

allow of immediate diagnosis of a previous pregnancy. Sommer (1912), also dealing with the bovine, makes the statement that after pregnancy the uterus never regains its virgin state. The weight of the uterus becomes permanently increased in the approximate ratio of 2 : 1. He maintains that as a result of previous pregnancy there may be an inequality in the size of the two uterine horns. In the pig Stegmann (1923) gives the weight-ratio between virgin and involuted uteri as 1 : 2. Richter (1936) agrees that this is so when average figures are considered, but he maintains that in individual cases there is much overlapping. He finds that a definite diagnosis of previous pregnancy can be made from the enormous thickening of the elastica interna of the mucosal arteries, from the tortuous course of the uterine rami of the middle uterine artery and from the thickened, translucent appearance of the ligamenta lata.

A further important uterine change associated with pregnancy is the increase in the blood supply. The increase in the vascular bed of the uterus has already been mentioned. Barcroft & Rothschild (1932) have determined the actual amounts of blood present in the rabbit uterus at different stages of gestation. In the resting state the organ contains about 2 ccm. of blood. From the fifth day the uterus shows an increased vascularity and by mid-term the content has reached 10 ccm. From now onwards the embryos begin to grow rapidly and the blood content of the uterus increases at a similar rate until the maximum of 30 ccm. is reached at the 27th day. Just prior to parturition there is a rapid diminution in the blood content of the uterus. That this increase in vascular content is not due to simple stagnation of blood is shown by Barcroft, Herkel & Hill (1933.) They prove that there is a corresponding increase in blood-flow to the uterus and that this process anticipates foetal growth. The increase in size and pulsation of the middle uterine artery is mentioned as a means of diagnosing pregnancy in the cow (Williams, 1921.) Hammond (1927) also mentions these points, although his observation was limited to one cow well advanced in pregnancy.

From the above it is evident that during pregnancy the weight of the uterus is greatly increased due to the presence of more muscular tissue, enlarged and multiplied vascular tissue and increased blood-content. In addition it is seen that many of these changes persist after parturition, and that any resting uterus can on morphological grounds be assigned to one of two groups - virgin or involuted. In comparing uteri the existence of these two classes must be borne in mind. Especially in the non-gravid and early pregnant stages will the differences be of importance. Later in pregnancy these class differences will tend to be obscured by the changes induced by the existing pregnancy.

Some workers have considered the weight of the gravid uterus. This is of interest in that it gives the weight of the entire foetal system. Knowledge of the growth in weight of this system is useful in the study of growth or fattening of pregnant animals - it allows of a correction being made for foetal material. In the bovine Bartlett (1926) has studied this matter from a different angle and has constructed a table giving the weight of the cow at each stage of pregnancy relative to her farrow weight.

For the sheep Curson & Malan (1936) tabulate the weight of the gravid uterus from 3 to 149 days. The increase is from 163 gm. to 3700 gm. It must be pointed out that the high value at 3 days is due to the author's having included under "gravid uterus" the vagina, vulva, tubes, ligaments and ovaries. In a further study, (Malan & Curson, 1937) the weight at 30 days is found to be approximately 130 gm., while the weight near term is given as 5320 and 6058 gm. The authors express the weight of the gravid uterus as a percentage of the nett body weight (i.e. total body weight of ewe less the weight of the gravid uterus) ~~mm~~ of the ewe, and then these values are plotted against gestation age. The result is a parabolic curve for which a fairly simple formula is given.

Bergmann's (1922) figures indicate that in the bovine the weight of the gravid uterus increases fifty-fold between the second and the tenth months. The increase is more rapid in the later months, hence the data would fit a curve similar to that given for

the sheep. Bergmann makes the statement that from the weight of the gravid uterus, foetal age may be determined with as much accuracy as from the weight or the length of the foetus itself. According to Hammond's (1927) figures for the bovine the increase of the gravid uterus from the beginning of pregnancy till the approach of parturition is one hundred-fold.

Brodermann (1921), dealing with the sow, maintains that the weight of the gravid uterus is very variable. Contributing causes to this variability are previous pregnancies, the number of foetuses and the amount of fluid present.

For the guinea-pig Draper (1920) gives figures which indicate that the position here is approximately similar to that already described for the sheep.

4. PLACENTA.

The sheep has a cotyledonary placenta - semiplacenta multiplex (Zeitschmann, 1923). The cotyledons are made up of two parts, maternal and foetal. In the sheep the maternal cotyledon is concave and encloses the foetal component. In the non-gravid uterus the cotyledons are exceedingly small and can be recognised merely as small/circular elevations on the surface of the uterine mucosa. During oestrus they appear to be somewhat more prominent. Ellenberger & Baum (1921) state the total number of cotyledons in the sheep to be between 88 and 96, arranged in each horn in four longitudinal rows.

By Assheton (1905) the diameter of the ovine cotyledon at 60 days' pregnancy is given as about 2 cm., while at full term the figure lies between 2.5 and 3 cm. Natural-size illustrations of the sheep's cotyledon at mid-term, ^{presented} ~~given~~ by Zeitschmann (1923), indicate that at this stage the diameter lies between 2 and 3 cm. It is evident that the small cotyledon of the non-gravid uterus must undergo enormous growth during pregnancy. The few figures ^{mentioned} ~~given~~ suggest that the major portion of this growth occurs during the first half of gestation. In the bovine the growth of the placenta has received some attention. Rorik (1907) gives the weight of the placenta at 7 weeks as 12 gm. and at 26 weeks as 5200 gm. From his figures there does not seem to be any further

increase after this stage. He shows how the ratio of foetal to placental weight widens with the advance of gestation. The area of the placental surface increases from .04 sq. metres at 7 weeks to 45.25 sq. metres at 31 weeks. Hilty (1908) traces the increase in size of the largest cotyledon. The diameter increases from .6 cm. in the virgin uterus to 7.8 cm. at the 26th week, after which the increase, if any, is only very slight. Similar results are reported for the increase in height of the cotyledon and in the length of its attaching stalk.

The idea of rapid enlargement of the placenta during the first part of pregnancy, followed by a period of little or no change is supported by the figures for the rabbit ^{tabulated} ~~given~~ by Lochhead & Cramer (1908.) Here placental weight is shown to increase rapidly up to the 22nd day, after which it remains stationary apart from a slight decrease at the approach of term. For the guinea-pig Draper (1920) gives some data. Unfortunately foetal membranes and placenta are grouped together, hence the use of the figures here is open to criticism. Nevertheless, Draper's graph shows a period of rapid increase followed by a period of little development.

