7. The mean percentage loss of weight in the sow over an 8 to 9 weeks' nursing period in Large Blacks is 11·07 lb., S.D. 9·66; in Large Whites 19·32, S.D. 11·68. The latter breed is probably the heavier milker. Size of litter and loss of weight of the sow are highly correlated.

8. Oestrus during the nursing period was recorded in only 4 per cent. of the population. If the nursing period is unduly protracted, oestrus ultimately appears spontaneously. Normally, oestrus cannot be induced through separation overnight of dam and litter.

9. The onset of oestrus does not favour day or night.

10. " Silent " oestrus in the pig is rare, only 1·49 per cent. of cases being recorded as such. " Split " oestrus is absent.

11. Neither sterile nor fertile coitus at zero hour has any influence on the duration of oestrus.

12. The sexual behaviour of the sow is discussed.

---

# PART 4.

## VII. Fertility Studies.

### *Observations on Certain Aspects of Fertility in the Sow, with Special Reference to the Optimum Service Period.*

The series of studies to be discussed in this section was undertaken mainly to determine whether an optimum service period obtains for the pig. While this work progressed much interesting data accumulated, which suggested further additional studies. These will be discussed in the subsequent paragraphs.

According to the general plan of this observation, groups of sows were to be mated at different intervals during the oestrous period and then slaughtered at about 26 days of pregnancy, when the number of embryos were to be determined. The study, however, resolved itself into various related aspects, their relevancy becoming apparent if presented as follows:—

1. The number of ova fertilized in each service group.
2. The incidence of atrophy of the embryo occurring at each of the various service intervals as a result of the particular period of mating.
3. The number of successful matings which result from services allowed at the different time intervals.

It is proposed to review, firstly, the literature covering all aspects of the different observations, then to present the data under appropriate headings and, finally, to relate the results of the separate studies in a comprehensive discussion.

*Literature.*

Haring (1937), by mating sows at different periods during oestrus, concluded that spermatozoa do not remain fertile in the sow for more than 24 hours. Marshall and Hammond claimed that spermatozoan vitality is low in non-vigorous boars and, for such boars, mating should occur shortly before ovulation to ensure fertility. That the life of the male germ cells in the female genital tract in various species of mammals probably never exceeds 48 hours, have been shown by different writers

(Hammond, 1930; Quinlan *et al.*, 1931; Knaus, 1931; Anderson, 1922). Lewis (1911) reported that in only three cases (in pigs) could live spermatozoa be found longer than 24 hours after breeding, and in only two instances 22½ hours after breeding. Of 19 sows bred and killed, the male cells were dead in 80 per cent. of cases examined where a period of 16 hours or more had elapsed between mating and slaughter.

Quinlan *et al.* (1941), by exercising ewes before insemination, showed that a transitory rise in vaginal temperatures of from 100·2 to 106·2° F. made no difference to their fertility. No relative literature on the sow could be traced.

Palmer (1917) gave the mean temperature of the pig as 102·5° F., with a range of 101·6 to 103·6° F., and Smith (1907) as 103·3° F., with a range of 100·9 to 105·6° F. Harder (1937), working on two sows, showed that minimum rectal temperatures of 37·8° C. (100·04° F.) and 38·1° C. (100·58° F.) respectively, were recorded at 4 to 4.30 a.m. and a maximum of 39·1° C. (102·38° F.) for both sows at 4 to 8 p.m.

The period during oestrus at which the sow should be mated for optimum results, as advised by different authors, is presented in tabular form below.

*The Optimum Service Period in the Pig, as Advised by Different Authors.*

| After Onset of Oestrus. | Authority. |
|---|---|
| 2nd to 3rd day | Marshall (1922). |
| 24 to 40 hours | Schmidt (1934, 1938). |
| 2nd to 3rd day | Asdell (1934). |
| 36 to 48 hours | Haring (1934). |
| On 1st and 2nd day (gilts) | McKenzie (1932). |
| 2nd day | McKenzie & Miller (1930). |
| 18 to 24 hours | Dettweiler & Muller (1924). |
| 3rd day | Allan (1939). |
| 2nd day | Davidson (1939). |
| After 18th hour | Quinlan (1932). |
| Beginning of 2nd day | Broner (1941). |
| No difference between early and late services | Krallinger & Schott (1933). |

Certain writers claim that services allowed at the onset of oestrus tend to be barren because of a lack of viable spermatozoa at the period of ovulation (Marshall, McKenzie and Marshall, Haring, McKenzie and Miller, Dettweiler and Müller, Allen). It should be noted that 10 of the 13 authors listed above advise that mating should be allowed at the second or third day of the oestrus period. The object, generally, is to secure a synchronization of arrival of viable spermatozoa and ova at the top of the fallopian tubes. The majority of authors, either through direct statement or by implication, adhere to the view that the male and female cells remain fertilizably viable for only a very limited period. Best results, they claim, are possible only if services are so timed as to ensure an adequate supply of fresh spermatozoa at the top of the fallopian tubes on the arrival of the ova.

