.28	6.56	5.20	7.34	7	17.12	1.03	8.08	7.04	2.43
764	25.93	0.93	4.29	3.36	7.71	263	14.37	1.21	5.78	4.57	3.14
797	16.38	1.20	5.85	4.65	3.52	DLW					
357	33.34	1.80	9.77	7.97	4.20	457	19.01	1.44	5.27	3.83	4.96
16	37.28	1.87	11.81	9.84	3.75	85	12.20	1.13	6.54	5.42	2.25
726	36.90	1.45	12.36	10.91	3.38	661	16.67	1.33	6.07	4.74	3.52
357	27.39	1.39	12.36	10.99	2.54	27	20.09	1.54	8.60	7.06	2.85
						184	16.88	1.11	3.93	2.82	5.99

CONTINUE →

ANIMAL NO	MILK INTAKE	BIRTH Cot	WEANING Wt	Wt Gained	Effici-ency
557	16.45	1.33	7.89	6.46	2.55
26	22.33	1.45	8.64	6.58	3.59
195	19.12	1.39	7.23	5.84	3.27
175	19.88	1.56	6.91	3.33	3.72
394	17.81	1.25	5.93	4.70	3.79
411	24.00	1.70	13.65	11.93	2.01
21	21.37	1.44	5.07	3.60	5.89
24	16.65	1.50	8.32	6.82	2.44
11	15.96	1.53	8.28	6.76	2.36
15	22.37	1.26	11.78	9.92	2.26
49	19.27	1.44	11.87	10.43	1.85
DLR					
98	15.67	1.27	5.71	4.44	3.33
97	16.74	1.35	7.73	6.37	2.63
126	15.09	1.28	6.94	5.66	3.67
49	18.86	1.14	5.92	4.60	4.10
38	16.45	1.24	6.11	4.87	3.38
249	19.78	1.41	7.61	6.26	3.29
226	17.84	1.22	7.66	6.68	2.71
626	28.28	1.69	12.61	10.93	2.59
406	13.91	1.47	7.89	6.42	2.17
425	27.51	1.56	9.58	9.02	3.43
34	19.68	1.58	8.36	6.32	3.11
212	26.48	1.68	10.17	8.59	3.12
37	27.44	1.50	11.76	10.26	2.67
58	21.03	1.39	10.60	9.21	2.28
LTLR					
367	17.62	1.80	8.65	6.85	2.57
613	21.31	1.23	8.21	6.98	3.05
995	16.13	1.40	5.59	3.99	4.04
74	13.75	1.18	6.45	5.27	2.61
75	17.75	1.36	8.94	7.59	2.34
706	5.36	1.63	16.20	14.57	3.68
990	25.44	1.07	9.59	8.52	2.99

ANIMAL NO	MILK INTAKE	BIRTH Wt	WEANING Wt	Wt Gained	Effici-ency
136	27.09	1.58	13.56	7.46	3.63
203	53.06	1.93	15.62	13.69	3.88
205	14.51	1.17	5.57	4.40	3.30
990	16.96	1.43	9.06	7.64	2.22
618	20.94	1.75	11.68	9.93	2.11
LRLW					
66	17.42	1.58	7.71	6.13	2.84
68	21.75	1.25	5.65	4.40	4.94
197	21.78	1.30	6.50	5.20	4.19
62	46.83	1.75	14.47	12.72	3.08
681	13.08	1.20	4.91	3.70	3.54
376	15.84	1.25	5.75	4.50	3.52
914	17.55	1.47	8.03	6.55	2.68
306	17.20	1.68	10.99	9.30	1.85
58	20.89	1.66	13.17	11.60	1.86
66	38.83	1.60	13.06	11.86	3.39
685	23.07	1.73	9.60	7.87	2.93
62	35.53	2.65	17.58	15.53	2.29

APPENDIX TABLE 6.Va

ANIMAL NO	FEED $W^{0.73}$	FEED/ Kg Milk Sow	CREEP/ Kg Litter Gain	MILK/ Kg Litter Gain	FEED Sow/Kg Litter gain	FEED/ Sow R Litter Kg L. gain
LW						
893	3.25	1.42	0.18	3.38	4.79	4.97
4567	2.93	0.88	0.14	4.46	3.94	4.08
293	2.42	0.50	0.08	4.63	2.33	2.41
844	2.77	9,74	0.57	4.45	3.30	3.87
LR						
764	1.88	0.37	0.39	7.71	2.84	3.23
773	1.75	0.57	0.32	3.66	2.07	2.39
2158	3.31	0.94	0.57	4.39	4.13	4.70
797	3.82	1.78	0.16	3.52	6.27	6.43
IND						
173	5.24	1.00	0.86	4.78	4.76	5.62
1	2.02	0.57	0.21	6.40	3.74	3.95
182	1.86	0.33	0.81	7.67	2.49	3.30
11	4.79	0.93	0.36	5.39	5.01	5.37
DLW						
184	3.53	0.79	0.18	5.99	4.73	4.91
15	3.12	0.59	0.20	2.26	1.33	1.53
49	2.07	0.37	0.13	1.85	0.86	0.81
27	2.47	0.74	0.11	2.85	2.12	2.23
DLR						
38	2.64	0.60	0.39	3.38	2.01	2.40
34	3.79	0.92	0.48	3.11	2.86	3.34
226	2.37	0.59	0.19	2.71	1.60	1.79
249	2.43	0.54	0.08	3.19	1.73	1.81
LWR						
990	2.37	0.56	0.14	2.11	1.18	1.32
75	3.46	0.85	0.24	2.34	1.99	2.23
74	3.35	0.94	0.48	2.61	2.45	2.93
205	4.10	0.95	0.45	3.30	3.14	3.59
LRW						
685	2.88	0.39	0.21	2.93	1.14	1.35
376	2.76	0.64	0.57	3.52	2.26	2.83
914	3.08	0.87	0.27	2.68	2.33	2.60
681	4.48	0.83	0.72	3.53	2.94	3.66