In the bovine the number of functional cotyledons has been considered. Rorik (1907) reports wide variations in the total number of cotyledons - 70 to 120. He shows that the number in the horn bearing the foetus is always in excess of that in the other horn, sometimes by as much as 150 per cent. He encountered accessory cotyledons in one-third of his cases. The presence of these was not necessarily associated with a small number of true cotyledons. Bergmann (1922) also reports a preponderance of functional cotyledons in the gravid horn. By counting the numbers of cotyledonary attachments he concludes that in the gravid horn no more attachments occur after the second month, whereas in the non-gravid horn these continue to be formed until the end of the third month.

The mode of attachment of foetal to maternal cotyledons has been studied by Assheton (1905.) In the sheep the first attack upon the maternal uterine mucosa occurs between the 17th and 18th days post-

coitum. At this stage the attachment is most frail, the membranes being held in position mainly by the pressure of the foetal fluids. At about the 30th day villi appear on the chorionic surface, resulting in a closer attachment. At the 44th day the foetal cotyledons are visible and have convex free surfaces which fit into the concavities of the maternal cotyledons. Assheton states that by the 78th day the general character of the fully formed placenta is apparent and that from this time the only change is a slight increase in size. He also mentions the presence of large reddish-black coagula in the centres of the fully formed cotyledons.

5. FALLOPIAN TUBES.

In the sheep the uterine tube has a length of 14 to 16 cm. (Ellenberger & Baum, 1921.) The gradual merging of the tube with the horn of the uterus has already been mentioned. Lee (1929) maintains that in most mammals there is a more-or-less well-developed valve at this junction. The sheep is not specifically mentioned, nor is it implied that the junction is always readily recognised from the exterior.

In none of the standard embryological or obstetrical textbooks is any mention made of specific pregnancy changes in the Fallopian tubes. Bergmann (1922) concludes that pregnancy has no influence on the length of the tubes. Lambert (1928) states that in the horse, the bovine, the cat and the dog he has found, associated with gestation, extensive vascularization of the tubes, accompanied by hypertrophy of connective and muscular tissue and a distinct increase of elastic tissue.

(b) FOETAL MEMBRANES & FLUIDS.

1. MEMBRANES.

The formation and the appearance of the foetal membranes of the ruminant are well described by Zeitschmann (1923.) He shows that there are two sacs, the inner being the allanto-amnion and the outer the allanto-chorion. Like Craig (1912) Zeitschmann states that early in pregnancy the outer sac increases rapidly and

soon comes to fill the entire uterine cavity. Meanwhile the inner sac has remained relatively small, investing the foetus closely. Later on the amniotic sac expands rapidly and soon it occupies a large portion of the allantoic space, practically obliterating the central part of the sac. At this stage the concentric arrangement of the two sacs is not very evident and the appearance is more that of a large amnio-allanto-chorionic sac with two allanto-chorionic appendages - one at either pole. These latter two sacs retain their communication with each other and with the umbilical infundibulum. This relationship is well indicated in a sketch given by Bailey & Miller (1921.)

The appearance of the ovine foetal sacs is described by Assheton (1905.) He shows how at 14 days post-coitum the blastocyst has extended the full length of both uterine horns. At this stage the membrane is very frail, is transparent and absolutely colourless. Unfortunately he does not trace the further development of the membranes to show at what rate these delicate sacs grow into the relatively large structures which come away as the afterbirth of the ewe. Malan & Curson (1937) give figures for the weight of the membranes during pregnancy. These show that the total weight increases steadily throughout the period, although this increase is not shared equally by the two components. The allanto-chorion is shown to undergo little or no increase after the second month, while the allanto-amnion increases steadily for four months, after which the rate of increase declines.

The weights of the membranes at different stages of gestation in the bovine are given by Rorik (1907) and by Hammond (1927.) From these sources it is seen that just prior to parturition the membranes have attained more than 1500 times their weight at the end of the first month of pregnancy. In addition Hammond's figures show that the membranes grow at a steady rate throughout the period.

The fact that Draper (1920) has included the weight of the placenta in his figures for the membranes of the guinea-pig, renders these data rather unsatisfactory. However, if it is assumed that during the second half of pregnancy the increase in weight of the placenta becomes negligible, then Draper's graph would tend to

indicate a steady growth of membranes throughout pregnancy.

Hammond (1937) deals with the foetal placenta and membranes of the rabbit. His graph shows that there is considerable increase in these structures and that a fairly steady rate of growth is maintained throughout the period of gestation.

2. FLUIDS.

Needham (1931) gives a summary of most of the available knowledge on the foetal fluids. Most of the researches quoted by him are spasmodic investigations on isolated chemical constituents of the fluids. For the purpose of an inquiry into the origin of the foetal fluids, Paton, Watson & Kerr (1907) selected the sheep as their subject "because, in this species, both fluids are present in relatively large quantities throughout the entire foetal period." The figures given by the authors bear out this statement. Moreover they show that both fluids undergo changes in physical and chemical properties with the advance of gestation, while at the same stage of pregnancy the two fluids differ. Malan & Curson (1937) show that, in the sheep, the total amount of fluid increases steadily with advancing foetal age. They find that the allantoic fluid shows little increase during the first three months, to which period the increase in the amount of amniotic fluid is mainly confined. Zeitschmann (1923) gives the amount of fluid at parturition as between 50 and 450 cc. for the allantoic and between 150 and 400 cc. for the amniotic.

For the bovine Bergmann (1922) shows that the quantity of foetal fluid increases rapidly during the first half of pregnancy, while later this increase is much less. Hammond (1927) shows that during the first half of pregnancy the increase in weight of the foetal system is due mainly to the accumulation of fluid, whereas towards the end of the term it is accounted for almost exclusively by foetal growth. Bergmann finds that what increase does occur after the fifth month concerns mainly the allantoic fluid. The latter fluid is present in greater amount than the amniotic. Zeitschmann (1923) asserts that the ratio at full term is 3:1 in favour of the amniotic fluid.

Hammond (1927) draws attention to the fact that cessation of

increase of the foetal fluids and inception of secretory activity of the mammary gland both occur at about the fifth foetal month. He suggests that this may be significant and no mere coincidence. In the case of the rabbit (Hammond, 1937) it is also seen that there is a steady increase in the amount of fluid up to the 24th day, after which there is absorption of fluid, so that at birth only a few drops remain. The absorption is active on the part of the foetus itself, but the decrease in amount tends to indicate a cessation of fluid formation. If this is so, then in this species too there is apparently some correlation between mammary secretory activity and inhibition of foetal fluid formation.

