THE EFFECT OF SEX UPON GROWTH IN THE PIG.

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EFFECT OF SEX UPON GROWTH IN THE PIG

INTRODUCTION.

Almost a quarter of a century has elapsed since D'Arcy Thompson (1) published his classical work "Growth and Form", in which he demonstrated that all living organisms, except the very simplest, owe their form to the phenomenan of differential growth. During this period there has been a realisation that the phenomena of differential growth are fundamental to many branches of biological study, and many of the broad empirical laws involved have been investigated. Huxley (2), in his book "Problems of Relative Growth", brings together the accumulated work of many scientists and clearly demonstrates the widespread occurrence of differential growth gradients in many diverse species and shows that many cases of heterogenic growth are capable of quantitative expression. He has also indicated the profound bearing which these laws governing growth have upon problems in other branches of biology.

Coincident with the investigation of the differential nature of growth in the general biological field, there has been an application of the principles involved to problems of animal production and in particular to the specialised field of meat production. Two factors have been chiefly responsible. Firstly, economic developments in the meat trade of recent years have caused greater attention to be devoted to the quality aspects of meat production. The old criteria of efficient meat production, namely the amount, rate and economy of live-weight increase, have been extended to embrace consideration of the nature of the live-weight increase and its mode of distribution throughout the various parts of the body, these latter being the major factors involved in carcase quality. Secondly, workers in this field have been quick to recognise the fundamental dependence of the form and comparison of the animal body upon the differential growth relationships existent not only between, but also within, each of the major tissues of the body - i.e., bone, muscle and fat.

One result of the development of meat investigations along these lines has been that the meat producer is now provided with a clear picture of the nature of the growth changes which take place in his animals during their development. He has also been shown how these changes are responsible for the proportions and composition which his animals attain by the time they are slaughtered. Thus in the sheep Hammond (3) has made a comprehensive investigation of the growth and development of mutton qualities. In the pig he initiated similar studies, recently reported upon by McMeekan (4). Both studies have described and emphasised the differential nature of growth in these species and have shown how an application of the principles involved can be of use to the animal producer.

A further outcome of carcase quality investigations based on the growth approach has been the development of standards of quality which have supplied the breeder of pedigree stock with ideals, measured in precise terms, towards which he can direct his selection and which have the added objective of diverting his attention from "fancy" points to those of real economic importance. In addition, these standards, by providing quick and reliable methods of estimating the relative merit of different carcases aim at encouraging the breeder to select upon a progeny test basis, which modern genetical research indicates as essential to further progress in increasing animal efficiency (Lush, 18). To the animal breeder, the elucidation, arising from these studies, of the nature of breed differences, is of considerable importance. It has been demonstrated that the changes involved during the evolution of the more highly improved meat animals, are not the result of isolated modifications to particular parts of the body, but rather the result of an orderly speeding up of the major growth gradients. Since the latter are effective throughout the whole of the body, the result has been the production of an earlier or later maturing type of animal as the case may be. By a thorough understanding of this process, it is possible to visualise extended improvement along similar lines and to predict the type of progress likely to occur in the future.

Studies have also been carried out to determine how the growth relationships typical of a species are capable of modification by hereditary and environmental influences. This is a most important aspect of growth studies for it is obvious that, only with the aid of precise knowledge of how the fundamental growth processes inherent in the animal can be modified, will the meat producer be able to take suitable measures to effectively control and direct them. Differences with a physiological basis, such as those between dairy and beef, and tropic and temperate zone cattle; differences concerned with the relative rate of reaching maturity such as those between pork and bacon types in swine, and most of the important differences between breeds themselves may be ascribed to the modifying effect of their respective genotypes upon growth differentials within the body.

Most important among the environmental factors, which are known to be concerned in modifying growth differentials, is the plane of nutrition. Quantitative differences are of much greater importance in this field than qualitative differences in rations, though in specific instances deficiencies in vital nutritive elements such as vitamins, minerals and proteins can also exert powerful effects (McMeekan, 4). By taking advantage of the existence of inherent growth differentials within the body, a considerable degree of variation can be affected in any direction by quantitative control of the nutritional environment.

Sex is also an important growth factor. It is a factor of common observation that, in many external characters, males differ markedly from females, and castrates from corresponding normal animals. Usually, the differences most obviously manifest upon casual inspection of farm animals are those concerned with the development of the so-called "secondary" sex characteristics, such as the appearance and shape of certain parts of the body, particularly of the head and neck, or the effects of castration on docility and ease of handling of the animal. Important as these readily observable effects are, sex has been shown to be responsible for differences which are of even greater practical significance to the modern producer of meat animals - namely differences in anatomical composition, which play a large part in determining carcase quality. Thus, when considered as a whole, the work of Hammond and Murray (7) , Woodman et al. (8), Woodman, Evans and Turpitt (9), Warner Ellis and Howe (10) and McMeekan (6) has shown conclusively that sex influences the relative proportion of bone, muscle and fat in the body of the pig to a material extent. The work of Hammond (3) with sheep, Foster and Miller (11) and Gramlich and Thalman (12) with cattle, Mitchell and Hamilton (13) with poultry, and Morris Palmer and Kennedy (14) with rats, all show that sex is likewise an important factor in determining body composition in these species.

That such sex differences in body composition do exist is understandable. The gonads are known to function as endocrine glands and with the recent rapid expansion of knowledge in the field of endocrinology, the manifold control of hormones over important metabolic processes within the body has become increasingly evident. As a specific example, certain of the hormones produced by the anterior pituitary are now known to be of major importance in controlling body growth and metabolism (14). The fact that castration in either sex results in modification to the structure of this gland (15) emphasises the possibility that the secretions of the gonads may control growth indirectly through influencing the output of growth hormones by other glands. Further evidence of the very intimate relationship between the gonads and the anterior pituitary is afforded by the fact that the capacity of the former to develop and function is dependent upon stimulus by hormones derived from the latter. Although there is at present no evidence available on the subject of direct control over body growth by the gonads' secretions, this important possibility must not be overlooked.

In view of the foregoing, any investigationddesigned to elucidate differences in body composition attributable to sex is of general sciëntific interest and importance to the extent that it adds to our existing knowledge of the animal body and its behaviour. The demonstration and nature of such differences present problems not only to endocrinologists but also to nutritionalists, physiologists, and geneticists.

As indicated above, sex differences are of practical importance to the meat industry. On the production side, the relative economy of live-weight increase, in relation to food consumption, influences volume of production. On the marketing side, in so far as it is responsible for variations in the anatomical and chemical composition of the body, it influences the sale value of the product. The recognition of the importance attached to sex by meat producers is reflected in the common adoption of the practice of castrating males animals. This operation is carried out not merely to destroy the potential capacity of the animals for breeding, but also because it is believed that animals so treated are more easily fattened and yield carcases of improved quality. This latter is attributed to the reduction in the thickness of the bones and to improvement in the flavour and tenderness of the meat.

Although, owing to the relatively difficult nature of the operation, the practice of spaying is not nearly so prevalent, it is by no means uncommon. Thus Hammond and Marshall (16) state that the spaying of sows not required for breeding is a commpn practice in some parts of England, and that this certainly favours fattening because such animals are undisturbed by the occurrence of heat periods which cause restlessness and loss of energy. Similarly the spaying of cattle is also carried out on account of the practical advantages which are thought to result. In New Zealand, it is commonly employed in some districts such as parts of Otago. Veetch (17) states that in New South Wales the practice of spaying is chiefly confined to beef-type cows no longer suitable for breeding, although of recent years a limited number of dairy-type cows have also been spayed. He maintains that by spaying unprofitable cows the quality of the meat is improved, and that by spaying heifers, they grow faster, fatten more easily, and mix more quietly with other cattle.

In view of its fundamental and practical importance, sex,as a growth factor,requires further investigation, for existing data as to the precise nature and extent of the differences in form and composition for which sex is responsible are very incomplete and frequently contradictory. Thus in investigations with swine, but for the notable exception of the work by Murray (7) at Onderstepoort, comparison has been restricted to gilts and barrows. Even Murray's experiments, however, in which natural and castrate animals of the two sexes were employed, cannot be classed as satisfactory, in that the animals were killed at different weights, and carcase measurements, only, were taken, and used as indices of relative leanness and fatness of the animals. Since weight alone markedly influences body form and composition, Murray's results do not show the precise effect of sex. Furthermore, while the assumption of a reasonable correlation of this nature is justifiable in the light of recent knowledge (McMeekan, 6), the use of such measurements must always be regarded as a possible source of error when these are used as the only criteria of differences. Such a study, moreover, allows no critical examination of the effects of sex and castration upon skeletal development.

Need for further investigation on the subject is also emphasised by recent work by McMeekan (6). McMeekan, working with swine, by the laboratory dissection of genetically comparable animals, was able to show that gilts had less fat and more bone and muscle than did barrows possessing similar growth curves. On the other hand, using the same method and similar material, but by using widely differing growth curves, he was able to reverse this situation and produce gilts containing more fat but less bone and muscle than comparable hogs. In the same way he was able to accentuate normal sex differences. The potency of the form of the growth curve as a modifying factor upon body form and composition is thus obvious, and the apparently contradictory results obtained by some workers studying sex differences may quite conceivably be due to differences in the form of the growth curve among the animals they compared.

On this account the literature dealing with sex differences, must be subject to critical examination in the light of any differences which may have existed in the form of the growth curve of the differently sexed animals, as such differences are likely to have affected the validity of the conclusions drawn. Using data from experiments which were not specifically designed to standardise the form of the growth curve, it is extremely difficult to elucidate the fundamental basis of sex differences. A typical example of such data is that of S. Bengston (29) who found that barrows were fatter than gilts and also that barrows were characterised by a higher growth rate. From the above facts it is extremely difficult to decide whether the greater deposition of fat in the barrows as compared with the gilts is due to some fundamental physiological difference between these two kinds of animals, or whether this is due merely to the fact that barrows gain in weight more rapidly than gilts and are therefore in a higher condition at slaughter weight. Again, why do the barrows gain more rapidly? Is it because of a greater capacity to consume food, or is it dependent upon some more fundamental difference between the animals which affects the efficiency of food utilisation?

In summary, it may be said of structural differences due to sex, that in view of their fundamental and practical importance, our present state of knowledge on the subject is most unsatisfactory. The present investigation has therefore been designed with the purpose of acquiring greater knowledge of the influence of sex upon the anatomical composition and the histology of the muscular tissue of the bacon pig. Attention has also been focussed upon the influence of sex upon food consumption and utilisation. All four sexes have been studied: namely, natural males, natural females, castrate males, and castrate females. In planning the experiment every attempt has been made to eliminate or at least standardise the modifying influence of factors, other than sex, which are known to affect body form and composition.

PART I

METHODS AND MATERIALS.

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1. THE EXPERIMENTAL MATERIAL.

The animals used in the investigation have been derived from the stud Tamworth herd maintained at Massey Agricultural College. The pigs were reared in successive groups of four animals, each group consisting of a natural male, a natural female, a castrate male, and a castrate female. Within the College herd, a moderately strong programme of inbreeding has been recently commenced, accompanied by selection upon a length of carcase basis for "long" and "short" types. Pigs for the experiment were chosen from litters out of sows of the long type, and with one exception were sired by the same long type boar. This possibly reduced the amount of variability between the different litters selected.

Just what effect the inbreeding has had in increasing or reducing the uniformity of the litter mates used, as compared with the uniformity which might have been expected in litter mates selected from a normal non-inbred population, is rather a matter for speculation. It is well recognised that prolonged inbreeding results in a reduction of heterosis in a population and that the potential variability of the animals is thereby redused (Lush, 18). Appreciation of this fact has led to the development of inbred strains in some species for special use in experimental investigations. In the case of

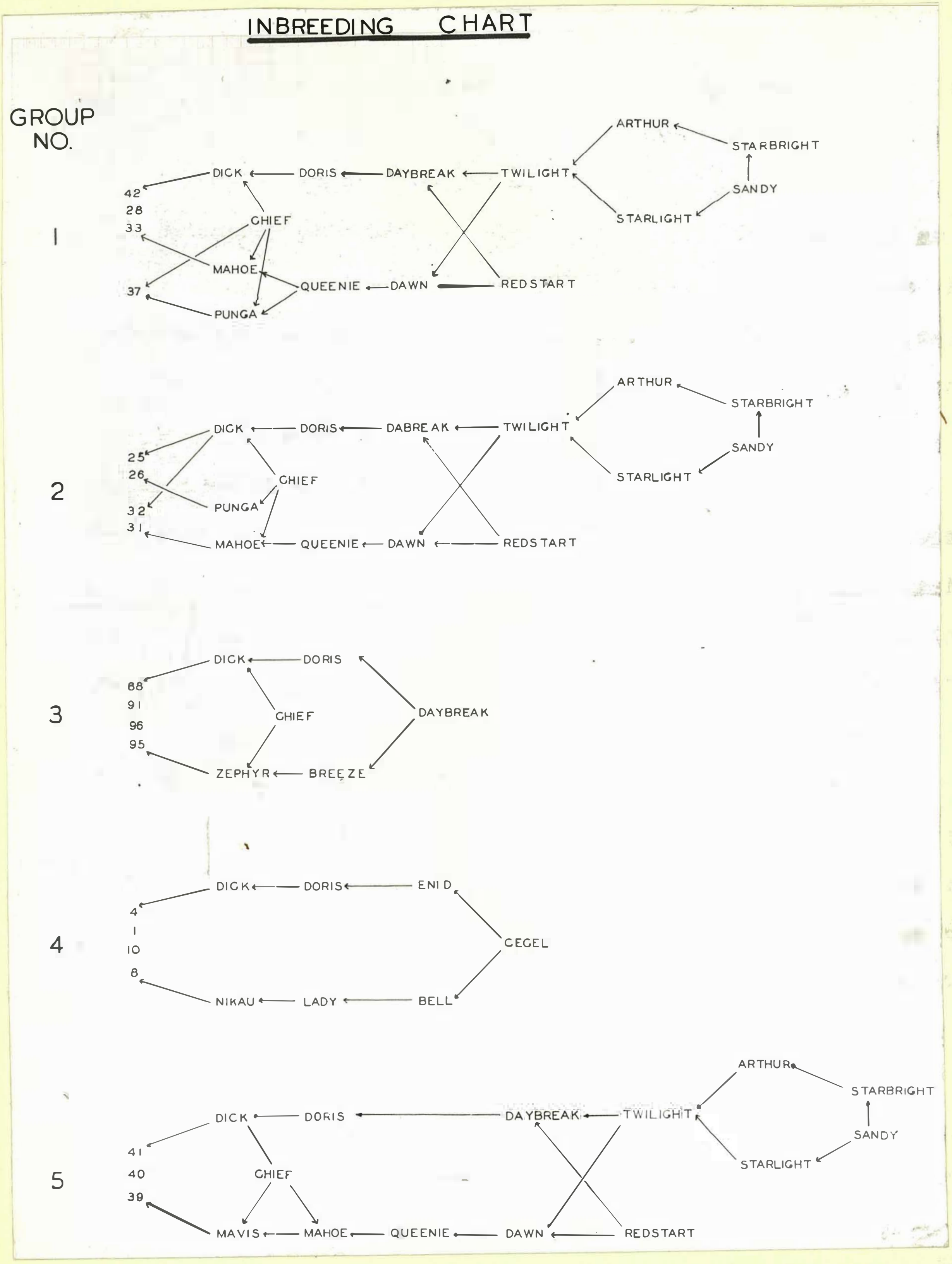

INBREEDING CHART
GROUP NO.
1
42
28
33
37
DICK
DORIS
DAYBREAK
TWILIGHT
ARTHUR
STARBRIGHT
SANDY
STARLIGHT
CHIEF
MAHOE
PUNGA
QUEENIE
DAWN
REDSTART
2
25
26
32
31
DICK
DORIS
DABREAK
TWILIGHT
ARTHUR
STARBRIGHT
SANDY
STARLIGHT
CHIEF
PUNGA
MAHOE
QUEENIE
DAWN
REDSTART
3
88
91
96
95
DICK
DORIS
CHIEF
DAYBREAK
ZEPHYR
BREEZE
4
4
1
10
8
DICK
DORIS
ENID
CEGEL
NIKAU
LADY
BELL
5
41
40
39
DICK
DORIS
DAYBREAK
TWILIGHT
ARTHUR
STARBRIGHT
SANDY
STARLIGHT
CHIEF
MAVIS
MAHOE
QUEENIE
DAWN
REDSTART

FIG. I.

the present material, however, inbreeding is still in the initial stages, in which it tends to separate the population into distinct lines, and has, accordingly, probably resulted in an increased rather than reduced variability within litters. This contention is supported by the work of Berge (20) with swine, who found that on inbreeding unaccompanied by selection, the variance of the litters increased in the early stages as regards most of the characters studied.

As an aid to determining the probable effect of the inbreeding practised, both the inbreeding coefficients of the animals and the coefficient of relationship of each animal to each of the remaining animals in the same group, were computed. Both coefficients were calculated by application of the formulae devised by Wright (19) and advocated by Lush (18).

Fig. I shows, in arrow diagram form, the nature of the inbreeding, the numbers representing the animals used in the investigation. These arrow diagrams were used in compiling the coefficient of inbreeding and relationship which are presented in Table I. The coefficient of inbreeding ranges from almost zero to a maximum of 0.25.

It is interesting to note that in no case does the figure for the degree of relationship between any two litter mates within any one group exceed 58 per cent. The degree of relationship between litter mates derived from any population in which no inbreeding has been practised is 50 per cent. Now, the coefficient of relationship of two individuals is a measure of the probable likeness of the genotypes. Since Lush (18) states that under an inbreeding system the

TABLE I

DEGREES OF INBREEDING AND RELATIONSHIP.

Group No.	Pig No.	Sex	Degree of Inbreeding	Animals Compared	Degree of Relationship %
I	37	♀	25.00	37.42	56.0
	42	♀	14.11	37.28	56.0
	28	♂	14.11	37.33	56.0
	33	♂	14.11	42.28	37.0
				42.32	37.0
				28.33	37.0
II	25	♀	14.11	25.26	56.0
	26	♀	14.11	25.32	45.0
	32	♂	14.11	25.31	45.0
	31	♂	14.11	26.32	45.0
				26.31	45.0
				31.32	56.0
III	88	♀	15.63	88.96	57.0
	91	♀	15.63	88.91	57.0
	96	♂	15.63	88.95	57.0
	95	♂	15.63	91.95	57.0
				91.96	57.0
				95.96	57.0
IV	4	♀	0.78	4.1	50.0
	1	♀	0.78	4.8	50.0
	10	♂	0.78	4.10	50.0
	8	♂	0.78	1.8	50.0
				1.10	50.0
				8.10	50.0
V	41	♀	19.55	41.40	58.0
	40	♀	19.55	41.39	58.0
				40.39	58.0
	39	♂	19.55		

individuals are "more alike in their heredity than they are in appearance, whereas under assortive mating they appear more like each other than they really are", the fact that the degree of relationship between members of the most inbred litter (i.e. 58 per cent.) is only slightly higher than the normal figure of 50 per cent., is considered as lending further support to the contention that the animals are, taken as a class, more variable in conformation than had they been derived from a normal non-inbred population.

2. SELECTION OF THE ANIMALS.

In order to reduce variability within any one group, the major consideration in selecting the pigs was that, whereever possible, each group should be completely derived from the same litter. As originally selected, all five groups were so constituted. Unfortunately, in the course of the experiment it was found necessary to discard certain individuals, and replace them with others. Throughout the investigation the individual pigs have been identified by their earmark number and Table II shows the number of each pig originally selected, its sex and the group to which it belonged, while Table III shows the final composition of each of the groups.

In every case where a replacement was made, care was taken to ensure that the new animal chosen was closely related to the remaining members of the group. This may be seen, either by examining Tables II and III in conjunction with the breeding pedigrees of Fig. I or directly by referring to the

TABLE II

GROUPS AS ORIGINALLY SELECTED.

Groups	Sex			
	Females	Castrate Females	Males	Castrate Males
I	25A	42	28	33
II	27	26A	32	29
III	88	91	96	95
IV	3	1	10	8
V	41	40	37	39

TABLE III

FINAL COMPOSITION OF GROUPS.

Groups	Sex			
	Females	Castrate Females	Males	Castrate Males
I	37	42	28	33
II	25	26	32	31
III	88	91	95	95
IV	4	1	10	8
V	41	40		39

relationship coefficients presented in Table I. Thus in Group I, Pig No. 37, which was substituted for Pig No. 25a, was farrowed upon the same day as the other three members of the group and the respective dams are full sisters. Also Pigs Nos. 42, 28 and 33, were sired by the son of the sire of Pig. No. 37 (see Fig I, Group I). The degree of relationship between Pig No. 37 and the remaining members of the set is 37 per cent. (Table I). In Group II, the dam of substitutes Nos. 25 and 26 is a full sister to the dam of the remaining two members of the group, (i.e. Nos. 31 and 32) while all four members were by the same sire (See Fig. L, Group II). Pig No. 31 which replaced pig No. 29 was a litter mate to it. In Group IV, Pig No. 4, which replaced Pig No. 3, was also a litter mate to the remainder of the group (See Fig. I, Group IV). The circumstances which necessitated these replacements will be presented later.

Selection was made when the pigs were approximately three weeks of age, and was, in the initial choice, naturally confined to litters containing at least two sows and two boars. A further stipulation was imposed - namely that the four piglets chosen should be reasonably well grown for their age and all of approximately the same weight. Selection at the early age of three weeks greatly reduced the possibility of selecting for animals of a uniform type. Although the latter would have been desirable, early selection was advantageous in that it ensured random selection of animals within each sex, after due attention had been paid to the weight requirement.

3. SPAYING AND CASTRATION.

The operations of spaying and castration were normally carried out when the animals were three weeks of age. Sows to be spayed were removed from their mother twelve to twentyfour hours before operating in order that the alimentary tract should be reasonably empty. This was found to be one of the major considerations contributing to the success of ovarectomy. In the actual operation itself, the pig was placed upon a table and the area where the incision was to be made shaved free of hair and thoroughly cleansed with disinfectant. The pig was then anaethetised with chloroform and an incision about one and a half inches long was made in the inguinal region of the abdomen, about one half of an inch from the medial line. The ovaries were located and removed by simple excision.

Considerable difficulty was occasionally experienced in locating the ovaries, these at the age of three weeks being small red kidney-shaped bodies of approximately the same size as a matchhead and exhibiting no signs of follicular development.

The wound was closed as in normal laparatomy technique, using three layers of sutures. The wound was sealed with collodion and the pig restored to its litter mates. As a rule, an initial stiffness was displayed by the animals, but this disappeared in the course of one or two days and operated pigs were occasionally observed suckling within a few minutes of the conclusion of the operation.

When performed upon animals of about three weeks of age, the spaying operation was usually successful. Unfavourable weather and other practical considerations, however, sometimes rendered it inadvisable to operate at this stage. Greater risk seemed to be attached to the spaying of older animals, particularly those of about weaning age.

age

no of

The following table shows the actual age at which the animals included in the investigation were spayed:

Group No.	Pig No.	Age in Weeks
I	42	12
II	26	4
III	91	4
IV	1	3
V	40	4

In the above table, Pig No. 42, of Group I, is conspicuous in that it was not spayed until 12 weeks of age. This was due to the death of the spayed animal originally included in this group, i.e. No. 25a, which contracted pleurisy during severe weather a few days after ovarectomy. Pig No. 42, when spayed, weighed approximately 70 lbs. In this particular case, the ovaries were removed through an incision in the flank and the left ovary contained developing follicles. The right ovary was smaller and no follicles could be observed.

The replacement of Pig No. 26a, originally selected for Group II, by Pig No. 26 arose through the incomplete removal of one ovary of the former during the spaying operation. Such small portion of the ovary which must have remained, regenerated and functioned as a normal ovary.

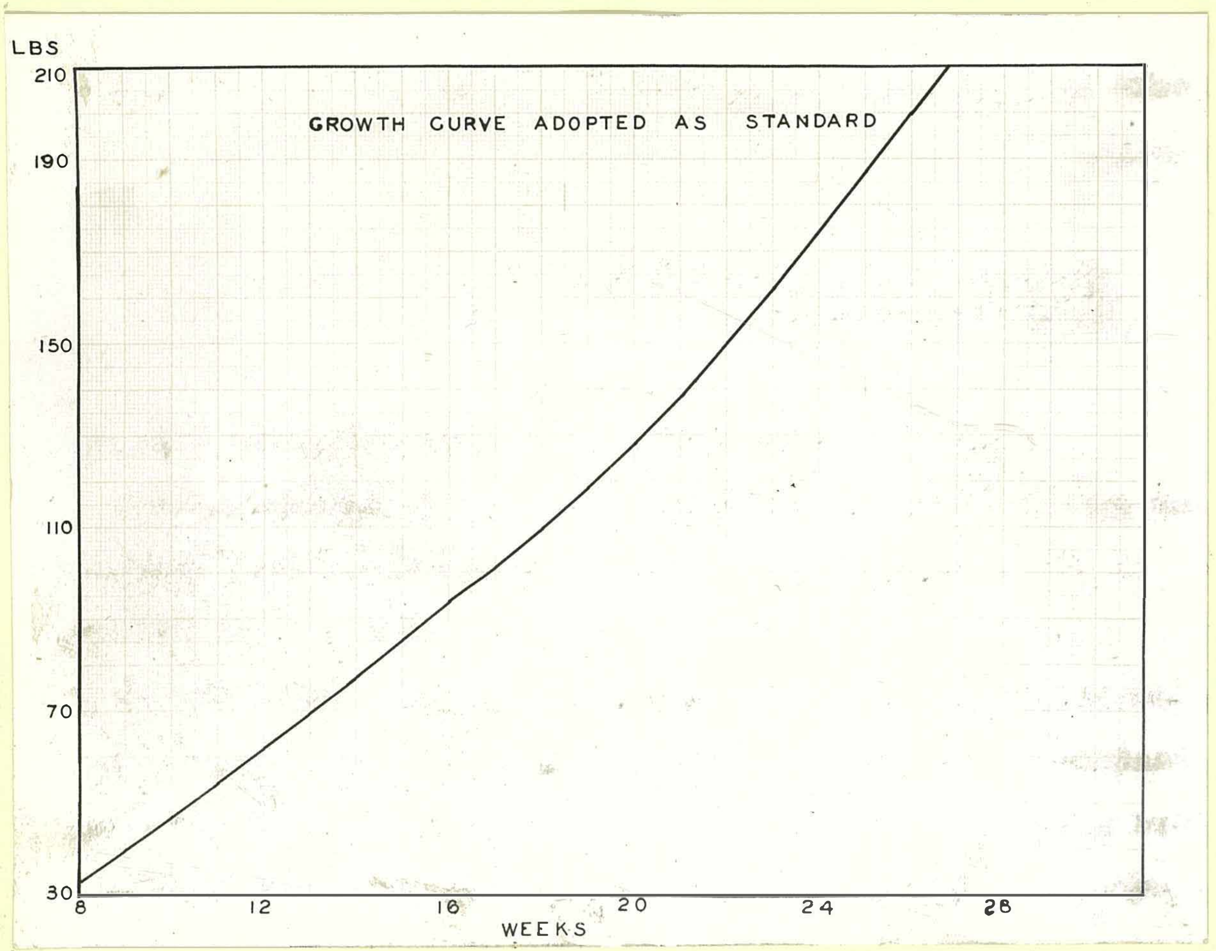

LBS
210
190
150
110
70
30
GROWTH CURVE ADOPTED AS STANDARD
8
12
16
20
24
28
WEEKS

FIG. II

Pig No. 27 was discarded at the same time in order that both female animals in the set should be reared together and be from the same litter.

Castration of the males was carried out at three weeks in each case, using normal methods and without anaesthetic.

4. EMPLOYMENT OF A STANDARD GROWTH CURVE WITHIN GROUPS.

The important effect of variation in the form of the growth curve of individual animals, in bringing about large differences in their body form and anatomical composition has been clearly shown by McMeekan (5,6). This emphasised the need, in the present investigation, for adopting a standard growth curve within each group, rather than a standard plane of nutrition as defined by a fixed level of food intake. Consequently all four animals of each group were made to follow the same growth curve, the quantity of food consumed being varied for each individual in order to achieve this object. The growth curve shown in Fig. II was drawn up at the commencement of the experiment and used as a basis for the rationing of all groups of animals.

The employment of a standard growth curve, must, however, be considered in relation to its possible disadvantages in preventing some characteristic sex effects from coming to expression. Thus in the present experiment, any differential ability for rapidity of growth between the four types of animals has been completely masked. Also, the usefulness of the food consumption data is limited to some extent by the employment of a standard growth curve, which of necessity involved variations to the quantitative plane of nutrition of different individuals. Both the maintenance requirement and economy of gain are to a certain extent dependant upon the quantitative level of food intake. (Hendricks et al. 27; and Ellis and Zeller, 28)

These objections to the application of the uniform growth curve concept were given careful consideration when planning the investigation. Even greater disadvantages, however, could be forseen if a system were adopted of rationing the animals according to their live weight. With such a method, differences which occurred in the rate of live weight increase would render impossible a comparison between the different varieties of animals at the same age and same carcase weight. This has been a major defect in the work of Murray (30) at Ondersterpoort.

Indeed, from a fundamental view-point the adoption of the standard growth curve must be considered advantagous, for it really results in segregating out those sex effects which are due to relative rapidity of live-weight increase, from the sex effects due to differential growth rates existent within the body itself.

The adoption of a standard growth curve within each group necessitated the use of individual feeding crates so that the growth of each animal could be adequately controlled by careful regulation of the food intake. Consequently,

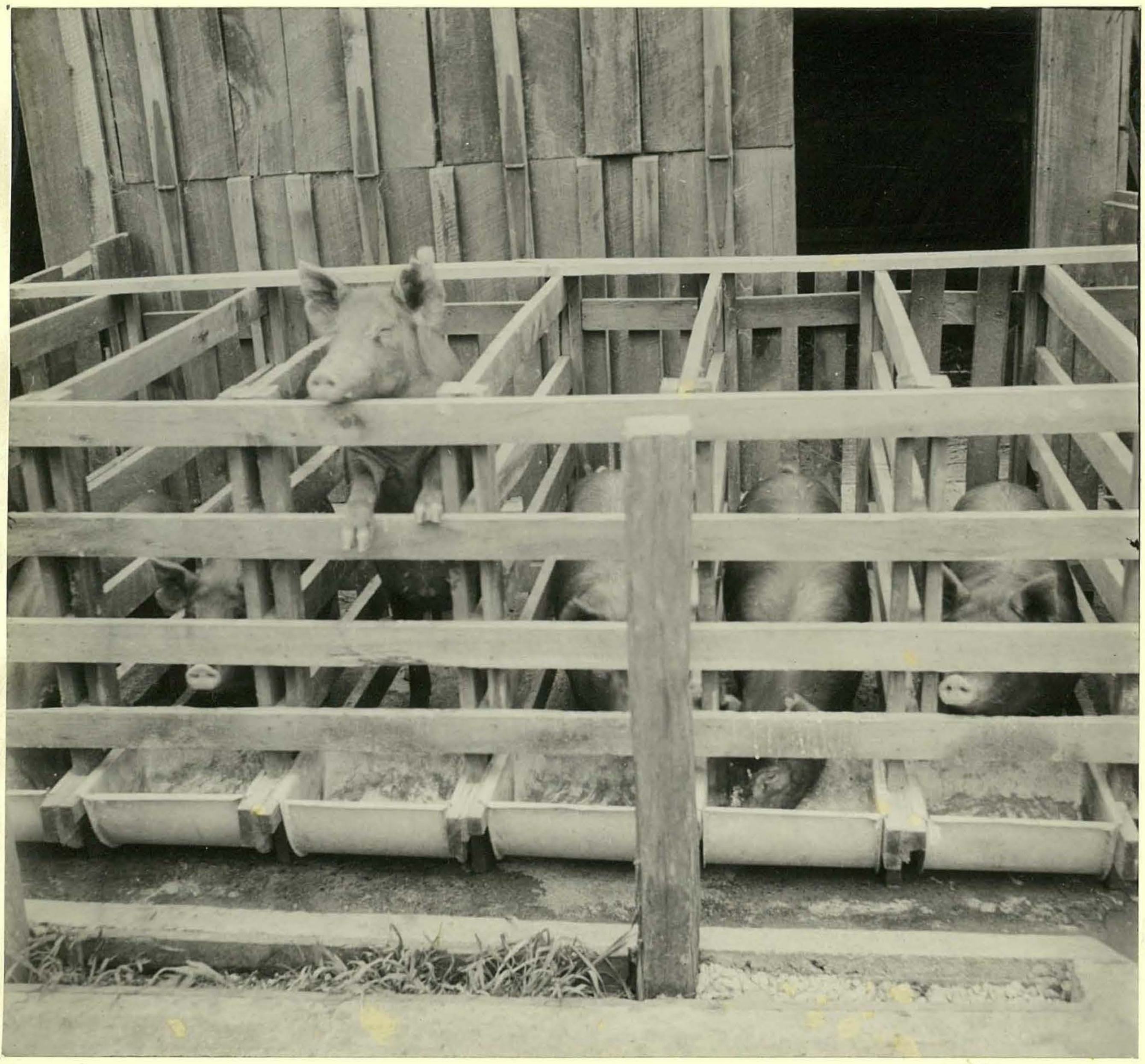


PLATE I

a set of eight crates was built in each of two adjacent pens. The design of the crates was based upon those used at Cambridge. Each crate was 4 feet 6 inches long, 1 foot, 3 inches wide and 3 feet high. A small galvanised iron trough was fitted to each crate and a sliding door provided at the rear, through which the pigs were admitted and released from the crates. Plate I illustrates the design employed.