Appendix Table 6.Vb

Efficiency of Feed and Milk utilization

ANIMAL NO	TOTAL FEED INTAKE	FEED/ DAY	BODY Wt	$W^{0.73}$	MILK	L.S	CREEP TAKEN	LITTER GAIN	Wt. LOST
LW									
893	120.87	2.15	138.00	37.21	85.40	6.0	4.42	25.23	33.00
4567	124.50	2.22	165.00	42.43	140.98	7.0	4.50	31.60	23.00
293	97.40	1.73	154.00	40.33	193.86	10.5	3.22	41.88	64.00
844	106.00	1.89	143.00	38.20	142.86	8.0	18.25	32.10	17.00
LR									
764	57.30	1.02	105.50	30.35	155.40	6.0	7.85	20.16	18.50
773	72.95	1.30	161.00	41.67	128.95	8.0	11.20	35.23	26.00
2158	107.00	1.91	114.00	32.34	113.68	4.0	14.89	25.90	20.00
797	145.75	2.60	143.00	38.20	81.90	5.0	3.72	23.24	28.00
IND									
173	75.70	1.35	38.00	14.44	76.08	7.0	13.65	15.92	16.00
1	53.95	0.96	88.00	26.75	92.38	7.5	3.01	14.43	38.63
182	27.45	0.49	39.00	14.72	84.40	5.0	8.96	11.01	19.00
11	60.25	1.08	48.00	12.58	64.80	6.5	4.28	12.03	15.00
DLW									
184	120.00	2.14	122.00	33.99	151.90	9.0	4.49	25.37	26.80
15	119.10	2.13	143.01	38.20	201.32	9.0	18.16	89.26	31.33
49	77.90	1.39	139.83	37.57	211.96	11.0	15.05	114.69	41.09
27	104.75	1.87	165.00	42.43	140.62	7.0	5.35	49.40	62.00
DLR									
38	83.25	1.49	109.87	31.48	139.86	8.5	16.05	41.42	50.85
34	126.45	2.26	118.95	33.37	137.76	7.0	21.33	44.24	29.97
226	94.40	1.69	151.18	39.79	160.58	9.0	11.19	59.18	49.37
249	85.75	1.53	128.48	35.31	158.20	8.0	3.84	49.60	46.53
LWR									
990	117.45	2.10	203.39	49.47	209.40	10.0	13.75	99.29	54.93
75	120.65	2.15	126.36	34.88	142.00	8.0	14.53	60.68	28.30
74	122.75	2.19	135.00	36.62	130.62	9.5	23.79	50.03	52.37
205	124.20	2.22	104.19	30.28	130.62	9.0	17.80	39.61	14.07
LRW									
685	89.65	1.60	108.05	31.09	230.72	10.0	16.47	78.73	24.06
376	91.70	1.64	118.00	33.17	142.52	9.0	22.99	40.51	56.71
914	145.00	2.59	192.50	47.15	166.76	9.5	16.70	62.26	30.88
681	119.65	2.14	87.74	26.69	143.92	11.0	29.45	40.72	21.18

APPENDIX TABLE 6.VI

MULTIPLE RANGE TEST FOR BREED DIFFERENCE IN EFFICIENCY OF PRODUCTION - 21 Df

Milk Produced							
Standard error of Mean	13.47						
R_p	39.75	41.76	42.83	43.78	44.45	44.99	
Mean	176.45	170.98	153.16	149.10	140.76	119.98	79.42
Differences	97.03	91.56	73.74	69.68	61.34	± -	-
	56.47	51.00	-	-	-	-	-
Feed Intake							
Standard efror of Mean	7.573						
R_p	22.34	23.48	24.08	24.61	24.99	25.29	
Mean	121.26	112.19	111.50	105.44	97.46	95.75	54.34
Differences	66.92	57.85	57.16	51.10	43.12	41.41	-
	25.51	-	-	-	-	-	-
	23.80	-	-	-	-	-	-
Food/Sow/kg gain							
Standard error of Mean	0.500						
R_p	1.47	1.55	1.59	1.63	1.65	1.67	
Mean	4.00	3.83	3.59	2.22	2.19	2.17	2.10
Differences	1.90	1.73	1.49	-	-	-	-
	1.83	1.66	1.42	-	-	-	-
	1.81	1.64	-	-	-	-	-
	1.78	1.61	-	-	-	-	-
Milk/kg litter gain							
Standard error of Mean	0.484						
R_p	1.43	1.50	1.54	1.57	1.60	1.62	
Mean	6.06	4.82	4.23	3.24	3.17	3.10	2.74
Differences	3.32	2.08	1.49	-	-	-	-
	2.96	1.72	-	-	-	-	-
	2.89	1.65	-	-	-	-	-
	2.82	1.58	-	-	-	-	-
	1.83	-	-	-	-	-	-