In the guinea-pig Draper finds that the amount of amniotic fluid when plotted against gestation time gives a double curve, indicating at first an increasing rate of formation and later a decrease in this rate. Until the middle of the period of gestation the amniotic fluid weight exceeds that of the foetus. Afterwards the foetal weight is the greater and the ratio between it and the amniotic weight becomes wider with the advance of pregnancy.

(c) THE FOETUS.

1. FOETAL AGE.

Although MacDowell et al (1927) speak of foetal age as distinct from age of the zygote, most workers use the term as indicative of the total age of the organism, from the time of fertilization of the ovum until the moment of death or examination of the foetus (Arey, 1931). In most cases it can be assumed that the time of death of the foetus coincides with that of the expiry of the mother. Especially is this the case where the mother is perfectly healthy right up to the time of slaughter. In the human being, where available knowledge is not sufficient to allow of accurate determination of the time of fertilization, such terms as "copulation age" and "menstrual age" have been introduced. Neither of these gives the true foetal age.

In order to be able to determine the exact time of fertilization it is essential to know the time of ovulation, the rate at which the

sperm traverses the female genital tract and the vitality of both ovum and sperm in the uterine passages. As a result of the investigations of Quinlan and his co-workers (1931 & 1932) a detailed knowledge of all these factors in the Merino sheep is available. They have shown that ovulation occurs at about the 30th hour after the onset of oestrus, and that the unfertilized ovum soon loses its vitality. The male sex cell reaches the Fallopian tube, in which fertilization occurs, within six hours of copulation, while it retains its vitality for 12 to about 36 hours. If, therefore, service has been allowed at such times during oestrus as to ensure a large number of active sperms being available in the tube at the time of ovulation, then it may be taken that fertilization occurs without delay i.e. at about the 30th hour after the onset of "heat."

The methods of determining the onset of oestrus and of calculating foetal age will be considered in the following chapter.

2. FACTORS AFFECTING GROWTH OF THE FOETUS.

In dealing with foetal growth it is essential that due consideration be given those factors which may influence development of the foetus. Where possible these factors should be controlled. Failing this they should at least be borne in mind in the interpretation of results. On consulting the literature one finds that in nearly all cases birthweight has been the criterion as to whether a factor has influenced foetal growth. Under these circumstances, therefore, even after the influence of a certain factor has been established, there is still the difficulty of not knowing whether this influence was exerted with equal force throughout the entire prenatal period or whether it had been intensified at certain stages.

The painstaking efforts of MacDowell and his collaborators to ensure pure strains and absolute accuracy in ageing have failed to eliminate considerable variation in the weights of foetuses of identical age. No doubt the causes of such variations are highly complex and only by the most extensive research would they be checked with accuracy. Even to attempt a detailed discussion of this problem is far beyond the scope of this work, hence but a few of the more obvious points will be mentioned.

Firstly, maternal influences may be considered.~

BREED & STRAIN.

To elaborate on the differences in size and conformation encountered in different breeds and strains of the same species would be superfluous. It is shown by Fitch, McGilliard & Drumm, (1924) that not only is there a difference in birthweight in four milk breeds, but that the ratio of calf to maternal weight also differs. This indicates that the birthweight differences cannot be regarded merely as proportional increases or decreases according to maternal size. In a detailed study of two closely related strains of albino rats ~~Freudenberg~~ (1932) shows that apart from differences in body weight, there are present, even at birth, distinct differences in organ weight-ratio.

These few comments should suffice to demonstrate that in studies on prenatal growth it is essential that material be drawn not only from the same breed but also, as far as is possible, from the same strain.

SIZE AND CONDITION.

His observations on both pure and cross-bred sheep lead Russel (1919) to state that in nearly every case [^] size of the lamb determined by size of the ewe. Humphrey & Kleinhenz (1908) maintain that large ewes produce lambs heavier than those from small ewes. Hammond (1932) mentions a crossing experiment at the University College, North Wales. Welsh ewes were bred to Border-Leicester and to Southdown rams. Although the former rams are large animals, ewes served by them lambed with only very little more trouble than did those bred to the Southdowns. For the rat, King (1915) states that as the weight of the mother increases, so does the birthweight of her young become greater. However, as in the rat weight and age are correlated, it is possible that the greater maturity of the heavier females played some part in her investigations.

Hammond (1932) points out that the maternal influence over foetal development is twofold - genetic and nutritional. He shows that in a favourable season, during which the ewes were in good condition prior to lambing, the birthweights were high. Further, when ewes were divided according to condition into good, medium and poor

groups, it was found that the average birthweights followed the same order. The difference between the first two groups was much less than that between the medium and the poor groups. It appears that improvement in condition beyond a certain stage is not reflected in the birthweights of the offspring from such ewes. In fact it is found by Quinlan & Roux (1936) that extremely fat cows produce very light calves. This finding is in accordance with the results of Eckles (1919 & 1920.) The latter concludes that, in the cow, nutrition of the mother has but little influence on the size of the calf at birth. Donald & McLean (1935) state that "increase in birthweight as the lambing season advances is due to improvement in the condition of the ewes." Apparently they contend that an improvement in the condition of the mother is rapidly communicated to the foetus. Hammond (1932) stresses the necessity for providing pregnant ewes with good feeding for six weeks prior to lambing. He may, however, be more concerned with procuring a good milk-supply subsequent to parturition than with actually producing a heavier lamb at birth.

Eckles (1919 & 20) and Fitch et al (1924) maintain that cows in quite poor condition produce calves of ^a average weight. The latter authors show that only when nutrition is severely depressed is calf weight affected. Even then the effect is not proportional to the loss of condition of the mother. This is demonstrated by the decrease in the calf-mother ratio. In their work on the breeding of cattle on pastures deficient in mineral content, du Toit & Bishop (1929) show that, between their "bone-meal" and their "control" herds, in spite of marked differences in condition, vigour and resistance to disease, there is no significant difference in birthweight. Groenewald (1935) also fails to find a reduction of birth-size in calves born of mothers fed on rations deficient in various mineral substances. Barry (1920) maintains that severe inanition in pregnant rats causes a decrease in body weight of the resulting litter. The different organs of the foetus are not ~~at~~ all affected to the same extent, hence a change in the weight-ratio of the organs results. Quinlan & Roux (1936) find that in cows subject to severe restriction of exercise and sunlight there is no change in either size or degree of

development of calves, provided that this treatment does not result in excessive deposition of fat, when low birthweights will be encountered.

AGE.

According to age, breeding stock may be divided into three classes - immature, mature and aged. In practical animal husbandry the breeding ability and production of animals in each of these classes have received much attention. All this work is of great interest here, for it brings out one essential fact - that both as a productive and as a reproductive machine the mature female exhibits an efficiency far superior to that of the female in either of the other two classes.