5. RATION USED.

Throughout the experiment, all pigs received the same qualitative ration, this consisting of meal and separated milk in the ratio of one pound of meal to one gallon of separated milk. In order to ensure that the meal fed at all stages should be of uniform quality, sufficient for the whole of the experiment was purchased at the commencement of the investigation. A composite sample of the meal was analysed by Mr. A.T. Johns of the Dairy Research Institute, Department of Scientific and Industrial Research. The nature of the meal used and its chemical composition are shown in Table IV.

At first sight, the employment of a standard qualitative ration in the investigation may be thought unnecessary. Most of the work upon the influence of purely qualitative differences between rations indicates that these are of very minor importance in influencing the proportions and anatomical composition of the resultant carcase. McMeekan (4) has also pointed out that, except in so far as differences in vital

TABLE IV

NATURE AND COMPOSITION OF MEAL

Constituent *	%	Composition	%
Barley	55	Moisture	14.50
Pollard	20	Ash	5.95
Peas	10	Fat	2.60
Meatmeal	10	Protein	16.30
Maize	5	Crude Fibre	5.30
		Nitrogen free extract	65.35
	100		100. 00

nutritive elements, such as vitamins, minerals and certain animo acids are concerned, the mode of expression of any modifying effect due to qualitative difference is through repercussion upon the form of the growth curve.

Certain evidence, however, does suggest the possibility that rations of equal energy value but containing different constituents, and even rations containing the same constituents but in differing proportions, act in a different way upon the growth relationships characteristic of differently sexed animals. For instance, Woodman et al (8) found that gilts tended to produce a leaner belly as the percentage of protein rich food in the diet was increased - a behaviour not displayed by their brother hogs. The same workers also found that as the percentage of protein in the diet was increased, there was a progressive rise in the percentage of fat in the fillet of barrows, but for gilts there was a progressive fall. It is probable, however, that these results may be more accurately explained on the basis of differences which existed in the form of the growth curve of the animals used, rather than on the basis of a differential response of the differently sexed animals to different rations.

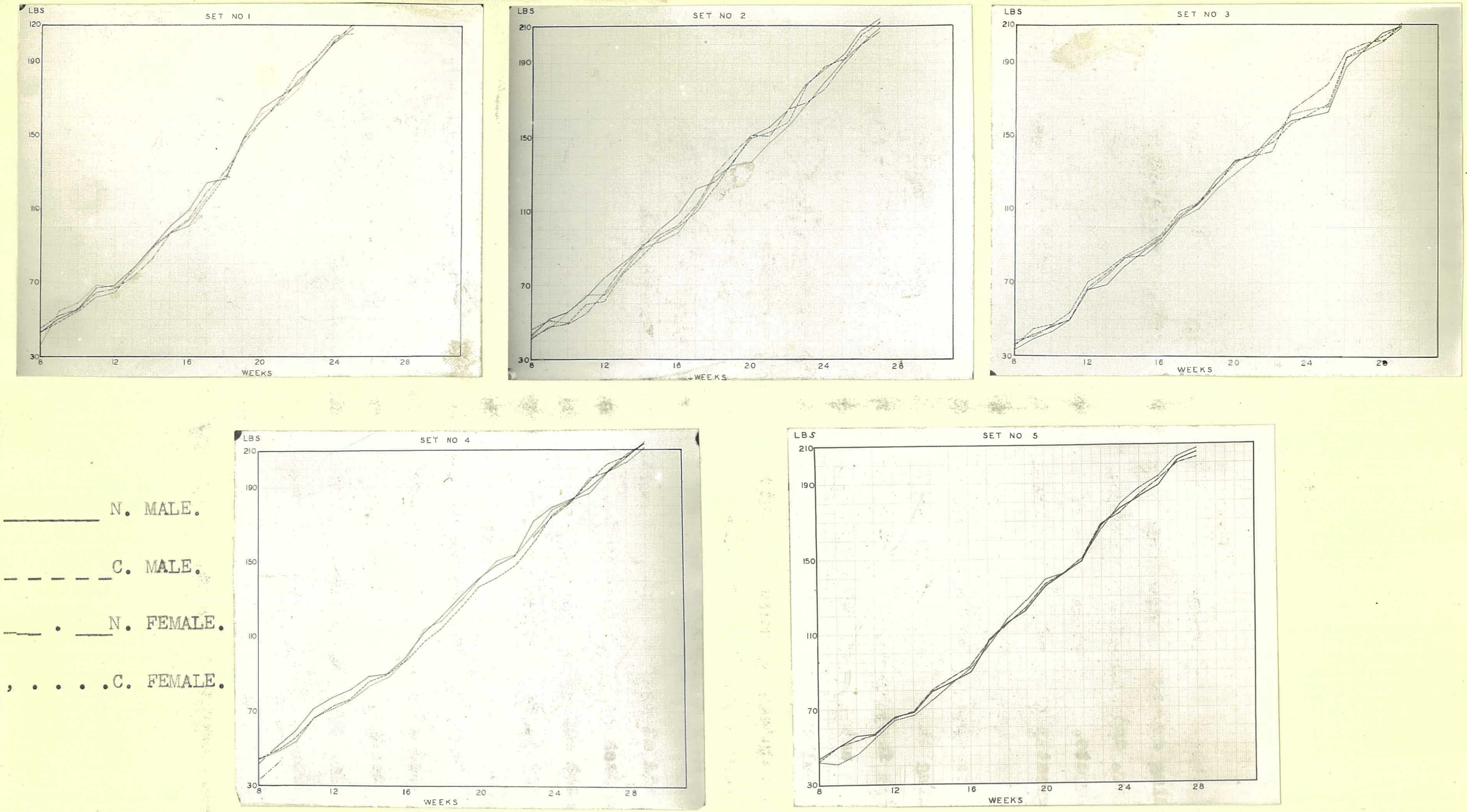
L

Although these findings alone are considered sufficient justification for the feeding of a standard ration, this latter was also desirable in the present work in that it greatly facilitated the treatment of the food consumption data. When fed separately, one pound of meal may be considered as of approximately the same productive value as one gallon of separated milk (44). When fed in the form of a mixture, however, the food value of each is increased (44, and Scott 45), the amount of the increase varying according to the proportionate composition of the mixture. In order, therefore, to make possible accurate comparison between the food consumption of the differently sexed animals and also between the different groups of animals, it was essential that the meal-milk ratio should be constant.

The ration used, was, in the main, satisfactory in regard to the normal functioning of the bowels, although two animals became constipated for a short period during the course of the experiment. Upon these occasions a dose of oil was administered not only to the distressed animals, but also to the remaining members of the group. This precaution was taken on account of the investigation being undertaken by Mr. Johns into the chemical nature of the depot fats of the differently sexed animals, differences in the amount and nature of the fats and oils consumed being known to influence the chemical composition of the fat deposited in the body of the pig (Hilditch,26).

6. REARING OF PIGS AND GROWTH CURVES ATTAINED.

Prior to the weaning, the experimental pigs were accorded the same treatment as the remainder of the litters, at the College piggery. They were provided with meal and separated milk under the creep system from two weeks until weaning at eight weeks of age. After weaning, for a period varying from one to three weeks in the case of different groups, the pigs were grazed upon young pasture, fed separated milk and were allowed constant access to meal. At the end of this period, individual feeding was commenced, all four members of each



________ N. MALE.

_ _ _ _ _C. MALE.

__ . __N. FEMALE.

, ...C. FEMALE.

FIG. III

group being transferred to one of the two pens containing the feeding crates. Each pig was allotted a feeding crate at random, and thereafter was allowed only into its own particular crate. This was desirable for two reasons. First, it greatly facilitated the feeding of the pigs, which very soon came to know their own crates. Secondly, it ensured that each pig consumed the whole of its own ration. Occasionally at feeding time, one of the animals would not consume the whole of the food supplied. This food was allowed to remain in the trough until the next feeding-time when it was eaten by its rightful owner. This obviated the estimation of the food left uneaten, an extremely difficult task, since the ration was fed in the form of a mixture of meal and separated milk.

Commencing at weaning time, each group of pigs was weighed at regular weekly intervals. The figures obtained from each weighing were used to determine the ration to be fed to each member of the group during the subsequent week. Thus the ration fed to fast growers was reduced and that fed to slow growers increased. It was found most satisfactory to weigh the animals immediately after they had been fed for upon being released from the crates they habitually defaecated and urinated, this tending to make their weight more uniform. In recording weights, corrections were made to allow for any differences in the amount of food just consumed.

From the weekly weight data (appendix), the individual growth curves of the members of each group of pigs and the mean

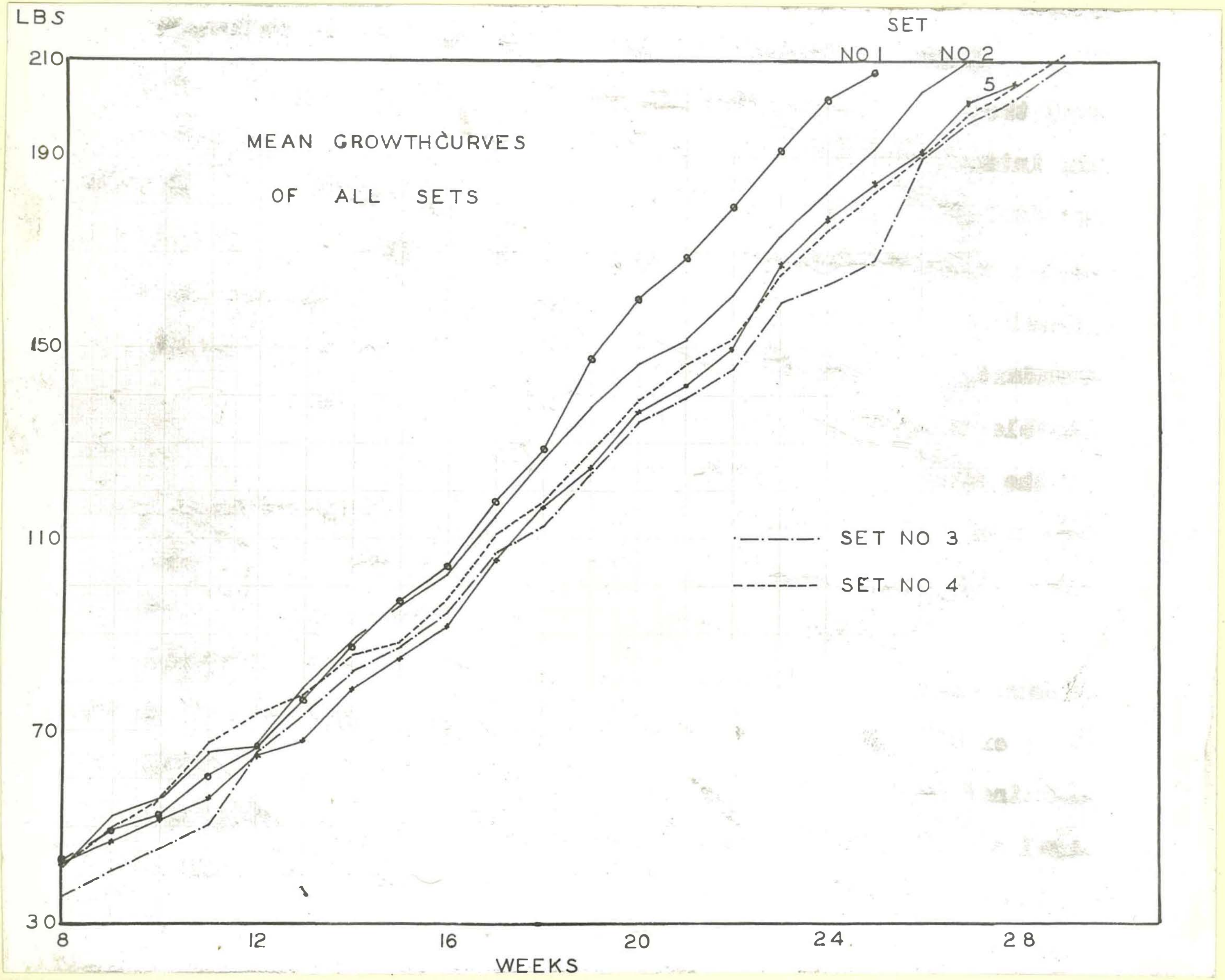

LBS
210
190
150
110
70
30
MEAN GROWTHCURVES
OF ALL SETS
SET
NO 1
NO 2
5
SET NO 3
SET NO 4
8
12
16
20
24
28
WEEKS

FIG. IV.

growth curve of each group have been constructed (Figs. III and IV). From a consideration of Figs III and IV, it is apparent that the aim of a standard growth curve within each set was to all intents and purposes achieved. Such small variations as are depicted in the growth curves of group members can be largely ascribed to variations in the weight of the gut contents of the animals at the time they were weighed - it being impossible to standardise completely this latter factor. It was found impracticable to maintain the same standard growth curve between each of the sets but, although the form of the mean growth curves for the successive groups of pigs differed appreciably (Fig. IV), all sets were slaughtered within an age range of 25 to 29 weeks.

The growth rate achieved by the groups must be considered most satisfactory in view of the fact that the growth rate of each group as a whole was governed by the rate of growth attained by its slowest growing member. Moreover, the individual crate system is not naturally suited to force feeding, for under such a system it is not possible to allow the animals constant access to food, while the amount of labour involved usually precludes the animals being fed more than three or four times a day.

The replacements made during the period when the pigs were confined to the individual feeding pens may now be considered in relation to their effect upon the uniformity of the growth curves characterising each group of animals.

Barrow No. 29, belonging to Group No. II was ded at the age of thirteen weeks, on account of rathe shaped hind quarters. This action was later sh justified for the animal soon developed an exc

PLATE II

leggedness and loose jointed condition. As it grew older, its condition became progressively worse, the fleshing of the hind quarters became very deficient and the animal experienced difficulty in remaining upon its feet. Plate II illustrates the abnormal development of the hind quarters at 27 weeks of age. As a result of the immediate substitution of a litter mate, the rejection of this animal had no adverse effects upon the comparability of the growth curves within the set (Fig. III, Set. No. 2). The occasional appearance of such peculiar abnormalities lends support to the contention that inbreeding so far practised within the herd has increased rather than decreased the variability within the litters.

The reason for the discard of the two females originally included in Group No. II (i.e. pigs No. 27 and 26A) has already been presented (Spaying and Castration). It was obviously essential that the two younger animals (i.e. pigs Nos. 25 and 26) which were selected to replace them should be made to follow growth curves similar to those already attained by the two male animals retained in the group. In endeavouring to do this, difficulty was experienced in securing a sufficiently rapid rate of live-weight increase with the replacement females, as they were reared during the autumn and winter months, whereas the corresponding male animals had been reared during the warmer spring and summer months. While the first pair of animals were slaughtered on the 10th January 1940, the second pair of animals were not slaughtered until the 28th June. The rearing of these two females clearly demonstrated the unsuitability of the individual feeding crates for force feeding, for, in order to attain the requisite rate of growth, it was found necessary to place the animals in the separate halves of a pen subdivided with netting where they were allowed constant access to the prescribed amount of food. By this method very satisfactory growth curves for the female animals were obtained, these coinciding very closely indeed with those of the male animals of the group (Fig. III, Set.No.2).

Group No. IV must be considered in respect to the replacement at 22 weeks of the natural female first included in this group (Pig No. 3) by a litter mate (Pig No. 4). The former animal was found dead one morning after having appeared perfectly normal at feeding time the previous evening. Post mortem examination revealed acute gastroenteritis infection and *Salmonella suipe~~r~~stifer* was subsequently isolated from plate cultures. Pig No. 4, when introduced into the feeding crate pen as a substitute for pig No. 3, weighed 163.5 pounds, a figure which agreed very closely indeed with the weights of the remaining members of the group, these being 165.5, 160.5, and 171.5 pounds respectively. Pig No. 4 had not been weighed weekly prior to being transferred to the feeding crate pen at 22 weeks of age, but at 8 weeks it was considerably lighter than the other three members of the Group (Fig. III, Set. No. 4), this indicating that it must have experienced a slightly higher rate of growth during this period than the other members of the group.

The fact that Group No. 5 is composed of only three members (Fig. III, Set. No. 5) instead of the customary four, resulted from the death from Salmonella infection of the boar of this group (Pig No. 37) when 20 weeks of age. Unfortunately no suitable animal was available for replacement purposes.

7. SLAUGHTER, DRESSING AND STORAGE OF CARCASE.

Each group of animals was slaughtered when its members had attained a recorded live-weight of approx. 210 pounds. Pigs were weighed upon each of the three days immediately prior to slaughter, the mean figure obtained for each animal being accepted as its final live-weight. A recorded weight of 210 pounds was estimated to correspond to a live-weight of 200 pounds, when the animals were in a reasonably fasted condition. All members of the same group were slaughtered upon the same day, this being carried out at the College piggery where a suitable gallows was erected especially for the purpose. The technique adopted in slaughtering the animals was similar to that employed by McMeekan (4) at Cambridge with the exception that in all cases bleeding was affected without anaesthesia. Subsequent to dehairing but before the removal of the viscera, each animal was laid upon its left side with its limbs extended and then photographed from above. After dressing, a further photograph was taken of each carcase suspended from a standard gamble. Body organs and offals were separated, examined, and the respective measurements recorded after the method described by McMeekan (4)

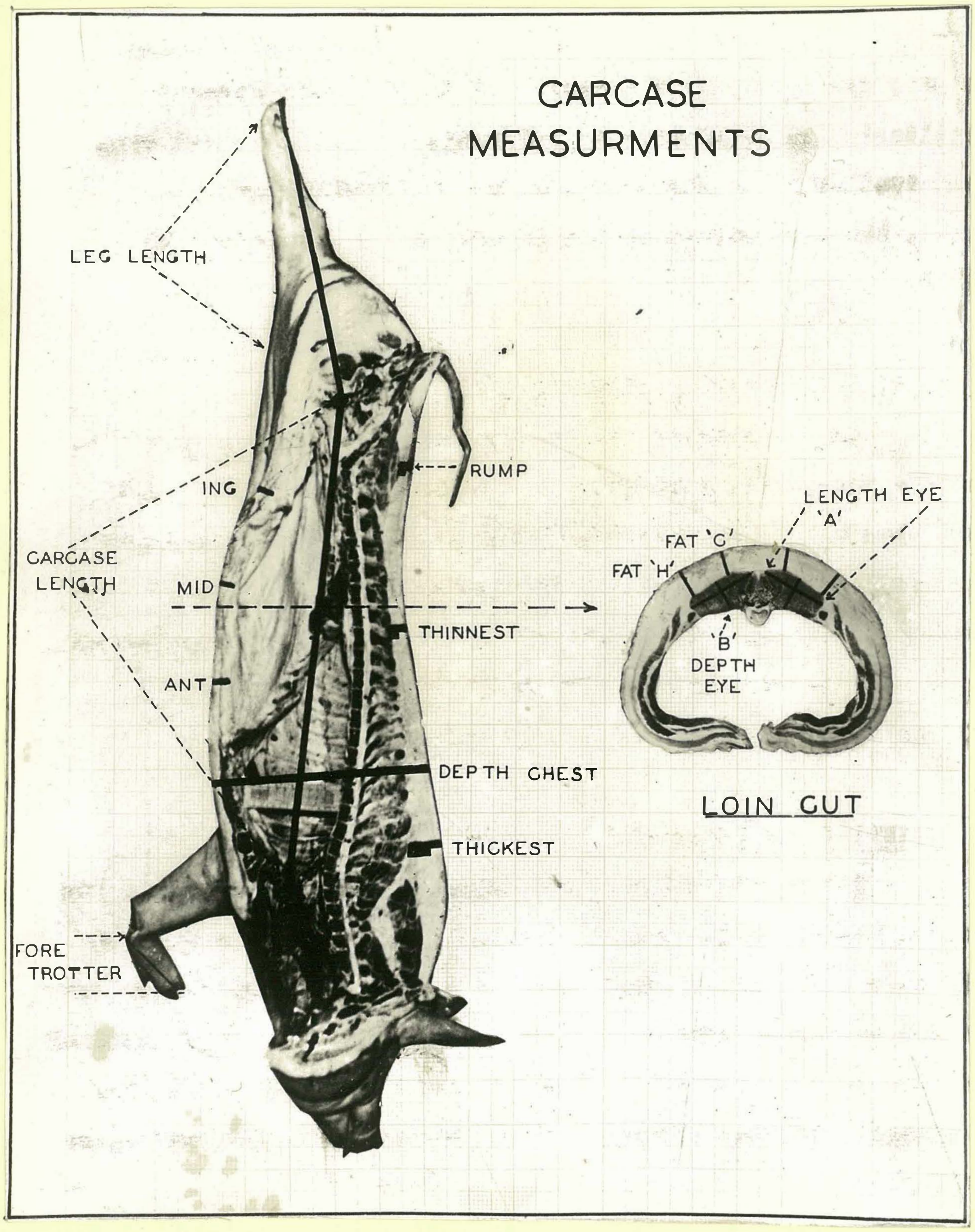

CARCASE MEASURMENTS
LEG LENGTH
RUMP
ING
CARCASE LENGTH
MID
THINNEST
ANT
DEPTH CHEST
THICKEST
FORE TROTTER
LENGTH EYE 'A'
FAT 'C'
FAT 'H'
'B' DEPTH EYE
LOIN CUT

FIG. V

As the dressing of each animal was completed, the carcase was immediately transferred to the Dairy Research Institute Factory where a suitable freezing chamber had been made available. The carcases were allowed to cool overnight, the temperature of the freezer being maintained at 32° F.

8. BODY AND CARCASE MEASUREMENTS.

On the morning following slaughter, numerous measurements - the positions of which are indicated in Fig. V - were made upon the frozen carcase. These measurements are those employed by McMeekan (4). In the case of the backfat thickness measurements, the thickness of the inner subcutaneous fat layer was measured at each of the three points indicated as well as the total depth of fat at these points.

9. JOINTING AND DISSECTION.

The complete laboratory dissection of the whole of the carcase was not attempted. Instead, the right hind leg and loin were selected as sample joints, and the composition of these two joints taken together used as an index of the composition of the carcase as a whole. These joints are comparatively easy to dissect, forming clearly defined anatomical units, which, by the employment of a standardised technique, described by McMeekan (4) may be removed from the body with a very high degree of precision.

Justification for the adoption of this method has been provided by McMeekan (6) who found that the total weight of bone, muscle, and fat in bacon carcases of the English Large White breed could be very accurately estimated from the amounts of each of these tissues in the leg and loin when these were jointed in the manner described. Using data available from the complete dissection of the carcases of twenty animals of 200 pounds live-weight, McMeekan obtained correlation coefficients of + 0.9444, + 0.9765, and + 0.9750 for bone, muscle and fat, respectively, between the weight of each of these tissues in the leg and loin and the weight of the same tissues contained in the whole of the carcase.

Although McMeekan has emphasised the possibility that regression coefficients derived from these relationships may not be entirely valid when applied to other breeds of pigs, he has advanced a considerable amount of evidence to show that the magnitude of any error introduced by so doing is likely to be very small, provided animals of the same weight are considered and their composition falls within the range covered by his material. McMeekan thus draws attention to the fact that the animals he used varied widely in proportions and composition, and considered these differences comparable in range and nature to those existing between widely different breeds.

In any case, it is worthy of note that the two hind legs and the loin together constitute a high proportion of the total carcase (approximately 30 per cent.) and also that these are the most valuable parts. Indeed, precise knowledge of the composition of these joints would still be of major importance even if the weight of each of the component tissues was not strongly correlated with the amount of these tissues present in the whole body.

The dissection technique employed was that described by McMeekan (4) and the same data were recorded in each case. Similar precautions were taken to minimise losses by evaporation. Approximately one hundred man hours of work were required for the dissection of the four hind legs and four loins derived from each group of pigs.

10. HISTOLOGICAL METHOD.

One of the aims of this work has been to determine the influence of sex upon the histology of the muscular tissue, and so attention has been given to the measurement of the size of the muscle fibres, to the kind of grain, and to the amount and manner of distribution of the marbling fat present. Hammond (3) found with sheep that each of these factors affected the eating quality of the meat and it is reasonable to suppose that they influence the tenderness and flavour of the lean in bacon.

During the slaughter and dissection of each animal, four separate muscles were sampled, namely the *psoas major*, *gastrocnemius*, *rectus femoris* and *longissimus dorsi*. The samples were preserved in 10 per cent formalin until examination. Every endeavour was made to secure samples from the same region of each muscle in each case. Since work by Hammond (3) with sheep indicates that the mean diameter of fibres situated at the end of a muscle is usually greater than that of fibres situated in the middle. In the present work the samples obtained from the *psoas major*, *gastrocnemius* and *rectus femoris*, were taken as nearly as was possible from the centre of these muscles, while the *longissimus dorsi* was sampled at a point three inches posterior to the first lumbar vertibra.

These four muscles were selected in consideration of their spacial distribution in the body and importance in relation to carcase quality. Thus the gastrocnemius, rectus femoris and psoas major are representative muscles of the leg, thigh, and loin respectively, while the longissimus dorsi muscle is by far the most valuable muscle in the bacon carcase.

The method adopted in measuring the diameter of the fibres of each muscle sample was essentially similar to that employed by Hammond (3) for sheep, and found satisfactory for pig muscle by McMeekan (4). A slice of muscular tissue about one inch square and one half a millimeter thick, was cut by hand with a microtome knife. Small fragments of this slice were then selected at random, transferred to a drop of dilute glycerine (50 per cent.) upon a slide and then teased out with needles under a binocular microscope. The diameters of one hundred fibres were then measured by means of a travelling stage eye-piece micrometer, the scale of which was standardised so that each minor division registered two microns. Each fibre was measured at approximately the middle point for the ends of the fibre had a slight tendency to fray as a result of cutting. As this procedure was very laborious, a lanameter was tried in an attempt to lessen the work involved. However, the definition obtained was not considered sufficiently good to allow accurate measurement of the fibre and so the method was not adopted.

For the study of grain and marbling fat, sections were cut from each muscle sample, the freezing method as described by Guyer (21, page 77) being employed. The sections were one half to three-quarters of an inch square and were cut 90 microns thick and at right angles to the direction in which the muscle bundles lay.

Sections for grain examination were stained in Van Giesen's stain for two minutes and then transferred through 50, 70, 80, 90 and 95 per cent. alcohol, successively, being left in each for approximately three minutes. From the 95 per cent. alcohol, each section was transferred to a slide and mounted in euparal. Sections for marbling fat examination were first stained for fifteen minutes with a saturated solution of Sudan III in 50 per cent. alcohol and then washed in 50 per cent. alcohol solution and mounted in Farrant's solution.

A print of each section, enlarged to four diameters, was obtained by placing the slide in a photographic enlarger and printing directly on sensitised paper, and these compared by eye evaluation.

11. STATISTICAL TREATMENT OF RESULTS.

Since the experimental design employed is strictly compararable to the randomised block layout widely used in field plot experimentation, the resultant data are readily subject to statistical treatment. In this investigation, the four varieties of animals the the five groups correspond respectively to the treatment and blocks of a field plot trial, while the standard growth curve maintained within each group is analogous to the uniformity of fertility within each block, which is the ideal in a field trial.

Fisher's analysis of variance (22) has been employed in the examination of the data, and in testing significance the F test has been employed, using the tables computed by Snedecor (23, p. 184). In carrying out each analysis of variance it was necessary to supply the one missing value occasioned by the loss of the entire male pig in Group V. This has been calculated by application of the following formula proposed by Allen and Wishart (24) and modified by Yates (25).

$$\text{Missing value} \quad x = \frac{pP + qQ - T}{(p-1)\ (q-1)}$$

where p = number of treatments (sexes)

q = number of blocks (groups)

P = Sum of items with same treatment as missing item

Q = Sum of items in same block as missing item

T = Sum of all observed items.

It should be emphasised that the significance of any effect is always slightly exaggerated in the analysis of variance of a set of data in which missing values have been supplied by calculation. However, Yates (25) states "In practice, however, the difference between the correct and approximate sum of squares is never likely to be great enough to affect the tests of significance seriously, except, perhaps, in cases where a large proportion of the plots is missing..... If only a single plot is missing the difference is likely to be quite trivial".

In testing the significance of differences between the means of the different sexes, the method outlined by Goulden (33, chapt. XI, ex. 32) has been employed.

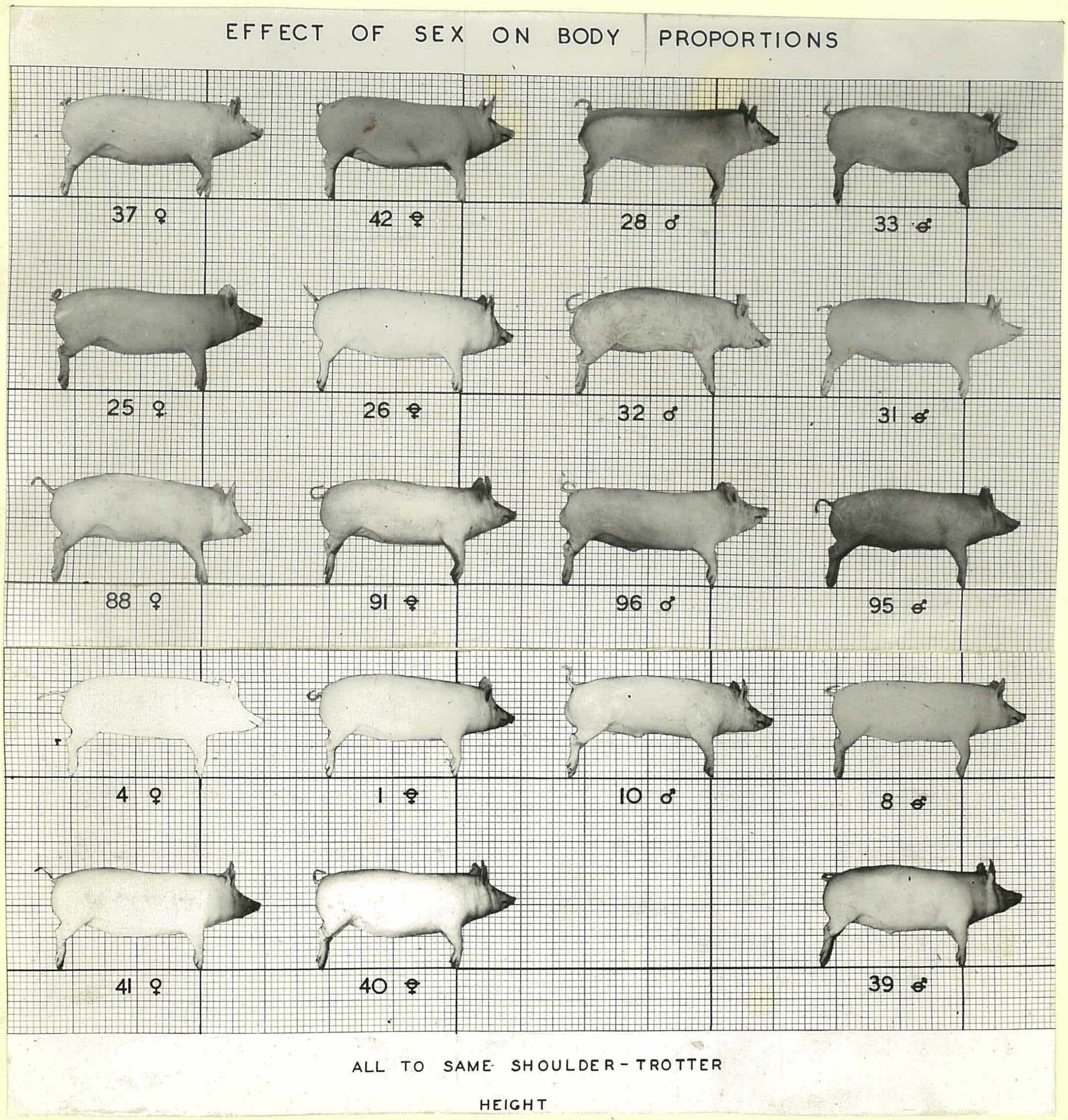

EFFECT OF SEX ON BODY PROPORTIONS
37 ♀
42 ♀̵
28 ♂
33 ⚦
25 ♀
26 ♀̵
32 ♂
31 ⚦
88 ♀
91 ♀̵
96 ♂
95 ⚦
4 ♀
1 ♀̵
10 ♂
8 ⚦
41 ♀
40 ♀̵
39 ⚦
ALL TO SAME SHOULDER-TROTTER
HEIGHT

PLATE III.