CONTINUE →

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Creep/kg pig gain							
Standard error of Mean	0.086						
R_p	0.252	0.267	0.273	0.279	0.284	0.287	
Mean	0.56	0.44	0.36	0.33	0.29	0.24	0.16
Differences	0.40	0.28	-	-0	-	-	-
	0.32	-9	-	-	-	-	-
	0.27	-	-	-	-	-	-
Feed by Sow & Litter/kg gain							
Standard error of Mean	0.514						
R_p	1.52	1.59	1.63	1.67	1.70	1.72	
Mean	4.56	4.19	3.83	2.61	2.52	2.37	2.34
Differences	2.22	1.85	-	-	-	-	-
	2.19	1.82	-	-	-	-	-
	2.04	1.67	-	-	-	-	-
	1.95	-	-	-	-	-	-

APPENDIX TABLE 6.VII

YIELD OF FEED NUTRIENTS/KG DM.

Genotype	Feed intake kg	Protein (kg)	Fat (kg)	DM (kg)	Ash (kg)
LW	119.19	18.23	4.70	98.36	6.74
LR	95.75	15.56	4.01	83.94	5.75
IND	54.34	8.83	2.28	47.64	3.27
DLW	105.44	17.13	4.42	92.44	6.34
DLR	97.46	15.84	4.08	85.44	5.86
LW.LR	121.26	19.70	5.08	106.31	7.29
LRLW	111.50	18.12	4.67	97.75	5.87

YIELD OF MILK NUTRIENTS

Gentotype	Milk	Protein (kg)	Fat (kg)	Total Solids (kg)	Ash (kg)
LW	140.76	8.57	10.10	26.49	1.03
LR	119.98	7.39	8.57	23.16	0.88
IND	79.42	5.56	7.22	17.54	0.68
DLW	176.45	10.98	13.46	35.45	1.32
DLR	149.10	9.57	12.42	31.27	1.19
LW.LR	153.16	10.74	12.76	32.12	1.29
LR.LW	170.98	11.52	14.19	34.47	1.42

APPENDIX TABLE 6.VIII

$$\text{Repeatability} = \frac{\sigma\ \text{Between}}{\sigma\ \text{Total}}$$

$$\text{Within} = MS_W$$

$$\frac{\text{Between}}{\text{Total}} = ns_B - MS_{W/k}$$

K = no of measurements for each genotype

FROM TABLE 6.24

	Feed eaten	Milk produced	S.Feed/ milk	S.Feed/ gain	Milk/ gain	Creep/ gain	S pig feed/ gain
MS_B	2502	4382	0.054	3.18	5.97	0.07	3.65
MS_W	344	1089	0.014	1.50	1.41	0.04	1.59
	2158	3293	0.040	1.68	4.56	0.03	2.06
K = 4	539	825	0.010	0.42	1.14	0.008	0.51
R =	539/883	823/1912	0.010/0.024	0.42/1.92	1.14/2.55	0.008/0.048	0.51/2.10
	0.68	0.43	0.42	0.22	0.45	0.17	0.24