Hammond (1932) refers to the inability of shearlings to produce lambs with a birth weight equal to that of the offspring of mature ewes. Donald & McLean (1935) conclude that the influence of age of the ewe is sufficiently strong to obscure the effects of sex differences in the lambs.

^Fitch et al (1924) find that mature cows produce calves larger than those of immature cows. Eckles (1919 - 20) states that first calves are smaller than later ones and that the maximum weights occur at the third to the sixth calving. Later in life, in the aged group, there is a decrease in birthweight. It is well-known that milk production increases in the 2nd and 3rd lactations and declines in aged cows.

King (1915) states that birth weight in the rat increases with the age of the mother. Donaldson (1924) mentions that the albino rat usually produces its largest litters at the 2nd to the 8th gestations. Long (1906) states that the average weight per pigling in the case of year-old sows is about 800 gm., and that this increases with age until at 5 years the figure is 1300 gm. Carmichael & Rice (1920) show that, in addition to this increase in the size of the individual pigling, there is also an increase in the number per litter as the age of the sow increases. These changes are evident up to the 4th litter. Schneider (1936) studying German pigs reports similar results.

A further indication of the greater reproductive ability

of the more mature female is the fact that in sheep multiple births occur with the greatest frequency in the most mature age-groups, (Jones & Rouse, 1920).

In the foregoing, reference has continually been made to the number of gestations as an index of maturity. In most cases this will also be indicative of age. But that maturity is actually a matter of age, and is not dependent on previous breeding, is shown by Joubert (1936). He finds that virgin ewes of mature age will produce lambs equal in weight to those ^{of} ewes of the same age which had previously been bred. Donaldson (1924) shows that if the female rat is prevented from breeding until she is four months of age, then the first litter will be as large as any of the subsequent ones.

To sum up the various maternal influences it may be stated that breed, strain and maturity are of importance in foetal development, whereas the state of nutrition, unless grossly beyond normal limits, should not receive undue attention.

PATERNAL INFLUENCES.

It is quite evident that the influence of the ram on ~~the~~ foetal size is limited to the genetic sphere. Mumford (1901) declares that the sire does not exert any influence on the size of its offspring. Humphrey & Kleinhenz (1908) find that paternal influence is rather limited. Their method of investigation, however, was not calculated to allow for differences in age and breed.

Hammond (1932) cannot agree that the ram has no influence over the size of its lambs. He draws attention to the fact that cross-bred lambs often differ in size from the pure breed. This difference must be induced by the sire.

In dairy cattle Fitch et al (1924) find that the sire does exert an influence upon calf weight, but that the degree of such influence is somewhat limited. Eckles (1919 - 20) shows that the calf produced by a Jersey cow when mated to a Fries bull is much heavier at birth than ^a pure-bred Jersey calf. Quinlan & Roux (1936) also find that the bull has an influence on calf-size.

Additional factors which should be considered are :--

NUMBER OF FOETUSES.

It has been shown by Murray (1921) and by Hammond (1932) that each member of a set of twins is lighter than a single foetus of similar age. The total weight of the set, however, exceeds that of the single individual. Between twins and triplets similar differences exist. These results are confirmed by numerous other workers. Schneider (1936) points out that in pigs the size of the individual pigling at birth decreases with the increase of the number per litter. King (1915) says that the same applies in the albino rat.

Zuntz (1909) shows that when rats are kept on unbalanced rations, the frequency of gestation and the number per litter are reduced much more than is the size of each individual foetus. Evidently, where nutriment is limited, reduction in number safeguards the size of the young.

SEX OF THE FOETUS.

That the birth weight of the male exceeds that of the female has been established for the human being (Jackson, 1909), the sheep (Hammond, 1932; Murray, 1921; Donald & McLean, 1935), the bovine (Fitch et al, 1924), the rat (King, 1915; Donaldson, 1924; Freudenberg, 1932) and the pig (Schneider, 1936.)

This difference in weight is not merely the result of an enlargement in all dimensions in the male. For the bovine it has been demonstrated by Keller (1920) and by Beer (1925) that somatic sex-differences do exist. These are detectable as early as the second month of prenatal life. The male is much more plump and is better muscled, especially in the cervical and the shoulder regions. The female is more slender and has a long, narrow head. The results of Keller are well controlled in that he used sets of twins of like and of unlike sex. Although variations were found in both groups he concluded that there was evidence of a definite inherent somatic sex-difference.

For the pig similar results are reported by Smetisko (1925.) Jackson (1909) refers to sex-differences in human foetuses and Scammon (1922) shows that in the height-weight index of new-born

babies this difference is also discernible.

In addition to the above influences there is still to be considered the effect of the time of the year at which birth occurs.

SEASONAL INFLUENCES.

Hammond (1932) and Donald & McLean (1935) find that birth weight increases with advance of the lambing season. Apparently, however, they consider that this is the reflection of an improvement in the condition of the ewes. Carmichael & Rice (1920) find no regular birth weight differences due to season, although they do state that piglings farrowed outside the regular seasons have smaller weights than usual. Schneider (1936) finds that the birth weight of piglings farrowed in winter exceeds by 70 gm. per foetus that of similar young born in summer. [~~Murray (1937) has also observed seasonal variations in the birth weight of rats kept at Onderstepoort.~~]

3. GROWTH IN WEIGHT.

Colin (1888) appears to have been the first investigator to study the growth in weight of the ovine foetus. A big gap in his figures between the ages of 57 and 120 days makes it impossible to determine the shape of the growth curve. Due to the absence of age figures the series of foetal weights given by Paton, Watson & Kerr (1905) is also useless for this purpose. These weights indicate only the range to be expected. Craig, (1912) ^{mentions} ~~gives~~ 4 Kg. as the weight of the lamb at birth.

Curson & Malan (1935) give detailed figures for a whole series of Merino foetuses. In general their figures are lower than those of Colin. This may be due to their having worked upon a different breed. They show by means of a chart that when weight is plotted against age the result is a logarithmic curve. The latter shows much fluctuation, especially after the age of 100 days. The authors state "that these fluctuations are well understood, for the series of lambs was taken at random, and there is considerable variation in the weight of individuals of the same age." In a subsequent paper (Malan & Curson, 1936 a) ~~the~~ additional weights are given and although these are not plotted against age, it appears that the curve so obtained would follow a course similar to that of

the earlier article. Further weights are ^{presented} ~~given~~ by Malan & Curson (1937) and these only serve to strengthen the previous findings of these authors.