PART II

EXPERIMENTAL RESULTS

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1. EFFECT OF SEX UPON BODY PROPORTIONS:

Differences in the body proportions have been studied in three ways:

(1) By the photographic method;

(2) By comparing the weights of leg and loin joints;

(3) By the use of the body measurements taken upon the dressed carcass.

Plate III has been prepared from the photographs taken during the slaughter process, of each pig after scalding, but prior to dressing. A print was taken from each negative, each pig being enlarged to the same shoulder-trotter height. "Cut outs" of each animal were prepared, arranged according to their group and sex, pasted upon suitable graph paper and rephotographed. By thus standardising to a major conformation character, differences existing in the relative proportions of the other parts of the body are more readily discerned.

The only conspicuous difference noticeable in Plate III relates to the entire males, the bodies of which appear shallow throughout and comparatively less well developed in the hind end. However, by use of dividers, it was ascertained that in both sexes without exception, the overall body length of each castrate animal is appreciably shorter than that of the corresponding normal animal. This higher ratio of shoulder-trotter length to overall body length characteristic of castrates may be as-

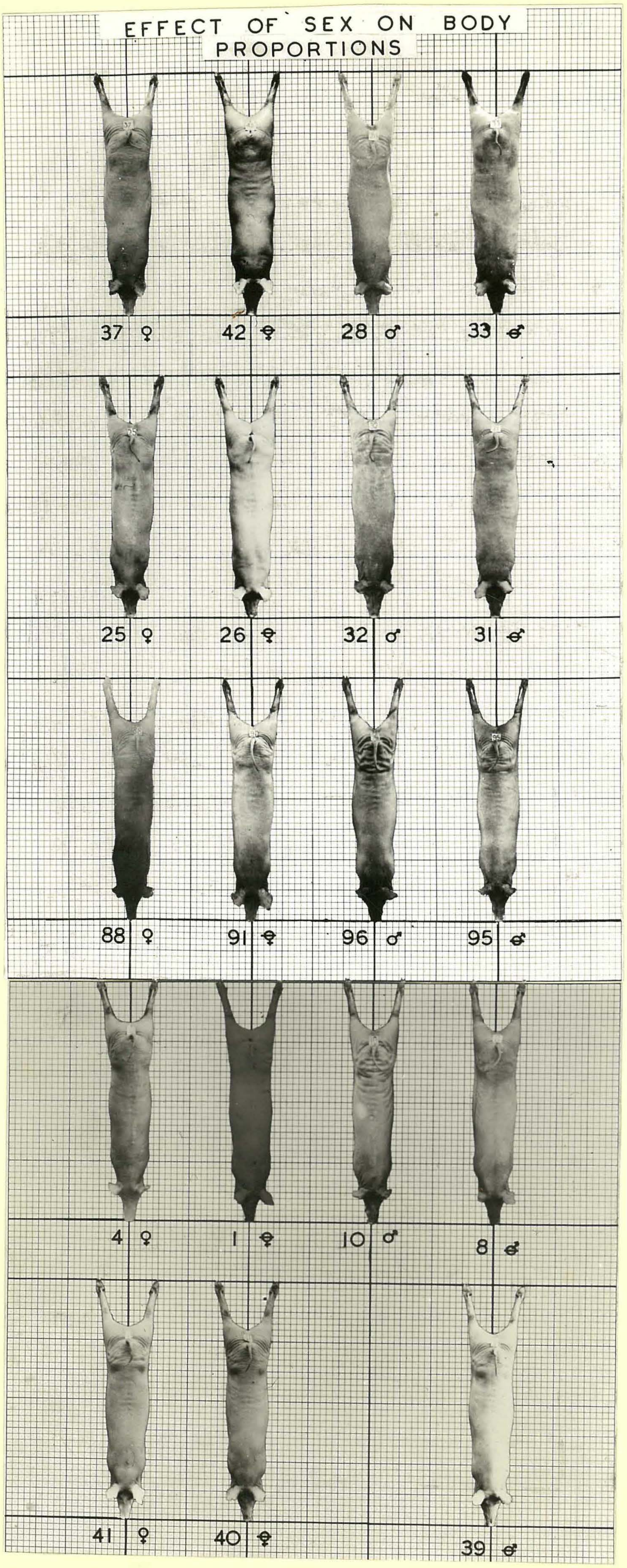

EFFECT OF SEX ON BODY PROPORTIONS
37 ♀
42 ♀
28 ♂
33 ♂
25 ♀
26 ♀
32 ♂
31 ♂
88 ♀
91 ♀
96 ♂
95 ♂
4 ♀
1 ♀
10 ♂
8 ♂
41 ♀
40 ♀
39 ♂

PLATE IV.

cribed to the greater depth of fat found over the shoulders of these animals (see carcase measurements) for this quite appreciably affects the shoulder-trotter height.

Plate IV was obtained in a similar manner to Plate III from the photographs of the dressed carcases, which were enlarged in this instance to the same body length as measured from the tip of the snout to the tip of the hind trotter. Again no striking differences in body conformation are apparent, although the boar animals have a tendency to be somewhat narrower throughout the length of the body, giving them a somewhat leaner appearance. This feature is particularly noticeable in the case of the first group of animals. In view of the commonly held opinion that male animals are heavier in the shoulder than other animals, it is interesting to note that in the present case the boar animals compare very favourably in this respect, probably due to the absence of "shield" which does not develop until later ages.

In Table V, the mean weights of both the leg and loin joints are given for each of the sexes. It should be mentioned that the number of lumbar vertebrae varied in different animals from six to seven. To permit comparison, loins containing seven vertebrae were reduced to a six vertebrae basis by deducting one seventh of their weight and the mean loin weights recorded in Table V have been obtained from these corrected individual values (see Appendix).

For comparative purposes, the leg and loin weight have each been expressed as a percentage of the carcase weight, and the leg weight as a percentage of the loin weight. Furthermore, the weight of each joint is shown as a percentage of the weight of the corresponding joint for the natural males. This provides a measure of the effect of sex upon each joint and the relative development of these two joints in the differently sexed animals.

TABLE V

EFFECT OF SEX UPON BODY PROPORTIONS.

Sex	Mean Weight (Grams)			Percentage Carcase Weight		Relative Proportion Natural Male = 100		Ratio Leg weight/ Loin Weight
	Carcase	Leg	Loin	Leg	Loin	Leg	Loin	
Natural female	66,822	6,243	7,393	9.35	11.06	103.6	106.9	0.844
Castrate female	66,230	5,851	7,679	8.83	11.59	97.1	111.0	0.762
Castrate Male	66,066	5,800	7,479	8.88	11.32	96.3	108.0	0.776
Natural male	66,834	6,025	6,916	9.01	10.35	100.0	100.0	0.871

From the data in Table V it is apparent that the castrate animals resemble each other very closely in respect to both leg and loin weight, although the castrate females have slightly heavier loins than do the castrate males. Consideration of the percentage figures for these sexes shows that the greater development of the loin in the castrate females has been accompanied by a small reduction in leg development. In a comparison, between the entire sexes, both leg and loin show greater development in the females. Since the mean carcase weight is substantially the same in each of these two sexes, this indicates that in the entire males there is a greater growth of the fore-end of the body, which is a relatively early developing part.

Castration in either sex has considerably increased the weight of the loin joint, and decreased the weight of the leg joint. It may be observed from Table V, however, that the proportional increase in loin weight has been greater than the proportional reduction in leg weight. McMeekan (4) has shown that the loin is a relatively later developing unit than is the leg. It would appear, therefore, that castration stimulates the growth of late developing parts to a greater extent than parts which are relatively earlier developing. This phenomenon may possibly be explained by the speeding up of the rate of internal secretion of the gonads as the animal becomes older. Hammond (3) states "We doubt whether there is any actual difference in the nature of the secretion of the gonad before and after puberty, but believe rather that the amount produced varies" and also ".. as it (the animal) grows up more and more secretion is produced by the gonad....". It would appear reasonable to suppose that the greatest difference between castrate and entire animals should be found in those parts which make most growth during the period when the gonads are most actively functioning. The high degree of development in castrate animals of the normally late developing loin region indicates that these are earlier maturing than natural animals. The general trend of the effects thus suggests that the presence of gonadial secretion depresses growth of different parts of the body in a differential manner, and in accordance with the order of development of these parts.

Mean weight and proportionate data relating to external carcase measurements are shown in Table VI. McMeekan (6) has shown that external linear body measurements are probably indicative of the amount of bone development more than of any other character since such measurements are principally dependant upon the size of the animal which is in turn largely determined by its skeletal structure. He has pointed out also that since all such measurements are influenced to some extent by the flesh and fat covering, of the animal, they cannot be reliable indises of skeletal development.

No outstanding differences in body proportions are revealed by the data in Table VI. Since carcase length and depth of chest are two important factors governing body proportions the data relating to these measurements have been statistically examined by the method of analysis of variance (Tables VII and VIII). The effect of sex upon carcase length has not been significant. It will be noted, however, that the mean carcase length of the normal females is greater than that of the castrate males, a finding consistent with those of Bengtsson (36) Beck (38) and Axelsson (39). From Table VIII, it may be

TABLE VI

EFFECT OF SEX UPON CARCASE MEASUREMENTS

	Mean measurements (Mms.)				Proportion: Natural Male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Length Body	1020.6	1014.0	995.0	982.6	102.6	101.9	100	98.8
Length carcase	759.8	765.0	763.5	755.4	99.5	100.2	100	98.9
Length Thorax	481.8	468.0	482.0	470.8	100	97.1	100	97.2
Length Leg	569.0	567.2	583.8	567.2	97.5	97.2	100	97.2
Length fore-trotter	110.6	108.6	113.5	106.0	97.4	95.7	100	93.4
Depth of Chest	353.8	356.8	344.3	354.2	102.8	103.6	100	102.9

TABLE VII

ANALYSIS OF VARIANCE OF LENGTH OF CARCASE (Millimetres).

Component	Degrees of Freedom	Sum of Squares	Mean Squares	F value for comparison	
Sexes	3	325	108.3	0.59	N.S.
Groups	4	3266	816.5	4.46	S
Error	11	5604	183.0		
Total	18				

N.S. = not significant

S. = Significant at 5 per cent point.

TABLE viii

ANALYSIS OF VARIANCE OF DEPTH OF CHEST (Millimetres)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	
Sexes	3	934	311.3	6.67	S.S.
Groups	4	4559	1139.8	24.41	S.S.
Error	11	514	46.7		
Total	18	6007			

S.S. = Significant at 1 per cent point

TABLE VIIIa

Means compared	Respective Means		Difference between means	Level of Significance
Natural females - castrate females	353.8	356.8	3.0	N.S.
Natural females - natural males	353.8	341.2	12.6	S.
Natural females - castrate males	353.8	354.2	0.4	N.S.
Natural males - castrate males	341.2	354.2	13.0	S.
Natural males - castrate females	341.2	356,8	15.6	S.S.
Castrate males - castrate females	354.2	356,8	2.6	N.S.

Difference of 9.51 m.m. between means significant when P = .05

" " 13.43 m.m. " " " " P = .01

seen that sex has had a highly significant affect upon chest depth. In Table VIIIa the significance of the differences between the various sex means has been tested. The mean chest depth of the entire males differs significantly at the 1 per cent. point from that of the spayed females and at the 5 per cent. point from the respective means of the natural females and castrate males. Comparison between the means of the other sexes do not even approach significance. That the chest depth of the entire males is less than that of the other sexes supports the observation previously made concerning fore-end development after inspection of Plate III. However, McMeekan (6) has drawn attention to the complete lack of relationship of this measurement with skeletal development due to the large contribution of fat and muscle cover. In the present investigation, although characterised by the shallowest chests, the normal males had the longest, thickest and heaviest bones (See Part II, Section 2).

Length of thorax, length of leg, and length of fore trotter, respectively, are greater in entire animals than in castrates and greater in entire males than entire females. The latter two measurements McMeekan (6) found to be strongly and significantly correlated with total weight of bone in the carcase. It is therefore of interest that the different sexes fall into the same order for total bone of leg and loin (Table IX) as for leg length and fore trotter length, a result which supports the strength of the correlation referred to.

2. EFFECT OF SEX UPON COMPOSITION OF LEG AND LOIN JOINTS:

Since the influence of sex on the composition of the carcase is the most important aspect of this study, the data

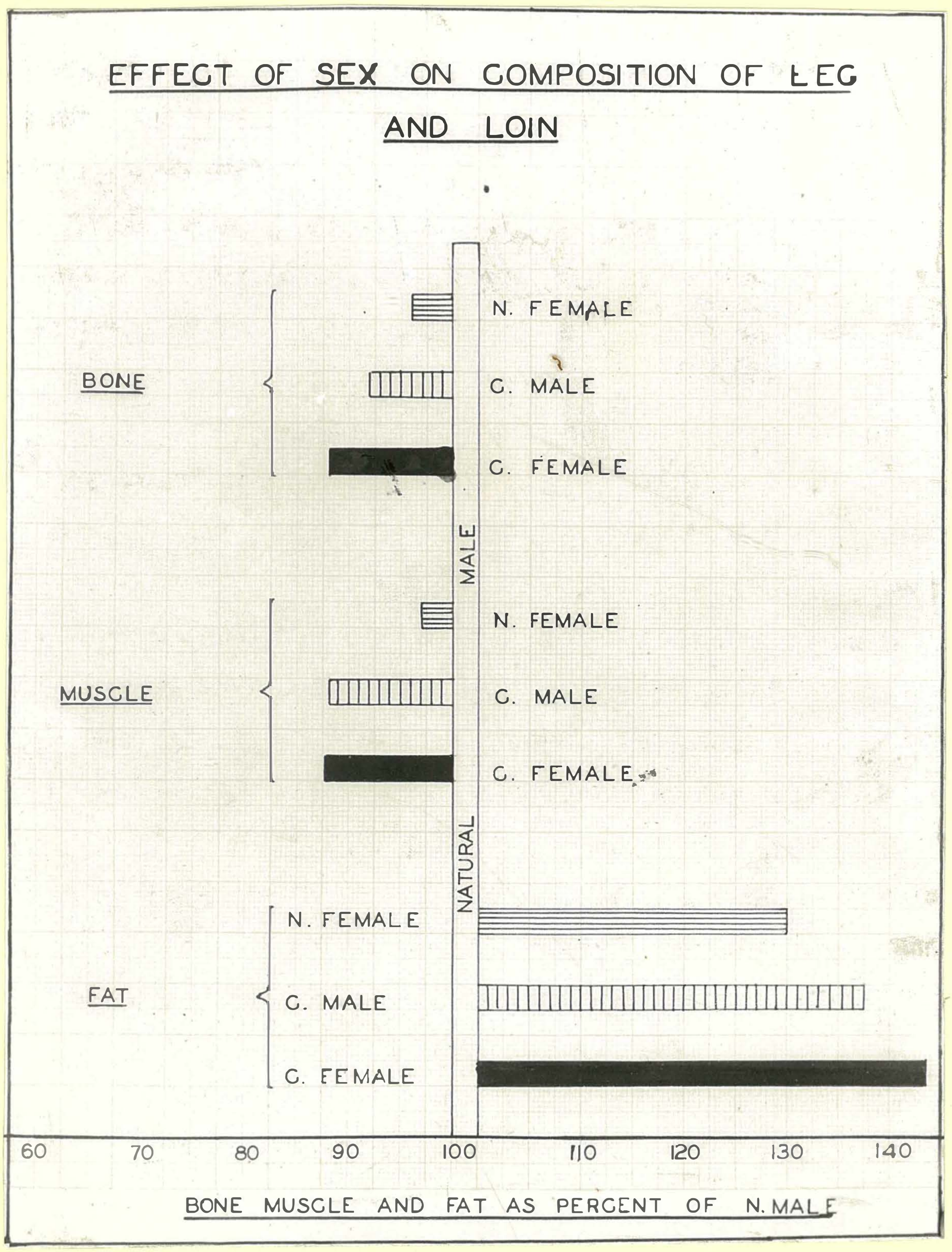

EFFECT OF SEX ON COMPOSITION OF LEG AND LOIN
BONE
N. FEMALE
C. MALE
C. FEMALE
MUSCLE
N. FEMALE
C. MALE
C. FEMALE
FAT
N. FEMALE
C. MALE
C. FEMALE
NATURAL MALE
60
70
80
90
100
110
120
130
140
BONE MUSCLE AND FAT AS PERCENT OF N. MALE

FIG. VI.

relating to the composition of the ham and loin are of major interest. In Table IX the dissection data for the combined totals of both these joints are given, the mean results of each tissue for the various sexes being summarised upon an absolute, a percentage and a proportional basis. It is obvious that the differently sexed animals are characterised by fairly large differences in composition. The figures for the mean weights for the various tissues in the several sexes show that the normal males have the greatest amount of both bone and muscle tissue, followed by the natural females, castrate males and castrate females in that order. With respect to fat, however, the order is precisely the reverse.

The magnitude of these differences can be assessed from the proportionate figures in Table IX. These have been derived by calculating the mean weight of each tissue in the natural females, castrate males and castrate females as a percentage of the mean weight of the corresponding tissue of the natural males. These data are also presented in histogram form in Fig VI which demonstrates clearly not only the relative effect upon each tissue in the various sexes, but also the relative development of the three tissues in each sex. It will be seen from Fig VI that the relative order of the sexes, arranged according to the extent to which their respective compositions diverge from that of the natural male, is natural females least, castrate male intermediate, and castrate female most. This order of the sexes is the same for each of the three tissues, being in a negative direction in the case of bone and muscle, and positive in the case of fat.

TABLE IX

EFFECT OF SEX UPON COMPOSITION OF LEG PLUS LOIN [x]

.	Mean Weight (grams).				Per cent.of Weight. Leg plus Loin				Proportion Natura male = 100			
Sex:	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C
Bone	1009	926	1051	940	7.4	6.8	8.1	7.1	96.0	88.1	100	89
Muscle	6272	5673	6464	5680	46.0	41.9	50.0	42.8	97.0	87.8	100	87
Fat	5114	5676	3949	5432	37.5	41.9	30.5	40.9	129.5	143.7	100	137
Skin	823	836	1086	797	6.0	6.2	8.4	6.0	75.8	77.0	100	73.
Tendon,Cord) Waste, etc.	224	221	240	256	1.6	1.6	1.9	1.9	93.3	92.1	100	106.
Loss in Dissection.	204	199	151	174	1.5	1.5	1.2	1.3				
Total:	13636	13531	12941	13279	100%	99.9	100.1	100				

---

x Loin upon 6 Vertibrae basis.

Since the animals have been compared at the same age and live-weight, with the consequence that the absolute weights of their component tissues can vary only within certain limits, the differences in composition obtained between the variously sexed animals are regarded as large. As may be seen from Table IX, the natural females have approximately 4 per cent., castrate males 11 per cent. and castrate females 12 per cent less bone than the natural males. Similarly, natural females have approximately 3 per cent. and castrate males and castrate females 12 per cent. less muscle. Again, natural females have approximately 30 per cent., castrate males 38 per cent., and castrate females 44 per cent. more fat than the natural males.

This differential development of fat, bone and muscle between sexes has been responsible for the large divergencies in the fat-bone and fat-muscle ratios which are shown in Table X.

Although castration in either sex has, relatively, penalised both bone and muscle development, these two tissues have been effected to much the same extent so that the muscle-bone ratio of the castrates is not markedly different from that of the corresponding normal animals. On the other hand, however, the greatly *increased* deposition of fat and the *reduced* bone and muscle development in castrates has profoundly modified the fat-bone and fat-muscle ratios characteristic of the normal animals.

It is interesting to note that the composition of the loin and leg of castrate males is very similar to that of the castrate females, the respective proportionate figures (Table IX) being 89.4 and 88.1 for bone, 87.9 and 87.8 for muscle, and 137.6 and 143.7 for fat. The natural type animals, however, differ more widely in composition -

TABLE X

EFFECT OF SEX ON PROPORTIONS OF BONE MUSCLE AND FAT IN LEG PLUS LOIN.

Ratio:	N.F.	C.F.	N.M.	C.M.
Muscle/ Bone	6.216	6.216	6.150	6.043
Fat/ Bone	5.068	6.129	3.757	5.779
Fat/ Muscle	0.815	1.001	0.611	0.956

particularly in respect to fat. This directs attention to the relative extent of the changes produced by castration in male as compared with female animals. That these changes have been relatively greatest for all three tissues in the case of the male sex may be seen from Table XI in which the mean weight of each tissue for the castrates has been expressed as a percentage of the mean weight of the same tissue in the corresponding normal animals. Although there is some difference in the mean carcase weight of the different sexes, this difference is very small when either the two natural sexes, or the two castrate sexes are compared (Table V, p.35) and the relatively greater effect in the male sex cannot be ascribed to this factor. It would appear, therefore, that both the ovaries and testes in some way inhibit fat development and favour bone and muscle development but that the latter do this more effectively than the former. When each is absent, bone, muscle and fat development proceeds in a very similar manner in the animals, irrespective of whether the animals be, genotypically, males or females.

Turning to skin development, the data of Table IX show that this is very similar in natural females, castrate males and castrate females, but development is much greater in natural males. This greater development of the skin of male animals appears to be characteristic of most species. It is well recognised that the hides of bulls are thicker than those of cows. Hammond (3) found the skins of rams to be very considerably heavier than those of ewes, while Wilson, King and Morris (34) with rabbits, found that bucks had heavier skins than does.

TABLE XI

RELATIVE EFFECT OF CASTRATION IN MALE AND FEMALE ANIMALS

Proportion : Natural Sex = 100

Sex	N.F.	C.F.	N.M.	C.M.
Bone	100	91.8	100	89.4
Muscle	100	90.4	100	87.9
Fat	100	111.0	100	137.6

As can be seen from Table IX, the mean weights of tendon, cord and waste for the various sexes have not followed, as was expected, a similar trend to the mean weights for bone. This is no doubt due to the greater experimental error involved in the dissection of these parts.

The statistical significance of the results for bone, muscle, fat and skin has been determined by analysis of variance (Tables XII, XIV and XVI). The degree of significance of the differences between the sex means for each of these tissues has also been established and results for all possible comparisons are summarised in Tables XIII, XV, and XVII. In each case, the difference between the various means compared is shown, together with the difference required for significance at both the 5 per cent. and 1 per cent. points. The lack of agreement between the mean figures for the natural males as shown in these tables, and the corresponding figures as given in Table IX is due to the former being calculated from the values of the four animals, while the latter have been devised for statistical purposes after supplying a value for the missing animal in Group V (see statistical Treatment of Data, page No. 31).

With regard to bone, it may be seen from Table XII that sex has had a highly significant effect upon bone weight. The standard error per pig is 57.3 grams or 5.8 per cent. of the mean, while the standard error of the sex means is 25.6 grams. From Table XIII it is apparent that the means for natural males and natural females and those for the castrate males and castrate females do not differ significantly. These are the two pairs of sexes which have already been mentioned as approaching each other most nearly in body composition. In a comparison of the natural females with

TABLE XII

ANALYSIS OF VARIANCE OF WEIGHT OF TOTAL BONE (LEG AND LOIN)
(Gramms)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sex	3	54052	18017.3	5.49	3.59	6.22	S
Groups	4	24580	6145.0				
Error	11	36073	3279.4				
Total	18	114705					

S = Significant

TABLE XIII

TABLE OF SIGNIFICANCE: WEIGHT OF TOTAL BONE (LEG AND LOIN)
(Grams)

Comparison	Respective Means		Difference between means	Level of Significance
Natural females - castrate females	1009.4	925.6	83.8	S.
Natural females - natural males	1009.4	1053.4	44.0	N.S.
Natural females - castrate males	1009.4	939.8	69.6	N.S.
Natural males - castrate males	1053.4	939.8	113.6	S.
Natural males - castrate females	1053.4	925.6	127.8	S.
Castrate males - castrate females	939.8	925.6	14.2	N.S.

Difference of 79.7 grams is significant when P = .05

the castrate females, the respective means differ significantly at the 5 per cent. point, while, although the difference between the means of the natural females and castrate males is not significant, it is very nearly so. The mean for the natural males differs significantly at the 5 per cent. point from the mean for either of the castrate sexes.

Sex has also had a highly significant effect upon muscle weight, (Table XIV) the value obtained for "F" being more than three times as great as that necessary to establish significance at the 1 per cent. point. It is interesting to note that there is a highly significant effect between different groups, although this is not as large as the sex effect. The standard error per pig is 222.6 grams or 3.7 per cent of the mean, while the standard error of the sex means is 99.5 grams. From Table X[illegible] it may be observed that, as in the case of bone, neither the means for the natural sexes nor those for the castrate sexes differ significantly. In the other four comparisons, however, significance has been established at the 1 per cent point. It will be noted that the mean for the natural males differs from that of both the castrate males and the castrate females by an amount approximately twice as great as is required for significance at the arbitrary 1 per cent. level. Whereas for bone, the means for the natural females differed from the mean of the castrate females at the 5 per cent point, for muscle these means are significantly different at the 1 per cent.point.

In respect to fat, the effect of sex is again highly significant, with an F value more than three times that sufficient for significance at the 1 per cent. point. As in the

TABLE XIV

ANALYSIS OF VARIANCE OF WEIGHT OF TOTAL MUSCLE (LEG AND LOIN)

(Grams)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = 0.05	F @ P = 0.01	
Sex	3	2,655,701	885,233.6	17.87	3.59	6.22	S.S.
Groups	4	1,414,841	353,710.2	7.14			
Error	12	544,924	49,538.6				
Total	18	4,615,466					

S.S. = Highly significant.

TABLE XV

TABLE OF SIGNIFICANCE - WEIGHT OF TOTAL MUSCLE - (LEG AND LOIN)

(Grams)

Comparison	Respective Means		Difference between means	Level of Significance
Natural females - castrate females	6271.6	5673.0	598.6	S.S.
Natural females - natural males	6271.6	6502.2	230.6	N.S.
Natural females - castrate males	6271.6	5680.2	591.4	S.S.
Natural males - castrate males	6502.2	5680.2	822.0	S.S.
Natural males - castrate females	6502.2	5673.0	829.2	S.S.
Castrate males - castrate females	5680.2	5673.0	7.3	N.S.

ference of 309.9 grams significant when
" 437.3 " " "

case of muscle, there has also been a significant effect between different groups. The standard error per pig is 406.0 grams, or 8.1 per cent. of the mean, while the standard error of the sex means is 181.6 grams.

Table XVII shows that the inter-relationships between the various sexes differ somewhat from those for bone and muscle. While, as in the case of muscle, the mean for the natural males differs significantly at the 1 per cent point from those for castrate males and castrate females, neither the difference between the means of the natural females and castrate males or the difference between those of the natural females and castrate females is significant. It might be mentioned, however, that in the natural female - castrate female comparison, the difference between the means is very nearly large enough for significance at the 5 per cent. point. Again, while, as in the case of bone and muscle, the mean for the castrate males is not significantly different from that for castrate females, in the natural male - natural female comparison the difference is highly significant at the 1 per cent. point, although not as great as in the natural male - castrate male, or natural male - castrate female comparisons.

The data from the analysis of variance of skin weight is given in Table XVIII. The sex effect is again significant at the 1 per cent. point, the value of F in this case being more than five times that required for significance at this level. Again, also, there is a significant effect between groups. The standard error per pig is 50.0 grams or 5.8 per cent. of the mean, while the standard error of the sex means is 25.7 grams. From Table XIX it is apparent that the

TABLE XVI

ANALYSIS OF VARIANCE OF WEIGHT OF FAT - TOTAL LEG AND LOIN (Grams)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sex	3	10,213,395	3,404,465	20.65	3.59	6.22	S.S.
Group	4	5,382,016	1,245,504	7.56			
Error	11	1,813,099	164,827				
Total	18	17,408,510					

S.S. = Highly significant

TABLE XVII

TABLE OF SIGNIFICANCE: WEIGHT OF FAT - TOTAL LEG AND LOIN (Grams)

Comparisons	Respective Means		Difference between means	Level of Significance
Natural female-castrate female	5114.4	5676.0	561.6	N.S.
Natural female - natural male	5114.4	3821.8	1292.6	S.S.
Naturale female-castrate male	5114.4	5431.2	316.8	N.S.
Natural male-castrate male	3821.8	5676.0	1609.4	S.S.
Natural female - castrate female	3821.8	5676.0	1854.2	S.S.
Castrate male-castrate female	5431.2	5676.0	244.8	N.S.

Difference of 565.2 grams is significant when P = .05
" " 797.6 " " " " P = .01

TABLE XVIII

ANALYSIS OF VARIANCE OF WEIGHT OF SKIN - LEG AND LOIN (Grams)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F. value for comparison	F @ P = .05	F @ P = .01	
Sexes	3	292,890	97,630	34.73	3.59	6.22	S.S.
Groups	4	115,916	28,979	10.31	3.36	5.67	S.S.
Error	11	30,932	2,811				
Total	18	439,738					

TABLE XIX

TABLE OF SIGNIFICANCE: WEIGHT OF SKIN OF LEG AND LOIN (Grams)

Sexes compared	Respective means		Difference between means	Level of significance
Natural females - castrate females	823.0	835.8	12.8	
Natural females - natural males	823.0	1096.2	273.2	S.S.
Natural females - castrate males	833.0	797.0	36.0	N.S.
Natural males - castrate males	1096.2	797.0	299.2	S.S.
Natural males - castrate females	1096.2	835.8	260.0	S.S.
Castrate males - castrate females	797.0	835.8	38.8	N.S.

Difference of 73.8 grams between means is significant when P = .05
" " 104.2 " " " " " " P = .01

natural males differ significantly in respect to weight of skin from the remaining three sexes. The respective differences between the means in question are in each case more than twice the figure necessary for significance when P-= 0.01. In none of the other comparisons doethe differences approach significance even when P = 0.05.

The results relating to the development of bone muscle and fat in natural females and castrate males are supported by the findings of a number of workers. McMeekan (6) with English Large White pigs, showed that on the average gilts had less fat, more bone and more/lean than did hogs, and also that the magnitude of the differences in composition was dependent upon the form of the growth curve. It should be stressed that in his work, the animals were subject to complete laboratory dissection, and that consequently the possibility of error contingent upon the use of carcase measurements was avoided. Woodman, Evans, Callow and Wishart (8) measuring the per centage of lean in rashers from pigs of bacon weight, also demonstrated that gilts produced leaner carcases than hogs. Woodman, Evans and Turpitt (9) in the course of an investigation by means of balance trials into the utilisation of food protein found that gilts were characterised by a considerably higher level of nitrogen retention than barrows - this being the case even when the amount of protein fed to the barrows was considerably greater than that fed to the gilts. This evidence also indicates the greater leanness of gilts as compared with barrows. Hammond and Murray (7) working with various English breeds and using carcase measurements, showed that the carcase of the hog contained more fat than that of the gilt. Since the ratio of depth of fat at the shoulder to depth of fat at the loin was substantially similar in each case, they concluded that this was not merely a case of earlier maturity in one sex than in the other, and maintained that castration tends toward increased fat deposition in the body. Hammond and Murray (7) also report upon work carried out at Onderstepoort with Large White pigs in which the four sexes were involved. On the basis of back-fat thickness measurements made over the shoulder, loin, and rump, they found that castrate boars and sows were fatter than corresponding normal animals, and also that normal sows were fatter than normal boars. From their data the relative degree of fatness between castrate males and castrate females is not clear, as the castrate males had a greater thickness of fat over the shoulder and rump, but less thickness over the loin than did the castrate females. The results lend considerable support to the findings of this present investigation.

Further confirmation of the greater fatness of barrows, as compared with gilts, is afforded by Hanson and Bengtsson (37) and Bengtsson (36) with Swedish pigs; Axelsson (39) and Berge (20) with Large White and Landrace pigs; Murray (35) with Large Blacks in South Africa; Beck (38) with German breeds and Woodman et al (8) and Callow and Boaz (40) with Large White pigs. These findings were all on the basis of carcase measurements. Warner et al (10) working on the basis of cutting yields as a measure of relative fatness also showed that barrows were fatter than gilts.