APPENDIX TABLE 6.IX MILK AND CONSTITUENTS 1–4 WEEKS

ANIMAL No	MILK 1-4wks	% CONSTITUENTS Protein	Fat	Lactose	Ash	TS	Ca	P	KG CONSTITUENTS Prot	Fat	Lactose	Ash	TS
LW 104	76.86	5.64	7.60	5.28	0.62	20.08	0.30	0.111	4.33	5.84	4.06	0.48	15.43
844	91.13	6.82	6.44	5.94	0.80	19.17	0.28	0.101	6.22	5.87	5.41	0.72	17.47
865	99.82	5.77	6.46	5.67	0.65	18.31	0.24	0.142	5.76	6.45	5.60	0.65	18.28
3933	105.21	5.65	7.10	4.84	0.65	18.24	0.19	0.127	5.94	7.47	5.09	0.68	19.19
3469	108.92	5.50	8.24	5.31	0.70	19.73	0.24	0.102	3.03	8.98	5.78	0.76	21.49
453	52.64	5.53	6.46	5.61	0.61	18.13	0.22	0.092	2.91	3.40	2.95	0.32	9.54
70x	108.86	4.89	7.98	6.05	0.66	19.57	0.24	0.129	5.32	8.69	6.59	0.72	21.30
893	94.22	5.51	8.25	4.45	0.67	18.98	0.21	0.131	5.19	7.77	4.19	0.63	17.88
464	65.52	6.68	6.27	4.11	0.69	17.75	0.31	0.131	4.38	4.11	2.69	0.45	11.63
3929	92.82	5.14	6.03	2.67	0.62	14.42	0.22	0.177	4.77	5.60	2.48	0.58	13.40
4567	96.88	5.92	5.88	4.52	0.64	17.07	0.20	0.128	5.74	5.70	4.38	0.62	16.54
293	130.56	7.36	6.32	3.72	0.71	18.11	0.34	0.131	9.61	8.25	4.86	0.93	23.64
LR													
795	145.40	6.05	7.86	4.80	0.73	1946	0.20	0.135	8.80	1143	6.98	1.06	28.29
797	65.83	5.17	7.03	4.14	0.76	17.09	0.22	0.311	3.40	4.63	2.73	0.50	11.25
764	65.80	4.95	5.98	5.89	0.66	17.50	0.16	0.120	3.26	3.93	3.88	0.43	11.52
1863	140.82	6.06	6.91	6.13	0.68	19.80	0.23	0.122	8.53	9.73	8.63	0.96	27.88
764	88.02	6.52	5.99	5.10	0.77	18.37	0.23	0.105	5.74	5.27	4.49	0.68	16.17
797	52.78	6.61	6.41	5.03	0.69	18.90	0.18	0.133	3.49	3.38	2.65	0.36	9.98
357	49.78	5.78	7.48	6.45	0.66	20.37	0.25	0.124	2.88	3.72	3.21	0.33	10.14
16	135.96	5.98	5.85	3.41	0.75	15.51	0.18	0.154	8.13	7.95	4.64	1.01	21.09
796	69.02	6.31	7.15	5.44	0.66	19.56	0.23	0.141	4.36	4.93	3.75	0.46	13.50
773	89.60	5.70	8.63	5.64	0.64	20.60	0.25	0.122	5.11	7.73	5.05	0.57	18.46
882	57.12	6.07	7.86	4.80	0.68	19.34	0.20	0.128	3.47	4.49	2.74	0.39	11.05
2158	69.58	6.61	6.75	6.03	0.69	20.08	0.24	0.135	4.60	4.70	4.20	0.48	13.97
IND													
92	42.58	7.97	10.47	4.68	0.94	23.32	0.38	0.189	3.39	4.46	1.99	0.40	9.93
3	22.64	6.56	7.51	5.00	0.70	19.76	0.31	0.111	1.49	1.70	1.13	0.16	4.47
4	43.88	6.85	8.86	4.75	0.79	21.26	0.26	0.187	3.01	3.89	2.08	0.35	9.33
182	44.32	7.44	8.88	5.38	0.73	22.42	0.28	0.189	3.30	3.94	2.38	0.32	9.94
173	42.92	6.88	9.23	5.45	0.71	21.97	0.40	0.145	2.95	3.96	2.33	0.30	9.43
174	37.72	6.98	9.91	4.77	0.79	22.15	0.35	0.212	2.63	3.74	1.80	0.30	8.36
182	40.00	8.81	9.56	5.89	0.87	25.06	0.19	0.159	3.52	3.82	2.36	0.35	10.02

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		% CONSTITUENTS							KG CONSTITUENTS				
ANIMAL No	MILK 1-4	PROT	FAT	LACT	ASH	TS	Ca	P	PROT	Fat	Lact	Ash	TS
173	26.04	5.65	7.83	4.55	0.83	18.62	0.30	0.180	2.04	2.82	1.64	0.30	6.71
174	30.86	6.23	6.68	5.75	0.91	18.55	0.35	0.183	1.92	2.06	1.77	0.28	5.72
1	47.62	5.74	7.36	5.24	0.74	19.08	0.28	0.198	2.73	3.50	2.50	0.35	9.09
11	39.52	5.99	7.91	4.70	0.66	19.24	0.40	0.170	2.37	3.13	1.86	0.26	7.60
2	60.54	5.37	6.11	5.04	0.80	17.32	0.37	0.195	3.25	3.70	3.05	0.48	10.49
DLW													
457	91.14	5.64	5.51	5.26	0.73	17.63	0.25	0.151	5.14	5.02	4.79	0.67	16.07
85	42.84	6.82	6.64	5.08	0.81	19.34	0.32	0.167	2.92	2.84	2.18	0.35	8.29
661	72.24	6.81	6.64	5.38	0.66	19.29	0.19	0.126	4.92	4.80	3.89	0.48	13.90
27	90.88	5.93	7.70	6.70	0.65	20.98	0.30	0.117	5.39	7.00	6.09	0.59	19.07
184	106.96	5.74	7.61	5.24	0.64	19.23	0.28	0.198	6.29	8.14	5.60	0.68	20.57
557	74.48	7.03	6.13	5.38	0.65	18.46	0.29	0.145	5.24	4.57	4.00	0.48	13.75
195	79.14	6.20	5.90	4.85	0.67	17.67	0.31	0.166	4.91	4.67	3.84	0.53	13.98
175	116.55	5.48	8.98	6.19	0.72	21.37	0.25	0.123	6.39	10.47	7.21	0.84	24.91
394	107.82	4.99	5.66	5.26	0.78	16.63	0.25	0.126	5.38	6.10	5.67	0.84	17.93
21	101.72	5.14	5.51	5.26	0.68	16.58	0.25	0.126	5.23	5.60	5.35	0.69	16.87
15	102.76	6.20	7.46	5.60	0.67	19.36	0.28	0.121	6.37	7.67	5.75	0.69	19.89
24	95.20	5.93	7.95	6.70	0.65	21.23	0.30	0.117	5.65	7.57	6.38	0.62	20.21
DLR													
98	71.54	6.29	9.69	5.25	0.62	21.63	0.29	0.175	4.50	6.93	3.76	0.44	15.47
97	82.96	6.12	6.62	5.89	0.83	19.46	0.41	0.133	5.08	5.49	4.89	0.69	16.14
126	68.38	6.31	7.40	5.46	0.71	19.46	0.23	0.141	4.31	5.06	3.73	0.49	13.31
38	92.96	6.91	7.51	4.93	0.69	20.04	0.29	0.133	6.42	6.42	4.58	0.64	18.63
249	109.90	6.42	6.27	5.32	0.63	18.89	0.45	0.104	7.06	6.89	5.85	0.69	20.76
226	117.88	6.91	6.90	4.94	0.80	19.55	0.28	0.216	8.15	8.13	5.82	0.94	23.05
6.26	76.44	5.08	8.16	5.27	0.83	19.33	0.22	0.134	3.88	6.24	4.03	0.63	14.78
121	86.24	6.31	7.40	4.96	0.79	19.96	0.23	0.141	5.44	6.38	428	0.68	17.21
406	108.84	6.40	7.95	4.31	0.87	19.52	0.18	0.163	7.03	8.73	4.73	0.96	21.44
34	91.56	6.29	9.69	5.25	0.77	21.75	0.29	0.175	5.76	8.87	4.81	0.71	19.91
37	166.60	6.12	6.70	4.48	0.74	18.07	0.27	0.148	10.20	11.16	7.46	1.23	30.10
212	133.56	4.79	10.00	6.01	0.75	21.54	0.25	0.110	6.40	13.36	8.03	1.00	28.77