For the bovine foetus a fair amount of data are available. Rorik (1907) and Bergmann (1922) ^{tabulate} ~~give~~ a considerable number of weights for foetuses of various ages. Craig gives the average weight of the calf at birth as 32.5 Kg. Hammond (1927) mentions the weights of eight accurately aged foetuses. In spite of many overlappings, and the fact that breed differences must be considerable, these figures all indicate that the age-weight curve for the bovine foetus is similar to that just described for the sheep.

The same type of curve has been established for other mammals e.g. the human being (Jackson, 1909) the guinea-pig (Draper, 1920₄), the rat (Stotsenberg, 1915) and the mouse (MacDowell et al, 1927.) Apparently the same type of curve holds good for other mammals, and it appears possible to express all foetal growth rates by the same general formula, the constants of which have merely to be adjusted for each species.

So far only absolute growth has come under consideration. When relative or percentage growth curves are considered there is a remarkable lack of unanimity amongst workers. When it is noticed that Brody (1927 a) using the identical data employed by Minot (1908), obtains radically different rates, then it is realised that the real problem here is of mathematical origin.

Brody (1927 b) gives graphs with which he attempts to show that the relative growth curve is not of a steadily decreasing nature, but that it is made up of a series of straight segments. MacDowell et al (1927) do not agree with this. They demonstrate an even and regularly decreasing curve. They criticise the data^a upon which Brody relied for his determinations and they also show that any curve may be approximated by a number of straight lines.

4. GROWTH IN LENGTH.

In the introduction to this paper was mentioned the failure of investigators to define with accuracy their procedure. Nowhere is this failure more apparent than in the case of length of foetuses.

By determining increase in length an idea of skeletal growth, rather than mass increase, is obtained. Later it will be seen that these two factors are actually correlated. It is evident that in each case the identical dimension should be measured. This can be done only when the extremities of the line are clearly defined. If the line is not straight then its course between the two fixed points should be indicated. Unfortunately in the literature the term "length of foetus" is often given without further amplification.

For the human foetus certain fixed measurements are in general use. These are described by Mall (1910). Commonest of these are sitting-height (crown-rump,) standing-height (crown-heel,) and vertebral column length. In the veterinary field most workers have, no doubt, made use of a dimension akin to the human sitting-height or crown-rump measurement. That the fixed points have varied is indicated by the few instances in which an attempt at defining "length" has been made. Hammond (1927) refers to a poll-base-of-tail measurement, while Curson & Malan (1935) use the forehead and the base of the tail as landmarks. In rats the nose-anus dimension is in general use (Donaldson, 1924.) Bergmann (1922) refers to a muzzle-rump measurement used by some investigators. He concludes that this is inferior to the poll-rump measurement.

In all these cases attempts have been made to indicate the length of the foetal body. All the measurements are of straight-line dimensions. Although "crown-rump" appears to be a most useful measurement in the human being, its value in an animal with a relatively long and flexible neck is greatly reduced by the possibility of large errors due to changes in posture. In the sheep foetus, even when it is laid out flat with the neck perfectly straight, relatively large variations may be introduced simply by flexing and extending the head on the neck. In making use of such dimensions it is essential that the position of the foetus as well as the landmarks be standardised and defined with care.

Malan & Curson (1936 a) express the opinion that a measurement along the back of the foetus, in preference to a straight line, should assist in eliminating the effect of posture. It was their intention to make use of Mall's (1910) "length of vertebral column" dimension.

They used as an anterior landmark for their "curved crown-rump" length, the midpoint of the line joining the medial canthi of the eyes. The posterior landmark was the root of the tail (Curson, 1937) The authors do not find that the use of this measurement improves the fit of the data in a weight-length curve. From this it would appear that the curved line is no more accurate than a straight measurement. The line used is obviously not the equivalent of that given by Mall, and it remains to be seen whether this line - length of the vertebral column - will give better results. The difficulty in making this measurement is that there is nothing to indicate that, in any species other than the human being, the extension of the eye-ear line indicates the point of origin of the vertebral column.

Lengths of sheep foetuses from the third to the twenty-second week ^(of prenatal life) are given by Gurlt (1847.) His figures show no close similarity to those of other workers. Better figures are those of Assheton (1905.) These are limited to the very young stages. A large amount of data concerning accurately aged Merino foetuses are ^{presented} ~~given~~ by Curson & Malan (1935.) On plotting these data against age the authors obtain a curve which resembles an elongated "S". This curve differs from the weight-age curve previously described. Due to the small number of foetuses used the data show much variability, but this cannot obscure the fact that there is a definite length-age curve for foetal growth. Apart from additional figures for straight crown-rump length, Malan & Curson (1936 a) also give their "curved crown-rump" measurements. Although the latter figures are not plotted, it appears that this would result in a curve of roughly the same shape as that obtained with the straight-line dimension. Galpin (1935) ^{indicates} ~~gives~~ the lengths of a number of accurately aged Romney foetuses. The measurement taken appears to have been somewhat akin to Malan & Curson's (1936 a) curved crown-rump dimension. If the figures represent straight crown-rump lengths then a Romney foetus must be considerably larger than a Merino foetus of identical age.

Craig (1912), who simply speaks of "length of the foetus," gives figures for the horse, the bovine, the sheep, the pig and the dog. As he ^{mentions} ~~gives~~ merely the average length for each of the seven periods

into which he divides the gestation period, no conclusions as to the nature of the growth curve may be drawn. His data for the sheep fit in well with the figures ^{supplied} ~~given~~ by Curson & Malan. For the length of the lamb at birth Craig gives 18 inches, which is considerably higher than the figure mentioned for a 145 day foetus by Curson & Malan (1935.) If Craig's figure is a good average one then the distinct flattening of the last part of Curson & Malan's curve should disappear, and the curve should be much more even. This would then produce a curve resembling that ^{presented} ~~given~~ by Draper (1920) in his work on the guinea-pig. His curve also has a double nature, but the second change of direction is very gradual. Draper concludes that from the 15th day of foetal life till the 64th day the percentage rate of growth in length decreases steadily. Hammond (1927) gives the measurements of eight bovine foetuses, ranging in age from 1 to 8 months. The figures would apparently fit a curve such as that under discussion.

Already it has been shown that there is a correlation between the age and the length of a foetus. In the human foetus this relationship has received a fair amount of attention. Simple empirical formulae for expressing each of these characteristics in terms of the other are given by Scammon & Calkins (1923.) Noback (1922) demonstrates the simple relationship between sitting-height and standing-height. Scammon (1937) shows that the simple relationship between these two lineal dimensions may be extended to embrace numerous other external measurements of the foetus. Noback (1925) demonstrates that in the lineal growth of a single system such as the respiratory, the age-length correlation is still present.