Only four of the 13 authors quoted have advanced experimental data in support of their statements. Haring (1937) mated sows 12 hours after the onset of oestrus to one boar, and again 24 hours later to a second and differently coloured boar. In a further test similar males were used only on the second day of oestrus and again 24 hours later. From the evidence afforded by the colour of the piglets he concluded that mating on the second day of oestrus is clearly indicated. His observations also led him to the conclusion that spermatozoa do not remain viable for more than 24 hours, and that a double service ("Doppelsprung") is superfluous if the correct time is chosen, that is, at about the second day of oestrus. McKenzie and Miller (1930) planned to determine an optimum service period by mating sows at the first signs of oestrus, 30 hours later, and at the last signs of oestrus, using boars of different breeds. In four of 15 triple matings piglets were not sired by the first services, indicating that service at the onset of oestrus is not optimum. In three other matings out of the 15 a mixed lot of piglets resulted from first and second matings, also indicating that sows could be served too early in the oestrus period for optimum results. In a further test McKenzie (1932) mated 13 Hampshire gilts, 12 hours after they came in oestrus and again 24 hours later (at tthe 36h hour), using a differently-coloured boar at each interval. This resulted in 8 litters from first matings only, 2 from second matings only and 3 were mixed. He concluded that 5 out of 13 matings show that breeding the gilt twice increases the litter size. Krallinger and Schott (1933) appear to be the only authors to demonstrate that an optimum service period does not obtain in the pig. By mating sows early and late during oestrus they obtained mean litter sizes of 9·8 and 10·05 piglets for the respective intervals. They considered the mean differences too small to favour any one period. Hammond (1934) working with rabbits, first mated vasectomised bucks to induce ovulation, then used fertile bucks in matings at different time intervals before, at, and after ovulation, and showed that the average litter size decreases progressively as the time of service approaches and passes the period of ovulation. He obtained 6·4 young per litter for all normal matings (10 to 5 hours before ovulation), 4·2 young for 2 hours before and 3·2 young for 2 hours after, ovulation. These results he ascribed to the fact that, as service is delayed, the "sperm swarm" at the top of the tubes is weakened and the number of active sperm available to fertilize the ova, as they are released from the "plug", are so reduced that fertility falls.

Hammond (1914, 1921) stated that the factors controlling the number of eggs which develop to reach birth have the greatest influence on fertility in domestic animals. A large number of eggs fail to develop, some perish at an early stage, while others develop to a certain extent before they die and become mummified *in utero*. Foetal atrophy, he stated, is quite general and, as a rule, absorption takes place either completely or the atrophic foetus is so reduced at birth that it passes unnoticed in the cleansings. By examining abattoir sows in the early stages of pregnancy, he showed that, on the average, only 12·1 corpora lutea per sow give rise to normal young. The number of atrophic cases, under the particular circumstances, were 2·2 per sow; 3·7 ova per sow could not be accounted for. He ascribed atrophy in domesticated mammals to a condition in which production has outstripped nutrition with regard to quality rather than to quantity. Congestion and breaking down of the blood vessels of the foetus and its membranes, are the first signs of approaching atrophy. Machens (1915), on the evidence of herd book records, found that, in the Northern Hemisphere, fecundity is higher from September to March than in the warm period of the year. As fertility is largely controlled by the incidence of degeneration of the embryo, the greatest numbers degenerate from March to September. Haring (1937), quoting the researches of Krizenecky, stated that 6·99 per cent. of all piglets born are still-born. Corner (1923) found that, in the pig, at the 8 to 40 mm. crown-rump length stage, 20 per cent. of the originally discharged ova were missing and 2·2 per cent. were present as abnormal embryos. In the group of pregnancies of the third week (13 to 21 days) he found that 26·6 per cent. of the ova were missing and 4·7 per cent. were abnormal. He concluded that " . . . it may fairly be said that in healthy sows with normal reproductive organs, not all the ova discharged, even though they are reached by spermatozoa, develop into normal young. Some of the ova, probably not more than 10 per cent., do never segment; others, forming roughly 10 per cent., develop into blastocysts but then degenerate; and still others, amounting to 5 to 10 per cent., become abnormal during the subsequent course of pregnancy, a few during implantation stages, others at various later stages of implantation. Only about 70 per cent. of the ova are represented at term by living pigs . . . " In a previous study Corner (1921) wrote that " . . . we are forced to the conclusion that the organism is liable to pathological changes before its attachment to the uterus . . . " From a mixed lot of packing house pigs he found 7·43 per cent. degenerates for a 20 days' pregnancy period and 4·25 per cent. for a 30 days' pregnancy period, involving 148 and 270 foetuses respectively. The number of ova unaccounted for for the two respective periods amounted to 20·28 per cent. and 25·00 per cent. Overcrowding, he thought, is an important but not the only factor, especially during the latter half of gestation. Degenerates are most numerous during the early stages. Marshall and Hammond (1937) wrote that most sows shed sufficient ova per oestrus to provide litters of 20 and a few less than 12, although litters of over 15 are only occasionally produced. Young sows ripen a smaller number of ova at each oestrus (average 14) than adults.

Davidson (1930) reported that partial foetal atrophy in sows is not due to a protein deficiency in the diet, but that calcium deficiency may be a contributory cause. McKenzie (1928) found a definite correlation between gains made by the sow the month following breeding and the number of pigs farrowed, and recommends adequate feeding immediately subsequent to, rather than prior to, breeding. Hughes *et al.* (1928), on feeding gilts on a vitamin A deficient ration, reported that of five gilts bred, none produced living young; they either aborted or carried atrophic piglets in various stages of resorption. Warwick (1927), working with a mixed lot of pigs, showed that 3·68 per cent. of foetuses were degenerate during all stages of pregnancy with the largest proportion in the youngest groups. Sinclair and Syrotuck (1928) have shown that the age of the sow has a decided bearing on the incidence of still-born piglets. They supply the following figures: for sows 1 to 5 years the percentages of still-births are 6·5, 7·08, 11·92, 12·77 and 20·98 respectively. Blendau and Young (1939), working on the effects of delayed fertilization on the development of the guinea-pig ovum, found that as the ovum ages the number of sterile inseminations increases, the average litter size decreases and the number of abnormal pregnancies increases, terminating by death of the embryo and abortion. They state: "The first effects were seen in the embryos of females inseminated 8 hours after ovulation. No normal development followed inseminations more than 20 hours after ovulation and no development followed inseminations 32 hours after ovulation. These effects are shown to be a consequence of the age of the egg at the time of fertilization rather than to a faulty implantation. . . . Many ova, aged before fertilization and removed after implantation, showed gross abnormalities and were undergoing reabsorption or were about to be aborted. Others appeared normal except that they were retarded in development. . . . A comparison of the results obtained during this study with work on other species suggests that, in general, late fertilization is followed by developmental abnormalities, especially in the early stages. . . . The lowered fertility and smaller litter size following late fertilization—(according to other workers)—and the sterility of matings shortly after heat and ovulation in the sow also indicate the importance of fertilization soon after ovulations . . . ".