ANIMAL No	MILK 1-4	% CONSTITUENTS Prot	Fat	Lact	Ash	TS	G	P	KG CONSTITUENTS Prot	Fat	Lact	Ash	TS
LW-LR													
367	67.76	6.48	9.75	4.85	0.78	21.85	0.23	0.05	4.39	6.61	3.29	0.53	14.81
613	77.00	7.10	7.43	5.20	0.84	20.57	0.51	0.252	5.47	5.72	4.00	0.65	15.84
995	77.92	6.46	7.29	5.18	0.88	20.31	0.23	0.145	5.03	5.68	4.04	0.69	15.83
74	64.82	6.42	8.99	4.93	0.73	20.82	0.30	0.103	4.16	5.83	3.20	0.47	13.50
75	88.24	6.35	6.63	6.44	0.71	19.37	0.37	0.209	5.60	5.85	5.68	0.63	17.09
706	52.36	7.24	7.88	4.80	0.84	20.72	0.30	0.122	3.79	4.13	2.51	0.44	10.85
990	42.70	6.25	7.41	5.20	0.68	19.54	0.25	0.176	2.67	3.16	2.22	0.29	8.34
136	74.48	5.94	7.66	5.43	0.86	19.88	0.22	0.121	4.42	5.71	4.04	0.64	1481
203	59.08	6.32	6.66	4.58	0.65	18.18	0.28	0.161	3.73	3.93	2.71	0.38	10.74
618	89.18	7.11	6.72	5.35	0.69	20.03	0.23	0.155	6.34	5.99	4.77	0.62	17.86
205	101.32	6.86	6.93	4.26	0.83	18.88	0.29	0.115	6.95	7.02	4.32	0.84	19.13
LR-LW													
66	67.76	4.96	9.45	5.47	0.71	20.59	0.27	0.145	3.36	6.40	3.71	0.48	13.95
68	82.04	6.91	6.59	4.76	0.75	18.76	0.23	0.146	5.67	5.41	3.91	0.62	15.39
197	42.70	6.37	7.00	6.03	0.72	20.16	0.24	0.135	2.72	2.99	2.57	0.31	8.61
681	90.58	5.89	9.19	5.24	0.83	20.86	0.35	.134	5.34	8.32	4.75	0.75	18.90
376	89.18	6.29	8.87	5.21	0.72	21.09	0.31	0.107	5.61	7.91	4.65	0.64	18.81
914	104.00	7.80	6.62	5.67	0.63	20.71	0.33	0.126	8.11	6.88	5.90	0.66	21.54
58	101.28	5.61	6.06	4.67	0.85	16.93	0.23	0.131	5.68	6.14	4.73	0.86	17.15
306	81.32	7.70	7.28	4.80	0.91	2071	0.25	0.123	6.26	5.92	3.90	0.74	16.84
66	61.32	4.96	9.45	5.47	0.71	20.59	0.27	0.145	3.04	5.79	3.35	0.44	12.63
62	141.96	6.48	6.35	4.86	0.92	19.10	0.34	0.168	9.20	9.01	6.90	1.31	27.11
685	77.12	6.46	8.31	4.30	0.71	19.78	0.35	0.167	4.98	6.41	3.32	0.55	15.25