Curson & Malan (1935) consider the correlation between weight and length. In addition to giving a graph for these two characteristics plotted one against the other, they show that relative increases in length and in weight may be plotted to a straight line. This is confirmed in a later article (Malan & Curson, 1936 a). It is also found that "fit" is not improved by the use of the curved crown-rump measurement. They conclude that increase in length is a function of body weight and that the reverse also holds good. They observe that the logarithmic values of weight and of crown-rump

length are equally variable. Hammond (1927) states that "weight is more variable than length." Curson & Malan (1935) show that when Arey's (1931) data for the human foetus are plotted, the same length-weight relationship becomes evident. According to Scammon (1923) there is a definite height-weight index for babies at birth.

Workers on post-natal growth have not been content with measuring one dimension. Instead they make use of a number of representative measurements, some of which are mentioned and illustrated by Ragsdale, Elting & Brody (1926.) It will be seen that there are two classes - straight and curved or circumferential. The purpose of all this is to obtain an idea of growth in all three dimensions, rather than to be limited to a "one-dimensional" conception of the process. It appears that by an extension of this idea to the study of foetal growth a much clearer and more accurate visualization of the changing proportions of the developing foetus may be attained. It is conceivable that ratios between dimensions may prove to be better indices of age than the absolute measurements themselves.

5. GROWTH IN SURFACE AREA.

Not only weight and linear dimensions but also surface area may be used as a measure for growth. In the living animal, especially after birth, surface area assumes an even greater importance, for it is intimately associated with heat regulation and metabolism. In the sheep foetus this aspect of growth has been studied by Malan & Curson (1936 b.) They find that the curve for surface area against age is similar to that for weight and age. Relative increases in area and in weight may be plotted to a straight line. This indicates a close correlation between them.

Owing to the desirability of preserving intact the foetuses used in the present work, surface area has not been considered.

6. CHANGES IN EXTERNAL APPEARANCE.

It is not intended to discuss here the earliest developmental stages of the sheep embryo and foetus. Rather is it the object to commence at the stage at which in textbooks the subject is usually left, and to consider the manner in which the early common mammalian type is moulded into the Merino lamb delivered at parturition. The changes which take place will be correlated with age so as to produce

something similar to Arey's (1931) "Table of Correlated Human Development."

Assheton (1905) intimates that the development of the sheep up till the 10th day has been worked out by him (1903) and that the further development has been fully described by Bonnet (1895 & 1898.) Unfortunately neither of these papers was available to me.

For the bovine Hammond (1927) gives a table which in spite of the small number of foetuses available for its compilation, is a useful guide in age-determination. An interesting feature of this table is the use that is made of the stage of pigmentation of the eye in the early foetuses. Attention is also directed to the value of the limb-bud and the development of the hoofs in aging foetuses. Some further details concerning the external form of bovine foetuses in the early stages of gestation are given Kupfer (1936.)

The appearance and distribution of hair on the foetus has long been used as a criterion of age. The spread of hair over the Merino foetus is described by Deurden & Ritchie (1924.) The time of the first appearance of hair is placed towards the end of the 2nd month. To this exception is taken by Curson & Malan (1935,) who maintain that hair is first visible on the forty-second day of prenatal life. Galpin (1935) describes the development of hair in the New Zealand Romney foetus. She draws a distinction between tactile hairs and body hairs. The former start to appear on about the 76th day, whereas the latter are first seen on the 90th day. These times refer to the actual emergence of the hairs through the skin. The hair follicles, of course, are distinguishable long before this. Like Deurden & Ritchie, she finds that the development of hair is furthest advanced on the most anterior parts of the body. The backward spread takes place in accordance with a plan so regular that it appears to offer an excellent means of age-determination.

Craig (1912), Bergmann (1922) and Hammond (1927) give details for hair development in the bovine. When due allowance is made for the increased length of the developmental period in this species, it is seen that the figures ^{mentioned} ~~given~~ correspond closely to those obtained for the sheep.

Other external features do not appear to have received much attention.

(d) THE MATERNAL MAMMARY GLAND.

Probably on account of the relative unimportance of the sheep as a milk producer, its udder does not appear to have excited scientific interest. That milk production in the sheep is of economic importance, especially in crossing for fat lamb production, has been shown by Joubert (1936.) From the above it must not be assumed that in other species the causes of mammary development and milk secretion have not been the subject of scientific investigation. On the contrary, much work has been done in this connection.

Early in the present century Lane-Clayton & Starling (1907) studied with inconclusive results the effects on mammary development of various foetal placental extracts. Loeb & Hesselmann (1914 a & b) show that mammary activity is correlated with the oestral cycle as well as with pregnancy. The changes occurring with each oestral cycle resemble closely those of the early part of gestation.

A close study of the whole problem has been carried out by Turner. This author (1930) traces the foetal development of the udder, indicating the stage attained at birth. In a later paper (1934) development in the postnatal period is followed up and it is shown that, excepting for the deposition of fat, there is no change between birth and the onset of puberty. From this time onwards, with each recurring oestral cycle, there is more and more growth and branching of the duct system and the gland tissue comes to resemble a tree without leaves. With the onset of pregnancy there is still more branching activity, followed by alveolar development. At mid-term the leafless tree picture has been altered to resemble a bunch of grapes, the ducts being the stalks and the alveoli the grapes. Now secretion commences and it is the accumulation of the secretory product which results in the visible filling out of the mammary gland. Hammond's (1927) results are in agreement with these views. Woodman & Hammond (1923) and Asdell (1925) find that at mid-term the watery secretion which, even in virgin heifers, may be withdrawn from the udder, begins to undergo qualitative and quantitative changes which foreshadow the formation of the cholostral milk. The above

results appear to explain why workers such as Ragsdale et al (1924) have found that in lactating cows a subsequent pregnancy does not have any effect upon milk yield until the end of the fifth month of gestation.

At the time of fertilization, therefore, mammary development is already under way [~~excepting in heifers impregnated at the first estral period.~~] The further development of the udder occurs in a slow and orderly manner, and is spread out over the entire period of gestation. It is incorrect to regard milk secretion as being initiated rapidly a short while prior to parturition.

This internal development and the accumulation of fluid must make itself evident in an increase in size and weight of the gland. Hammond (1927) shows that in heifers in their initial gestation period, the weight of the udder increases from 2220 gm. at the end of the first month, to about 3000 gm. at mid-term and to between 6000 and 9000 gm. shortly before parturition. Thus the major portion of the increase in weight occurs in the second half of pregnancy. Hammond further indicates that in considering udder weights, especially in dry cows, the age and the condition of the subject should receive due attention as both these factors have an influence on the weight of the organ.

(e) THE MATERNAL ENDOCRINE GLANDS.