No tendency to modification in normality of the embryo, as the result of "stale" spermatozoa, could be demonstrated by the following workers: Dunn (1927) for fowls, Riddle and Behre (1921) for ring doves and Hammond and Asdell (1926) for rabbits.

Nearly all writers seem to agree that maximum fertility is attained at about four years of age or with the sixth to the seventh litter (Sinclair and Syrotuck, 1928; Yamane and Makita, 1934; Johansson, 1929, 1931; Machens, 1916; Zorn *et al.*, 1933; Krizenecky, 1935; Bertram, 1926; Marshall and Hammond, 1937).

The majority of authors adhere to the view that inbreeding *per se* does not effect fertility and litter size adversely. Such may be practised with impunity so long as the genetic back-ground of the material does not harbour recessive weaknesses in a heterozygous state (Krallinger, 1937; von Ecktaedt, 1928; Simpson, 1912; Buchanan-Smith, 1930; Marshall and Hammond, 1937).

Harris (1916) showed that the cause for the influence of age on fertility is that young sows shed fewer eggs (mean 14) than older sows (mean 20). This view is supported by Hammond (1914).

That breeds differ appreciably with regard to litter size has been shown by the following authors: Marshall and Hammond (1937), Christensen, Thompson and Jorgenson (1926) and the National Pig Breeders Association of Great Britain (1937-38). Their data are presented in summarised form below.

| Breed. | Mean Litter Size. |
|---|---|
| Large Whites | 10·0, 11·7, 10·61. |
| Middle Whites | 9·6, 9·78. |
| Wessex Saddle Back | 9·6, 10·08. |
| Berkshire | 7·8, 8·7, 7·65. |
| Tamworth | 7·94, 7·9. |
| Poland China | 7·15, 8·2. |
| Duroc Jersey | 7·14, 10·7. |
| Chester Whites | 9·6. |

The opinion is generally held that the boar has no influence on the size of the litter sired by him and that boars do not differ with regard to this character. (Oestermeyer, 1934; Langlet, 1934; Schmidt, 1937; Krallinger and Schott, 1933). The latter two co-workers state that experiences to the contrary are due to other causes, such as: age of sow, natural differences in fertility between sows, atrophy, etc. Wentworth and Aubel (1916) agree with the previous authors and add that the size of the litters a sow produces represents the segregation of the tendencies transmitted to her by her sire and dam, which opinion is also subscribed to by Schmidt (1937). Norby (1929), however, reported the case of a boar which sired small litters in a good herd where previously large litters obtained, the boar on subsequent examination showing spermatozoa below normal motility, etc.

All authors agree that the ovum retains its vitality for a very brief period after being shed, probably for not longer than six hours (Lewis, 1911; Knaus, 1931; Marshall and Hammond, 1937; Hammond, 1934).

Pincus and Enzmann (1932) and Pincus (1936) have shown that the ovum of the rabbit becomes coated with an albumin layer in its descent in the fallopian tube, rendering same infertile, but Robson (1940) states that this does not hold good for the majority of mammals. No reference bearing on the pig could be traced.

Hammond (1921) has shown that, in the sow, the number of ova may sometimes be in excess of the number of corpora lutea, but Corner (1921, 1923) mentioned that, in the examination of many hundreds of pregnant uteri in pigs, he has found the number of embryos to exceed the corpora lutea counts by one in only three or four instances. This he ascribes to poly-ovular follicles, to the rare occurrence of single-ovum twinning or to failure of the corpus luteum to develop from the ruptured follicle. Long and Evans (1922) state that, in the rat, about 10 corpora lutea are formed per ovulation, one of which retains the egg.

Hammond (1914), and Corner (1921), agree that wandering of the ovum in the body cavity may be possible, not having been caught up by the fallopian tube. Corner (1923) proposed the hypothesis that, in the pig, the ova and embryos are transported through the tubes and uterus by contraction cycles which represent a mechanism probably peristaltic in action. He also mentioned the presence of an efficient spacing mechanism by which the embryos are evenly distributed before implantation, the process occurring during the first week or nine days of pregnancy. Warwick (1926), working on pigs, semispayed four sows and ligated the corresponding horn of the uterus, then bred them and concluded " . . . that, on the average, the number of foetuses tends to become equalised in the two horns by migration, even when there is an unequal number of ova shed by the right and left ovaries, as indicated by the distribution of the corpora lutea . . . . " Küpfer and Quinlan (1926), employing a similar technique, demonstrated that migration does not take place by the trans-abdominal route in the pig but that trans-uterine migration does take place. (Personal communication by Quinlan).

The gestation period, according to different authors, is presented in tabular form below:—

| Author. | Breed. | Period. |
|---|---|---|
| Johansson (1929)........................ | Yorkshires....... | 114·3 days. |
| Corner (1921)........................... | ?............... | 16–17 weeks, range 116–120 days. |
| Carmichael & Rice (1920)................ | Yorkshires....... | 113·2 days. |
| Zorn & Krallinger (1930)................ | Improved Landschwein | 114·93, range 109–122 days. |
| | Edelschwein...... | 114·6, range 109–123 days. |
| Buchanan Smith (1930).................. | ?............... | 113 to 115½ days. |
| Sebatani (1908)......................... | ?............... | 114·7 days. |
| Krizenecky (1942)....................... | Edelschwein,..... | 114·4 ± 3·14 days. |
| | Cornwall........ | 115·3 ± 3·39 days. |

McKenzie (1928) could find no difference in the length of this period between sows bred for the first time at different ages, between first and last litters, between sows on different planes of nutrition, nor between sows with different litter sizes. He remarked: " . . . in fact the constancy of this period is remarkable ".

## *Observation 5.*

## *The Optimum Service Period.*

*Object.*

The object was to determine whether an optimum period exists for mating the sow.