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APPENDIX TABLE 6.X

MILK & CONSTITUENTS - 5-8 WEEKS

ANIMAL No	MILK 5-8	Prot	Fat	Lact	Ash	TS	G	P	Prot	Fat	Lact	Ash	TS
LW													
104	43.96	7.10	7.40	5.61	0.80	20.90	0.27	0.122	3.12	3.23	2.47	0.35	9.20
844	56.06	6.71	6.55	6.24	0.81	20.56	0.32	0.107	3.76	3.67	3.50	0.45	11.53
165	48.86	6.12	10.58	3.70	0.81	21.19	0.38	0.133	2.99	5.17	1.81	0.40	10.35
3933	75.46	5.00	6.90	3.61	0.85	16.30	0.44	0.117	3.77	5.21	2.72	0.64	12.30
3469	78.49	7.50	10.52	3.05	0.85	21.94	0.42	0.155	5.89	826	2.39	0.67	17.22
453	35.00	5.12	7.06	3.45	0.89	16.49	0.38	0.130	1.79	2.47	1.21	0.31	5.77
70x	96.01	5.52	7.18	6.53	0.78	20.05	0.24	0.208	5.30	6.89	6.26	0.75	19.25
893	44.38	6.10	8.33	6.90	0.76	22.09	0.36	0.194	2.71	3.70	3.06	0.34	9.80
464	34.49	7.22	5.66	4.33	0.86	17.31	0.37	0.140	2.49	1.95	1.49	0.30	5.96
3929	53.62	6.22	5.85	5.33	0.66	18.31	0.33	0.217	3.34	3.14	2.86	0.35	9.82
4567	44.10	7.56	5.60	5.82	0.78	19.76	0.24	0.100	3.33	2.47	2.57	0.34	8.71
293	63.30	5.55	7.53	5.48	0.77	19.32	0.32	0.146	3.51	4.77	3.47	0.49	12.23
LR													
795	74.54	5.45	8.75	3.65	0.80	18.64	0.30	0.122	4.06	6.52	2.72	0.60	13.89
797	36.44	6.54	6.08	6.69	0.72	20.02	0.26	0.187	2.38	2.22	2.44	0.26	7.30
764	46.20	5.49	6.80	3.43	0.69	16.60	0.38	0.147	2.54	3.14	1.58	0.32	7.67
1863	53.08	6.10	6.62	3.88	0.75	17.38	0.49	0.184	3.24	3.51	2.06	0.40	9.23
764	67.38	6.73	6.68	5.77	0.79	20.01	0.34	0.132	4.53	4.50	3.89	0.53	13.48
797	29.12	5.25	9.10	5.76	0.60	20.70	0.34	0.164	1.53	2.65	1.60	0.17	6.03
357	33.88	6.35	7.82	6.98	0.77	21.92	0.24	0.208	2.15	2.65	2.36	0.26	7.43
16	66.22	7.34	5.65	5.64	0.87	19.49	0.32	0.183	4.86	3.74	3.73	0.58	12.91
796	48.02	7.46	10.25	7.15	0.66	25.52	0.33	0.150	3.58	4.92	3.43	0.32	12.25
773	39.35	6.29	5.58	6.60	0.75	19.21	0.23	0.176	2.48	2.20	2.60	0.30	7.56
882	36.82	5.45	8.75	3.65	0.77	18.49	0.30	0.159	2.01	3.22	1.34	0.28	6.81
2158	45.64	7.30	5.66	6.01	0.88	19.87	0.31	0.161	3.33	2.58	2.74	0.40	9.07
IND													
92	37.03	10.06	12.31	5.52	1.19	29.09	0.49	0.260	3.73	4.56	2.05	0.44	10.77
3	25.55	7.46	9.88	5.88	0.83	24.05	0.31	0.191	1.91	2.52	1.50	0.21	6.14
4	29.12	7.66	10.98	5.36	0.88	25.92	0.24	0.226	2.23	3.20	1.56	0.26	7.55
182	40.08	8.70	9.97	6.33	0.92	25.92	0.32	0.218	3.49	4.00	2.54	0.37	10.39
173	33.16	5.93	9.57	4.77	1.03	21.30	0.44	0.184	1.97	3.17	1.58	0.34	7.06
174	35.52	6.85	11.25	5.43	0.92	24.70	0.41	0.277	2.43	4.00	1.93	0.33	88.77