Contrasted to the findings of the above workers, however, and those of the present investigation, are the results of Olsen and Bull (41) and also Mitchell, Card and Hamilton(13).

The former, who worked on the basis of cutting yields, found that hogs were only very slightly fatter than gilts and regarded this difference as insignificant. The latter workers estimated the fat content of these two sexes chemically and reported that there was no appreciable difference in the composition of the two sexes, the system of feeding being the same. They maintained that swine are to be clearly distinguished from cattle in this respect.

A certain amount of information concerning other species is available. With cattle, Foster and Miller (11) report that the carcasės of steers contain more bone, more lean, but less fat than heifer carcases. Gramlich and Thalman (12) support the conclusions of Foster and Miller regarding the relative fatness of heifers and steers and also report that spayed heifers are fatter than normal heifers. It appears that the difference between normal females and castrated males do not follow those obtained for swine.

With sheep, Hammond found that the muscle - bone ratio was greatest in wethers and least in rams, that for ewes, occupying an intermediate position. Wethers were fatter than ewes and ewes fatter than rams.

Although the results of Mitchell and Hamilton (42) Wilson and King and Morris (34) with rabbits, and Morris, Palmer and Kennedy (43) with rats, support the general conclusion that natural females are fatter than natural males; the two last-mentioned groups of workers produced evidence suggesting that natural females have a slightly heavier skeleton than natural males.

Summarising the position, it would appear that between species there are considerable differences in the relative composition of the various sexes. Castration, however, in all species appears to favour fat deposition at the expense of bone and muscle development. It is suggested that the opposing results obtained between certain species is due to characteristic differences in the magnitude rather than in the nature of the effect of castration in these species, and no doubt this latter is influenced to some extent by the age at which castration is carried out. Comparison of animals at different live weights and characterised by growth curves of different form may be a factor which has profoundly modified the results obtained.

3. EFFECT UPON ORGANS AND OFFALS.

The mean weights of the main group of body organs and offals are given in Table XX and those of the individual items in Table XXI. In both tables the proportionate development for the different sexes has been shown by expressing each of the respective means for the natural females, castrate females, and castrate males as a percentage of the mean of the natural males.

The differences apparent in the weight of the body organs and offals may be largely explained by the differential effect of sex upon early and late developing parts. McMeekan (4) has shown that of the organs, the skin and hair, and the blood behave as early, and abdominal organs, as late, developing parts, while the thoracic organs occupy an intermediate position.

TABLE XX

EFFECT OF SEX UPON DEVELOPMENT OF ORGANS[ø]

	Mean Weight of Part				Proportion: Natural male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Skin, Hair, hoofs & Blood	3508	3527	3751	3382	93.5	94.0	100	90.2
Thoracic organs	1769	1830	1833	1797	96.5	99.9	100	98.2
Abdominal organs:								
(a) Alimentary Tract	3258	3522	2865	3184	113.7	122.9	100	111.1
(b) Remainder	6614	7459	6475	6946	102.1	115.2	100	107.3
Total Abdominal	9872	10981	9340	10130	105.7	117.6	100	108.4
TOTAL ORGANS:	15149	16338	14924	15309	101.5	109.5	100	102.6

[ø] Including other parts removed as offals.

Including all parts removed during dressing, except genital organs.

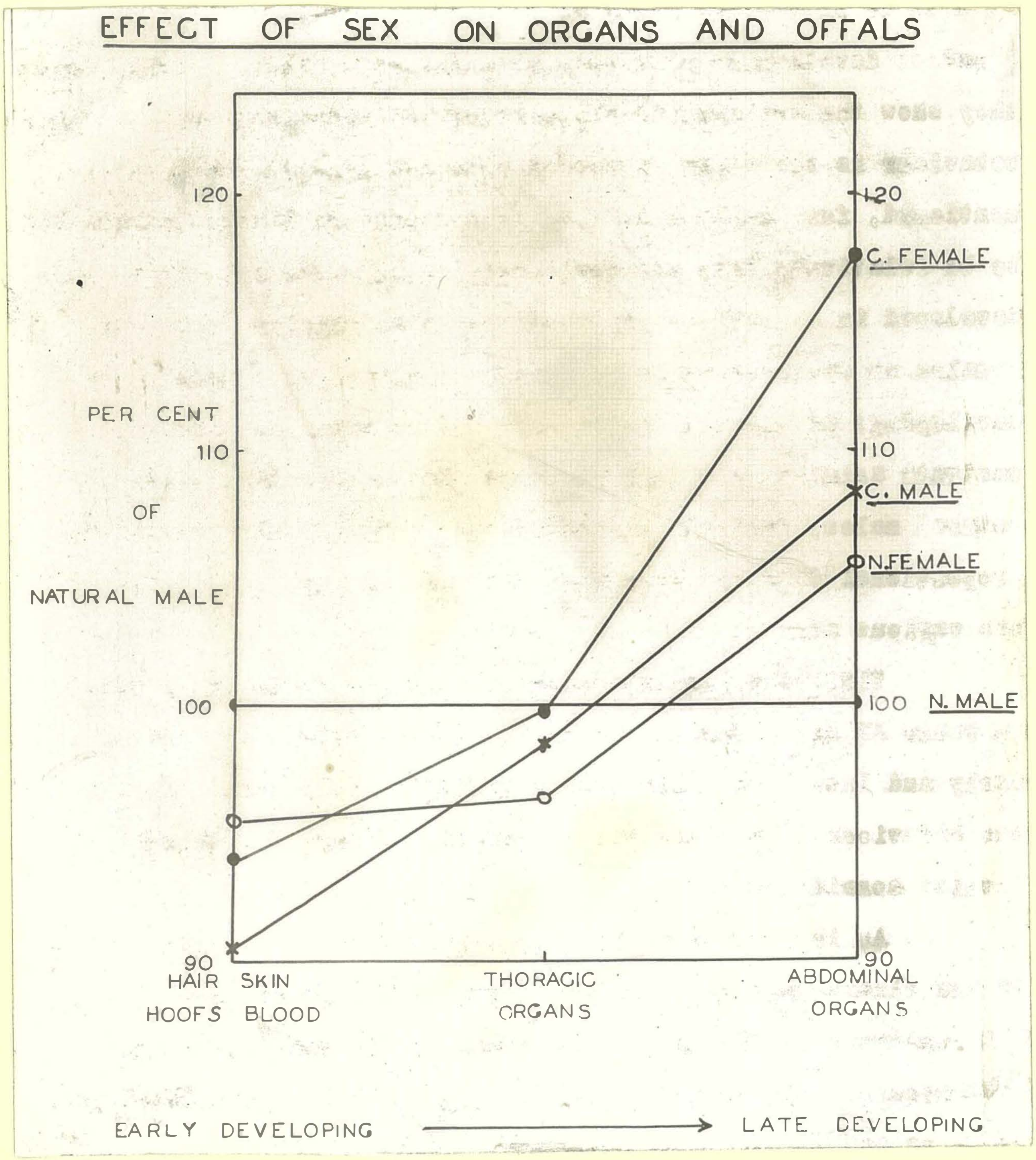

EFFECT OF SEX ON ORGANS AND OFFALS
PER CENT OF NATURAL MALE
120
110
100
90
C. FEMALE
C. MALE
N.FEMALE
N. MALE
HAIR SKIN HOOFS BLOOD
THORACIC ORGANS
ABDOMINAL ORGANS
EARLY DEVELOPING
LATE DEVELOPING

FIG. VII.

It will be noted from Table XX that while natural males show the greatest development of blood, skin and hair, and thoracic organs, they show the smallest development of the abdominal organs. This behaviour is therefore in accord with the general trend already mentioned, for the late developing regions and tissues of the body to be relatively less and early developing parts relatively more developed in natural males than in natural females, castrate females or castrate males. That the abdominal organs (Late developing) of natural females are not so heavy as those of the castrate animals, although considerably heavier than those of natural males, follows expectations. Fig. VII illustrates the proportional development of the different groups of organs of the various sexes.

While the proportionate figures for the major groups in Table XX can be explained by the differential response of early and late developing organs in differently sexed animals, the behaviour of certain of the individual organs requires special consideration.

An inspection of Table XXI shows that the behaviour of the bladder, kidneys, spleen, pancreas and psoas muscle is not consistent with that of the remaining items in the abdominal group. However, although included in the late developing group on account of their anatomical position in the body, these are relatively early developing organs (McMeekan - 4) and have merely behaved in the manner expected of such, being well developed in the boar and less well developed in entire females, spayed females and barrows. The fact that the mean weight of the pancreas is greatest in the boar animals which had the lowest level of food intake (Table XXV) is interesting in view of

TABLE XXI

EFFECT OF SEX UPON DEVELOPMENT OF INDIVIDUAL ORGANS

	Mean Weights				Proportion : Natural male = 100			
	N.F.	C.F.	N:M.	C.M.	N.F.	C.F.	N.M.	C.M.
Hoofs	48	44	61	47	78.7	72.1	100	77.0
Hair & Skin	324	341	372	317	87.1	91.6	100	85.2
Blood	3136	3142	3318	3017	94.5	94.7	100	90.9
Thoracic Organs:								
Neck Thymus	58	53	57	55	101.7	93.0	100	96.4
Heart Thymus	29	26	29	27	100.0	89.7	100	93.1
Lungs & Trachea	642	712	695	654	92.4	102.4	100	91.7
Heart	253	256	278	255	91.0	92.1	100	91.7
Blood vessels & Pericardium	352	325	317	387	111.0	102.5	100	122.1
Diaphragm	433	457	456	419	95.0	100.2	100	91.9
Oesophagus	74	78	90	76	82.2	86.6	100	84.4
Stomach	606	642	622	594	97.4	103.2	100	95.5
Abdominal Organs;								
Small Intestine	1459	1488	1164	1377	125.3	127.8	100	118.3
Rectum	179	196	176	180	101.7	111.4	100	102.3
Large Intestine	767	946	665	787	115.3	142.3	100	118.3
Caecum	173	171	148	170	116.9	115.5	100	114.9
Kidney & leaf fat	2161	2712	2136	2660	101.2	127.0	100	124.5
Psoas (major Plus minor)	604	572	632	571	95.6	90.4	100	90.3
Pancreas	107	106	108	99	99.1	98.1	100	91.7
Liver	1785	1839	1488	1580	123.3	127.0	100	106.2
Spleen	92	89	100	86	92.0	89.0	100	86.0
Caul fat	231	306	221	258	104.5	138.4	100	116.7
Mesentery & Fat	1251	1435	1292	1293	96.8	111.1	100	100.1
Bladder	60	64	70	57	85.7	91.4	100	81.4
Gall Bladder	61	43	93	78	65.6	46.2	100	83.9
Reproductive Organs;								
Testis - Right	-	-	223					
Left			250					
Penis			299	117			100	39.1
Vesiculae Seminals			144					
Cowpers Gland			147	2.6			100	1.8
Uterus & Vagina	480.6	39.5	-	-	100	8.2		
Ovaries	10.5							

T

McMeekan's (6) suggestion that the size of this gland may be increased by a high plane of nutrition.

The relative development of the psoas muscles in the four sexes is similar to that for muscle in the leg and loin, these muscles being heaviest in the natural males, followed by the natural females, while their weight is very nearly the same in castrate males and castrate females. This greater development of the psoas in gilts than in barrows is in accordiwith the finding of Woodman et al (8). The effect of sex upon kidney weight is in accord with, though greater than, could be expected from, the early developing nature of the organ. In view of the generally accepted opinion (Woodman et al -(8), Emmet and Grindley - (32), McMeekan (5)-) that kidney weight is largely influenced by the quantitative level of protein intake, the data relating to the kidneys is particularly interesting. Though treatment by Fisher's analysis of variance shows that the greater kidney weight of the natural males is strongly significant at the 1 per cent point (Table XXII and XXIII) the level of protein intake of these animals was significantly lower than in the other sexes (Table XXIV and XXV) While the mean kidney weights of the normal females and the castrate animals do not differ significantly (Table XXIII) it is noteworthy that the castrate females, which were characterised by a higher weekly consumption of food (Table XXV) than either natural females or castrate males, have ~~a~~ greater mean kidney weight than these latter. In the case of the natural females as compared with

TABLE XXII

ANALYSIS OF VARIANCE OF WEIGHT OF KIDNEYS (Grams)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P=.05	F @ P = 0.01	
Sexes	3	18,175	6,055	9.51	3.59	6.22	S.S
Groups	4	688	172	0.27	3.36	5.67	
Error	11	7,009	637				
Total	18	25,872					

S.S. Highly significant
N.S. Not significant

TABLE XXXIII

TABLE OF SIGNIFICANCE - WEIGHT OF KIDNEYS (Grams)

Sexes compared	Respective means		Difference between means	Level of Significanc
Natural females - castrate females	261.4	292.2	30.8	N.S.
Natural females - natural males	261.4	335.8	74.4	S.S.
Natural females - castrate males	261.4	263.0	1.4	N.S.
Natural males - castrate males	335.8	263.0	72.8	S.S.
Natural males - castrate females	335.8	292.2	43.6	S.
castrate males - castrate females	263.0	292.2	29.2	N.S.

Difference of 35.1 grams between means significant when P = .05
" " 49.6 " " " " " P = .01

TABLE XXIV

ANALYSIS OF VARIANCE - MEAN WEEKLY CONSUMPTION OF MEAL EQUIVALENT UNITS - Live-Weight range 70-80 lbs to 200-210 lbs.

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F at P = .05	F at P = .01	
Sexes	3	122.07	40.69	8.15			S.S.
Groups	4	110.27	27.57	5.53			
Error	11	54.87	4.99				
Total	18	287.21					

S.S. Highly significant

TABLE XXV

TABLE OF SIGNIFICANCE - MEAN WEEKLY CONSUMPTION OF MEAL EQUIVALENT. Live-Weight range of 70-80 lbs to 200-210 lbs.

Comparison	Respective Means		Difference between means	Level of Significance
Natural female-castrate females	33.00	34.90	1.90	N.S.
Natural females - natural males	33.00	28.02	4.98	S.S.
Natural females-castrate males	33.00	33.02	0.02	N.S.
Natural males - castrate males	28.02	33.02	5.00	S.S.
Natural males - castrate females	28.02	34.90	6.88	S.S.
Castrate males - castrate females	33.02	34.90	1.88	N.S.

Difference of 3.25 units between means is significant when P = .05

Difference of 4.58 units between means is significant when P= .01

the castrate males - sexes in which the mean weekly food consumption was much the same, the respective mean kidney weights approximate very closely. The differential response of the liver between sexes, also, has not been in accord with the expectations of an early developing organ. Its relative development in the four sexes may, however, be explained upon the basis of its glycogenic function for its weight has increased in the four sexes according to increases in food consumption (Table XXV). Increase in the quantitative level of nutrition has no doubt increased the amount of work to be performed by the liver , both in the manufacture of glycogen and in deamination of surplus protein. McMeekan (5) obtained a significant functional response in the case of the liver to variation in both the quantitative and protein plane of nutrition.

The statistical relationships for the weight of the alimentary tract (exclusive of the oesophagus) are presented in Table XXVI (Analysis of variance) and Table XXVII (Table of significance). It is apparent that the difference between the mean weights for the natural males and castrate females is statistically significant at the 5 per cent. point. The fact that significance has not been established between the mean weights for the other sexes does not imply that the differences between these are not real. As in the case of liver weight, the divergencies in alimentary tract weight probably rest upon a functional basis, for the order of the sexes for increasing tract weight is the same as for increasing food consumption - namely natural males, castrate males, natural females, and castrate females (Tables XXIV and XXV) and it

TABLE XXVI

ANALYSIS OF VARIANCE OF WEIGHT OF ALIMENTARY TRACT (1 unit = 10 gram)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = 0.05	F @ P = 0.01	
Sexes	3	7,085	2,361.7	4.37	3.59	6.22	S
Groups	4	15,363	3,840.8	7.10	3.36	5.67	SS
Error	11	5,949	540.8				
Total	18						

S. = Significant
S.S. = Highly significant

TABLE XXVII

TABLE OF SIGNIFICANCE : WEIGHT OF ALIMENTARY TRACT (1 unit = 10 grams)

Sexes Compared	Respective means		Difference between means	Level of Significance
Natural females - castrate females	325.8	352.4	26.6	N.S.
Natural females - natural males	325.8	300.0	25.8	N.S.
Natural females - castratemales	325.8	318.4	7.4	N.S.
Natural males - castrate males	300.0	318.4	18.4	N.S.
Natural males castratefemales	300.0	352.4	52.4	S.
Castrate males - castrate females	318.4	352.4	34.0	S.

Difference of 31.1 units between means is significant when P = .05

would appear natural to expect the greatest development of the alimentary tract in animals ingesting the greatest amount of food. The mean lengths of the small intesting, large intestine, caecum and rectum for the four sexes are shown in Table XXX, Though the differences are not great, they follow the proportionate differences in the weight of the tract, for the mean total length is greatest for the castrate females and least for the natural males.

Consideration of the proportionate figures in Table XXI, relating to the caul, and the kidney and leaf fat, reveals the comparatively large differential response for internal fat development in differently sexed animals. On analysis of the variance of the combined weights of these two items, the influence of sex was found to be significant at the 1 per cent. point (Table XXVIII). The significance of the differences between the sex means has been tested in Table XXIX.In four out of the six possible comparisons significance was established, both natural males and natural females having significantly less internal fat than either of the castrate types. Sex therefore has influenced internal fat development in the same direction as it did the fat of the carcase.

These results are in accord with the findings of Woodman et al (8) who showed that barrows possessed heavier flares than gilts.

The large progressive increase in the weight of the gall bladders (including contents) derived from spayed sows, nowmal sows, barrows and boars is shown in Table XXI. This follows the order of slaughter, and it would appear that the gall bladder content is directly dependant upon the length of the interval over which an animal fasts. The discharge of the'bile from the bladder is known to be

TABLE XXI

EFFECT OF SEX UPON LENGTH OF ALIMENTARY TRACT.

	Mean Length (cm.)				Proportion: Natural male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Small intestine	1956	2017	1951	1980	100.3	103.4	100	101.5
Large intestine	399	394	351	367	113.6	112.2	100	104.5
Caecum	25	23	24	26	104.2	95.9	100	108.4
Rectum	107	89	85	94	125.9	104.9	100	110.6
Total length	2487	2523	2411	2467	103.2	104.6	100	102.3

TABLE XXVIII

ANALYSIS OF VARIANCE OF WEIGHT OF INTERNAL FAT (Grams) (Flane and Kidney fat plus Caul fat)

Component	Degrees of Freedom	Sum of Square	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sexes	3	2,174,509	724,836	8.20	3.59	6.22	S.S
Groups	4	979,015	244,754	2.77	3.36	5.67	N.S
Error	11	971,861	88,351				
Total	18	4,125,385					

S.S. = Highly significant

TABLE XXIX

TABLE OF SIGNIFICANCE - WEIGHT OF INTERNAL FAT (Grams) (Flane and Kidney fat plus Caul fat)

Sexes Compared	Respective means		Difference between means	Level of Significance
Natural females - castrate females	2391.8	3018.2	626.4	S.S.
Natural females - natural males	2391.8	2249.2	142.6	N.S.
Natural females-castrate males	2391.8	2918.6	626.8	S.S.
Natural males - castrate males	2249.2	2918.6	669.4	S.S.
Natural males - castrate females	2249.2	3018.2	769;0	S.S.
Castrate males - castrate females	2918.6	3018.2	99.6	N.S.

Difference of 413.7 grams between means is significant when P = 0.05
" " 583.8 " " " " " " P = 0.01

stimulated by the passage of food from the stomach to the small intestine.

Castration in both sexes has greatly reduced the size of the reproductive organs. In the barrow, both the seminal vesicles and Cowpers gland have been reduced to vestigal proportions, while the penis has attained only 39 per cent. (Table XXI) of the weight of this organ in the boar. A further point of interest is that the mean weight of the left testis is considerably greater than that of the right. This was consistently the case for each of the four boars and is in accord with the results of McKenzie et al (31) who found that in seven of nine boars the left testis was the heavier. In the spayed sows the mean weight of the uterus and vagina was but 8.2 per cent of the weight of these parts in normal females.

4. EFFECT OF SEX UPON TISSUES IN LOIN AND LEG.

As yet, the relative development of bone, muscle and fat in the differently sexed animals has been discussed only in relation to the total weight of each of these tissues contained in the leg and loin joints considered together. Attention will now be given to the relative magnitude of the sex effects upon bone, muscle and fat in the leg as compared with the loin. Sex differences in bone form, as opposed merely to those in bone weight, and the relative response in the different sexes of subcutaneous and intermuscular fat as opposed to that of total fat will also be given attention.

(a) Effect upon Bone.

The mean weights of the various skeletal units and their proportional development in the four sexes (natural male as standard) are given in Table XXXI.

It is apparent that the order of the sexes for increasing bone weight is, in general, the same for the separate skeletal units as for the total amount of this tissue in the hind limb and loin, this order being castrate females, castrate males, natural females and natural males. The most obvious exception is the lumbar vertibrae, where the order of the castrates is reversed. These are the two sexes, however, which have been shown to approach each other very closely in body composition, and the difference in question is only of the order of 6 grams.

In order to show that sex has affected the separate bones in a similar manner to the combined skeletal weights of the leg and loin, the variance of the femur weights has been analysed (Table XXII) . The influence of sex is significant at the 5 per cent. point. The standard error per pig is 16.5 grams of 6.5 per cent of the mean, while the standard error of the sex means is 7.4 grams. The level of significance of the differences between the sex means is shown in Table XXXIII. The mean for the natural males differs significantly at the 5 per cent point from that of either the castrate males or the castrate females, and the mean of the normal females from that of the castrate females. The means of the natural females and castrate males, although not significantly different, are very nearly so. These results

TABLE XXXI

EFFECT OF SEX UPON DEVELOPMENT OF BONE

	Mean weight (Grams)				Proportion : Natural Male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Loin								
Vertebrae	343.0	312.8	344.3	306.4	99.6	90.9	100	89.0
Hind Limbs								
Femur	261.6	237.0	267.3	239.2	97.9	88.7	100	89.5
Patella	14.6	12.1	16.6	13.5	88.0	72.9	100	81.3
Tibia-Fibula	176.0	157.4	184.3	167.2	95.5	85.4	100	90.7
Astragalus	30.2	29.3	32.9	30.1	91.8	89.1	100	91.5
Coleaneum	36.6	34.7	40.8	36.1	89.7	85.0	100	88,5
Tarsals	26.1	25.3	30.1	28.0	86.7	84.1	100	93.0
Splints	10.8	10.0	12.0	10.5	90.0	83.3	100	87.5
Cannon	51.5	49.5	55.8	50.7	92.3	88.7	100	90.9
TOTAL LEG:	607.4	555.3	639.8	575.3	94.9	86.8	100	89.9
Dew Claws	9.6	10.0	11.7	9.8	82.1	85.5	100	83.8
Pasterns	22.7	21.8	25.0	21.9	90.8	87.2	100	87.6
Coronets	13.9	13.8	15.2	13.5	91.4	90.8	100	88.8
Naviculars and Sess.	4.9	4.4	5.5	4.5	89.1	80.0	100	81.8
Pedals	7.9	7.5	9.7	8.0	81.4	77.3	100	82.5
TOTAL FOOT:	59.0	57.5	67.1	57.7	87.9	85.7	100	86.0

TABLE XXXII

ANALYSIS OF VARIANCE OF WEIGHT OF FEMURS (Grams)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F at P = .05	F at P = .01	
Sexes	3	3989.9	1329.7	4.86	3.59	6.22	S
Groups	4	3203.3	800.8	2.92	3.36		N.S.
Error	11	3011.5	273.8				
Total	18	10203.8					

S =-Significant
N.S.= Non significant

TABLE XXXIII

TABLE OF SIGNIFICANCE - FEMUR WEIGHT

Sexes Compared	Respective Means		Difference Between means	Level of Significance
Natural females - castrate females	261.6	237.0	24.6	S
Natural females - natural males	261.6	269.8	8.2	N.S.
Natural females- castrate males	261.6	239.2	22.4	N.S.
Natural males - castrate males	269.8	239.2	30.6	S.
Natural males - castrate females	269.8	237.0	32.8	S.
Castrate males - castrate females	239.2	237.0	2.2	N.S.

Difference of 23.0 grams is significant when F = .05

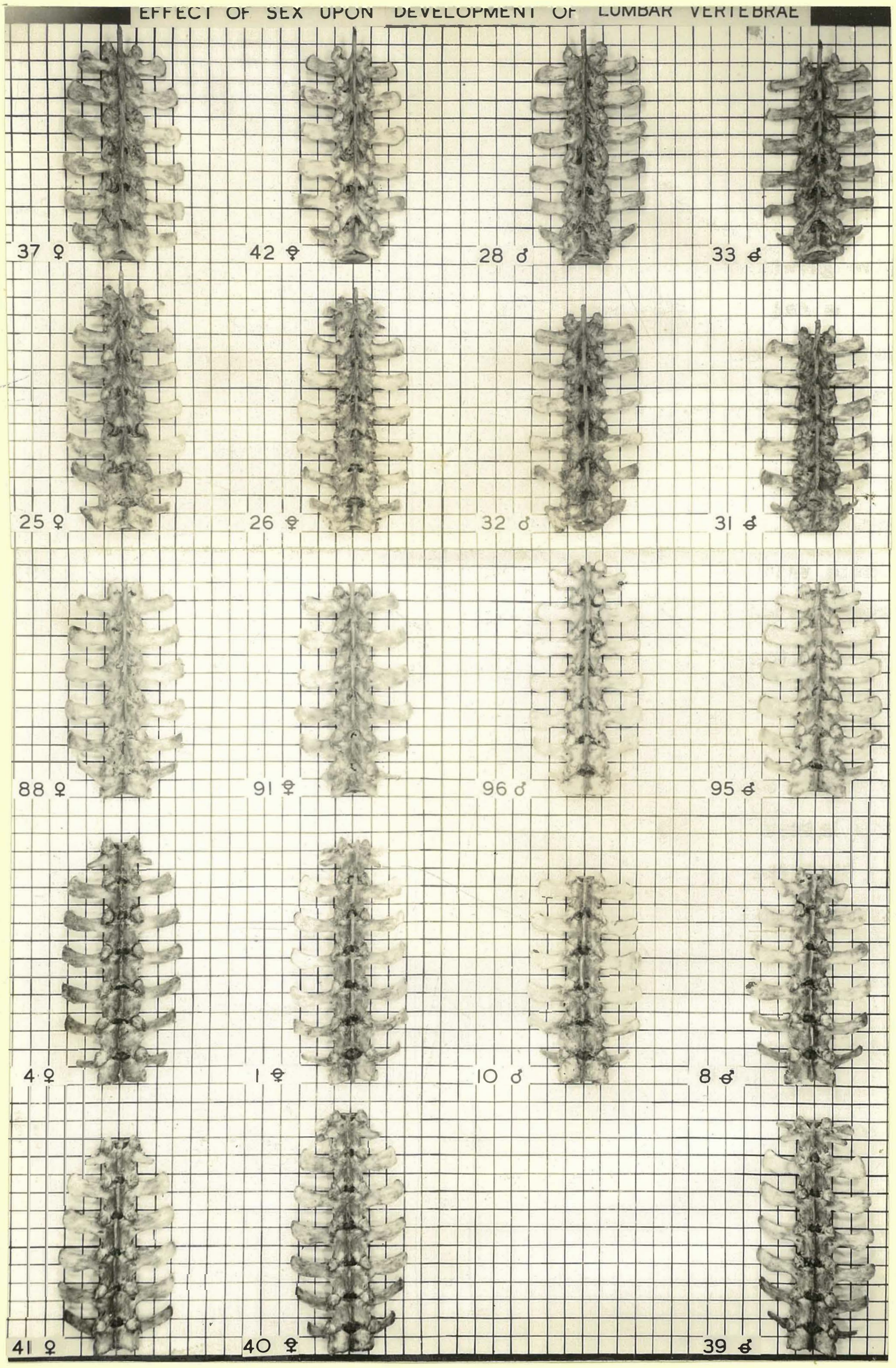

EFFECT OF SEX UPON DEVELOPMENT OF LUMBAR VERTEBRAE
37 ♀
42 ♀̶
28 ♂
33 ♂̶
25 ♀
26 ♀̶
32 ♂
31 ♂̶
88 ♀
91 ♀̶
96 ♂
95 ♂̶
4 ♀
1 ♀̶
10 ♂
8 ♂̶
41 ♀
40 ♀̶
39 ♂̶

PLATE V.

are thus in general accord with those in Table XIII.

The depressing effect of the sex glands upon the relative growth of later developing parts is clearly indicated again in the data of Table XXXI. The skeletal units of the leg and loin have been shown to exhibit a well defined growth gradient from foot to loin (McMeekan -4). In each sex, castration has resulted in a proportionately greater effect upon the earlier developing skeletal units, or alternatively, a smaller relative effect upon late developing units. Even within the entire female this phenomenon and the existence of this gradient is demonstrated by the greater effect upon the bones of the lower leg than upon the upper leg. Thus the bones of the foot are 12.1 per cent lighter, the cannon, 7.7 per cent, the tibia-, fibula 4.5 per cent., the femur 2.1 per cent. and the lumbar vertebrae 0.4 per cent lighter than in the natural male. This latter picture supports the suggestion previously advanced that the male sex glands exert a more powerful depressing effect upon the relative growth of late developing units than do the female glands.

Plates V, VI, VII and VIII show the effect of sex upon the form and size of three typical bones of the hind limbs, namely the femur, tibia-fibula and cannon, and also the lumbar vertebrae. Bones derived from every pig slaughtered are shown in each plate, these being arranged according to the group and sex.

From Plate V it will be observed that the lumbar column is a most unsuitable skeletal unit for determining the effect of sex upon the development of bone, since of the nineteen loin bones, eight have seven vertebrae and eleven have six. Only in the case of the first group of pigs was the vertebrae number constant. Plate V emphasises the desirability of reducing the data relating to the loin to a six vertebrae basis. It is noteworthy that there is a great deal of variation in the form of the first and also the last lumbar vertebra.

The best examples of peculiarity in the form of the last vertebrae may be seen in Pigs Nos. 25 and 26. In each of these animals their vertebra extended partly into the sacral region, and firmly fused with the pelvis. In the case of the first vertebra, the variation is particularly apparent in loin bones containing seven vertebrae, as in Pigs Nos. 25, 26, 1 and 39, for in these the first segment has two pairs of comparatively small transverse processes instead of the usual one pair. In Pig No.96, although the loin bone has seven segments, the form of the first vertebra is quite typical, while in Pig No. 41, which has a loin bone of sex segments, the form is considerably modified.

A particularly interesting question is the relation of rib number to the number of vertebrae in the lumbar region. McMeekan (6) has mentioned how pig breeders have long been interested in improving carcase length by increasing the number of ribs and that considerable success has been achieved along these lines. He has also pointed out that this breeding practice is undesirable from a carcase quality point of view if it results in a reduction in the number of vertebrae in the lumbar column. That a large rib number is associated with a small number of vertebrae in the loin region is suggested by the present data. Of the nineteen pigs used in the investigation, eleven had fourteen pairs of ribs/and the other eight had fifteen pairs. Of the eleven possessing fourteen pairs, eight had lumbar columns containing seven vertebrae, while all the animals with the greater number of ribs had only six lumbar vertebrae.