*Material and Method.*

The Large White and Large Black breeds were used. Starting from zero hour, groups of 10 females from each breed were mated at 12-hour intervals during oestrus. In Large Blacks, with a mean duration of oestrus of 68·19 hours, it was possible to obtain sufficient pregnancies at the 60th hour period to have six groups, but in Large Whites, with a mean duration of only 49·91 hours, it was not possible to obtain sufficient positive matings at the 48th hour interval to have more than four groups. Even then, owing to declining fertility during the latter part of oestrus, and because many sows intended for the last groups were already out of oestrus by that time, difficulty was experienced in arriving at the full quotas for the late service intervals. All sows were housed in a modern piggery during the periods when they were being tested for the presence of oestrus. As testing was carried out at three-hourly intervals with vigorous " teasers " or fertile boars, the onset or disappearance of oestrus was known to within three hours. As a general rule matings were allowed in a serving crate; " free " services being permitted only in those instances in which the sow was intensely in oestrus and strong enough to carry the boar without the probability of moving or sagging. Strong leather straps were fitted to the crate as supports to prevent sows from sagging during service. With few exceptions all females were temperatured before service and, in a number of instances, also after service, to obtain data on the rise in temperature of the sow during mating. The duration of coitus was recorded in minutes and seconds and, in those instances in which broken services occurred, only the actual time spent in coitus was recorded. Only boars of known fertility were used, occasional microscopic tests on semen-overflow being carried out as a check on the abundance and motility of the spermatozoa. A service record was kept for each boar and, whenever practicable, not more than one service in two or three days was allowed. Pure-breeding was practised at all times. Boars were permitted ample exercise on free range and managed so as to be in a good service condition.

After oestrus had passed over females were returned to free range on lucerne grazing, and again brought in to the pens for testing as their next oestrus became due. Pregnancy was assumed if oestrus was absent on the 21st day, but a further period of five days was allowed to include those individuals having unusually long cycles. The majority of sows were slaughtered 26 days after service, exceptions occurring only for unavoidable reasons. The " humane killer ", a type of pistol, was used to kill the animals. The sows were immediately opened and the uterus and ovaries removed, care being taken to preserve the identity of the left and rights sides. The cornua were carefully cut open and the embryos removed, those from each cornu being bottled and labelled separately. Before removal from the cornua and thereafter, all embryos were closely scrutinised for any sign of atrophy, but none was recorded as such unless abnormalities were evident. The following conditions were regarded as the most important indications of a state of atrophy: all stages of resorption, abnormal congestion and breaking down of the blood vessels of the embryo and its membranes (Hammond, 1921). Whenever reasonable doubt existed as to the normality of an embryo, the normal state was assumed. The morphology of each ovary was recorded, particular attention being paid to number and appearance of the corpora lutea gravitatis.

*Results.*

Detailed descriptions of the morphological findings on the ovaries and embryos appear in Appendix 6, and further particulars for each 12-hour service group are presented in Appendix 6, Table I.

It has to be explained that great difficulty was experienced to settle sows to the boar for the 60th and 48th hour groups for Large Blacks and Large Whites respectively. Fertility at these two periods was very low and, furthermore, roughly 50 per cent. of females was already out of oestrus by then. In order, therefore, to complete the last group in each breed, it was necessary to mate a number of females prior to those two extreme intervals. In the majority of cases those services were allowed as soon as the metoestrous phase appeared. It was nevertheless not possible to establish a 48-hour group for Large Whites. Of the eight pregnancies appearing in the 60-hour group for Large Blacks, four resulted from matings occurring at somewhat earlier intervals. This latter group of pregnancies should, therefore, be considered more as a result of matings during the last phases of oestrus than as an actual 60-hour service group.

Attention is drawn to the fact that in all calculations in respect of the optimum service period, all embryos were considered, whether normal or atrophic, the implications of which will be discussed under the relevant heading.

As fecundity in the sow is to a considerable extent dependent on the number of ova shed (as will be shown in the subsequent paragraphs), it is of importance to demonstrate, firstly, whether selection of material for the various time groups has been truly random. The number of corpora lutea for each service period group, together with the analysis of the data, appear in table 40.

TABLE 40.

*The Optimum Service Period: Number of Corpora Lutea Gravitatis at Different Service Intervals in Large Black and Large White Pigs.*

| | SERVICE PERIOD. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 Hours. | | 12 Hours. | | 24 Hours. | | 36 Hours. | |
| | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. |
| | 12 | 22 | 18 | 10 | 11 | 14 | 13 | 16 |
| | 13 | 14 | 12 | 19 | 18 | 14 | 12 | 21 |
| | 11 | 18 | 14 | 17 | 15 | 19 | 12 | 18 |
| | 17 | 19 | 13 | 17 | 14 | 14 | 11 | 16 |
| | 14 | 19 | 12 | 14 | 10 | 21 | 10 | 17 |
| | 16 | 16 | 14 | 16 | 11 | 12 | 16 | 14 |
| | 12 | 17 | 13 | 16 | 14 | 14 | 15 | 18 |
| | 16 | 14 | 15 | 18 | 14 | 14 | 16 | 15 |
| | 16 | 12 | 13 | 17 | 13 | 21 | 13 | 21 |
| | 6 | 15 | 15 | 20 | 13 | 11 | 12 | 15 |
| Mean......... | 13·3 | 16·6 | 13·9 | 16·4 | 13·3 | 15·4 | 13·0 | 17·1 |

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Service Period........... | 3 | 7·75 | 2·58 | 0·35 | ns |
| Breeds.................. | 1 | 180·00 | 180·00 | 24·30 | SS |
| Interaction............. | 3 | 11·80 | 3·93 | 0·53 | ns |
| Error................... | 72 | 533·20 | 7·41 | — | — |
| TOTAL.......... | 79 | 732·75 | — | — | — |

The analysis shows that no significant differences exist between the mean number of corpora lutea for the different service periods, but that highly significant breed differences obtain. The greater fecundity of the Large White breed, as indicated by the corpora lutea counts, is obvious. The minimum significant breed difference, as culculated is 1·56 at the 1 per cent. level.

The number of embryos per service group, together with the relevant analysis of the data, are presented in Table 41.