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ANIMAL No	MILK 5-8	Prot	Fat	Lact	Ash	TS	G	P	Prot	Fat	Lact	Ash	TS
182	34.72	8.47	10.39	5.67	0.96	25.43	0.24	0.247	2.94	3.61	1.97	0.33	8.83
173	29.62	6.78	8.71	4.55	0.75	20.82	0.43	0.219	2.02	2.58	1.35	0.22	6.17
174	26.84	5.61	8,19	3.92	0.94	18.68	0.28	0.213	1.51	2.20	1.05	0.25	5.01
1	44.75	6.07	7.16	4.64	0.80	18.92	0.41	0.219	2.72	3.20	2.08	0.36	8.47
11	25.28	7.53	12.78	6.88	0.91	28.10	0.43	0.157	1.90	3.23	1.74	0.23	7.10
2	39.76	5.99	6.93	3.67	0.92	18.10	0.28	0.178	2.38	2.76	1.46	0.37	7.20
DLW													
457	6.90	5.76	8.08	5.56	0.88	20.24	0.38	0.166	3.51	4.92	3.39	0.54	12.33
85	30.38	7.05	8.52	5.10	0.75	21.42	0.48	0.205	2.14	2.59	1.54	0.23	6.51
661	36.12	6.78	8.10	5.72	0.81	21.65	0.24	0.109	2.45	2.93	2.07	0.29	7.82
27	49.74	6.33	7.46	6.18	0.72	20.69	0.32	0.135	3.15	3.71	3.07	0.36	10.29
184	44.94	6.08	7.16	5.14	0.80	19.42	0.40	0.218	2.73	3.22	2.31	0.36	8.73
557	65.38	7.81	8.19	6.05	0.81	22.85	0.36	0.196	5.11	5.35	3.96	0.53	14.94
195	54.72	6.05	7.75	5.17	0.88	19.85	0.36	0.173	3.31	4.25	2.83	0.48	10.86
175	62.34	6.00	9.81	5.21	0.74	21.76	0.38	0.127	3.74	6.12	3.25	0.46	13.57
394	52.50	6.48	9.05	6.03	0.95	22.31	0.40	0.167	3.40	4.75	3.17	0.50	11.71
21	58.52	6.01	9.33	6.04	0.88	22.74	0.40	0.167	3.52	5.46	3.53	0.51	13.01
15	55.44	6.64	10.61	3.83	0.79	21.81	0.38	0.123	3.68	5.88	2.12	0.44	12.09
24	64.40	6.33	6.96	6.18	0.80	20.28	0.32	0.135	4.08	4.48	3.98	0.52	13.06
DLR													
98	46.00	5.85	1079	5.02	0.82	22.47	0.29	0.146	2.69	4.96	2.31	0.38	10.34
97	59.36	6.19	8.12	4.27	0.92	19.50	0.52	0.167	3.67	4.82	2.53	0.55	11.58
26	44.76	7.46	8.75	7.15	0.76	23.87	0.33	0.167	3.34	3.92	3.20	0.34	10.68
38	46.90	6.57	8.66	5.33	0.86	21.42	0.35	0.137	3.08	4.06	2.50	0.40	10.05
249	48.30	6.43	7.74	5.03	0.90	20.09	0.34	0.116	3.11	3.74	2.43	0.43	9.70
226	4270	7.33	7.91	5.69	0.90	32.81	0.25	0.149	3.13	3.38	2.43	0.38	9.31
626	36.68	6.39	9.00	5.11	0.89	21.39	0.34	0.124	2.34	3.30	1.87	0.33	7.85
121	45.92	7.46	8.75	7.15	0.81	23.92	0.33	0.163	3.43	4.02	3.28	0.37	10.98
406	10.20	6.44	9.24	4.65	0.87	21.20	0.26	0.166	7.10	10.18	5.12	0.96	23.36
34	46.20	5.85	10.79	5.02	0.84	22.50	0.29	0.146	2.70	4.99	2.32	0.39	10.40
37	48.52	7.09	8.35	6.20	0.78	22.92	0.35	0.178	4.15	4.15	3.92	0.46	13.41
212	58.52	7.04	7.28	7.59	0.81	22.70	0.30	0.152	4.12	4.26	4.44	0.47	13.28

ANIMAL No	MILK 5-8	Prot	Fat	Lact	Ash	TS	G	P	Prot	Fat	Lact	Ash	TS
LWLR													
367	37.94	6.15	9.86	4.07	0.87	21.20	0.34	0.148	2.33	3.74	1.54	0.33	8.04
613	61.52	7.56	8.87	4.85	0.94	21.97	0.37	0.215	4.65	5.46	2.98	0.58	13.52
995	35.00	7.26	8.65	6.12	0.92	23.02	0.26	0.128	2.54	3.03	2.14	0.32	8.06
74	65.80	6.44	9.85	4.53	0.83	21.64	0.27	0.122	4.24	6.48	2.98	0.55	14.24
75	53.76	6.34	9.33	6.30	0.77	22.72	0.42	0.176	3.41	3.41	3.39	0.41	12.21
706	54.88	8.24	8.82	6.06	0.90	24.02	0.24	0.155	4.52	4.84	3.33	0.49	13.18
990	46.34	6.66	9.36	4.78	0.74	21.52	0.32	0.214	3.09	4.34	2.22	0.34	9.97
136	33.88	6.67	10.16	5.35	0.85	23.27	0.172		2.26	3.44	1.81	0.29	7.88
203	47.04	6.06	8.87	4.81	0.72	20.75	0.35	0.187	2.85	4.17	2.26	0.34	9.76
618	4.44	6.52	8.68	5.62	0.73	21.57	0.38	0.164	2.70	3.60	2.33	0.30	8.94
205	68.32	6.71	7.58	4.50	0.87	19.66	0.28	0.132	4.58	5.18	3.07	0.59	13.43
LRLW													
66	45.50	5.25	8.05	4.80	0.77	21.62	0.29	0.124	2.39	3.66	2.18	0.35	9.84
68	48.44	6.41	9.01	5.22	0.71	21.35	0.34	0.136	3.11	4.36	2.32	0.34	10.34
197	55.30	7.30	6.16	6.02	0.86	20.34	0.31	0.153	4.04	3.41	3.33	0.48	11.25
681	53.34	6.16	8.73	5.70	0.95	21.02	0.23	0.113	3.29	4.66	3.04	0.51	11.21
376	53.34	6.33	9.82	5.41	0.79	22.35	0.26	0.117	3.38	5.24	2.89	0.42	11.92
914	62.26	7.92	8.25	6.01	0.74	22.91	0.27	0.168	4.97	5.14	3.74	0.46	14.26
58	79.28	6.19	7.16	4.94	0.86	19.14	0.35	0.148	4.91	5.68	3.92	0.68	15.17
306	96.28	6.99	8.35	4.92	0.95	21.20	0.37	0.155	6.23	8.04	4.74	0.91	20.41
66	55.16	5.25	10.80	4.80	0.77	21.62	0.29	0.123	2.90	5.96	2.65	0.42	11.93
62	88.76	6.88	8.64	4.24	0.81	20.56	0.33	0.176	6.11	7.67	3.76	0.72	18.25
685	65.00	7.02	9.71	4.45	0.84	22.02	0.41	0.186	4.56	6.31	2.89	0.55	14.31