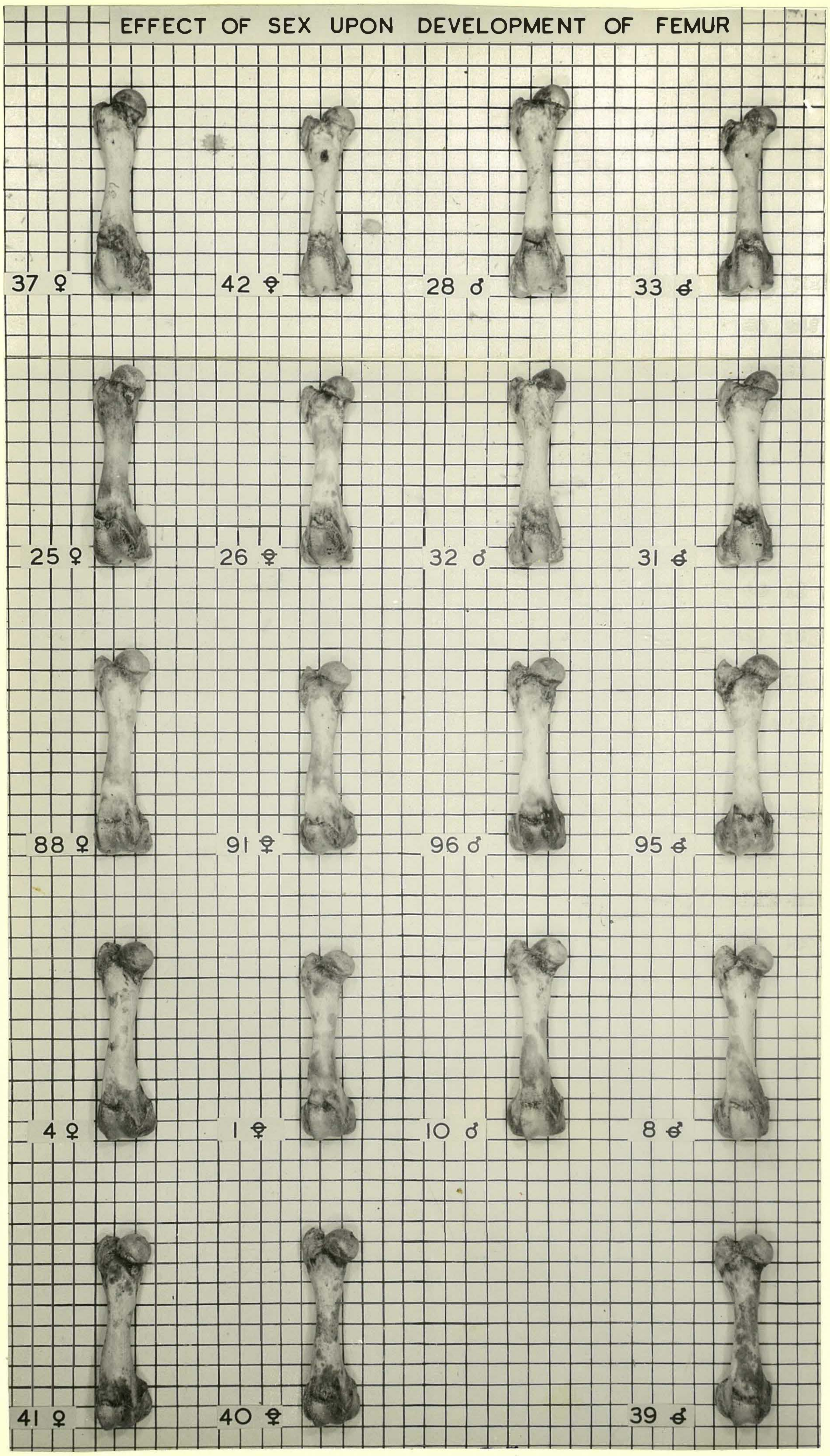

EFFECT OF SEX UPON DEVELOPMENT OF FEMUR
37 ♀
42 ♀̵
28 ♂
33 ♂̵
25 ♀
26 ♀̵
32 ♂
31 ♂̵
88 ♀
91 ♀̵
96 ♂
95 ♂̵
4 ♀
1 ♀̵
10 ♂
8 ♂̵
41 ♀
40 ♀̵
39 ♂̵

PLATE VI.

In Plate VI, the femurs are shown and in these the modifying influence of sex is much more clearly evident than in the case of the lumbar vertebrae. It is noticeable that the femur of the natural female is longer than that of the castrate male in all groups, and longer than that of the castrate female in all groups except in the case of pigs Nos. 41 and 40. Here the difference in favour of the castrate females is very slight. Note also that the femur of the natural male is, in each group, longer than that of the castrate female and longer than that of the castrate male in three out of the four comparisons. There is very little difference between the respective lengths for the castrate or for the entire sexes. Plate VI also shows that the bones of castrates are considerably more slender than those of entire animals.

Plates VII and VIII show the effect of sex upon the tibia-fibula and cannon respectively. Differences may be observed similar to those discussed in connection with the femur.

In order to gain more precise knowledge of the effect of sex upon bone form, the length of each femur, tibia-fibula, and cannon was measured. The data relating to the weight, length and thickness (weight/length) of these bones are presented in Table XXXIV.

It is apparent that the natural males have not only the heaviest, but also the longest and thickest bones, while the castrate females have the lightest, shortest, and thinnest. The entire females occupy a position intermediate between these two extremes, while the castrate males resemble the castrate females very closely indeed, both in respect of length and

EFFECT OF SEX UPON DEVELOPMENT OF TIBIA-FIBULA

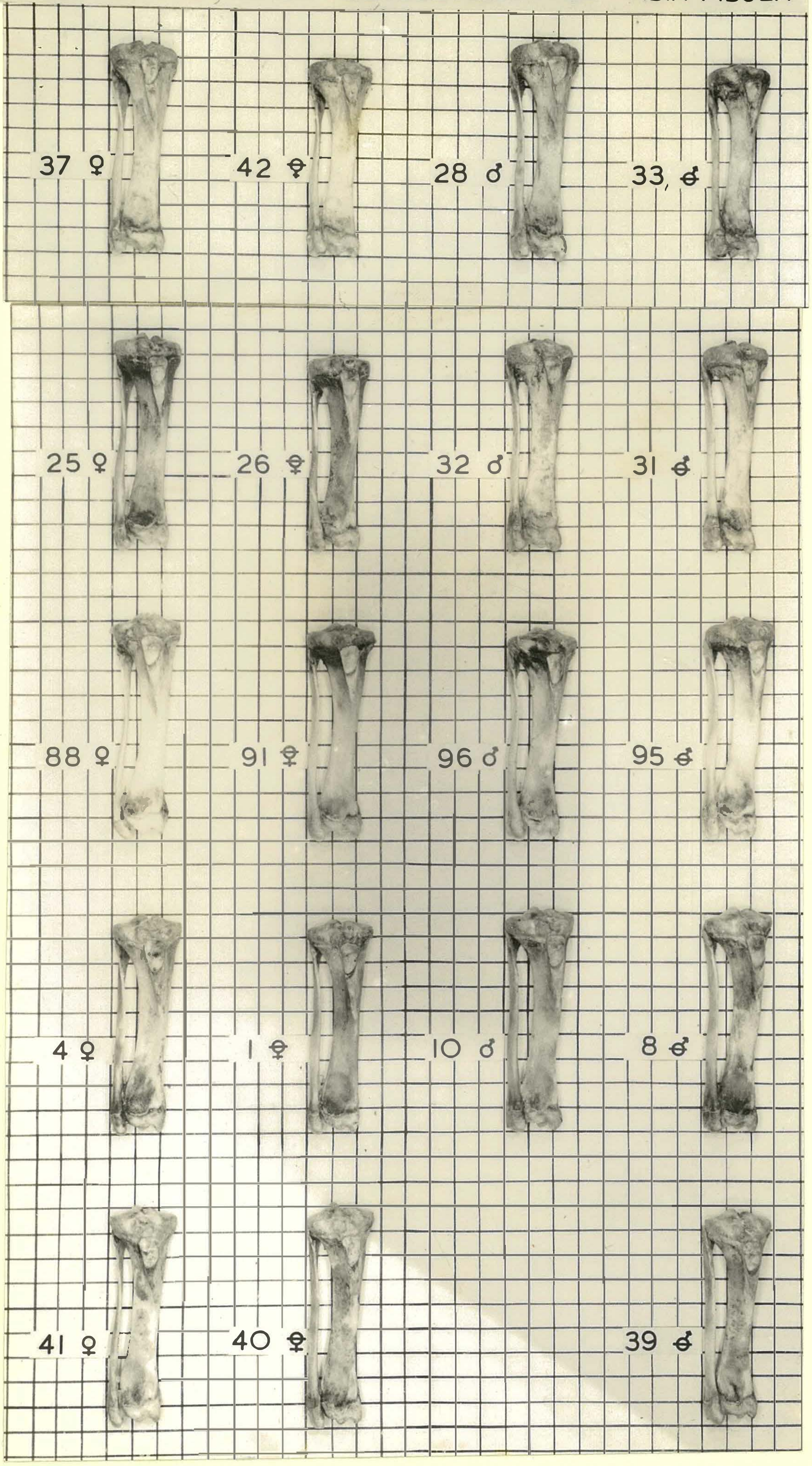


PLATE VII.

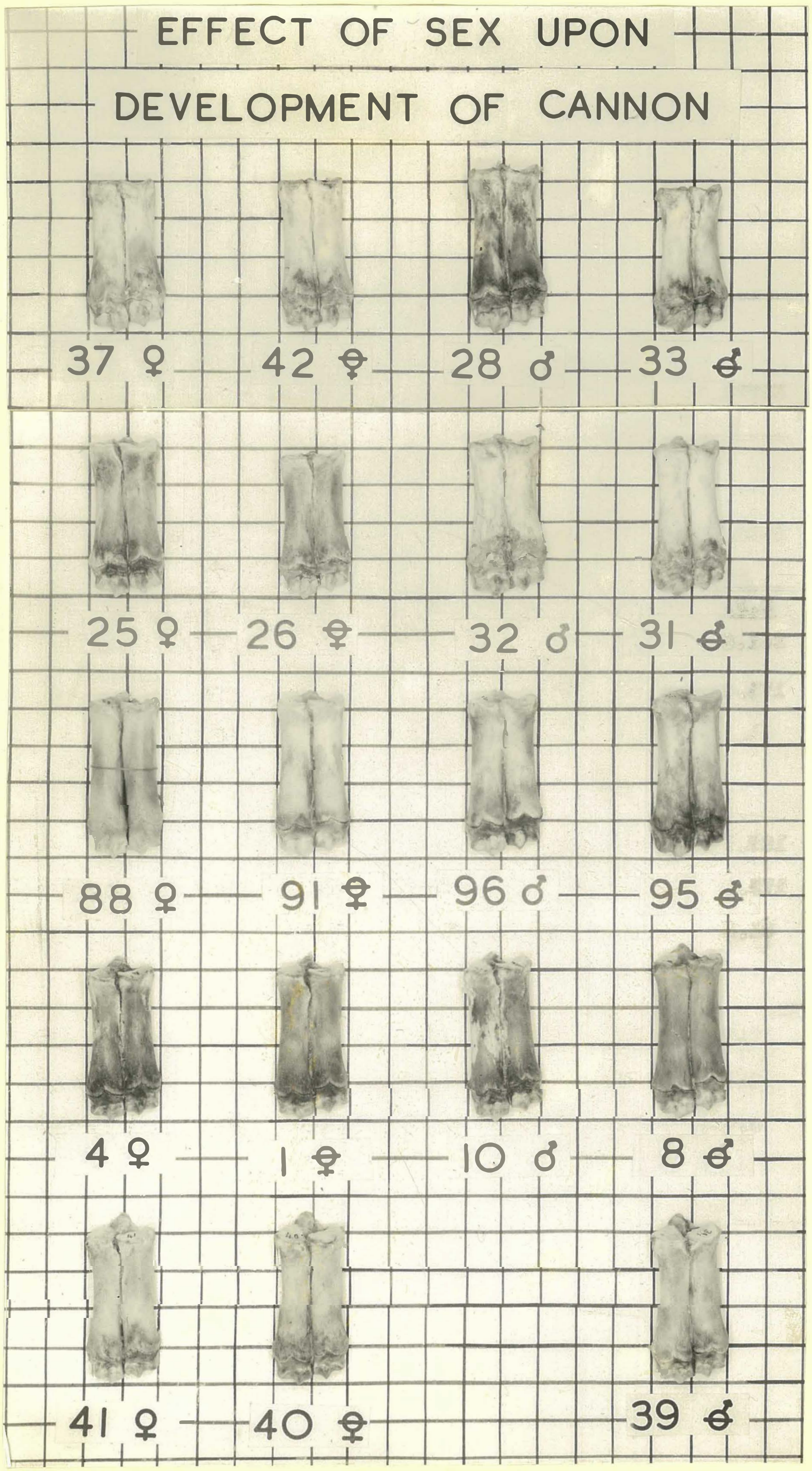

EFFECT OF SEX UPON
DEVELOPMENT OF CANNON
37 ♀
42 ♀̶
28 ♂
33 ♂̶
25 ♀
26 ♀̶
32 ♂
31 ♂̶
88 ♀
91 ♀̶
96 ♂
95 ♂̶
4 ♀
1 ♀̶
10 ♂
8 ♂̶
41 ♀
40 ♀̶
39 ♂̶

PLATE VIII.

TABLE XXXIV

EFFEX OF SEX UPON WEIGHT AND FORM OF FEMUR, TIBIA-FIBULA and CANNON

	Mean (Weight in Grams: Length in m.m.)				Proportion: Natural Male = 100			
WEIGHT:	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Femur	261.6	237.0	267. 3	239.2	97.9	88.7	100	89.5
Tibia	176.0	157.4	184.3	167.2	95.5	85.4	100	90.7
Cannon	51.5	49.5	55.8	50.7	92.3	88.7	100	90.9
LENGTH :								
Femur	188.9	180.9	188.3	181.5	100.3	96.1	100	96.4
Tibia	173.5	167.7	174.0	171.0	99.7	96.4	100	98.3
Cannon	81.2	80.9	841	82.6	91.6	96.2	100	98.2
WEIGHT/ LENGTH								
Femur	1.385	1.310	1.420	1.318	97.6	92.3	100	92.8
Tibia	1.014	0.939	1.059	0.978	95. 8	88.7	100	87.6
Cannon	0.636	0.612	0.663	0.614	95.9	92.3	100	92.6

TABLE XXXV

ANALYSIS OF VARIANCE OF LENGTH OF FEMUR (Millimetres)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = 0.05	
Sexes	3	326.8	108.9	3.45	3.59	N.S.
Groups	4	262,7	65.7			
Error	11	341.7	31.6			
Total	18	931.2				

N.S. = Not significant

thickness of bone. It is noteworthy that the influence of castration has been greater in respect to thickness growth than length growth. Since growth in length is relatively earlier developing than growth in thickness (Hammond -(3), McMeekan - (4) Pálsson (56), this is a reasonable expectation for it is analogous to the situation existing in respect to the tissues. It will be remembered that there was a greater proportionate difference between the various sexes in the case of fat (late developing) than in the case of bone and muscle (early developing).

The data relating to femur length has been subject to analysis of variance and the results are given in Table XXXV It will be observed that the F value for the sex component is not quite great enough to allow significance to be established at the 5 per cent point.

(b) Effect Upon Muscle.

In Table XXXVI the amount of muscle tissue in the leg and loin is shown for the various sexes both upon the basis of mean and relative weight.

In the case of both joints, the natural males have the most muscle, with the natural females having slightly less. The two castrate sexes have approximately the same amount, but considerably less than the natural sexes. Note from the proportionate figures in Table XXXVI that in castrate males and females, as compared with natural males, the earliest developing leg muscle has been affected to a greater extent than the late developing loin muscle, although the difference is small.

The growth of late developing parts and tissues is encouraged in castrate animals, and on this account the decline with age in the intensity of growth of early developing parts will be greater in them than in natural animals.

TABLE XXXVI

EFFECT OF SEX UPON DEVELOPMENT OF MUSCLE.

	Mean Weight (Grams)				Proportion: Natural male = 100			
Sex	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Loin	2932	2755	3022	2721	97.0	91.2	100	90.0
Leg	3339	2918	3442	2959	97.0	84.8	100	86.0

TABLE XXXVII

EFFECT OF SEX UPON DEVELOPMENT OF FOOT

	Mean weight (Grams)				Proportion : Natural male = 100			
Sex:	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
Loin								
Subcutaneous	2828.0	3260	2139	3077	132.2	152.4	100	140.6
Intermuscular	674	730	652	762	103.4	112.0	100	116.9
Total:	3502	3990	2791	2839	125.5	143.0	100	137.6
Leg								
Subcutaneous	1410	1458	963	1363	146.4	151.4	100	141.6
Intermuscular	203	228	195	230	104.1	116.9	100	117.9
Total:	1613	1686	1158	1593	139.3	145.6	100	137.6
TOTAL:	5115	5676	3949	5432				

(c) Effect upon Fat.

The effect of sex upon the amount of subcutaneous, intermuscular, and total fat for each of the joints is shown in Table XXXVII.

It will be observed that the subcutaneous fat has been influenced by sex to a much greater extent than has the intermuscular fat, although both types have been affected in a similar direction. The relative increase with age of subcutaneous fat is greater than it is with true intermuscular fat (McMeekan - (4) -) so that the sex differences have again been greatest in respect to the later, rather than the earlier developing tissue.

5. EFFECT OF SEX UPON CARCASE MEASUREMENTS

The data relating to internal carcase measurements are presented in Table XXXVIII (Back fat and belly thickness and measurements) and Table XXXIV (loin cut measurements).

From Table XXVIII, it may be seen that the mean belly thickness of the entire and castrate females is approximately the same, and greater than that of the entire or castrate males. Hammond and Murray (7), report that the presence of the ovaries in the sow tends to thicken the mammary gland region, and found that entire females had the thickest belly, followed, in order, by castrate females, castrate males and entire males. Little reliability is attached to the streak data owing to the small number of animals upon which the present results are based, the difficulty in accurately deter-

TABLE XXXVIII

EFFECT OF SEX UPON BACK FAT AND BELLY THICKNESS.

	Mean Measurements (mms)				Proportion; Natural Male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
SHOULDER FAT:								
Inner	26.7	33.4	29.8	37.2	89.5	112.1	100	124.6
Outer	12.3	13.1	9;2	11.5	133.7	142.4	100	12550
Total:	39.0	46.5	39.0	48.7	100.0	119.2	100	124.9
LOIN FAT:								
Inner	13.8	18.5	14.0	2118.	98.5	132.1	100	152.1
Outer	9.3	11.9	7.3	7.8	127.4	163.0	100	106.8
Total:	23.1	30.4	21.3	29.1	108.5	142.7	100	136.6
RUMP FAT:	28.3	32.6	21.3	30.1	132.9	153.0	100	141.3
MEAN BACK FAT:	30.1	36.5	27.2	35.7	110.7	134.2	100	131.3
RATIO SHOULDER FAT/ LOIN FAT	1.69	1.53	1.83	1.67				
BELLY THICKNESS:								
Anterior	33.3	33.3	32.5	30.6	102.5	102.5	100	94.2
Medial	30.4	29.0	26.0	26.0	116.9	111.5	100	100
Inquinal	29.5	31.2	26.4	26.9	111.7	118.2	100	101.9
MEAN BELLY THICKNESS:	31.1	31.2	28.3	27.8	109.9	110.2	100	98.2

mining this measurement, and the fact that no consistent trend was shown in the measurement by members of different groups.

The sex effects upon the back fat thickness measurements are of considerable magnitude and in line with the effect, already discussed, upon the combined weight of fat in the leg and loin joints. Thus the mean back fat thickness which McMeekan (6) found to be very highly correlated with the total weight of fat in the carcase, is greatest for gonadectomised animals and least for the entire males, with the entire females intermediate. The spayed females were shown from the dissection data to be slightly fatter than the castrate males, and the mean back fat measurement of the former is a little larger than for the latter.

An interesting feature revealed by the proportionate figures in Table XXXVIII is that, in general, the thickness of the outer layer has been influenced by the sex differences between the animals to a greater extent than has the thickness of the inner layer. McMeekan (6) found that the inner fat layer was later developing than the outer layer and that it was effected to a greater extent by variations in the plane of nutrition. It should be mentioned that the line of demarkation between the internal and external fat layers was not always clearly defined. This was particularly so in the case of the rump where, for this reason, inner and outer measurements were not recorded. The relatively high margin of error in determining inner and outer backfat measurements may account for the exceptional order of the effect on these measurements at the loin of the castrate males, where the inner layer has been affected by castration to a greater extent than the outer.

Greater proportional differences exist between the sexes in respect of the loin fat measurement than the shoulder fat measurement, and in respect of the rump fat measurement than the loin fat measurement. This is reflected in the shoulder fat - loin fat ratio (Table XXXVIII). Castration in either sex has reduced this ratio, indicating more early maturity (Hammond and Murray - 7) in castrate than in normal animals, while on the same basis entire females are shown to be more early maturing than entire males.

Since the various back fat measurements have all been influenced by sex in the same general manner, although not to the same degree, the statistical significance of the differences has only been tested in one case - that of the measurement at the loin. Table XL shows that the effect of sex has been significant at the 1 per cent point. The standard error per pig is 2.75 millimetres of 10.8 per cent of the mean, while the standard error of the sex means is 1.23 millimetres.

The statistical relationships of the different sex means are shown in Table XLI. These differ somewhat, in the case of the three comparisons involving the entire females, from those previously presented for the weight of fat in the leg and loin joints (Table XVII). Thus in the present natural female - natural male comparison, the difference between the respective means is not quite great enough to allow significance to be established even at the 5 per cent.point while in the case of the weight data the difference was highly significant at the 1 per cent. point.

TABLE XL

ANALYSIS OF VARIANCE OF DEPTH OF BACKFAT - THINNEST
(1/10 millimetres).

Component	Degrees of Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sex	3	39,606	13,202	17.42	3.59	6.22	S.S.
Groups	4	24,825	6,206	8.19	3.36	5.67	S.S.
Error	11	8,338	758				
Total	18	72,769					

S.S.= Highly significant

TABLE XLI

TABLE OF SIGNIFICANCE. DEPTH OF BACKFAT - THINNEST
(1/10 millimetres)

Sexes Compared	Respective Means		Difference between means	Level of Significance
Natural females - castrate females	231.0	304.0	73.0	S.S.
Natural females - natural males	231.0	194.6	36.4	N.S.
Natural females - castrate males	231.0	291.0	60.0	S.S.
Natural males - castrate males	194.6	291.0	96.4	S.S.
Natural males - castrate males	194.6	304.0	109.4	S.S.
castrate males - castrate females	291.0	304.0	13.0	N.S.

Difference of 37.3 units between means is significant when P.=.05
" " 54.1 " " " " " " P =.01

The situation is still less comparable in the case of the entire male - castrate male comparison. The difference between these sex means has been shown to be significant at the 1 per cent. point for the loin measurement figure, but quite insignificant in the case of the leg and loin fat weight data. The foregoing emphasises the desirability of using sample joint dissection data in addition to carcase measurements as indices of carcase composition.

The sex effects on the fat at "C" measurement (Table XXIX), which McMeekan (6) found also to be very strongly correlated with total carcase fat, are in the expected direction, the order of the sexes again being similar to that for the weight of fat in the two joints which were dissected. The response of the fat at "H" measurement is somewhat at variance with expectation, being slightly greater for castrate males than spayed females and substantially the same in the entire sexes. This irregularity is probably due to variability in the shape of the lateral extremeties of the longissimus dorsi muscle for upon this the value of the fat at "H" measurement is to a certain extent dependant. The variability in the shape of the muscle may be observed from Plate IX.

The sex effect upon the muscle measurements of the loin cut are in the main consistent with the effect upon the weight of muscular tissue in the leg and loin joints. The entire type animals tend to resemble each other, as do the castrate sexes. In both sexes, the length measurement "A" and the depth measurement "B" has been reduced by

TABLE XXXIX

EFFECT OF SEX UPON LOIN CUT MEASUREMENT.

	Mean Measurements (mms)				Proportion: Natural Male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
MUSCLE:								
Length of "Eye" "A"	82.8	78.2	82.9	80.8	99.9	94.3	100	97.5
Depth of "Eye" "B"	43.9	39.0	42.4	37.9	103.5	92.0	100	89.4
Shape Index $= \frac{B \times 100}{A}$	540	499	511	469	103.7	97.7	100	91.8
FAT:								
At "C"	26.8	32.9	25.6	31.3	104.7	128.5	100	122.2
At "H"	30.7	36.2	30.8	37.7	99.7	117.5	100	122.4

castration. The statistical significance of the results for the depth measure "B" has been tested by analysis of variance (Table XLII) and the sex effect has been strongly significant at the 1 per cent. point. The standard error per pig is 1.96 millimetres of 4.8 per cent of the mean. The standard error of the sex means is 0.88 millimetres. Comparison of the entire females with the entire males, or the castrate females with the castrate males, shows that the respective means of these sexes do not differ significantly. In all other comparisons, however, the significance of the differences between the appropriate means has been established at the 1 per cent. point (Table XLIII). These results are, therefore, in agreement with and substantiate those obtained from the statistical treatment of the data relating to the weight of muscle in the leg and loin joints (Tables XIV and XV).

The values for the "Shape Index " ($\frac{\text{"B"}}{\text{"A"}}$ x 100) are given in Table XXXIX. This is a measure which McMeekan (6) found to show no significant correlation with total weight of muscle in the carcase, but which, as he mentions, is nevertheless of considerable importance in relation to carcase quality. In discriminating markets an "eye" muscle with a high depth("A") / length ("B") ratio is required. The entire sex animals are superior to castrates in this respect.

Plate IX provides a comparison of the relative development of muscle and fat as revealed by the cross-section at the last rib. The photographs have all been enlarged to a standard "eye" muscle length (i.e. measurement "A" Fig V) and arranged according to group and sex.

TABLE XLII

ANALYSIS OF VARIANCE OF DEPTH OF EYE "B" (1/10 mms)

Component	Degrees Freedom	Sum of Squares	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sex	3	13,214	4404.7	11.49	3.59	6.22	S.S.
Groups	4	4,482	1210.5	3.17			
Error	11	4,218	383.5				
Total	18	22,274					

S.S. = Highly significant.

TABLE XLIII

TABLE OF SIGNIFICANCE: DEPTH OF EYE "B"(1/10 mms)

Comparison	Respective Means		Difference between Means	Level of Significance
Natural females - castrate females	439	390	49	S.S.
Natural females - natural males	439	431	8	N.S.
Natural females - castrate males	439	379	60	S.S.
Natural males - castrate males	431	379	52	S.S.
Natural males - castrate females	431	390	41	S.S.
Castrate males - castrate females	379	390	11	N.S.

& & &

Difference of 27.4 units is significant when P = .05
Difference of 38.7 " " " P .01

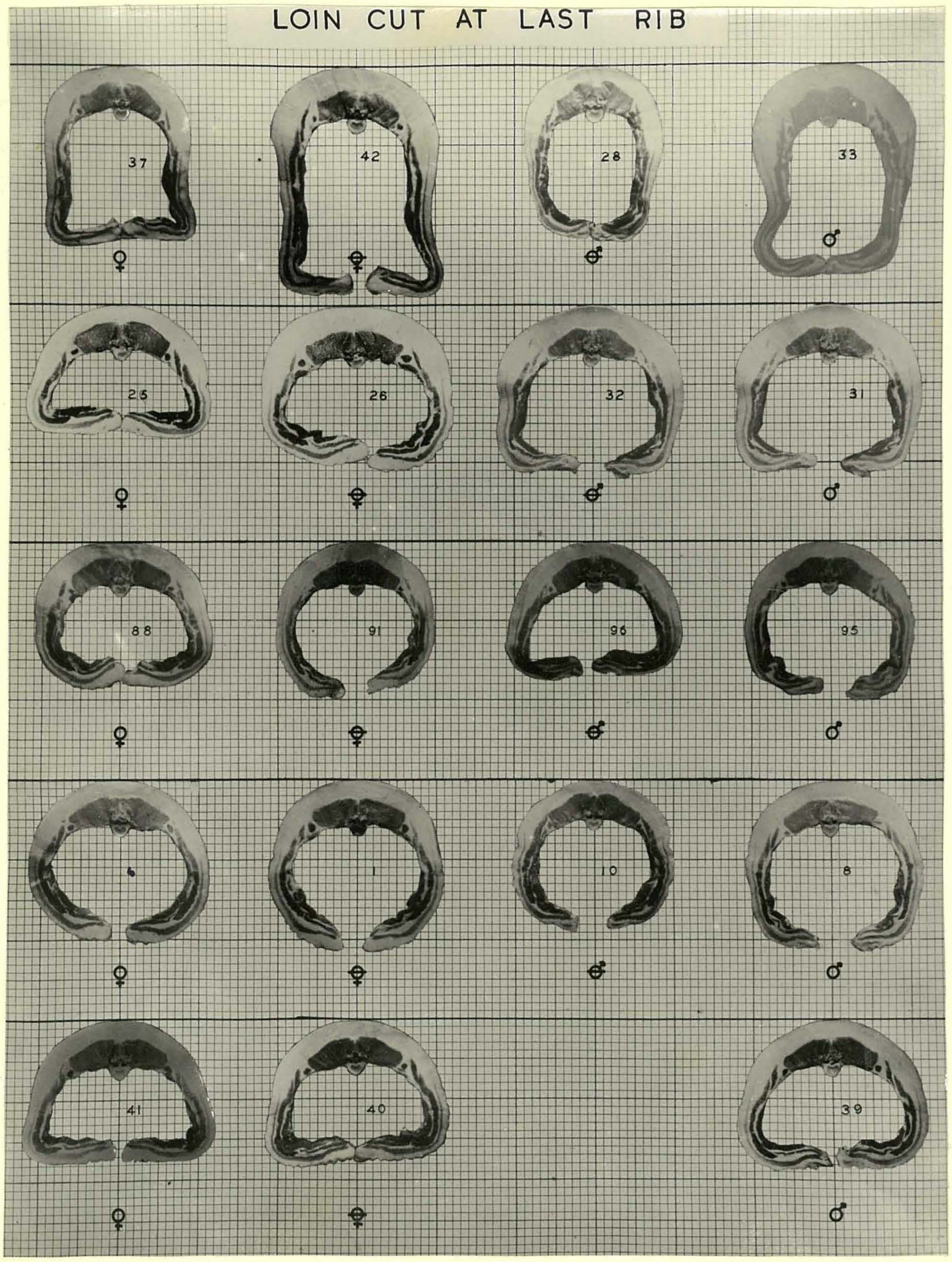

LOIN CUT AT LAST RIB
37
♀
42
♀
28
♂
33
♂
25
♀
26
♀
32
♂
31
♂
88
♀
91
♀
96
♂
95
♂
♀
1
♀
10
♂
8
♂
41
♀
40
♀
39
♂

PLATE IX.

Note that the castrate animals show on the average a greater proportion of fat than do the corresponding normal animals. The difference is outstanding in the case of the first group. This set of animals were characterised by a plane of nutrition considerably higher than any of the subsequent sets due to practical considerations which predetermined an early date of slaughter. The animals for a period during the latter stages of their growth were fed six times a day - a 2 a.m. 8 a.m., 12 a.m., 3 p.m., 6 p.m. and 10 p.m. Particular interest is attached to the fact that in this group the differences between the sexes were most profound in respect to all three tissues, for this has a bearing upon the question of the most suitable environment under which to practice selection. The above results suggest that extravagant feeding tends to permit maximum expression of differences inherent in animals and if this is true, under these conditions selection for the most desirable type of animals would be greatly facilitated. It is, however, obviously impossible to draw definite conclusions upon this important point from the limited evidence available from this investigation. It is quite conceivable that the wide differences obtained between the animals of the four sexes in the case of Group I may be due simply to normal sex differences having been accentuated by chance variability in the animals concerned. The variable nature of the experimental material has already been discussed (Part I, Section).

The lack of uniformity of the material has also been emphasised by the results of the investigation. Thus while extensive and significant sex differences in composition have been elucidated, the inherent variability of certain of the animals has been sufficient in some cases to completely eliminate or reverse the characteristic sex effect. For instance, although entire males have been shown on the average to have significantly more bone than castrate males, in one group (Group III) this situation was reversed. Again, while the bone of entire females has been demonstrated significantly heavier than that of castrate females, the latter type animal in Group V has heavier bone than the entire female animals Similar comparisons might be made in respect to fat development.

6. EFFECT OF SEX UPON HISGOLOGY OF MUSCLE:

The histological differences between the musclesof the several sexes are of direct interest not only in respect to carcase quality, but also on account of the substantial differences which existed between the entire sexes in regard to the development of muscle as determined by weight, and in view of the retardation in muscle growth resulting from castration.

(a) Effect upon Diameter of Muscle Fibres.

The technique adopted in the measurement of the diameters of the fibres of the four muscles selected for study - namely the longissimus dorsi, psoas major, rectur femoris and gastrocnemius - has already been described (Part I, Section 10).