TABLE 41.

*The Optimum Service Period: Number of Embryos at Different Service Intervals in Large Black and Large White Pigs.*

| | Service Period, (Hour). | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | | 12 | | 24 | | 36 | |
| | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. |
| | 6 | 8 | 13 | 8 | 10 | 13 | 12 | 15 |
| | 8 | 7 | 12 | 16 | 7 | 3 | 6 | 11 |
| | 5 | 16 | 13 | 15 | 2 | 15 | 5 | 14 |
| | 16 | 14 | 9 | 17 | 7 | 11 | 11 | 9 |
| | 12 | 13 | 8 | 9 | 4 | 18 | 3 | 13 |
| | 8 | 15 | 11 | 9 | 8 | 8 | 11 | 14 |
| | 12 | 12 | 10 | 14 | 9 | 15 | 12 | 6 |
| | 14 | 12 | 11 | 13 | 13 | 11 | 9 | 9 |
| | 9 | 10 | 12 | 17 | 13 | 18 | 12 | 16 |
| | 2 | 14 | 10 | 16 | 8 | 11 | 11 | 5 |
| Mean............. | 9·2 | 12·1 | 10·9 | 13·4 | 8·1 | 12·3 | 9·2 | 11·2 |

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Service period........... | 3 | 51·30 | 17·70 | 1·35 | ns |
| Breeds.................. | 1 | 168·20 | 168·20 | 13·27 | SS |
| Interaction.............. | 3 | 13·30 | 4·43 | 0·35 | ns |
| Error.................... | 72 | 912·00 | 12·67 | — | — |
| TOTAL........... | 79 | 1,144.80 | — | — | — |

The results show that the differences between the mean numbers of embryos, obtained at the various time-intervals, fall far short of significance at the 5 per cent. level; breeds, however, differ highly significantly.

As it was possible to establish also 48-hour and 60-hour groups for Large Blacks, a separate analysis was conducted for this breed; the results appear in Tables 42 and 43.

TABLE 42.

*The Optimum Service Period: Number of Corpora Lutea Gravitatis at Different Service Intervals in Large Black Pigs.*

| | Service Period, (Hour). | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 12 | 24 | 36 | 48 | 60 |
| | 12 | 18 | 11 | 13 | 15 | 11 |
| | 13 | 12 | 18 | 12 | 12 | 14 |
| | 11 | 14 | 15 | 12 | 10 | 10 |
| | 17 | 13 | 14 | 11 | 18 | 12 |
| | 14 | 12 | 10 | 10 | 10 | 16 |
| | 16 | 14 | 11 | 16 | 13 | 17 |
| | 12 | 13 | 14 | 15 | 14 | 13 |
| | 16 | 15 | 14 | 16 | 11 | 15 |
| | 16 | 13 | 13 | 13 | 15 | — |
| | 6 | 15 | 13 | 12 | 14 | — |
| Mean.................. | 13·3 | 13·9 | 13·3 | 13·0 | 13·2 | 13·5 |

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Service period........... | 5 | 4·697 | 0·939 | 0·16 | ns |
| Error.................... | 52 | 312·700 | 6·013 | — | — |
| TOTAL.......... | 57 | 317·397 | — | — | — |

The analysis shows that selection of material was random.

TABLE 43.

*The Optimum Service Period: Number of Embryos at Different Service Intervals in Large Black Pigs.*

| | Service Period, (Hour). | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 12 | 24 | 36 | 48 | 60 |
| | 6 | 13 | 10 | 12 | 7 | 9 |
| | 8 | 12 | 7 | 6 | 11 | 13 |
| | 5 | 13 | 2 | 5 | 9 | 3 |
| | 16 | 9 | 7 | 11 | 10 | 6 |
| | 12 | 8 | 4 | 3 | 8 | 8 |
| | 8 | 11 | 8 | 11 | 13 | 8 |
| | 12 | 10 | 9 | 12 | 12 | 9 |
| | 14 | 11 | 13 | 9 | 6 | 12 |
| | 9 | 12 | 13 | 12 | 13 | — |
| | 2 | 10 | 8 | 11 | 7 | — |
| Mean................. | 9·2 | 10·9 | 8·1 | 9·2 | 9·6 | 8·5 |

TABLE 43 (*continued*).

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Service period.......... | 5 | 46·187 | 9·238 | 0·90 | ns |
| Error.................. | 52 | 531·400 | 10·219 | — | — |
| TOTAL........... | 57 | 577·587 | — | — | — |

The results yielded by this analysis again show that, even where fertile matings were possible up to about the 60th hour of oestrus in Large Blacks, no significant differences between the mean number of embryos for the various intervals could be demonstrated.

The number of embryos yielded by each female was calculated as a percentage of the relative number of corpora lutea, and this fertilization index employed as a further basis on which to test out the data on the optimum service period. In the calculations to follow, the index was considered as being 100 in the few instances in which the number of embryos exceeded the relative number of corpora lutea. The results appear in Table 44.

TABLE 44.

*The Optimum Service Period in Large Black and Large White Pigs as Calculated on a Fertilization Index.*

SERVICE PERIOD, HOUR.

| 0 | | 12 | | 24 | | 36 | |
|---|---|---|---|---|---|---|---|
| Large Black. | Large White. | Large Black. | Large White. | Large Black. | Large White. | Large Black. | Large White. |
| 50·00 | 36·36 | 72·22 | 80·00 | 90·91 | 92·86 | 92·31 | 93·75 |
| 61·53 | 50·00 | 100·00 | 94·12 | 38·89 | 21·43 | 50·00 | 52·38 |
| 45·45 | 88·89 | 92·86 | 88·24 | 13·33 | 78·95 | 41·67 | 77·78 |
| 94·12 | 73·68 | 69·23 | 100·00 | 50·00 | 78·57 | 100·00 | 56·25 |
| 85·71 | 68·42 | 66·67 | 64·29 | 40·00 | 85·71 | 30·00 | 76·47 |
| 50·00 | 93·75 | 78·57 | 56·25 | 72·72 | 66·67 | 68·75 | 100·00 |
| 100·00 | 70·59 | 76·92 | 87·50 | 64·29 | 100·00 | 80·00 | 33·33 |
| 87·50 | 85·71 | 73·33 | 72·22 | 92·86 | 78·57 | 56·25 | 60·00 |
| 56·25 | 83·33 | 92·31 | 100·00 | 100·00 | 85·71 | 92·31 | 76·19 |
| 33·33 | 93·33 | 66·67 | 80·00 | 61·54 | 100·00 | 91·67 | 33·33 |
| 66·4 | 74·4 | 78·9 | 82·3 | 62·5 | 78·8 | 70·3 | 65·9 |