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APPENDIX TABLE 7.1 SELECTION INDEXES

ANIMAL NO	NUMBER born	NUMBER weaned	Weaning Weight	Index	ANIMAL NO	Number born	Number Weaned	Weaning Wt.	Index
104	6	6	36.26	40.84	357	3	3	37.09	22.95
844	6	6	49.94	42.66	16	8	8	61.33	56.18
865	9	9	51.95	60.93	796	6	5	38.60	37.15
158	10	10	66.45	68.86	384	5	5	37.36	34.98
401	8	7	36.29	48.34	283	7	6	28.12	41.75
3933	8	8	53.09	55.08	234	8	8	44.07	53.88
3469	9	7	35.37	50.72	773	9	7	44.33	51.91
453	6	6	30.44	40.06	882	4	4	32.52	28.34
453	8	8	50.83	54.77	2158	3	3	31.92	22.36
70x	6	6	16.24	38.17	2158	4	4	32.40	28.32
70x	9	9	58.11	61.75	IND				
893	6	5	39.36	37.25	92	5	5	19.20	32.56
464	5	5	29.16	33.89	3	3	2	9.90	15.32
517	5	3	21.70	24.89	4	6	6	32.58	40.34
3929	8	6	27.88	43.72	914	5	5	20.28	32.70
4567	11	7	42.20	55.63	182	5	5	15.01	32.00
293	11	10	52.38	68.98	173	7	7	20.32	44.71
4509	7	5	28.43	37.79	174	6	3	16.06	26.14
844	9	7	43.30	51.77	182	4	4	11.20	25.49
455	5	4	29.12	29.88	173	6	2	7.50	21.00
893	6	6	34.23	40.56	174	3	3	12.30	19.64
LR					183	2	1	3.80	8.51
795	8	8	53.07	55.08	172	3	3	12.13	19.62
797	3	3	26.33	21.51	1	8	7	22.43	46.99
764	6	4	25.10	31.35	11	7	6	17.23	40.30
547	5	4	18.64	28.49	2	9	8	46.35	56.18
1863	5	5	32.80	34.37	6	4	4	34.25	28.57
764	6	6	25.76	39.44	7	6	6	48.45	42.46
797	5	5	29.24	33.90	263	6	6	34.67	40.62
357	2	2	19.54	14.61					
16	3	3	35.43	22.72					
726	5	5	61.78	38.24					

ANIMAL No	No born	No weaned	weaning wt	Index	Animal No	No born	No weaned	Weaning wt.	Index
DLW					LRW				
457	10	8	42.15	57.62	66	7	6	50.12	44.68
85	6	6	39.26	41.23	68	6	6	33.92	40.52
661	7	6	39.47	43.26	197	5	4	29.25	29.90
27	11	7	60.23	58.03	62	2	2	28.93	15.86
184	10	8	35.37	56.72	681	12	10	53.97	71.20
557	9	8	66.18	58.82	376	9	9	51.76	60.90
26	7	4	44.20	35.89	914	10	9	76.25	66.17
195	7	7	50.60	48.75	306	11	10	115.22	77.36
175	11	8	62.17	62.29	66	3	3	39.17	23.22
394	9	9	53.53	61.14	685	12	10	95.98	76.80
411	5	5	68.23	29.10	62	4	4	70.33	33.38
21	10	6	30.44	53.10	58	9	8	111.93	64.92
24	10	9	79.02	66.54					
11	10	10	82.85	71.05	LWR				
15	9	9	100.61	67.41	367	6	6	51.89	42.92
49	11	11	130.54	76.74	613	7	6	53.39	45.12
DLR					995	8	6	37.72	45.03
98	8	7	42.80	49.71	74	10	9	61.78	64.17
97	10	8	65.67	60.76	75	8	8	71.53	57.54
126	10	7	52.94	54.94	706	2	2	32.39	16.32
49	6	5	32.54	36.34	990	4	3	33.58	24.48
38	9	8	51.92	56.92	136	4	4	54.22	39.23
249	8	8	60.85	56.11	203	2	2	31.23	16.16
226	9	9	68.93	63.19	990	10	10	90.62	72.08
626	4	4	50.45	30.73	205	9	9	50.11	60.68
406	10	9	74.96	65.99	618	10	10	116.79	75.57
34	9	5	44.24	43.90					
212	9	8	72.14	59.62					
37	7	7	71.80	51.57					
58	9	9	82.89	65.05					
425	9	7	76.67	56.22					