TABLE XLIV

MUSCLE FIBRE DIAMETER MEASUREMENTS

Muscle	Group	Diameter(microns) - means of 100 fibres							
		N.F.		C.F.		N.M.		C.M.	
Y		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Gastrocnemus	I	61.88	2.348	64.42	1.881	65.20	1.469	62.06	1.865
	II	72.28	1.626	62.98	1.465	53.52	1.249	59.40	1.561
	III	57.04	1.426	50.64	0.811	58.02	1.553	60.20	1.534
	IV	59.56	1.657	59.00	1.656	64.88	1.425	57.60	1.602
	V	53.18	1.875	57.30	1.996	-	-	50.44	1.465
Rectus Femoris	I	57.58	1.598	51.98	1.545	56.92	1.616	52.30	1.498
	II	58.34	2.016	57.74	1.842	56.58	1.597	67.00	1.725
	III	52.10	1.215	51.86	1. 105	54.00	1.705	53.12	1.323
	IV	54.20	1.828	50.56	1.255	63.90	1.580	49.06	1.223
	V	51.10	1.622	45.00	1.920	-	-	50.40	1.880
Psoas Major	I	40.06	1.099	40.64	1.366	49 ;48	1.450	43.50	1.580
	II	56.90	1.654	46.80	1.771	51.56	1.124	57.26	2.005
	III	42.84	1.412	42.68	1.506	40.52	1.552	[illegible]	[illegible]
	IV	49.22	1.172	39.83	11304	47.72	1.658	47.20	1.585
	V	47.30	1.292	40.66	1.405	-	-	37.58	1.448
Longissimus Dorsi	I	65.18	1.712	53.82	1.540	60.30	2.032	49.72	2.093
	II	59.10	1.921	56.58	2.150	65.98	2.197	55.90	1.818
	III	63.84	1.980	71.48	1.705	63.16	1.868	70.10	2.189
	IV	64.74	2.292	61.04	1.946	85.34	2.492	62.92	2.000
	V	64.80	1.797	62.32	1.609			71.20	1.944

In Table XLIV the mean diameter in microns (i;e. mean of 100 fibres) of each muscle is given together with its standard error. It is apparent that the mean fibre diameter of each of the four muscles varies greatly in different animals. Thus the mean diameter for the longissimus dorsi varies from 49.72 to 75.34 microns, the gastrocnemius from 50.44 to 72.88 microns, the rectus femoris from 45.00 to 67.00 microns and the psoas major from 37.58 to 57.26 microns. The mean fibre diameters of the different muscles of each pig have been averaged for each sex and the resultant data are presented in Table XLV. It will be noted that in the case of each muscle, both the entire males and the entire females have larger fibre diameters than do either of the castrate sexes. With the exception of the gastrocnemius where the difference between the sexes is very small, the order of the sexes in respect to increasing muscle fibre diameter is the same as previously found for increasing weight of muscle in the leg and loin joints - namely castrate females, castrate males, entire females and entire males.

In order to test the statistical significance of the sex effect and also to determine whether or not there is any significant difference between the size of the fibres of the different muscles, the data in Table XLIV has been subject to analysis of variance. The values for the missing entire male in Group V have been supplied by the formula given by Yates (25) and the method employed in the analysis has been that described by Wishart (58). The results of the analysis are shown in Table XLVI. It will be obser-

TABLE XLV

EFFECT OF SEX UPON DIAMETER OF MUSCLE FIBRES (Gastrocnemius, Rectus Femoris, Psoas Major and Longissimus Dorsi).

	Microns			
	Natural Female	Castrate Female	Natural Male	Castrate Male
Gastrocnemius	60.79	58.87	59.91	57.94
Rectus Femoris	54.66	51.43	58.10	54.38
Psoas Major	47.26	42.12	47.32	46.50
Longissimus Dorsi	63.53	61.05	66.18	61.97

ved that the F value of 2.26, obtained for the sex component, is not sufficiently great for significance to be established at the arbitrary 5 per cent. point (F = 2.78). On the other hand, however, there has been a highly significant effect between muscles, the F value obtained being more than eight times as large as that required for the establishment of significance at the 1 per cent. point. The significance of the differences between the mean fibre diameters of the different muscles is shown in Table XLVII. All four muscles differ significantly from each other, and except in the case of the gastrocnemius - rectus femoris, and gastrocnemius -longissimus dorsi comparisons the differences are significant at the 1 per cent point.

The above results in respect of the differences in fibre diameter of the longissimus dorsi, gastrocnemius and rectus femoris are of interest in view of the fact that McMeekan (4) was unable to demonstrate consistent significant differences between the fibre size of these muscles. This may perhaps be explained by the fact that although his results are based upon a considerable number of animals, these formed an age series, and it is conceivable that the extent of the differences between the muscles varies according to the stage of development.

Hammond (3) with sheep, found that there was a general relationship between the relative development of muscles and fibre diameter size, the tendency being for these muscles which made the largest post-natal growth to have the largest fibres. This trend, however, he found to be modified by the length growth and function of the muscles, as well as by conditions of nutrition and exercise. It will be noted that in this investigation the order of the muscles for increasing fibre diameter - namely psoas major,

TABLE XLVI

ANALYSIS OF VARIANCE OF DIAMETER OF MUSCLE FIBRES OF GASTROCNEMUS, RECTUS FEMORIS, PSOAS MAJOR and LONGISSIMUS DORSI (microns)

Component	Degrees of Freedom	Sum of Squares	Mean Square	F Value for comparison	F at P = .05	F At P.= .01	
Muscles	3	3372.0778	1124.0259	34.10	2.78	4.16	SS
Sexes	3	223.6198	74.5399	2.26	2.78	4.16	NS
Interaction of Muscles & Sexes	9	79.5846	8.8427	0.27	2.80	4.51	NS
Groups	4	168.3600	42.0900	1.28	2.54	3.68	NS
Error	56	1845.8103	32.9609				
Total	75	5689.4525					

S.S. = Highly significant
N.S. = Not significant.

TABLE XLVII

TABLE OF SIGNIFICANCE : DIAMETERS OF FIBRES OF DIFFERENT MUSCLES (Microns)

Comparison	Respective means		Difference between means	Level of Significance
Longissimus Dorsi - Psoas Major	63.19	45.80	17.39	S.S.
Longissimus Dorsi-Gastrocnemius	63.19	59.38	3.81	S.
Longissimus Dorsi-Rectus Femoris	63.19	54.62	8.57	S.S.
Psoas Major-Gastrocnemius	45.80	59.38	13.58	S.S.
Psoas Major Rectus Femoris	45.80	54.62	8.82	S.S.
Rectus Femoris-Gastrocnemius	54.62	59.38	4.76	S.

Difference of 3.63 microns is significant when P = .05
Difference of 4.86 microns is significant when P = .01

rectus femoris, gastrocnemius and longissimus dorsi - does not follow their order of relative development, as disclosed by the growth study of McMeekan (4).

Even though the sex effect upon fibre size has not proved statistically significant the tendency revealed in Table XLV for the entire sex animals to have slightly larger muscle fibres is regarded as indicative of the existence of a real difference between the sexes in this respect.

It is obvious, however, that muscle fibre size has not been as sensitive as weight differences in demonstrating differences in muscle development. McMeekan (6) found the same to be true in a study of the changes brought about by differences in the growth curve of animals. As he has pointed out, this is understandable in view of the high variability in fibre diameter within any one muscle, and the practical difficulties of measuring more than a limited number of fibres. Also it must be remembered that, the number of muscle fibres remaining constant, a small difference in diameter will be reflected in a comparatively large difference in muscle size and weight since these latter are dependant upon the square of the diameter and not its absolute value. In addition, variations in muscle weight may be accentuated by differences in the length of the muscle fibres.

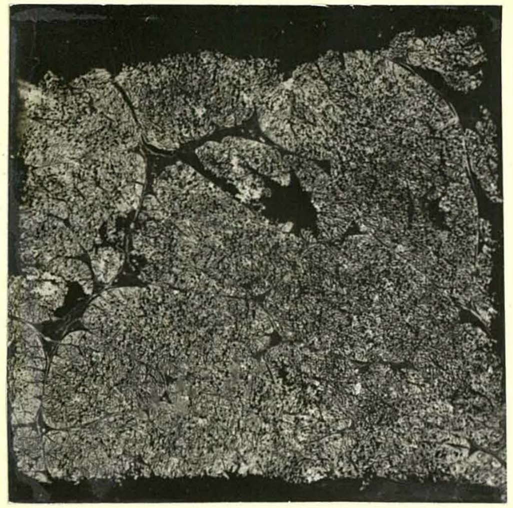
It is the generally accepted belief (Hammond - 13) that after birth in most species at least, little or no increase takes place in the number of muscle fibres, growth taking place by hypertrophy. McMeekan (4) has advanced considerable evidence to show that the above theory is true with regard to the pig. The smaller diameter found for the castrate animals is in line with the above, for disregarding initial inherent variability, both castrate and entire animals must be assumed to possess an equal number of muscle fibres. Muscles of castrate animals have been shown to be smaller than those from the corresponding entire animals, and the smaller diameter of the fibres in the castrates is therefore to be expected if there is no alteration in the number of fibres in the muscles of either type of animal during growth.

The present results in respect to sex differences in muscle fibre diameter are in general agreement with the findings of other workers. In reviewing the literature Hammond (3) states that Adametz (59) found the fibres of bulls were much larger than those of cows, but that he found only a small difference between bulls and steers. He also mentions that Schwalbe and Mayeda (60) found the size of muscle fibres to be larger in man than in woman Hammond, himself, with sheep, found rams to have slightly larger fibres than ewes, while those of wethers were intermediate. It should be mentioned, however, that animals of differing age and live-weight were compared. Janeba (57) found no sex dimorphism between the mean thickness of the muscle fibres of the German pigs, and Black Pied Lowland Cattle which he studied. This is not surprising in view of the comparatively small differences obtained in this investigation. Also McMeekan (6) has shown that muscle fibre size may be greatly influenced by plane of nutrition. As a consequence, any variations existing in the form of the growth curves of the animals used, would, as in the case of carcase of composition investigations, render the detection of sex differences more difficult.

(b) Effect upon the Size of the Muscle Bundles (Grain)

The size of the muscle bundles (grain), like muscle fibre size, is of importance in relation to carcase quality through its influence upon the tenderness and therefore the eating quality of the meat. Muscle fibre size partially governs the type of grain, but this latter is also influenced by the amount of connective tissue, and by the number of fibres present in the bundles. McMeekan (4), with pigs, found that it was not possible to differentiate between the number of fibres per bundle in different muscles, due to the very great variation which existed in this respect between individual bundles in the same muscle. In this investigation, an attempt to distinguish sex differences in the grain of meat by meansof eye evaluation of photographic prints of muscle sections enlarged to a standard size (x4), has proved most unsatisfactory. Hammond (3) and Palsson (56) with sheep employed this method with considerable success. Pig flesh is, however, much more closely grained than is the

LONGISSIMUS DORSI (X4) GROUP IV.



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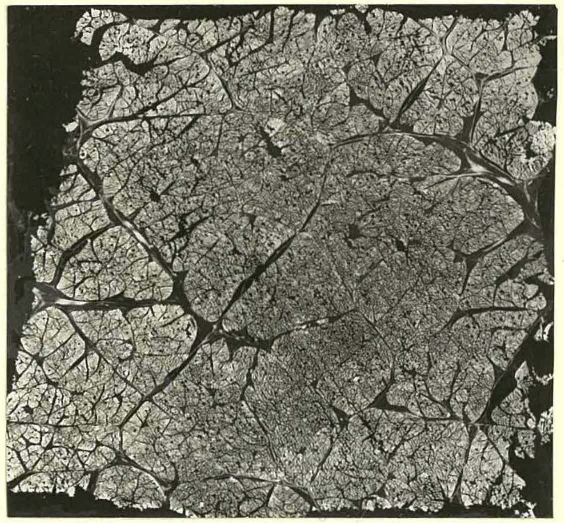

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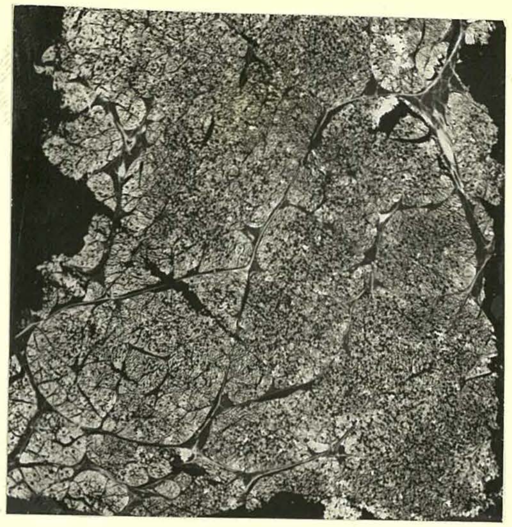

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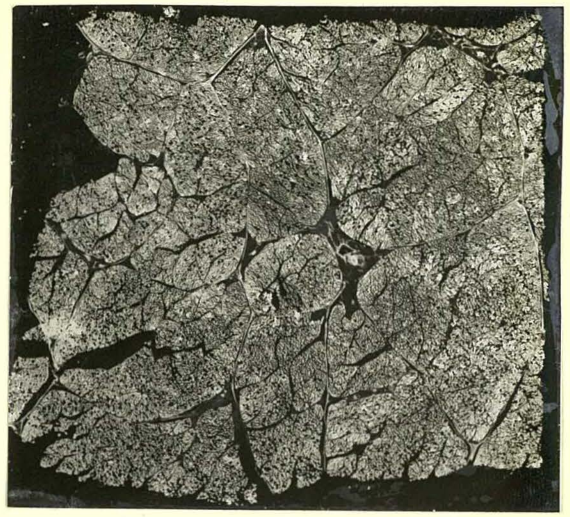

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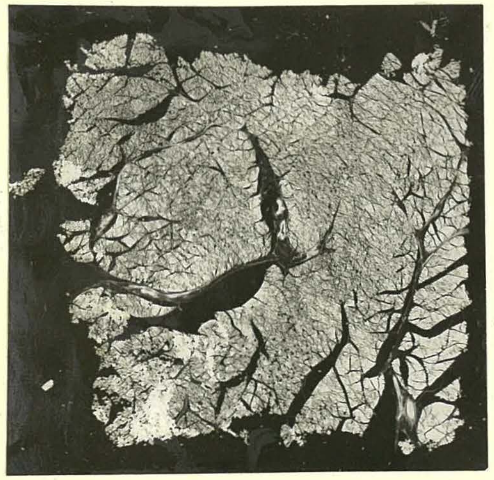
GASTROCNEMEUS (X4) GROUP IV.



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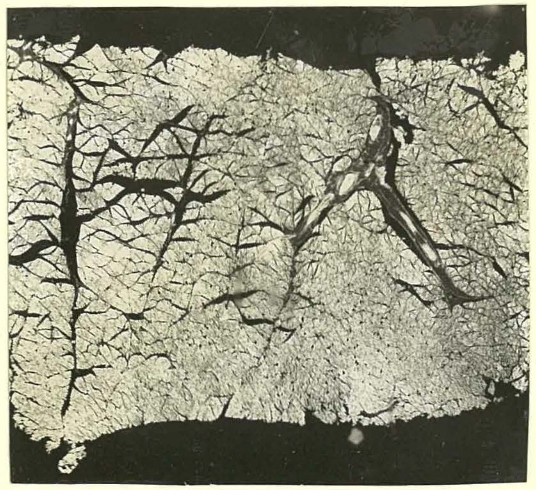

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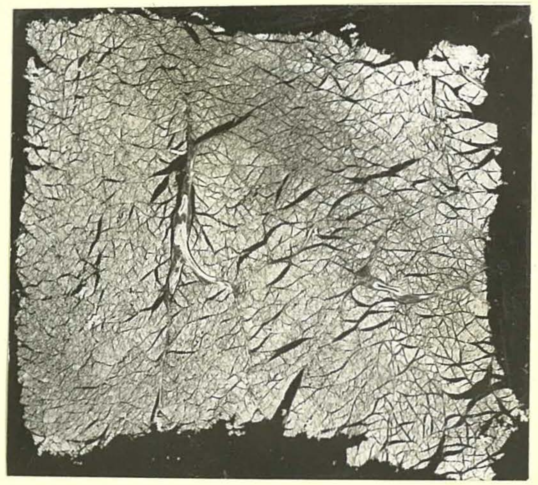

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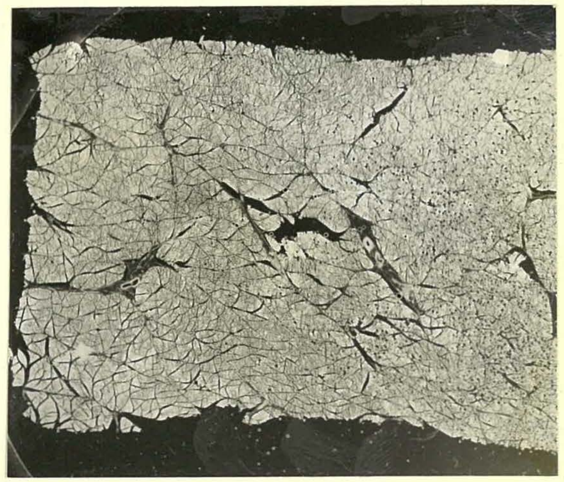

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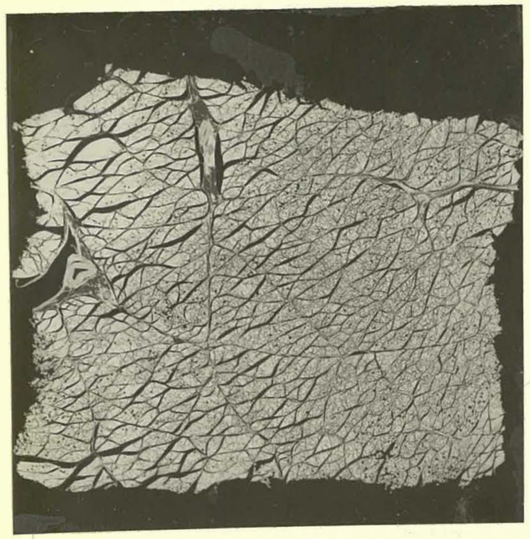
PLATE X. GRAIN.

RECTUS FEMORIS (X4) GROUP IV.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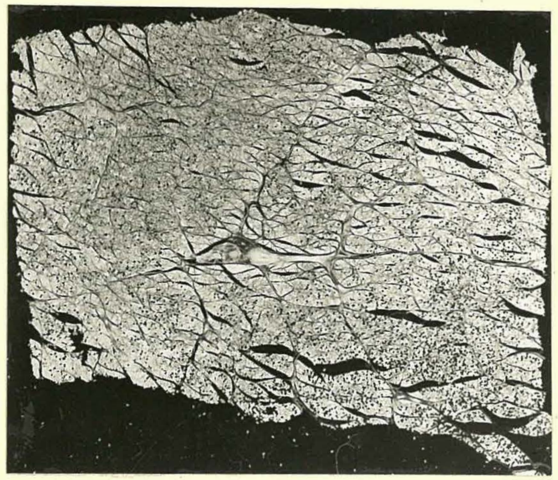
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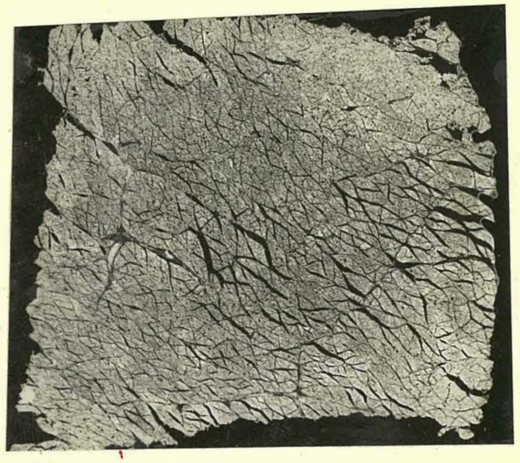
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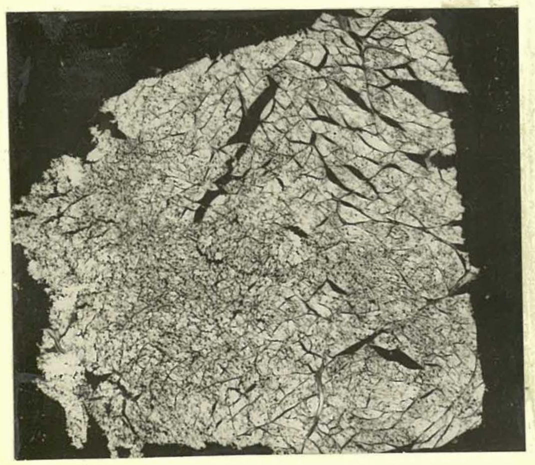
PSOAS MAJOR (X4) GROUP IV.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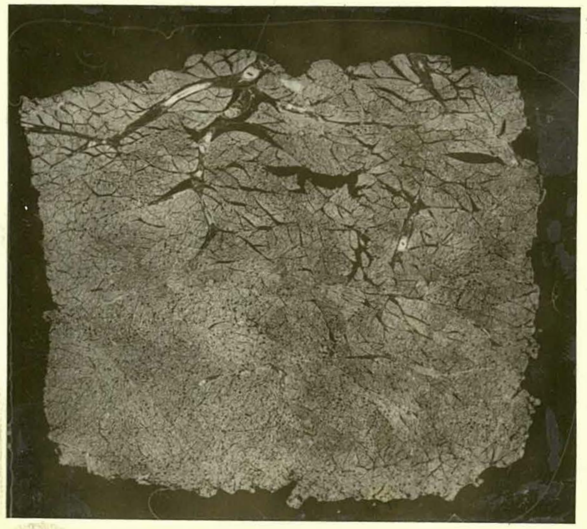
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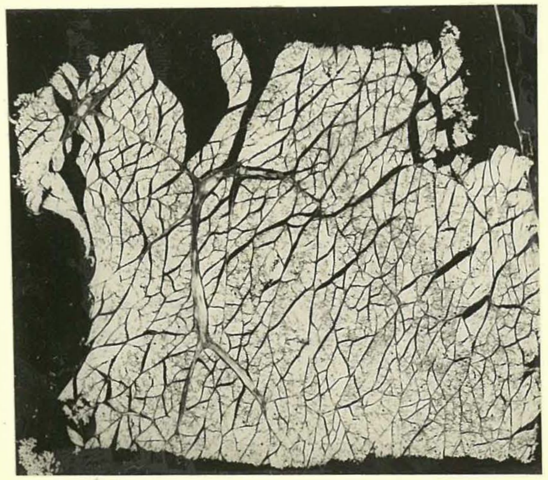
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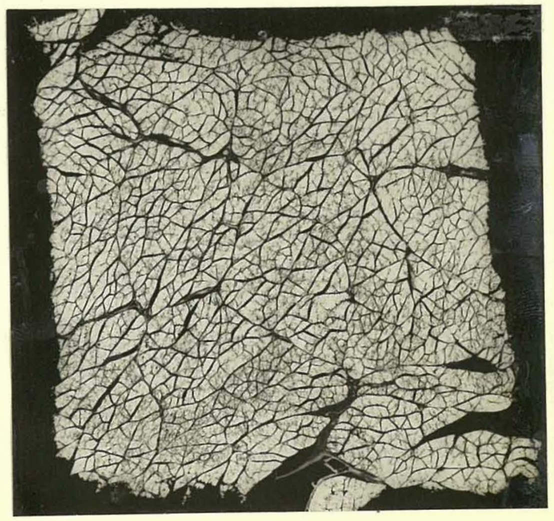
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GRAIN PLATE XI.

RECTUS FEMORIS (X4) GROUP IV.


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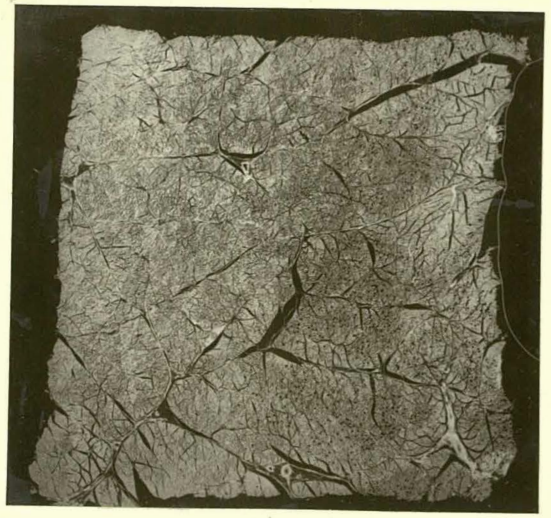
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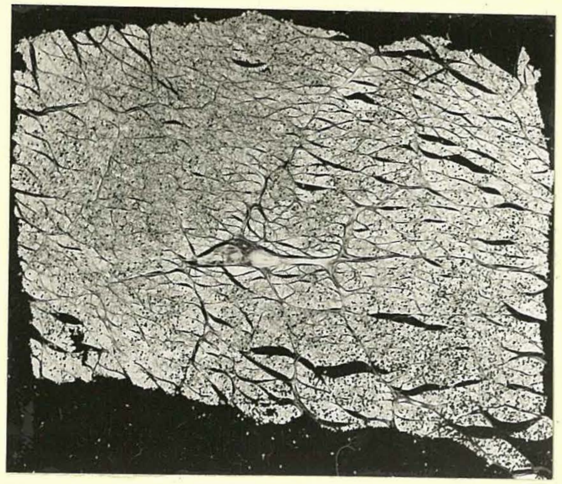
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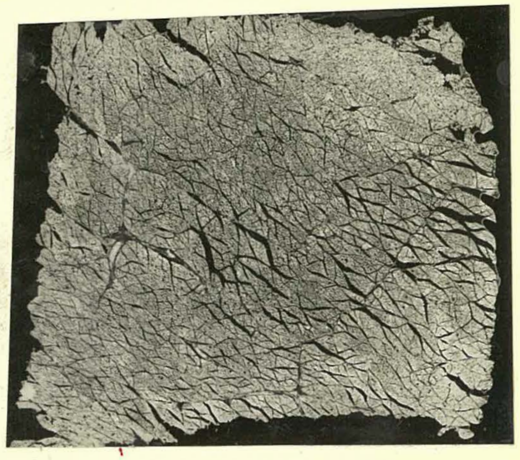
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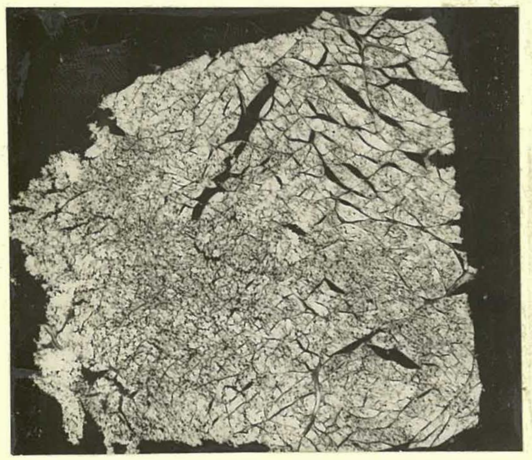
PSOAS MAJOR (X4) GROUP IV.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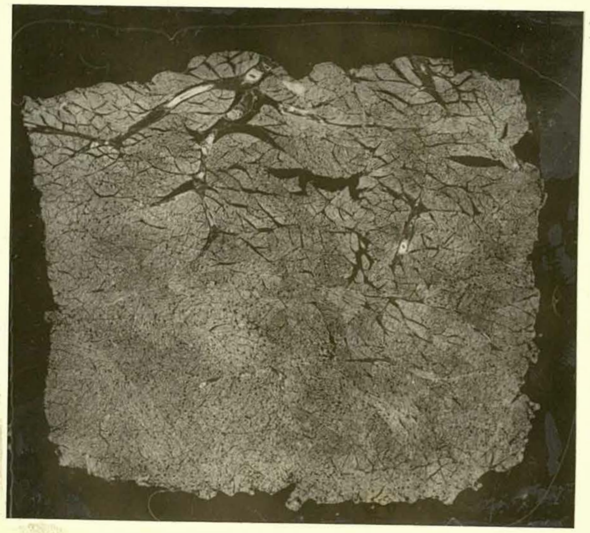
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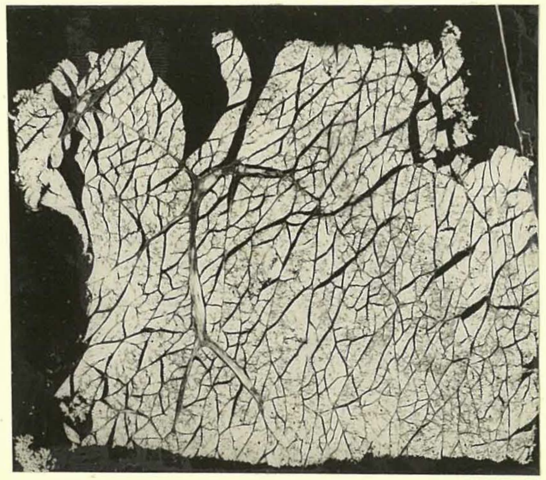
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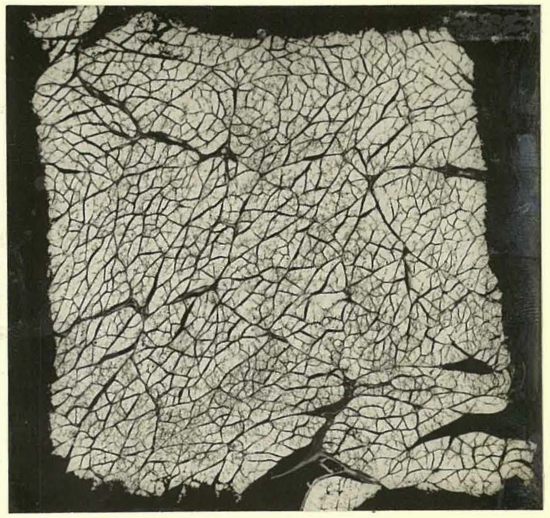
NO. 8

GRAIN PLATE XI.

flesh of sheep, the subdivision of the larger and smaller bundles appearing incomplete. Also, the appearance of the grain, as judged from the photographic prints, is dependant to a certain extent upon the degree to which the sections have "spread" during the process of mounting. In view of the above considerations no attempt has been made to classify the four sexes in respect to grain, as it was apparent that no very striking consistent differences existed, and since it was therefore felt that the results obtained would be unreliable and of little real value.

A photographic series of the cross-sections derived from one of the groups of animals (Group IV) is shown in Plates X and XI. These illustrate the difficulty of making a comparative study between the sexes in respect to coarseness of grain. Discrimination, even between sections derived from different muscles, was found very difficult and in many cases impossible, although upon close examination sections from the longissimus dorsi could usually be identified.

(c) Effect upon Intra-Muscular Fat.

In beef animals "marbling" is an important quality character, but it is of much less importance in sheep and pigs. In the course of cooking trials, Hammond (3) with sheep, found only a very weak relation between the amount of marbling and either the tenderness or flavour of the meat. The relative extent to which intra-muscular fat is present in the four sexes is, nevertheless, interesting in view of the differences shown to exist between the sexes in respect to the behaviour of other types of fatty tissue.

Plate XII

Missing

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Ruakura Animal Research Station

The technique adopted in the preparation of the sections for marbling fat examination, and the method by which the photographic prints were obtained, has already been described (Part I, Section 10). Justification for the histological method of marbling fat evaluation is supplied by the work of Hammond (3) with sheep for he found that the results obtained by this method agreed fairly closely with those from chemical determinations.

Plate XII shows the scale actually used in the award of points. In order to avoid possible prejudice the identification marks upon the back of the photographs were not consulted during the grading process. The mean points gained by animals of each sex are given in the case of the four muscles in Table XLVIII. The complete data are shown in the appendix. Examination of Plate XII in relation to Table XLVIII provides a fairly good picture of the relative development of intra-muscular fat in the four muscles, and in the different sexes. This plate also illustrates very clearly the extremely wide range of variation of individual muscles in respect to content of intra-muscular fat.

From Table XLVIII it may be observed that the results obtained for intra-muscular fat are in line with those obtained for the relative development of other types of fat in different parts of the body. In the case of each muscle, the castrate animals have shown, on the average, a greater amount of marbling fat than have the corresponding entire animals. Also, except in the case of the <u>longissimus dorsi</u>, the natural males have shown less marbling than the natural females.

TABLE XLVIII

EFFECT OF SEX UPON INTRA-MUSCULAR FAT - (scale of points ranging from 1 (leanest) to 10 (fattest)

Muscle	Mean number of points Awarded				
	Natural females	Castrate females	Natural Males	Castrate Males	Mean Values
Longissiumus Dorsi	6.2	7.8	7.0	8.2	7.3
Psoas Major	2.2	4.0	2.0	4.0	3.1
Rectus femoris	3.0	4.0	2.25	3.8	3.2
Gastro cnemius	4.0	4.2	2.0	4.6	3.8
Sum of means	15.4	20.0	13.25	20.6	

RECTUS FEMORIS (X4) GROUP IV.