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Service period........... | 3 | 1,842·32 | 614·11 | 1·34 | ns |
| Breeds.................. | 1 | 687·14 | 687·14 | 1·50 | ns |
| Interaction............. | 3 | 1,129·65 | 376·55 | 0·82 | ns |
| Error.................. | 72 | 33,091·00 | 459·60 | — | — |
| TOTAL........... | 79 | 36,750·11 | 456·19 | — | — |

The analysis on this basis confirms the conclusions yielded by the analysis in Table 41. Furthermore, the results reveal that the two breeds do not differ with regard to the number of embryos expressed as a percentage of the number of corpora lutea gravitatis. This latter conclusion would therefore seem to indicate that the highly significant breed differences revealed by the previous analyses, must be due to a close relationship between the number of ova shed and the number of embryos resulting therefrom. This aspect has been studied, the calculations yielding highly significant correlation coefficients of 0·44 and 0·47 for Large Blacks and Large Whites respectively. (Large Blacks: $t = 3{\cdot}67$. For $n = 56$, $P = {\cdot}01$, $t = 2{\cdot}58$. Large Whites: $t = 3{\cdot}28$. For $n = 38$, $P = {\cdot}01$, $t = 2{\cdot}58$).

A frequency distribution of the fertilization index has been prepared and is presented in histogrammatic form in Figure 16. The mode is shown to be 90 and the range 10 per cent. to 100 per cent. The histogram is distinctly skew to the right.

Examination of the data in Appendix 6, Table I, shows that, out of a total of 102 observations, the number of embryos exceeded the relative number of corpora lutea in only two instances in Large Blacks and in only one instance in Large Whites, or in 2·9 per cent. of instances over both breeds. A further 7 (6·8 per cent.) cases were recorded in which the number of embryos equalled the relative number of corpora lutea. Hence, over both breeds, 10 out of 102, or 9·8 per cent. of cases, were recorded in which the embryo counts equalled or exceeded the relative corpora lutea counts.

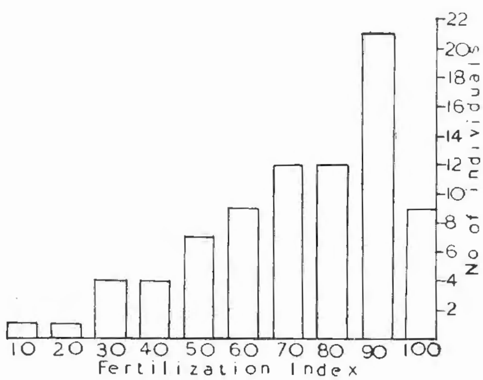


FIG. 16.—Frequency distribution of the fertilization index in Large Black and Large White sows.

*Atrophy in Relation to the Time of Service During Oestrus.*—The sows slaughtered at about 26 days of pregnancy yielded valuable material for a study of the incidence of atrophy as related to the different service intervals within the oestrous period. Details appear in Appendix 6, Table II, from which Table 45 has been compiled.

The data would seem to indicate that, in both breeds, the smallest number of atrophic cases occur at the zero hour of service. In Large Blacks no clear indications exist for any definite tendency for the number of atrophic embryos to increase from the 12th to the 36th hour and possibly the 48th hour, but the mean at the 60th hour is distintcly greater than at any other period. It should further be noted that at the 60th hour only 8 individuals were available instead of 10, **as** originally planned. Similarly, in Large Whites, the variations from zero to the 24th hour appear to be normal, but the mean at the 36th hour definitely indicates a much higher incidence of atrophic embryos than at any of the previous intervals.

TABLE 45.

*Atrophy of the Embryo and Service Interval in Large Black and Large White Pigs at 26 Days of Pregnancy.*

| | Large Blacks. | | | | | | Large Whites. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Service interval, hour... | 0 | 12 | 24 | 36 | 48 | 60 | 0 | 12 | 24 | 36 |
| Number of individuals... | 10 | 10 | 10 | 10 | 10 | 8 | 10 | 10 | 10 | 10 |
| Total No. of embryos... | 93 | 109 | 81 | 92 | 96 | 68 | 122 | 134 | 125 | 112 |
| Atrophic embryos: | | | | | | | | | | |
| Total Number... | 6 | 12 | 9 | 10 | 14 | 21 | 3 | 8 | 5 | 16 |
| Mean.......... | 0·6 | 1·2 | 0·9 | 1·0 | 1·4 | 2·6 | 0·3 | 0·8 | 0·5 | 1·6 |

*Pregnancies Resulting from Matings at Different Time Intervals.*

Irrespective of whether sows were being mated for the optimum service period study or not, all services were regulated to fit in with one or other of the predetermined twelve-hour intervals. However, in a number of instances in the 60-hour group for Large Blacks and in the 48-hour group for Large Whites, matings occurred somewhat before the actual hour, as explained above. Females which were negatively served and which were subsequently suspected of being sterile, owing to failure to conceive repeatedly at other more favourable periods, have been discarded for the purposes of this observation. All matings which could reasonably be classified as falling in one of the 12-hour groups were studied, the results and the analysis of the data appearing in Table 46.

TABLE 46.