1. THE PITUITARY.

This gland is most intimately associated with all the sexual functions of the animal body. A sex-difference in pituitary size has been demonstrated in man (Rasmussen & Herrick, 1922), in the albino rat (Jackson, 1913; Hatai, 1913 & Addison & Adams, 1926₁), and in the pigeon and the dove (Riddle & Nussmann, 1933.) In each case it is the female that has the larger pituitary, and in this sex the gland also has a steeper growth curve. Addison & Adams show that 95 per cent. of the excess weight is accounted for by the anterior lobe of the hypophysis, while the remaining portions are but slightly heavier than in the male. This is in agreement with the conclusions

drawn by Rasmussen & Herrick from a study of a few human pituitaries.

Working with albino rats, Andersen (1933) shows that, at different times in the sexual cycle, the hypophyseal weight varies. The maximum weight is encountered during oestrus. From then onwards there is a gradual decrease to the minimum weight, which is reached twenty-four hours prior to the onset of the next heat period. In the fowl it has been shown that during the laying period the pituitary is heavier than during the moulting stage, (Marza & Blinov, 1936.) For the mare Schopf (1935) gives pituitary weights at different stages of gestation. He states that due to differences in the size of his subjects, no conclusions may be drawn from the absolute weights. When relative weight is the criterion then it appears that pregnancy is accompanied by an increase in pituitary weight. Whether Schopf is justified in assuming that pituitary size is proportional to body weight is questionable. Upon this point no direct evidence is available, yet it must be admitted that in the results of Addison & Adams (1926) some correlation between body weight and pituitary weight is evident.

From a study on the albino rat, Herring (1920) concludes that the effect of pregnancy is to reduce the weight of the pituitary. Hammond (1927) considers the oestral cycle to be the homologue of the reproductive cycle, with dioestrus corresponding to the gestatory period. If this is the case, Herring's view receives confirmation from Andersen's (1933) findings.

In the bitch (Wolf, Cleveland & Campbell, 1933), in the sow (Cleveland & Wolf, 1933), in the mare (Schopf, 1935) and in the sheep (Warbritton & McKenzie, 1937) it has been shown that widely differing histological pictures are associated with the various phases of sexual activity. The changes take the form of qualitative as well as quantitative variations in the chromophil cells of the glandular lobe. The changes described in the bitch and the sow suggest that during pregnancy a decrease in the size of the glandular lobe is to be anticipated.

2. THE ADRENAL.

In the albino rat the sex-differences and the growth curves of

the adrenals resemble closely those of the pituitary (Jackson, 1913; Hatai, 1913.) Barker (1937) shows that the adrenal of the dog is lighter than that of the bitch. Mature females have heavier adrenals than immature bitches. In mice Deanesley (1928) demonstrates histological differences between male and female adrenals.

Andersen & Kennedy (1933 b) ^{maintain} ~~show~~ that in female albino rats adrenal weight is very variable, and that factors such as age, body weight, sexual season and the presence of infection must receive attention. They contend that bacterial infections of the lungs make for increased adrenal weight. Mutow (1937) does not agree with this. Rosenbluth & Gayet (1932) ^{conclude} ~~show~~ that the adrenal is relatively stable, both in weight and in adrenin content, to changes in diet.

Andersen & Kennedy (1932) show that during oestrus the rat adrenal is heavier than in dioestrus. This increase during oestrus is associated with definite histological changes, the cortex being increased in thickness at this stage of the cycle. Nahm & McKenzie (1937) demonstrate variations in the adrenal of the ewe.

Deanesley (1928) ^{states} ~~shows~~ that in the mouse there is associated with pregnancy a degeneration of the inner portion of the cortex, described by him as the "inner dark staining zone."

Herring (1920) maintains that during pregnancy the adrenals of the rat are slightly hypertrophied. This finding is criticised by Andersen & Kennedy (1933 a) who maintain that the figures do not show any significant changes. The latter authors, after reviewing all the available literature, conclude that the case for pregnancy hypertrophy of the adrenal has not been established. They admit that there is a possibility that all species may not react in an identical manner. After careful consideration of all the available data they maintain that in the case of the human being, the rat, the mouse, the rabbit and the cat, the balance of evidence is against such a hypertrophy. Their own results, in which relative adrenal weight is employed, indicate that during pregnancy the adrenals resemble those of the dioestrus period, which again are lighter than the adrenals of the oestrus period. During lactation a significant rise in adrenal weight is evident.

Mutow (1937) finds the adrenals to be heavier at oestrus than during dioestrus. When he considers a combined group of pregnant ~~and~~

and lactating rats, a weight slightly above the dioestral standard is obtained. This increase may be accounted for entirely by the lactating rats in the group.

3. THE THYROID.

Andersen (1933) states that the great variability in weight of this organ is due partly to the difficulty of dissecting it free from the surrounding tissue. Jackson (1913) shows that during growth the relative weight of the thyroid changes, being highest at birth.

Zimmermann (1933) ^{maintains} ~~shows~~ that with increasing age the thyroid undergoes regressive changes, the isthmus in particular being affected.

Orywall (1933) ^{indicates} ~~shows that there is~~ a definite weight difference between thyroids from female rats at Leipzig and from similar rats in Stuttgart. This may be a strain difference or it may be of dietary origin.

With all these possible sources of variation, only exceedingly large changes in the size of the thyroid would be of significance. It is not surprising to find that Andersen (1933) concludes that she is unable to demonstrate changes due to sexual season.

Guggisberg (1933) maintains that in the pregnant woman the thyroid is enlarged to such an extent as to render the increase clinically detectable. He states that although there is hypersecretion from the thyroid, this cannot be termed hyperthyroidism because the thyroxin content of the maternal blood is not raised. The surplus secretion is for the use of the developing foetus, which, until late in foetal life, is devoid of its own supply.

Herring (1920) claims to have shown that in the rat there is a decrease in thyroid size during pregnancy.

4. CORPUS LUTEUM.

It is now agreed that this body should be regarded as a temporary endocrine gland. Its function has been studied in great detail. With this aspect the present paper is not concerned. Only its macroscopic appearance will be considered here. The appearance of the ovine corpus luteum, both in the oestral cycle and in pregnancy, has been well described and illustrated by Quinlan & Mare (1931.) The microscopic appearances have been reported upon by Marais (1936.) From these works it is learned that the corpus luteum of the sheep

maintains its structure for a long time. The corpus luteum of menstruation shows its first signs of deterioration shortly prior to the next oestrus, while that of pregnancy remains unchanged until the approach of parturition. The latter corpus luteum tends to sink deep into the ovarian tissue, especially during the latter half of gestation. This fact may be responsible for the statements of certain observers to the effect that the size of the corpus becomes reduced during the second half of pregnancy.