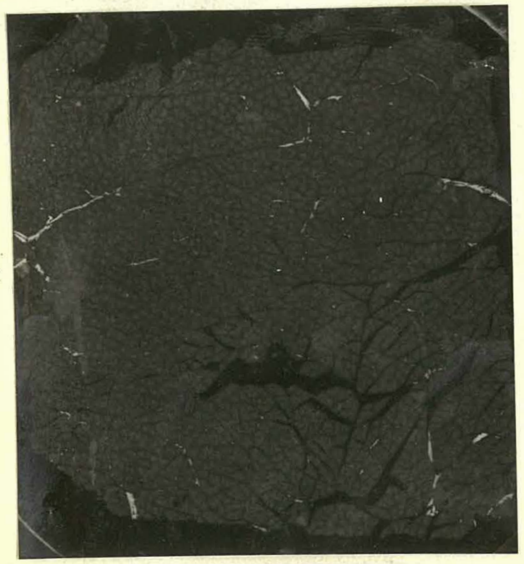

NO 4.


NO I.


NO IO.


NO 8.

PSOAS MAJOR. (X4) GROUP IV.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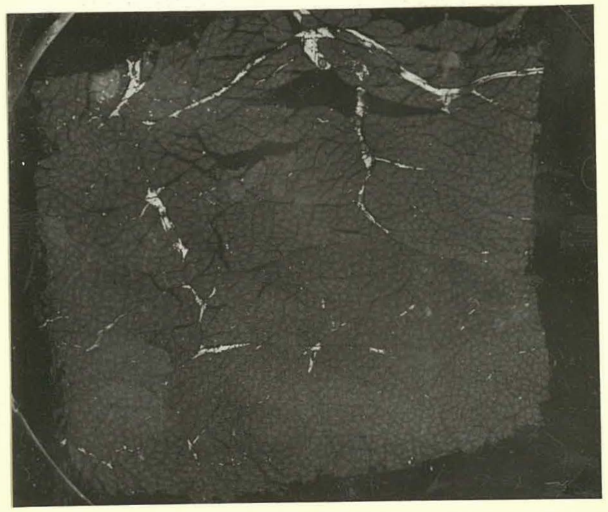
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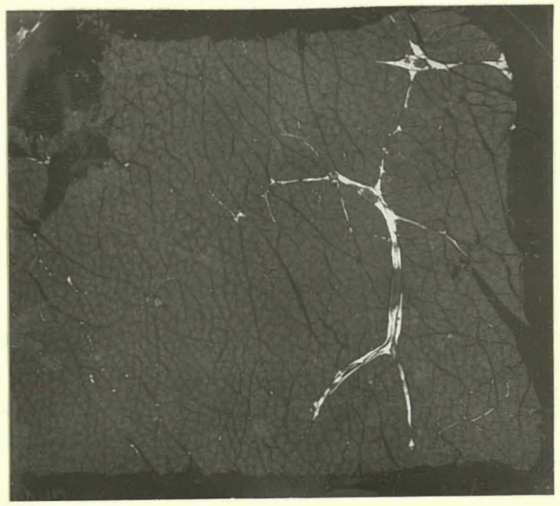
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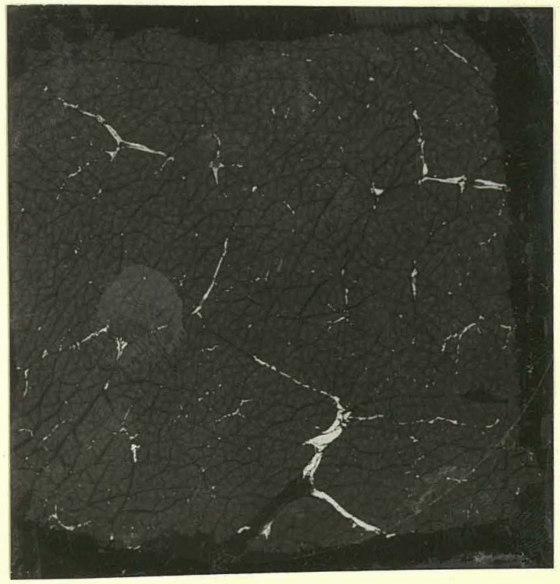
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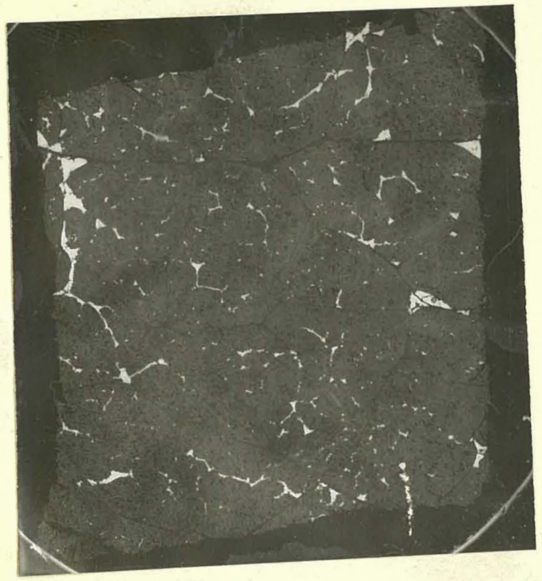
PLATE XIII. INTRA-MUSCULAR FAT.

LONGISSIMUS DORSI. (X 4) GROUP IV.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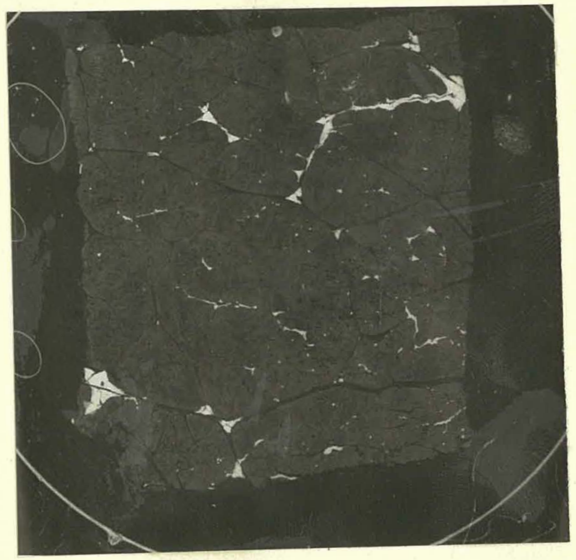
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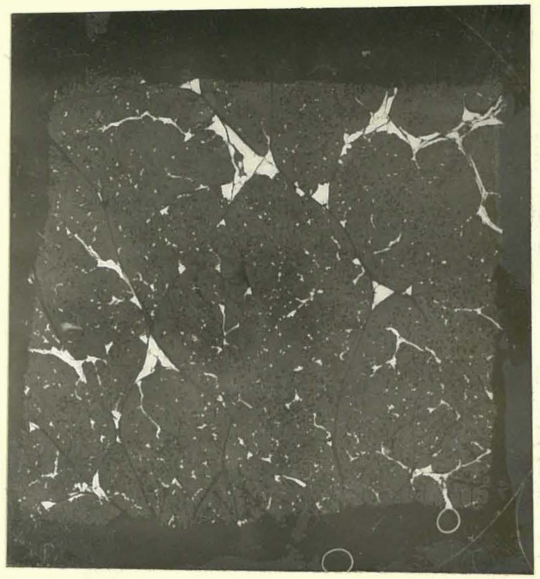
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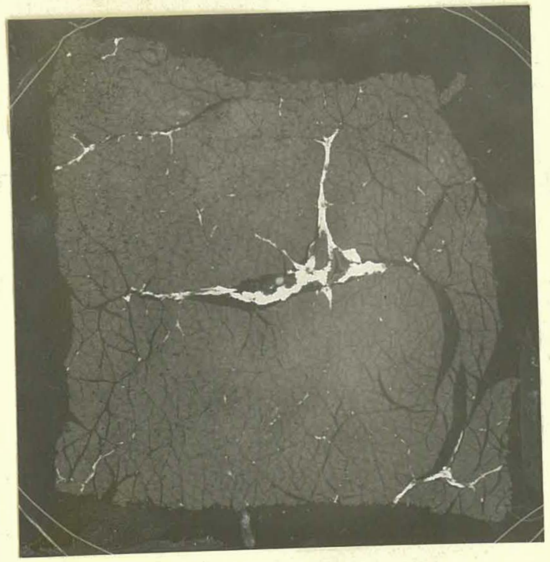
GASTROCNEMIUS. (X4) GROUP IV.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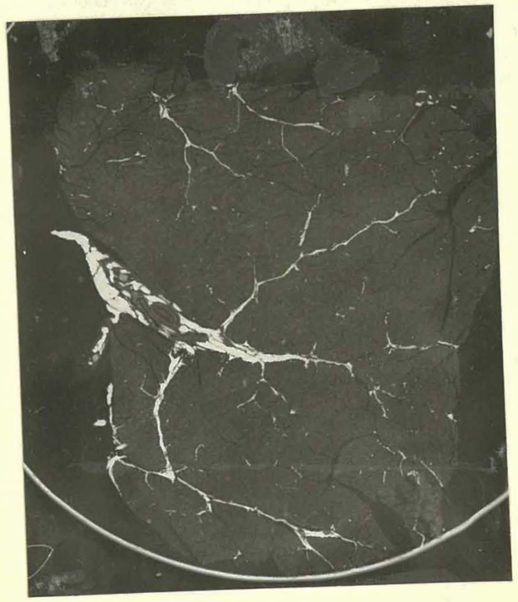
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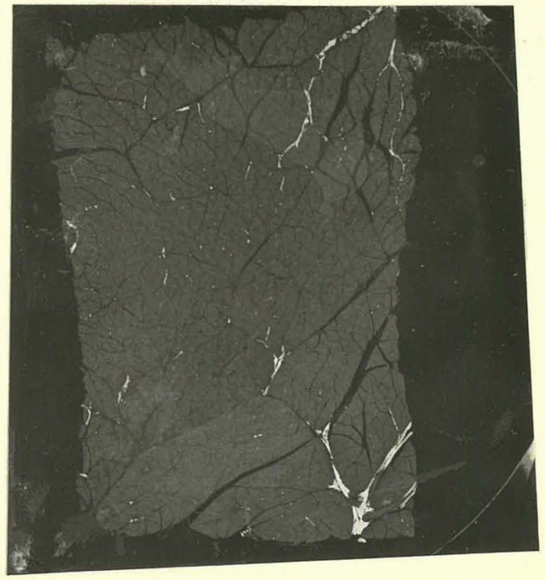
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NO 8.

PLATE XIV. INTRA-MUSCULAR FAT.

The photographs shown in Plate XIII and XIV illustrate the trend outlined above. In order to ensure that the differences shown by these plates should be truly representative of those actually obtained, the photographic series for different muscles havebeen chosen to relate to different groups of animals.

From the "mean values" column of Table XLVIII, it will be noted that the longissimus dorsi contains on the average very much more intra-muscular fat than does the psoas major, rectus femoris or gastrocnemus. Hammond (3) with sheep, also found considerable variation in the degree of marbling of different muscles. Not only did the amount of fat present vary, but also the evenness with which it was distributed. It may be noted from Plates XIII and XIV that the marbling pattern of the longissimus dorsi is characteristically different from that of the other three muscles.

7. EFFECT OF SEX UPON FOOD CONSUMPTION AND UTILISATION.

In comparing the sexes in respect to economy of food consumption, the amount of food required per pound of live weight increase has been determined for the growth range of 70-80 pounds to 200-210 pounds. The initial weight, final weight, the live-weight increase, and the food consumption during the period over which this live weight increase was obtained, are shown for each pig in Table XLIX. The "initial weight" figures have been obtained by calculating the mean of three consecutive weekly weighings and the "final weight" figures are means of three weighings made on consecutive days immediately prior to slaughter. To obtain a basis of comparison, the food consumption of each pig has been expressed in terms of

TABLE XLIX

FOOD CONSUMPTION AND UTILISATION - 70-80 lbs to 200-210 lbs live weight.

Set No.	Sex	Pig. No.	Initial Weight *	Final Weight ø	Live weight Increase	Meal equivalent consumption	Meal equivalent per lbs grain
I	♀	37	74.7	210.2	135.6	470.5	3.47
	♀̶	42	77.0	209.8	132.8	439.5	3.31
	♂	28	77.0	208.5	131.5	366.0	2.78
	♂̶	33	74.7	205.0	130.3	457.0	3.51
II	♀	25	78.7	207.0	128.3	465.8	3.63
	♀̶	26	76.8	209.0	132.2	574.3	4.34
	♂	32.0	82.0	214.0	132.0	396.5	3.00
	♂̶	31	74.0	212.0	138.0	465.0	3.37
III	♀	88	75.3	210.0	134.7	471.5	3.50
	♀̶	91	74.0	210.5	136.5	523.5	3.83
	♂	96	71.2	210.5	139.3	462.9	3.32
	♂̶	95	73.3	211.0	137.7	479.5	3.48
IV	♀	3 & 4	75.8	213.0	137.2	500.0	3.64
	♀̶	1	76.3	214.5	138.2	522.8	3.78
	♂	10	76.3	215.5	139.2	443.3	3.18
	♂̶	8	77.8	216.0	138.2	515.6	3.73
V	♀	41	78.3	205.2	126.9	507.5	3.99
	♀̶	40	75.0	206.3	131.3	503.5	3.83
	♂						
	♂̶	39	75.0	203.2	128.2	506.0	3.95

*- Mean of three consecutive weighings at weekly intervals
ø Mean of three weighings on consecutive days immediately prior to slaughter.

"meal equivalent" units, a gallon of separated milk or a pound of meal each being evaluated as one unit.

Complete weekly food consumption data was available for all pigs except Pig No.4 of Group IV which, when introduced into the feeding crate pen as a substitute for Pig No. 3 (See Part I, Section 2) weighed 163.5 pounds. The data in Table XLIX relating to the natural female of Group IV has been compiled from the food consumption records (see appendix) of both Pig No.4 and Pig No. 3. This is considered justifiable since these two animals were of equal weight at the time the substitution was made, and since the purpose of the investigation is to elucidate sex differences rather than differences between individual animals. The "meal equivalent per pound of live-weight increase" data appearing in the right hand column of Table XLIX has been re-arranged in Table L, and, in addition, expressed upon a proportionate basis. It is apparent that entire male animals have consistently made the most economical gains and that the difference in their favour is large. The castrate females, natural females and castrate males, respectively have consumed 22 per cent, 16.6 per cent and 15.3 per cent more food per pound of live-weight increase than have the entire males. There is little difference between the economy of live-weight increase of the entire females and the castrate males, although in both these, the gains have been less costly than for the spayed females.

Considering all the animals in the investigation, the mean figure of 3.55 units of meal equivalent per pound of live-weight increase must be considered most satisfactory for the live-weight range involved.

TABLE L

MEAL EQUIVALENT CONSUMPTION PER POUND LIVE WEIGHT INCREASE

70-80 pounds to 200-210 pounds live weight.

Group	Meal Equivalent				Proportion: Natural Male = 100			
	N.F.	C.F.	N.M.	C.M.	N.F.	C.F.	N.M.	C.M.
I	3.47	3.31	2.78	3.51	124.8	119.1	100	126.3
II	3.63	4.34	3.00	3.37	121.0	144.7	100	112.3
III	3.50	3.83	3.32	3.48	105.4	115.4	100	104.8
IV	3.64	3,78	3.18	3.73	114.5	118.9	100	117.3
V	3.99	3.83	3.36[x]	3.95	118.8	114.0	100	117.6
Mean	3.65	3.82	3.13	3.61	116.6	122.0	100	115.3

[x] Value supplied by application C. Yates formula - (See Part I, Section II).

The statistical significance of these differences among the four sexes has been investigated by the analysis of variance method (Table LI). The sex effect is significant at the 1 per cent point. The standard error per pig is 0.234 meal equivalent units, or 6.6 per cent. of the mean. The standard error of the sex means is 0.104 meal equivalent units. Table LII shows the inter-relationships of the four sexes. The mean for the entire males differs significantly at the 1 per cent point from the respective means of the remaining three sexes. In none of the three other comparisons possible, is the difference between the appropriate means sufficient for significance to be established.

The above findings are of particular interest in relation to the results and opinions of other workers. Maynard (46) states "The lowering of the basal metabolism which results from castration is due presumably to alterations in the endocrine relationships. This lowered basal energy requirement is reflected in the cheaper feed costs of gains in castrated farm animals". While it is well established that castration results in a lowered basal metabolism (Ritzman et al, 53) the findings of this investigation are strongly opposed to the view that this is accompanied by a more economical live weight increase. Stahl (48) using Landrace pigs, found that castration of female animals did not influence the rate of gain or food consumption. He also found that castrate males surpassed non-castrate females in gain of

TABLE LI

ANALYSIS OF VARIANCE OF MEAL EQUIVALENT PER POUND LIVE WEIGHT INCREASE
(Live weight range 70-80 pounds to 200-210 pounds)

Component	Degrees of Freedom	Sum of Square	Mean Square	F value for comparison	F @ P = .05	F @ P = .01	
Sexes	3	13124	4374.7	5.98	3.59	6.22	S.S
Groups	4	5458	1364.5	2.49	3.36	5.67	N.S
Error	11	6028	548.0				
Total	18	24610					

S.S. = Highly significant

TABLE LII

TABLE OF SIGNIFICANCE - MEAL EQUIVALENT PER POUND LIVE WEIGHT INCREASE.

Sexes compared	Respective means		Differences between means	Level of Significance
Natural females - Castrate females	3.646	3.818	0.172	N.S.
Natural females - castrate males	3.646	3.228	0.518	S.S.
Natural females - castrate males	3.646	3.608	0.038	N.S.
Natural males - castrate males	3.128	3.608	0.480	S.S.
Natural males - castrate females	3.128	3.818	0.690	S.S.
Castrate males - castrate females	3.608	3.818	0.210	N.S.

Difference of 0.325 pounds is significant when P =.05
" " 0.458 " " " " P =.01

weight but that they were inferior as regards food utilisation. Woodman et al (8) however, reported no significant difference between the mean daily live-weight increase of barrows and gilts, when these were comparable in respect to initial weight and when the animals were rationed according to live weight. In regard to food conversion, however, they found a strongly significant sex difference, the gilts showing a greater efficiency than barrows. Mansfield et al, (52) also worked with pigs of the large White breed, which were fed individually and divided into two groups, one group being fed a restricted ration while the other was fed ad lib. While the castrate males in the unrestricted lot showed greater efficiency than the entire females, the reverse was found to be true in the unrestricted group. The results of Bengtsson (29 and 36) and Murray (35) support the belief that under conditions of unrestricted feeding, castrate males have a higher rate of gain than entire females. Murray (35) found that, at birth, males had appreciably higher weights than females but that this difference decreased until it was actually lowest from the ninth to the thirteenth week. This drop in the growth rate of the males Murray attributed to the combined effect of castration and weaning. Subsequent to the thirteenth week the castrated males relative to the females started increasing again in weight. Murray also found that between three and four months the growth of the female was retarded.

This he attributed to their normal growth being disturbed at the onset and recurrence of heat periods. Marshall and Hammond (16) and Veetch (17) have also stated that spayed animals fatten more easily and attribute this to such animals being undisturbed by heat periods, which cause restlessness and loss of energy during the fattening process after puberty.

In the present investigation, although abundant evidence has been produced to show that castration in either sex tends towards the deposition of fat in the body, there has been nothing to suggest that growth and fattening of the entire female animals has been influenced detrimentally during heat periods. The occurrence of successive heat periods of each of the animals was noted and the feeding habits and appetite carefully observed, but no unusual behaviour could be detected. Similarly, no regular variations occurred in the weekly live-weight increase records which could be ascribed to this cause, although each of the natural females came on heat at least three times before being slaughtered. The age at which oestrus was first observed in each of the five animals concerned, is shown below :

Group No.	Pig No.	Age (Weeks)
I	37	16
II	25	18
III	88	14
IV	4	18½
V	41	17

A limited amount of information/is available regarding the influence of sex upon growth and food consumption and utilisation in cattle. Gramlich and Thalman (12) found that steers and normal heifers made larger and more economical gains than spayed heifers. Richter et al (50) from a comparison of the results of fattening bulls and oxen showed that the latter required 21 per cent more energy value per unit of gain in weight. The oxen fattened more slowly taking 43-47 weeks while the bulls were fattened at the end of 33 weeks.

Dunlop (54) has shown that the type of tissue (i.e. fat or protein) being laid down in the body is a most important factor governing the live-weight increase of an animal This sgrongly suggests that the differences existing between the sexes in respect to economy of food conversion may be explained on this basis for the carcase composition of the four types of animals has been shown to be widely different. Armsby (55) estimates that due to differences in the moisture content and also in the energy content per unit of dry matter, the gain of a unit of adipose tissue represents the storage of seven to eight times as much energy as does the storage of muscle tissue. The inherent capacity of castrate animals to lay down a relatively high proportion of fat per unit of live-weight increase should be reflected in a reduced efficiency of food conversion when this is measured in terms of live-weight increase. In the present investigation it is therefore in accord with expectations that the natural males, which of the four sexes have stored very considerably the least amount of fat, should be characterised by substantially the lowest food consumption per pound of live-weight increase. Similarly it is significant that the castrate females, which contain the most fat, have made the least economimical gains.

It is possible that differences may exist in the efficiency of the digestive system of the differently sexed animals which have some influence upon the efficiency with which food consumed is converted into live-weight increase. Work by Woodman *et al* (9) upon the nitrogen retention of barrows as compared with gilts showed that although there was little difference between these sexes in respect to the amount of nitrogen digested, there was a selective utilisation of the digested nitrogen. Also, since the maintenance requirement of an animal is in part determined by its basal metabolism, differences between sexes in respect to the value of this must govern to some extent the economy of the gains made.

That the composition of the live-weight increase can be profoundly influenced by the form of the growth curve, the possibility of differently sexed animals adopting characteristically different levels of intake when fed *ad lib.*, and the fact that the maintenance requirement is known to vary according to the amount of food ingested and the sex of the animal, are all considerations which may conceivably be responsible for the apparently contradictory results obtained by different workers in respect to the rate of growth and the food consumption and utilisation of the different sexes.

Interesting additional supporting evidence of the findings of the present investigation is afforded by the recent work carried out by Berndt (51), who found that preparations of testicular hormones, administered orally to both entire female and castrate male pigs gave a marked improvement in growth rate and carcase quality, especially when supplemented by minerals. This was accompanied by an improvement in economy of food consumption. Similar treatment with preparation from the ovaries proved inef-

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A point of practical importance raised by this study - similar to that raised by Hammond (8) in connection with sheep - is the possibility of refraining from castrating male pigs under conditions where the animals are marketed at an early age. Before this question can be satisfactorily answered, further investigations involving carefully conducted cooking trials are required in order to determine the extent of the effect of such a practice upon the tenderness and flavour of the meat. In this work facilities for the conduct of such trials were not available, but a limited amount of indirect evidence was obtained. After the removal of the loin and legs from each pig during the jointing process, the two short sides remaining were cured at the Kiwi Bacon Factory, Longburn, and disposed of privately. Upon enquiry being made from those individuals receiving the bacon, it was ascertained that no unusually strong flavour had been detected by those who had been allotted sides derived from entire male animals. Although admittedly inadequate, this would appear to suggest that at an age of about six months, the quality of bacon is not very seriously impaired by failure to castrate.

SUMMARY.

1. Entire and castrate male and female pigs have been compared to determine the nature and extent of the differences in body proportions and composition, and in economy of production. Every endeavour was made to eliminate or at least standardise the influence of factors other than sex known to effect carcase composition.

2. In respect to body proportions, castrate animals show a greater shoulder-trotter/body length ratio than entire animals, due to the greater fat cover found over the shoulders of these animals. Chest depth of entire males was significantly less than that of the other three sexes, the same factor being responsible. Although no significant difference was found between the sexes in respect to length of carcase, in line with the finding of other workers, entire females had longer carcases than castrate males. Length of leg, thorax, and spare trotter were, respectively, greater in entire than castrate animals and greater in entire males than entire females. In the castrate sexes, the loin joint was heavier but the leg joint lighter than in the entire sexes. Entire males showed the greatest development of the fore-end in spite of their being characterised by the shallowed chests. The general trend of effects suggests that the presence of the gonads effects the growth of various parts of the body differently and in accordance with the order of development of these parts.

?

3. As determined from the composition of the leg and loin joints, very large and statistically significant differences existed in respect to the amount of bone, muscle and fat present in the carcases of the differently sexed animals. Entire animals had more bone and muscle than did castrates, and males more than females. On the other hand, castrate animals have more fat than entire animals, and females more than males. Entire males have a significantly greater weight of skin than the other three sexes.

4. Castration of male animals results in more extensive changes in carcase composition than castration of female animals. Male and female castrate animals tends to resemble each other very closely in carcase composition, but large differences exist between male and female entire animals, particularly in fat development, where the difference is of the order of 30 per cent. It appears that the gonads in some way retard fat development and favour bone and muscle development but that the testes do this more effectively than the ovaries. When each is absent, bone, muscle and fat development proceeds in a very similar manner, irrespective of whether the animals be, genotypically, males or females.

5. In respect to organs and offals, the development of blood, skin and hair, and thoracic organs is greater in entire males than in entire females and greater in either of these sexes than in castrates. This situation is reversed in the abdominal organs. These differences, as in the case of the effects upon body proportions and upon the major tissues, may be largely

explained by the differential response between the sexes of early and late developing units. The response of certain individual organs, such as the liver, which have not behaved in a manner consistent with their relative order of development may be due to their functional adaptation to differences existing between the sexes in respect to plane of nutrition. Tremendous reduction was effected in the weight of the reproductive organs of both males and females as a result of castration.

6. The weight of the kidneys was considerably and consistently greater in entire males than in the other three sexes, the difference being highly significant. This result was unexpected in view of the generally accepted opinion that kidney weight is largely dependant upon the quantitative level of protein intake. No physiological reason could be advanced in explanation of the finding.

7. Sex differences, demonstrated in the total amount of each of the major tissues in the leg and loin joints, were also apparent when particular anatomical units were considered. The magnitude of the differences, however, varies with different units according to their order of development. Comparison of the weights of individual bones clearly indicated the depressing effect of the sex glands upon the relative growth of late developing parts. Such comparison also supported the suggestion that the gonads of the male are more effective in this connection than are those of the female.

8. Differences found between entire and castrate animals were greater in respect to subcutaneous fat than in respect to intermuscular fat. This also supports the view that in entire animals the relative rate of growth of late developing parts is retarded, or, alternatively, that the relative growth of early developing parts is encouraged.

9. Castration results not only in a reduction in bone weight but also in changes in bone form. Growth in length and thickness is reduced, but the changes are relatively greater in the case of the latter characteristic.

10. Entire and spayed females were found to possess bellies of approximately equal thickness and were superior in this respect to both entire and castrate males. On account of several factors little significance is attached to these findings.

11. Differences between the sexes in respect to back fat thickness and "eye" muscle measurements were statistically significant, of considerable magnitude, and in line with the differences found to exist in fat and muscle, as determined from examination of the leg and loin dissection data.

12. The inherent variability of the animal material was such that it was sufficient in some comparisons to completely reverse the nature of typical sex differences in body composition.

13. The data examined suggests a large number of fibs is associated with a small number of vertibrae in the loin region.

14. Histological study of the *rectus femoris*, *longissimus dorsi*, *psoas major* and *gastrocnemius* muscles revealed a tendency for the diameters of muscle fibres to be larger the entire animals than in castrates. Muscle fibre size, however, was not as sensitive as weight differences in demonstrating differences in muscle development.

15. Differences which proved highly significant were found between the fibre diameters of the different muscles examined, the order of the muscles for decreasing diameter being *longissimus dorsi*, *gastrocnemius*, *rectus femoris* and *psoas major*.

16. No large, consistent differences could be detected between the sexes in respect to grain of meat.

17. In the case of each muscle studied, castrate animals had, on the average, a greater amount of marbling fat than did corresponding entire animals. Muscles from entire males tended to be more marked than those from entire females.

18. Entire male animals consistently made very much more economical gains than did animals of the other three sexes. Both entire females and castrate males proved more economical growers than castrate females. The basis of these differences in efficiency of food conversion is considered to rest mainly in the differing energy content of the live-weight gains made by the differently sexed animals.

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CONCLUSION.

The secretion of the gonads have been demonstrated responsible for differences, widespread throughout the body and of very considerable magnitude. The exact mechanism whereby the gonads exert their modifying influence, is, at the present state of knowledge, very largely a matter of speculation. The method of control may be proven later a simple and direct one: more likely, complex hormonic interactions and inhibitions are involved. Whatever the final pronouncement, when it is remarked that the gonads are but one of the many endocrine glands directing body growth and development, one cannot but be impressed by the intricate, extensive, and co-ordinated nature of hormonic control.

Reviewing the investigation from a somewhat different angle, attention is forced upon the very great variability which may exist between animals even though these be closely related. Bearing in mind the extent of average sex differences, it is surprising to find that these may be completely eliminated or even reversed by the vagaries of random assortment during the m maturation of the germ cells.

The great dependence of body form and composition and of economy of production of the bacon pig upon the presence and nature of the gonadial secretions introduces the question as to whether it would not be possible for the animal producer to exercise a more direct control over the growth and form of his animals than he is able to do at the present time. Much attention has, of recent years, been devoted toward the feasibility of increasing milk production by the injection of hormones. Could carcase quality and the efficiency of meat production be improved by similar means? It must be admitted that the commercial application of the principles involved is, at the present time, at the present time, at least remote if not visionary. On the other hand the possibility, previously discussed, of refraining from castrating male pigs is well worthy of consideration, particularly where the animals are to be marketed at a reasonably early age. One of the major faults of New Zealand bacon carcases is a tendency toward over-fatness. If, as the results of this investigation strongly suggest, barrows require approximately 15 per cent. more food for the same live-weight increase and at the same time produce a carcase of inferior quality in respect to the proportionate development of lean and fat, then the above possibility is not one to be lightly dismissed.

It must be remembered that in this investigation, the differently sexed animals have not been allowed to express any inherent differential abilities in respect to the rate of live-weight increase. It is quite conceivable that had the animals been rationed according to live-weight rather than made to conform to a common growth curve, the margin in favour of the entire males, in respect to efficiency of food conversion, would have been even greater on account of their attaining market weight at an early age.

One further aspect of the findings of this work merits attention. The differences in body composition between the entire femalesand castrate males are of sufficient magnitude to be given careful consideration in the planning of experiments with swine. They are also of importance in relation to litter-testing schemes. It is also obvious that in complet competitive bacon exhibitions, as at present conducted, breeders entering entire female animals enjoy a somwehat unfair advantage over those showing castrate males.

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--- APPENDIX ---

WEEKLY LIVE WEIGHTS.

Age in weeks.

Set No.	Sex	Pig No.	3	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
		37 ✓	13.5	45	52	58	65	67	74	84	97	104	119	131	146	158	169	180	190	202	210.25				
I		42 ✓	13.5	36	55	59	69	67	76	88	96	104	116	131	149	162	167	175	192	202	209.75				
		28 ✓	11.5	43	51	56	66	68	78	89	100	109	124	126	149	164	171	178	190	201	208.50				
		33 ✓	8.5	44	52	55	62	65	78	89	96	100	115	128	148	158	169	185	192	204	205.5				
		25	15.5	41	48	49	55	66	80	91	97	102	113	130	141	150	151	165	169	176	189	200	207		
II		26 ✓	13.5	43	48	55	65	65	77	98	98	98	112	128	135	137	147	156	168	180	191	200	209		
		32 ✓	10.5	43	52	56	64	74	82	90	100	108	122	126	136	151	156	165	179	187	194	208	214		
		31 ✓	11.5	46	51.	50	60	61	76	85	95	101	110	123	137	150	153	158	178	189	192	206	212		
		88	7.5	36	42	46	50	67	75	84	88	95	107	113	124	137	139	142	163	170	178	195	200	202	210.0
		91	10.5	38	41	46	50	66	74	84	85	93	105	110	121	129	138	148	162	163	166	193	196	201	210.5
III		96	9.5	33	39	43	50	66	69	79	87	94	106	113	127	136	139	151	158	160	162	187	197	206	210.5
		95	11.0	35	45	47	54	70	76	84	90	96	109	113	124	135	141	146	156	161	167	192	198	204	211.0
		x 4	12.5	44	50	56	71	73	75	80	87	97	111	121	127	134	146	151	164	175	183	195	198	207	213
		1	14.0	44	48	54	66	71	76	83	88	97	114	118	129	141	151	154	166	178	183	187	198	203	214.5
IV		10	13.0	42	51	59	71	77	80	89	90	98	112	121	131	141	149	154	174	170	184	190	198	206	215.5
		8	12.0	44	49	56	66	72	76	86	90	97	107	115	125	137	142	148	161	175	183	193	202	206	215.0
		41	10.5	44	50	54	57	65	69	80	87	93	106	115	124	137	142	150	168	174	184	191	200	205.2	
V		40	11.5	42	41	47	55	64	67	75	84	92	104	118	128	139	142	150	166	180	187	193	204	206.3	
		39	12.0	42	50	56	56	66	68	80	84	90	106	116	123	135	142	149	168	177	183	189	202	203.2	

x Figures 3 weeks to 22 weeks inclusive relate to Pig No.3
" 22 " " 29 " " " " Pig No.4

COMPOSITION OF RIGHT HIND LEG.