(*a*)

*Positive and Negative Services at Different 12-hour Intervals.*

| | SERVICE INTERVAL, (HOUR),. | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 12 | 24 | 36 | 48 | 60 |
| Large Blacks: | | | | | | |
| Number positive..... | 19 | 20 | 25 | 29 | 17 | 8 |
| Number negative..... | 5 | 4 | 4 | 7 | 15 | 46 |
| TOTAL............ | 24 | 24 | 29 | 36 | 32 | 54 |
| Per cent positive.......... | 79·2 | 83·3 | 86·2 | 80·6 | 53·1 | 14·8 |
| Per cent negative.......... | 20·8 | 16·7 | 13·8 | 19·4 | 46·9 | 85·2 |
| Large Whites: | | | | | | |
| Number positive..... | 20 | 23 | 28 | 14 | 7 | — |
| Number negative..... | 7 | 2 | 4 | 8 | 18 | — |
| TOTAL.... ....... | 27 | 25 | 32 | 22 | 25 | — |
| Per cent positive..... | 74·1 | 92·0 | 87·5 | 63·6 | 28·0 | — |
| Per cent negative..... | 25·9 | 8·0 | 12·5 | 36·4 | 72·0 | — |

TABLE 46 (*continued*).

(*b*)

*Chi-squared: The Percentage Conceptions in Large Black and Large White Pigs at Different Time-intervals.*

| Intervals, (Hour). | Large Black. | Large White. | m. | x. | x/m. |
|---|---|---|---|---|---|
| 0 | 79·2 | 74·1 | 76·65 | 2·55 | 0·08 |
| 12 | 83·3 | 92·0 | 87·65 | 4·35 | 0·22 |
| 24 | 86·2 | 87·5 | 86·85 | 0·65 | 0·05 |
| 36 | 80·6 | 63·6 | 72·10 | 8·50 | 1·00 |
| 48 | 53·1 | 28·0 | 40·55 | 12·55 | 3·88 |

$X^2=10 \cdot 46$. For $n=4$, $P=\cdot 05$, $X^2=9 \cdot 49$.

The analysis shows that the reaction of the breeds at the different intervals differ significantly, but it is to be noted that the greatest contribution to the value of Chi is derived from the 36 and 48-hour intervals. The breed differences up to and including the 36-hour period are non-significant.

The actual numbers of positive and negative matings, recorded in Table 46 (*a*), were further submitted to a 2 x 2 Chi-squared test, according to the method as advised by Yates (1934). The results appear in Table 47.

TABLE 47.

*Comparative Schedule Showing the Probabilities of Conception at one Service Interval Against Other Service Intervals.*

| Service Period, (Hours). | PROBABILITIES OF CONCEPTION. | | |
|---|---|---|---|
| | Significantly Better than. | Significantly Worse than. | Similar to. |
| LARGE BLACKS. | | | |
| | Hours. | Hours. | Hours. |
| 0 | 48 | None | 12 |
| | 60 | — | 24 |
| | — | — | 36 |
| 12 | 48 | — | 0 |
| | 60 | — | 24 |
| | — | — | 36 |
| 24 | 48 | — | 0 |
| | 60 | — | 12 |
| | — | — | 36 |
| 36 | 48 | — | 0 |
| | 60 | — | 12 |
| | — | — | 24 |
| 48 | 60 | — | — |
| | — | 12 | — |
| | — | 24 | — |
| | — | 36 | — |
| 60 | — | All | — |

TABLE 47 (*continued*).

LARGE WHITES.

| | | | |
|---|---|---|---|
| | Hours. | Hours. | Hours. |
| 0 | 48 | — | 12 |
| | — | — | 24 |
| | — | — | 36 |
| 12 | 36 | — | 0 |
| | 48 | — | 24 |
| 24 | 36 | — | 0 |
| | 48 | — | 12 |
| 36 | 48 | 12 | 0 |
| | — | 24 | — |
| 48 | — | All | — |

The data in Table 47 show that, for Large Blacks, the probabilities of conception resulting from matings occurring at 0, 12, 24 and 36 hours are almost identical and, also, that these four intervals are significantly more favourable than both the 48 and 60-hour periods. Conceptions decline steeply from 80·6 per cent at the 36th hour to 53·1 per cent. at the 48th hour and to 14·8 per cent. at the 60th hour. For Large Whites, the probabilities of conceptions occurring at zero hour are similar to those occurring at 12, 24 and 36 hours, but both the 12th and 24th hours are better than the 36th hour. All intervals from zero to 36 hours are significantly more favourable than the 48th hour. A reduction in the rate of conception is clearly indicated after the 24th hour interval, declining from 87·5 per cent. at that period to 63·6 per cent. at 36 hours and to 28·0 per cent. at 48 hours. Calculation shows that, for Large Whites, the rate of conception of 92 per cent. at the 12th hour is considerably superior to that of 74·1 per cent. at the zero hour, the odds being 11 to 1 in favour of the former.

## *Additional Studies.*

### *Fertility and Age.*

An increase in fertility with age has been demonstrated by various authors (Sinclair and Syrotuck, 1928; Johansson, 1929; etc.) An attempt has been made to determine whether this condition could be ascribed to the maturation of progressively larger numbers of ova, in terms of corpora lutea, as the pig ages. The available data have been examined for this purpose and different age groups classified, ranging from 7 tot 57 months. Owing to an insufficiency of material, it has been necessary to group females of 7 to 8, 11 to 13, 14 to 16 and 17 months and over in the same classes. The data appear in Appendix 6, Table III and analysis of variance in Table 48.

TABLE 48.

*Analysis of Variance: Fertility and Age in Terms of Corpora Lutea Number in Large Black and Large White Pigs.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Breeds | 1 | 499·64 | 499·64 | 138·02 | SS |
| Ages | 5 | 87·63 | 17·53 | 4·84 | SS |
| Interaction | 5 | 1,082·53 | 216·51 | 59·81 | SS |
| Error | 190 | 688·60 | 3·62 | — | — |
| TOTAL | 201 | 2,358·40 | — | — | — |

Minimum significant differences at P= ·05; breeds 0·53; ages 0·30; interaction 0·22.