From actual weights of bovine corpora lutea, Bergmann (1922) concludes that there is no decrease in size throughout the period of pregnancy. Kaltner (1923) shows that during the entire term the bovine corpus luteum conforms closely to the average weight of 4.26 gm. Even at parturition he could not detect macroscopic changes in the size and appearance of this structure. In twin pregnancies he finds that each of the two corpora is smaller than the average referred to above. He finds that the presence of dead, mummified or macerated foetuses does not prevent degeneration of the corpus nor even the approach of a new ovulation. Hammond (1927) also ^{concludes} ~~finds~~ that there is no change in the size of the corpus luteum during the course of pregnancy. He mentions that during gestation follicular atrophy is much more severe than during the sexual cycle. This tends to cause a decrease of ovarian weight, especially in the case of the ovary not containing the corpus luteum.

5. THE PINEAL.

No reference to the macroscopic appearance of this organ during pregnancy has been encountered.

(f) GENERAL.

1. THE SITUATION OF THE FOETUS.

From a consideration of the mode of liberation of the ovum and of fertilization it will be evident that the foetus should in most cases be situated on the same side of the body as the corpus luteum. From the figures of Kupfer (1923) and those of Curson & Quinlan (1934) it is seen that this is the case. In a small number of cases, however, "migration" occurs. This may take place via the abdominal route

(Leopold 1888.) or it may occur by the internal or uterine route (Warwick, 1926.) This type of migration is not possible in mammals which have a uterus duplex - e.g. the rabbit.

When more than one foetus is carried, the corpora lutea may be in one or in both ovaries. Irrespective of the distribution of the corpora between the ovaries, the foetuses are usually spaced evenly along the entire tract (Warwick, 1926.) Even in a case of uniovular twins, Henning (1937) found the foetuses lying one in each horn.

In cattle it has been found that the foetus is carried in the right horn more often than in the left (Keefer, 1937.) Clark (1936) shows that this is not due to more frequent ovulation from the right ovary. It appears, therefore, that in the bovine migration usually occurs from the left to the right horn. Clark failed to find justification for the belief that there is usually a relationship between the sex of the calf and the horn in which it is carried.

In the sheep, due to the prolonged persistence of the corpus luteum, it is a simple matter to determine whether ovulation has occurred from alternate ovaries or not. Quinlan & Mare (1931) find that usually there is alternation between the two ovaries, but that on occasion ovulation may occur twice or even three times in succession from the same ovary. Ruhl (1925) mentions the fact that, in the human being, after unilateral ovariectomy the length of the sexual cycle is not doubled. This, he states, indicates that there is no inherent mechanism preventing successive ovulations from the same ovary.

2. EFFECT OF GESTATION ON MATERNAL WEIGHT.

In view of the scarcity of data on prenatal growth, some investigators (e.g. Ragsdale, Elting & Brody, 1926) have attempted to gauge foetal development by noting the increases in weight of the pregnant cows. This method at best can but give an indication of the growth of the whole foetal system, which is neither equal nor proportional to foetal growth.

Bartlett (1926 b) states that in experimental work on pregnant cows it is often necessary to be able to apply a correction for foetal weight. He is of opinion that the only increase in weight

of mature pregnant cows is that due to the foetal system, while in immature cows there is actual growth up to the fourth month of gestation. The former class will regain its service weight after parturition, while the farrow weight of the immature cow is the same as that shown at the fourth month of pregnancy.

Reference has already been made to Curson & Malan's (1936) treatment of the weight of the gravid uterus as a percentage of the nett live weight of the ewe.

CHAPTER 3.PLAN OF INVESTIGATION.(a) MATERIAL.

Apart from a few references to some of the material already reported upon by Curson & Malan, the data for this paper are derived entirely from observations upon a series of ewes slaughtered at Onderstepoort during the period April to November, 1937. These sheep, typical Merinos, were drafted from the available flock on the research station at Ermelo, Transvaal. The methods of sheep husbandry practised on this farm are described by Hoffman (1935) and Roux & Hoffman (1935.) Information regarding the physiography of the station and its effect on Merino sheep is given by Roux (1936.)

The known sexual history of the ewes has been arranged in tabular form (Appendix - A.) As the ewes had not been kept under constant supervision from the time of attaining sexual maturity, it is certain that many occurrences of oestrus are not recorded. However, the information concerning previous services and pregnancies is complete and accurate.

Regarding the service of the ewes, the "controlled" method (Roux & Hoffman, 1935) was practised. "Teasing" was carried out twice daily and service was allowed soon after the detection of oestrus, and again twelve hours later. Where an ewe was still willing to stand for the ram at the next testing (i.e. 24 hours after the onset of oestrus) a third service was allowed.

Four rams were employed to serve the ewes. All were typical specimens of the Merino breed, of mature age (about six years) and of fairly uniform size (around 140 lbs live weight.) The rams were used at random, no attempt being made to mate a certain ram to any particular ewe, nor were the two consecutive services of any ewe necessarily given by the same ram.

Most of the ewes were tested daily for 22 days following service

and where oestrus reappeared it was assumed that the ewe had failed to conceive. In the case of those ewes required for the study of the earliest stages of pregnancy this testing was impracticable. When slaughtered, many of these ewes proved to be non-pregnant.

Soon after completion of the testing (or, in cases where no testing was carried out, soon after service) the ewes were railed to Onderstepoort, where they were placed in a small camp (100 x 50 ft) in which a good water-supply was always available. They were allowed the ration^x usually fed to sheep at this Institute.

At first each sheep was weighed once only i.e. just prior to slaughter. However, it was later decided to weigh the ewes at weekly intervals, this taking place at 11 a.m. on Monday mornings. The sheep were not starved before being weighed.

Although the ewes were selected at random, they were nevertheless drafted from a flock of fairly uniform size and age. As a result the ewes of the experimental group showed but slight variations in these respects.

Had the weights of the ewes at the time of service been available, it would have been an easy matter to test the group for uniformity of weight. As there were differences in condition (fatness) it cannot be claimed that the weights would have been a true index of skeletal size - the factor which is of importance in the determination of size of the foetus.

It was decided to make use of brain weight as an indication of size. It must at once be pointed out that there is no definite authority for this procedure, and that no undue importance should be attached to it. However, in the human being it is known that the brain reaches its fullest development relatively early in life (Scammon & Dunn, 1922; Kappers, 1936.)

X This is as follows :-

Roughage always available in racks;
 $\frac{3}{4}$ lbs of maize per sheep per day;
 green feed or, when this is not procurable,
 lucerne hay two or three times a week.