Sex:	Males						Castrate Males.					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	23	32	96	10		Mean	33	31	95	8	39	Mean
Total Wgt.	6010	5585	6323	6180		6024.5	5301	5557	6152	6095	5897	5800.4
BONE:												
Femur	268.0	248.0	272.0	281.0		267.3	196.0	220.0	271.0	260.0	249.0	239.20
Tibia Fibula	182.0	178.0	183.0	194.0		184.3	140.0	153.0	192.0	186.0	165.0	167.20
Patella	15.6	15.5	17.1	18.1		16.58	11.1	13.4	16.3	15.3	11.5	13.52
Calcaneum	41.6	39.0	43.0	39.5		40.78	32.8	31.4	41.6	37.9	36.6	36.06
Astagalus	35.9	31.5	33.1	31.1		32.90	29.0	29.7	34.2	28.6	31.8	30.66
Cannon	56.5	56.0	56.5	54.2		55.80	44.1	45.0	57.1	54.6	52.7	50.70
Tarsals	30.1	32.5	29.5	28.3		30.10	25.7	32.5	29.1	26.6	26.0	27.98
Splints	10.9	11.3	12.8	12.9		11.98	9.9	9.5	11.5	11.1	10.5	10.50
Dewclaws	11.1	11.5	11.4	12.7		11.68	9.8	8.6	10.3	10.5	8.9	9.82
Pasterms	25.4	25.5	24.8	24.2		24.98	20.5	21.4	24.0	22.3	21.4	21;92
Coronets	15.6	15.4	14.7	15.1		15.20	13.2	13.4	14.7	13.4	12.9	13.52
Pedals	8.9	10.9	8.5	10.4		9.68	6.9	8.0	9.1	8.7	7.3	8.00
Naviculars	0.8	0.9	0.6	0.7		0.75	0.6	0.7	0.8	0.5	0.6	0.64
Sessumoids	5.8	4.4	4.1	4.6		4.73	4.1	4.4	4.0	3.8	3.0	3.86
TOTAL BONE	708.2	680.4	711.1	726.8		706.63	543.7	591.0	715.7	679.3	637.2	633.38
Muscle:												
Thigh	2773	2443	3078	3005		2824.8	2012	2416	2722	2537	2376	2412.6
Leg	592	507	620	655		593.5	406	491	605	610	510	424.4
Round Cannon	26	25	23	20		23.5	22	20	26	20	21	21.8
TOTAL MUSCLE	3391	2975	3721	3680		3441.8	2441	2927	3352	3167	2907	2958.8

(con.)

COMPOSITION OF RIGHT HIND LEG (Con.)

Sex:	Males						Castrate Males.					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No.	28	32	96	10		Mean	33	31	95	8	39	Mean
Fat:												
Subcutaneous (thigh)	1077	1012	880	880		962.5	1675	1354	1149	1394	1241	1362.6
Inter.musc (leg)	156	168	176	107		151.8	182	163	179	157	190	174.2
Inter.musc	32	41	56	53		43.0	33	51	82	59	53	55.6
TOTAL FAT	1255	1221	1112	1040		1157.3	1890	1568	1410	1610	1484	1592.4
Skin	331	448	464	464		426.8	216	280	415	351	318	316.0
Tendons etc.	185	214	253	245		224.3	131	169	237	246	221	240.8
Loss in Dissection	140	47	62	24		68.3	79	22	22	42	329	98.8

COMPOSITION OF RIGHT HIND LEG.

Sex:	Females						Castrate Females.					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean.
Total Wgt.	6379	5925	6352	6521	6039	6243.2	5613	5670	6010	5840	6124	5851.4
Bone:												
Femur	259.0	263.0	261.0	270.0	255.0	261.60	210.0	229.0	246.0	236.0	264.0	237.00
Tibia-Fibula	173.0	176.0	179.0	185.0	167.0	176.00	145.0	150.0	164.0	158.0	170.0	157.40
Patella	14.9	13.7	14.2	14.5	15.9	14.64	10.8	11.6	14.0	14.2	9.9	12.14
Calcaneum	35.1	37.2	37.5	34.0	39.0	36.56	31.2	33.6	39.0	31.4	38.1	34.66
Astraglus	28.8	33.2	32.0	28.0	29.0	30.20	28.8	26.6	32.0	27.4	31.5	29.26
Cannon	50.8	52.9	53.2	51.4	49.3	51.52	47.4	44.4	52.3	49.6	54.0	49.54
Tarsals	24.0	27.7	28.9	23.2	26.9	26.14	24.4	23.2	25.2	22.9	30.7	25.28
Splints	11.0	11.1	11.8	10.8	9.3	10.80	9.5	8.6	9.9	9.8	12.0	9.96
Dew Claws	9.4	10.1	9.3	9.2	9.9	9.58	9.7	8.9	10.2	9.3	11.8	9.98
Pasterns	21.7	22.2	24.5	22.5	22.4	22.66	20.9	19.2	22.7	21.7	24.4	21.78
Coronets	13.4	14.1	14.7	13.7	13.7	13.92	13.2	12.1	14.6	13.6	15.5	13.80
Pedals	8.4	7.4	7.3	8.8	7.8	7.94	8.1	5.6	7.7	7.6	8.7	7.54
Naviculars	0.9	0.8	0.4	0.7	0.6	0.68	0.7	0.6	0.5	0.6	0.7	0.62
Sessumoids	5.2	3.8	4.9	3.5	3.6	4.20	4.2	3.5	3.1	4.1	4.2	3.82
TOTAL BONE:	655.6	673.2	678.7	675.3	649.4	666.40	563.9	577.1	641.2	606.2	675.5	612.78
Muscle:												
Thigh	2545	2654	2796	3117	2640	2750.40	2131	2276	2582	2402	2666	2391.4
Leg	543	558	549	640	550	568.0	444	491	521	527	558	508.2
Round Cannon	23	22	20	21	20	21.2	15	18	19	20	22	18.8
TOTAL MUSCLE:	3111	3234	3365	3778	3210	3339.6	2590	2785	3022	2949	3246	2918.4

(con.)

COMPOSITION OF RIGHT HIND LEG. (con.)

Sex:			Females						Castrate Females			
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Fat:												
Subcutaneous (Thigh)	1818	1215	1432	1242	1341	1409.6	1679	1474	1397	1434	1305	1457.8
Inter.musc.	146	126	182	146	168	153.6	177	153	147	161	198	167.2
Inter.musc(leg)	68	67	35	35	40	49.0	38	49	79	74	63	60.6
TOTAL FAT:	2032	1408	1649	1423	1549	1612.2	1894	1676	1623	1669	1566	1685.6
Skin	280	347	397	362	315	340.2	251.	374	386	340	372	344.6
Tendon etc.	215	206	199	232	187	207.8	186	181	194	221	237	203.8
Loss in Dissection	85	57	63	51	129	77.0	128	77	144	55	27	86.2

CARCASE MEASUREMENTS.

Sex :	Males						Castrate Males.					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Length Body	985	1010	992	993		995.0	885	990	1029	1009	1000	982.6
" Carcase	750	766	775	763		763.5	710	750	792	767	758	755.4
" Thorax	475	477	477	499		482.0	428	490	513	470	453	470.8
" Leg	580	571	586	598		583.8	510	569	604	582	571	567.2
" Fore trotter	109	108	115	122		113.5	88	102	119	117	104	106.0
Depth chest	365	343	332	337		344.3	388	363	340	337	343	354.2
BACKFAT (total layer):												
Thickest	48.0	34.0	30.0	34.0		39.0	61.0	49.5	40.0	46.0	47.0	48.7
Thinnest	24.5	23.5	16.0	19.0		21.3	37.0	33.5	25.0	28.0	22.0	29.1
Rump	21.5	26.0	18.0	18.0		21.3	35.0	35.5	28.0	27.0	25.0	30.1
BACKFAT (inner layer):												
Thickest	40.0	30.0	25.0	24.0		29.8	49.0	38.0	31.0	35.0	33.0	37.2
Thinnest	16.5	14.5	12.0	13.0		14.0	25.0	20.5	17.0	17.0	13.0	21.3
BELLY THICKNESS:												
Anterior	33.5	28.0	31.5	37.0		32.5	34.5	27.5	31.0	31.5	28.5	30.6
Medial	29.5	25.0	21.5	28.0		26.0	29.5	25.0	27.0	27.0	21.5	26.0
Inquinal	26.0	25.5	19.0	35.0		26.4	19.5	32.5	28.5	30.0	24.0	26.9
LOIN CUT:												
Fat at "C"	31.0	27.5	25.5	18.5		25.6	44.5	33.0	25.5	29.0	24.5	31.3
"H"	35.0	36.0	28.5	23.5		30.8	49.0	45.0	32.0	33.0	29.5	37.7
Eye muscle at "A"	75.0	84.5	81.0	91.0		82.9	80.0	81.0	78.5	81.0	83.5	80.8
"B"	44.0	39.0	45.5	41.0		42.4	36.0	35.5	39.0	37.5	41.5	37.9
No. of Ribs	14.5	14.5	14.0	14.5		14.5	14.0	15.0	15.0	14.0	14.0	14.5

(Con.)

CARCASE MEASUREMENTS.

Sex:	Females 0						Castrate Females 0					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Length Body	1018	1022	1032	1016	1016	1020.6	1000	1010	1026	1018	1016	1014.0
Length carcase	760	752	761	757	768	759.8	740	756	785	772	772	765.0
Length Thorax	513	458	501	458	474	481.8	446	452	505	459	478	468.0
Length Leg	523	586	596	572	568	569.0	528	559	582	578	589	567.2
Length fore-Trotter	108	112	111	113	109	110.6	99	104	112	119	109	108.6
Depth Chest	390	337	354	347	341	353.8	380	360	351	349	344	356.8
BACKFAT (total)												
Thickest	38.0	40.0	37.0	43.0	37.0	39.0	51.0	47.5	46.0	46.0	42.0	46.5
Thinnest	24.5	22.0	25.0	24.0	20.0	23.1	35.5	34.5	30.0	27.0	25.0	30.4
Rump	30.5	25.0	32.0	29.0	25.0	28.3	34.0	38.0	30.0	33.0	28.0	32.6
BACKFAT (inner layer)												
Thickest	26.5	26.0	27.0	29.0	25.0	26.7	39.0	33.0	33.0	32.0	30.0	33.4
Thinnest	14.0	14.0	16.0	14.0	11.0	13.8	22.5	20.0	18.0	16.0	16.0	18.5
BELLY THICKNESS												
Anterior	34.0	37.0	35.5	35.0	25.0	33.3	32.0	38.0	30.5	39.5	26.5	33.3
Medial	28.0	35.5	34.5	32.0	22.0	30.4	26.0	38.0	25.0	35.5	20.5	29.0
Inquirnal	3.0	32.5	31.0	33.0	28.0	29.5	28.0	36.0	30.0	38.0	24.0	31.2
LOIN CUT												
Fat at "C"	34.0	24.0	27.5	27.0	21.5	26.8	40.0	36.5	31;5	30.5	26.0	32.9
"H"	36.0	30.0	32.5	29.0	26.0	30.7	45.0	42.0	35.0	28.5	30.5	36.2
Eye at "A"	76.0	83.5	82.5	86.5	85.5	82.8	70.5	77.0	80.0	79.0	84.5	78.2
"B"	41;5	44.5	42.0	45.0	46.5	43.9	37.0	39.5	37.5	39.5	41.5	39.0
No. of ribs	14.5	14	14.5	14	14	14.2	14.5	14.0	15.0	14.0	14.0	14.3

WEEKLY FOOD CONSUMPTION.

	SET I Galls. Milk - lbs. meal				SET II Galls milk - lbs meal.			
Pig No.	37 0	42 0	28 0	33 0	25	26	32	31
8-9 weeks								
9-10 "								
10-11 "								
11-12 "								
12-13 "								
13-14 "	10.50	10.50	10.50	10.50	14.125	15.375	10.50	10.50
14-15 "	10.50	10.50	10.50	10.50	14.50	13.75	10.50	10.50
15-16 "	10.50	10.50	10.50	10.50	11.25	12.50	10.50	10.50
16-17 "	19.25	17.50	13.25	17.50	14.50	18.25	13.25	15.75
17-18 "	21.50	22.00	11.00	21.75	16.00	22.25	10.50	20.75
18-19 "	22.50	23.00	21.25	23.50	15.00	19.75	14.75	17.25
19-20 "	21.50	20.75	20.25	21.50	16.00	17.25	15.00	16.25
20-21 "	24.25	19.00	17.50	23.50	14.50	21.00	15.50	17.00
21-22 "	25.25	24.00	19.00	28.75	16.75	22.00	16.75	20.25
22-23 "	23.00	23.00	18.00	21. 50	17.50	23.25	13.00	20.75
23-24 "	26.75	21.00	17.00	22.00	18.25	23.00	17.75	19.75
24-25 "	19.75	18.00	14.25	17.00	19.25	22.50	16.75	19.50
25-26 "					20.75	26.00	16.25	16.50
26-27 "					24.50	30.25	17.25	17.25
	235.25	219.75	183.0	228.5	232.88	287.13	198.25	232.50

WEEKLY FOOD CONSUMPTION.

	SET III Galls milk - Lbs. meal				SET IV. Galls milk - lbs. meal			
Pig No.	88 0	91 0	96 0	950	40	1 0	10 0	8 0
8-9 weeks								
9-10 "					6.875	6.875	6.875	6.375
10-11 "					9.750	9.750 8.125	9.625	9.625
11-12 "					7.125	8.750	7.250	8.125
12-13 "	10.25	9.75	10.00	10.00	7.250	8.750	7.250 6.750	8.750
13-14 "	8.25	8.50	8.50	8.75	8.500	7.125	6.125	8.250
14-15 "	9.25	8.75	9.50	9.00	9.125	8.250	7.250	7.125
15-16 "	10.50	11.50	11.00	10.25	11.50	14.50	10.00	7.750
16-17 "	13.00	13.75	13.00	12.75	13.25	14.25	11.00	10.50
17-18 "	10.00	10.75	10.50	8.75	15.00	15.25	14.75	14.50
18-19 "	13.50	14.25	12.75	12.50	17.75	17.00	14.50	16.50
19-20 "	12.50	14.00	12.50	12.25	15.00	18.00	12.25	16.50
20-21 "	10.00	15.75	11.25	11.75	16.50	13.50	11.25	13.25
21-22 "	17.75	18.25	13.00	12.25	14.50	15.75	13.50	15.00
22-23 "	22.00	20.25	15.25	15.50	15.00	17.75	14.00	16.50
23-24 "	20.75	20.50	15.50	19.50	18.00	18.00	14.00	20.75
24-25 "	17.25	18.00	18.25	10.00	20.75	19.25	20.50	20.75
25-26 "	15.00	20.50	20.50	23.50	18.25	25.75	18.00	20.25
26-27 "	17.75	20.75	18.00	22.75	17.00	22.50	18.00	24.25
27-28 "	15.25	18.25	16.50	18.25	20.50	22.50	19.50	22.00
28-29 "	24.00	28.00	25.00	24.00	21.75	26.00	24.25	24.00
	246.00	271.50	241.00	249.75	281.00	294.89	252.64	290.77

WEEKLY FOOD CONSUMPTION.

Set No. V

Galls. milk - lbs meal.

Pig No.	41 0	40 0	39 0
8-9 weeks			
9-10 "	5.375	5.625	5.375
10 -11 "	5.625	7.375	5.375
11-12 "	7.750	8.250	5.875
12-13 "	6.125	6.125	6.125
13-14 "	10.375	9.875	10.125
14-15 "	10.25	10.50	8.75
15-16 "	9.00	9.00	9.00
16-17 "	12.50	12.50	12.50
17-18 "	14.75	15.25	14.75
18-19 "	17.00	17.00	17.00
19-20 "	17.50	17.50	17.25
20-21 "	18.75	18.75	20.00
21 -22 "	20.50	20.50	20.50
22-23 "	21.25	21.25	23.50
23-24 "	21.75	21.75	22.00
24-25 "	23.00	22.75	19.50
25-26 "	19.75	20.00	20.25
26 -27 "	23.00	23.00	23.50
27-28 "	24.75	22.00	24.50
	289.00	289.00	286.90

FOOD CONSUMPTION AND UTILISATION

70-80 lbs to 200-210 lbs Live Weight.

Set No.	Sex	Pig No.	Initial Weight*	Final Wgt. ø	L.W.I.	Meal equivalent consumption	Meal equivalen per lbs gram.
I		37	74.7	210.3	135.6	470.5	3.47
		42	77.0	209.8	132.8	439.5	3.31
		28	77.0	208.5	131.5	366.0	2.78
		33	74.7	205.0	130.3	457.0	3.51
II		25	78.7	207.0	128.3	465.8	3.63
		26	76.8	209.0	132.2	574.3	4.34
		32	82.0	214.0	132.0	396.5	3.00
		31	74.0	212.0	138.0	465.0	3.37
III		88	75.3	210.0	134.7	471.5	3.50
		91	74.0	210.5	136.5	523.5	3.83
		96	71.2	210.5	139.3	462.9	3.32
		95	73.3	211.0	137.7	479.5	3.48
IV		4	75.8	213.0	137.2	500.0	3.64
		1	76.3	214.5	138.8	522.8	3.78
		10	76.3	215.5	139.2	443.3	3.18
		8	77.8	216.0	138.2	515.6	3.73
V		41	78.3	205.2	126.9	507.5	3.99
		40	75.0	206.3	131.3	503.5	3.83
		39	75.0	203.2	128.2	506.0	3.95

* Mean of three consecutive weighings at weekly intervals.

ø Mean of three weighings on consecutive days immediately prior to slaughter.

ORGANS AND OFFALS.

Sex:	Males						Castrate Males					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Empty live weight	82485	84899	85306	85964		84663	82636	83317	83193	86182	80830	83232
Hooves	69	57	42	77		61.3	56	47	43	51	37	46.8
Hair & Skin	283	284	311	608		371.5	234	251	309	472	321	317.4
Blood	3005	3544	3274	3448		3317.8	2972	3042	2590	3166	3317	3017.4
TOTAL	3357	3885	3627	4133		3750.6	3262	3340	2942	3689	3675	3381.6
Neck Thymus	44	58	60	64		56.5	28	42	77	60	70	55.4
Heart Thymus	25	36	27	29		29.3	20	29	30	27	27	26.6
Lungs & Traiches	687	705	566	821		694.8	693	655	706	620	595	653.8
Heart	277	316	285	235		278.3	235	264	266	241	271	255.4
(Blood vessels (Pericordum etc.	236	323	454	256		317.3	363	347	498	355	370	386.6
Diaphragm	438	420	445	522		456.3	388	273	479	476	481	419.4
TOTAL THORACIC	1707	1858	1837	1927		1832.5	1727	1610	2056	1779	1814	1797.2
Oesophagus	101	93	86	81		90.3	67	85	86	80	61	75.8
Stomach	565	651	640	632		622.0	558	507	683	569	655	594.4
Small Intestines	1060	1067	1239	1288		1163.5	1043	1225	1326	1532	1758	1376.8
Rectum	136	192	184	193		176.3	103	168	183	216	228	179.8
Large Intestines	646	664	736	615		665.3	760	711	799	615	1048	786.6
Caecum	140	160	161	130		147.8	163	169	156	156	207	170.2
TOTAL TRACT	2648	2827	3046	2939		2865.2	2694	2865	3233	3168	3957	3183.6

(Con.)

ORGANS AND OFFALS.

Sex:	Males						Castrate Males.					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Kidney &) Rt.	1000	1085	1135	997		1054.3	1460	1488	1299	1255	1037	1307.8
Leaf fat) Lt.	928	1210	1218	969		1081.3	1467	1517	1447	1300	1031	1352.4
Kidneys Rt.	169	153	174	181		169.3	129	110	121	148	147	131.0
Lt.	163	164	159	177		165.8	121	115	135	144	145	132.4
Psoas Major Rt	320	260	235	292		276.8	241	264	261	214	260	248.0
Lt.	288	262	236	278		266.0	249	278	261	239	238	253.0
Psoas Minor Rt	47	35	26	47		38.8	39	29	25	37	34	32.4
Lt.	57	59	34	51		50.3	49	38	26	37	36	37.2
Pancreas	100	124	108	100		108.0	98	91	106	100	101	99.2
Liver	1222	1390	2011	1330		1488.3	1628	1511	1391	1550	1819	1579.8
Spleen	115	94	92	100		100.3	83	88	97	83	79	86.0
Caul fat	221	244	156	265		221.5	260	245	269	304	214	258.4
Mesentry & fat	1268	1428	1189	1293		1298.0	1109	1251	1301	1474	1332	1293.4
Bladder	61	78	80	61		70.0	47	61	58	55	65	57.2
Gall Bladder	87	78	46	159		92.5	116	93	79	73	28	77.8
TOTAL ABDOMINAL	6046	6654	6899	6300		6475.2	7096	7179	6876	7013	6566	6946.0
Testes Rt.	240	170	191	290		222.8						
Lt	245	182	232	341		250.0						
Penis	263	311	224	399		299.3	149	110	108	88	134	117.8
Vesiculae semi,	114	138	137	188		144.3						
Cowpers Gland	165	87	151	183		146.5	4	3	4	1	1	2.6
Total	1027	888	935	1401		1062.9	153	113	112	89	135	120.4
GRAND TOTAL	14785	16112	16344	16700		15986.4	14932	15107	15219	15738	16147	15428.8

All weights recorded in grams.

LENGTH OF ALIMENTRY TRACT.

Sex:	Males						Castrate Males					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Small Intestines	2040	1987	1864	1914		1951.3	1915	1980	1940	2100	1967	1980.4
Large Intestines	378	256	428	340		350.5	300	373	400	340	420	366.6
Caecum	20	27	24	24		23.8	25	25	22	28	31	26.2
Rectum	63	99	77	100		84.8	110	92	66	104	100	94.4
Total Length	2501	2369	2393	2378		2410.4	2350	2470	2428	2572	2518	2467.6

ORGANS AND OFFALS.

Sex:	Females						Castrate Females					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No.	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Empty live wgt.	86917	82715	85276	85897	81547	84470	82950	84215	84396	86299	83741	84320
Hooves	58	44	42	46	51	48.2	50	40	44	43	45	44.4
Skin & Hair	242	350	268	415	344	323.8	212	339	353	418	384	341.2
Blood	3011	2931	2629	3576	3533	3136.0	2906	3053	3252	3296	3202	3141.8
TOTAL:	3311	3385	2939	4037	3928	3508	3168	3432	3649	3757	3631	3527.4
Neck Thymus	60	59	54	58	60	58.2	38	45	70	61	53	53.4
Heart Thymus	31	34	32	13	37	29.4	38	23	22	27	21	26.2
Lungs & Tracher	799	621	638	615	538	642.2	807	570	715	696	770	711.6
Heart	260	259	252	229	267	253.4	256	249	226	287	263	256.2
Perecordium) Blood vessels) etc.)	402	442	320	301	295	352.0	308	258	389	242	418	325.0
Diaphragm	354	452	427	468	466	433.4	401	431	408	532	515	457.4
TOTAL THORACIC	1906	1867	1723	1684	1663	1768.6	1848	1586	1830	1845	2040	1829.8
Oesophogus	68	87	88	62	67	74.4	64	76	63	98	89	78.0
Stomach	546	677	564	558	687	606.4	600	628	646	595	740	641.8
Small intestines	1440	1488	1498	1103	1760	1457.8	1501	1345	1444	1599	1554	1488.6
Rectum	218	174	160	134	211	179.4	225	213	153	203	184	195.6
Large intestines	759	809	726	697	843	766.8	959	1215	834	716	1006	946.0
Caecum.	147	159	174	172	215	173.4	160	138	197	118	246	171.8
TOTAL TRACT	3178	3394	3210	2726	3783	3258.2	3509	3615	3337	3329	3819	3521.8

(Con.)

ORGANS AND OFFALS

Sex:		Females						Castrate Females					
Set No:		I	II	III	IV	V	Mean	I	II	III	IV	V	
Pig No:		37	25	88	4	41		42	26	91	1	40	Mean
Kidney and Leaf Fat	Rt.	1401	904	1218	1164	854	1108.2	1384	1237	1365	1663	1238	1377.4
	Lt.	1244	827	1186	1145	860	1052.4	1255	1292	1358	1554	1216	1335.0
Kidneys	Rt.	147	147	118	112	134	131.6	140	151	143	154	140	145.6
	Lt.	145	139	131	116	118	129.8	140	146	148	156	143	146.6
Psoas Major	Rt.	290	260	229	259	272	262.0	276	223	245	214	299	251.4
	Lt.	320	273	266	247	283	277.8	306	215	240	218	283	252.6
Psoas Minor	Rt.	35	21	22	41	32	30.2	24	37	30	30	33	30.8
	Lt.	43	25	29	42	33	34.4	40	42	31	33	38	36.8
Pancreas		103	111	125	89	107	107.0	108	112	111	97	104	106.4
Liver		2073	1717	1840	1554	1743	1785.4	1851	1847	1795	1672	2032	1839.4
Spleen		108	85	96	83	86	91.6	95	98	77	86	88	88.8
Caul fat		189	218	221	232	296	231.2	282	357	264	336	290	305.8
Mesentry & Fat		1110	1229	1511	1080	1327	1251.4	1208	1553	1410	1535	1471	1435.4
Bladder		69	61	70	52	47	59.8	61	61	73	62	64	64.2
Gall Bladder		37	85	28	76	79	61.0	9	35	109	21	43	43.4
TOTAL ABDOMINAL		7314	6102	7090	6292	6271	6613.8	7179	7406	7399	7831	7482	7459.4
Uterus & Vagina		227	697	604	559	216	480.6	36	37	34	49	42	39.6
Ovaries		10	16	12	10	4.5	10. 5						
TOTAL REPRODUCTION		237	713	616	669	221	491.1						
GRAND TOTAL		15946	15401	15578	15408	15866	15639.7	15740	16086	16249	16811	17014	16378.0

All weights recorded in gra

LENGTH ALIMENTRY TRACT.

Sex:	Females	0					Castrate Females 0					
Set No.	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Small Intestines	1900	1924	2080	1800	2076	1956.0	2150	1700	2100	2312	1823	2017.0
Large Intestines	365	437	400	365	430	399.4	400	305	472	356	435	393.6
Caecum	25	23	28	25	24	25.0	15	23	24	27	28	23.4
Rectum	140	90	119	83	105	107.4	115	80	78	100	74	89.4
TOTAL LENGTH	2430	2474	2627	2273	2635	2487.8	2680	2108	2674	2795	2360	2523.4

COMPOSITION OF LOIN

Sex:	Females						Castrate Females					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Total Wgt.	7399	8278	7654	8392	7625	7869.6	8562	9412	7285	8845	8051	8431.0
Vertebrae	347	390	354	410	329	366.0	306	338	339	346	383	342.4
No.	6	7	6	7	6		6	7	6	7	7	
Muscle	2573	3471	3024	3294	3265	3125.4	2734	3019	2781	3394	3221	3029.8
Fat:												
Subcutaneous	3072	3077	2844	3385	2688	3013.2	3952	4390	2875	3509	3155	3576.2
Inter-musc	834	693	763	596	667	710.6	955	976	631	819	612	798.6
Total fat.	3906	3770	3607	3981	3355	3723.8	4907	5366	3506	4328	3767	4374.8
Skin	386	567	523	574	527	515.4	441	618	515	540	591	541.0
Cord	20	20	16	16	14	17.2	16	22	15	21	21	19.0
Loss in dissection	167	60	130	117	135	121.8	158	49	129	216	68	124.0

(Con.)

COMPOSITION OF LOIN. (Con.)

Sex:	Males 0						Castrate Males 0					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig. No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Total Wgt.	7286	7201	7370	6861		7179.5	8392	7655	6775	7428	8335	7717
Vertibrae	348	361	381	341		357.8	275	285	366	318	336	316.0
No.	6	6	7	6			6	6	6	6	7	
Muscle	3130	2953	3310	3167		314.0	2701	2613	2694	2898	3158	2812.8
Fat:												
Subcutaneous	2296	2445	2129	1990		2215.0	3618	3635	2483	2840	3277	3170.6
Inter-musc	774	637	738	565		678.5	1078	619	655	745	831	785.6
Total fat:	3070	3082	2867	2555		2893.5	4696	4254	3138	3585	4108	3956.2
Skin	599	773	716	652		685.0	450	462	475	483	624	498.8
Cord	16	16	17	17		16.5	13	15	18	15	17	15.6
Loss in Dissection	123	16	79	129		86.7	257	26	84	129	92	117.6

(Con.)

COMPOSITION OF LOIN (con.)

Corrected to Six Vertibrae Basis.

Sex:	Females						Castrated Females					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Total Wgt.	7399	7095	7654	7193	7625	7393	8562	8067	7285	7581	6901	7679.2
Vertebrae	347	334	354	351	329	343.0	306	214	339	298	328	312.8
Muscle	2573	2975	3024	2823	3265	2932.0	2734	2588	2781	2909	2761	2754.6
Fat:												
Subcutaneous	3072	2637	2844	2901	2688	2828.4	3952	3763	2875	3008	2704	3260.4
Inter-musc	834	594	763	511	667	673.8	955	837	631	702	525	730.0
Total	3906	3231	3607	3412	3355	3502.2	4907	4600	3506	3710	3229	3990.4
Skin	386	486	523	492	527	482.8	441	530	515	463	507	491.2
Cord	20	17	16	14	14.[illegible]	16.2	16	19	15	18	18	17.2

(con.)

COMPOSITION OF IN

Corrected to Six Verteb Basis

Sex:	Males						Castrate Males					
Set No:	I	II	III	IV	V	VI	I	II	III	IV	V	Mean
Pig No.	23	32	96	10								
Total weight	7286	7201	6317	6861	-	691	8392	7655	6775	7428	7144	7478.8
Vertebrae	348	361	327	341		34	275	265	366	313	288	306.4
Muscle	3130	2958	2837	3167		302	27o1	2613	2694	2898	2701	2721.4
Subcutaneous	2296	2445	1825	1990		212	3618	3635	2483	2840	2809	3077.0
Intermusc	774	637	633	565		6	1078	619	655	745	712	761.8
Total Fat	3070	3082	2465	2555		27	4696	4254	3138	3585	3521	3838.8
Skin	599	773	614	632		6	450	462	475	483	535	481.0
Cord	16	16	15	17		1	13	15	18	15	15	15.2

LENGTH OF BONE.

Sex :	Females						Castrate Females					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	37	25	88	4	41	Mean	42	26	91	1	40	Mean
Femur	186.5	186.0	197.0	191.0	184.0	188.90	172.0	178.0	182.0	181.0	186.5	180.90
Tibia Fibula	167.8	173.5	179.5	174.7	172.2	173.54	158.8	158.5	174.0	170.3	176.7	167.66
Cannon	77.7	81.5	84.7	80.5	81.8	81.24	78.0	76.0	85.5	82.5	82.5	80.90

Sex:	Male						Castrate Males					
Set No:	I	II	III	IV	V		I	II	III	IV	V	
Pig No:	28	32	96	10		Mean	33	31	95	8	39	Mean
Femur	191.0	183.0	185.5	193.5		188.25	168.0	181.0	190.5	187.0	181.0	181.50
Tibia Fibula	176.2	172.0	169.2	178.6		174.00	157.3	172.0	178.8	180.0	167.0	171.02
Cannon	84.5	82.5	85.0	84.3		84.08	75.7	79.7	87.0	87.0	83.5	82.58

All recordings in m.m.

TABLE

POINTS AWARDED FOR INTRA-MUSCUIAR FAT

(Scale of points ranging from 1
(leanest) to 10 (fattest).)

Muscle	Group No.	Points Awarded N.F.	 C.F.	 N.M.	 C.M.
Longissimus Dorsi	I	2	8	8	10
	II	8	9	7	8
	III	8	10	7	7
	IV	6	6	6	9
	V	7	6	-	7
Rectus Femoris	I	1	4	1	4
	II	2	3	2	2
	III	3	4	2	3
	IV	4	4	4	5
	V	5	5	-	5
Psoas major	I	2	4	1	4
	II	1	5	3	4
	III	4	5	2	3
	IV	1	4	2	5
	V	3	2	-	4
Gastrocnenius	I	1	3	1	3
	II	5	5	1	5
	III	5	5	3	4
	IV	5	6	3	5
	V	4	2	-	6