The analysis shows that the mean difference of 3·16 corpora lutea between the breeds is highly significant. Similarly, the influence of age on fertility is evident over the two breeds, the mean corpora lutea number rising from 14·12 at 7 to 8 months to 16·17 at 17 to 57 months. Dissimilar conditions, however, are revealed within the breeds. In Large Blacks there is, with the exception of the 10-month class, a steady and consistent increase in corpora lutea number from group to group. It is not clear why the 10-month group should be significantly lower than the preceding one. In Large Whites the evidence shows that no demonstrable increase in basic fertility exists up to and including the 10th month, beyond which, however, highly significant increases occur at the 11 to 13th and 17 to 54th month groups. In this latter breed, significant regressions in corpora lutea number are reflected at the 9th and the 14-16th month stages, but as no acceptable biological explanation can be advanced for such a condition, the findings must be considered as tentative, especially in view of the small number of cases available for the 14-16th month group. Considered as a whole, there can be no doubt that pigs shed significantly large numbers of ova with advancing age (the ages in this study being 57 and 54 months, for Large Blacks and Large Whites respectively). Basic fertility has increased from 7-8 to 17-57 months by 22·8 per cent. in Large Blacks and by 13·2 per cent in Large Whites.

*Fluctuations in the Number of Ova Liberated at Consecutive Oestrous Periods.*

During any oestrous period the ovary carries at the same time corpora lutea of the previous ovulation and the mature follicles destined to rupture at that period. Assuming that, as a general rule, each corpus or follicle represents one ovum, females slaughtered during an oestrous period present material from which variations in the number of ova, liberated at two consecutive ovulations, could be studied. The material, which became available in the study on the morphological changes of the ovary during oestrus, was utilised for this purpose. The data are presented in Appendix 6, Table IV. The strength of the relationship between these two variables has been calculated and correlation coefficients of -0·09 and 0·15 obtained for Large Blacks and Large Whites respectively. Both coefficients fall far short of significance at the 5 per cent. level.

*The Number of Ova Unaccounted for at 26 days of Pregnancy.*

The number of ova liberated at any one oestrus is nearly always in excess of the number that can be accounted for in terms of embryos or of piglets at term (Hammond, 1921; Corner, 1921, 1923). During the observation on the optimum service period material became available for quantitative study of this aspect of fertility in the sow. As sows were slaughtered at about 26 days of pregnancy, the number of ova shed could be determined in terms of the number of corpora lutea and this in turn related to the number of embryos. Hence the number of ova unaccounted for could be arrived at. The data are presented in Table 49.

On applying the Chi-squared test to the percentages of ova unaccounted for, the reaction of the breeds was found to be non-significant ($X^2 = 5 \cdot 64$. For $n = 3$, $P = \cdot 05$, $X^2 = 7 \cdot 82$). Previous calculations have already shown that the number of embryos and corpora lutea at the various intervals do not differ significantly. Employment of all the data (as shown in Table 49) in the calculation of an over-all percentage loss of ova, is therefore justified. The result shows that, out of a total of 1,434 ova liberated, only 1,030 could be accounted for at 26 days of pregnancy, leaving 404, or 28·17 percent., of ova unaccounted for at that stage. Over the two breeds the mean number of ova unaccounted for is 4·12.

TABLE 49.

*The Number of Ova (in Terms of Corpora Lutea) Unaccounted for at 26 Days of Pregnancy, in Large Black and Large White Sows, Mated at Different Time-intervals.*

| Service Interval, (Hour). | C.L. No. | Total No. of Foetuses. | No. of Ova Unaccounted for | Per Cent. Ova Un-accounted for. | No. of Individuals. |
|---|---|---|---|---|---|
| *Large Blacks.* | | | | | |
| 0 | 133 | 93 | 40 | 30·07 | 10 |
| 12 | 139 | 109 | 30 | 21·58 | 10 |
| 24 | 133 | 81 | 52 | 39·10 | 10 |
| 36 | 130 | 92 | 38 | 29·23 | 10 |
| 48 | 132 | 96 | 36 | 27·27 | 10 |
| 60 | 108 | 68 | 40 | 37·04 | 8 |
| TOTAL | 775 | 539 | 236 | 30·45 | 58 |
| *Large Whites.* | | | | | |
| 0 | 166 | 122 | 44 | 26·51 | 10 |
| 12 | 164 | 134 | 30 | 18·29 | 10 |
| 24 | 158 | 123 | 35 | 22·15 | 10 |
| 36 | 171 | 112 | 59 | 34·50 | 10 |
| TOTAL | 659 | 491 | 168 | 25·49 | 40 |
| TOTAL (both breeds) | 1,434 | 1,030 | 404 | 28·17 | 98 |

*Ova Unaccounted for at Parturition.*

Careful records were kept over the experimental period of all normal and still-born piglets delivered at each farrowing. These data, together with those appearing in Table 49, have been utilised in a further study of the fate of the ova liberated. Averages were used as the bases of calculations. The results are presented in Table 50.

It will be observed that, considering all piglets, whether normal or still-born, the average number of ova unaccounted for at parturition amounts to 5·42 (40·57 per cent.) and 6·84 (41·53 per cent.) in Large Blacks and Large Whites respectively. If piglets born alive only be considered, the average number of ova unaccounted for or which failed to result in normal piglets at parturition, amounts to 6·14 (45·96 per cent.) and 8·01 (48·63 per cent.) in Large Blacks and Large Whites respectively. Over the two breeds this figure is 6·92 (47·30 per cent.). Calculation shows that, for Large Blacks, 9·09 per cent. of piglets were still-born, with a mean of 0·72 still-born piglets per litter. In Large Whites, 12·16 per cent. of piglets were still-born, with a mean of 1·17 still-born piglets per litter.

TABLE 50.

*Ova Unaccounted for at Parturition in Large Black and Large White Pigs.*

| | Large Blacks. | Large Whites. | Large Blacks and Large Whites. |
|---|---|---|---|
| Number of individuals | 58 | 40 | 98 |
| Total Number of ova | 775 | 659 | 1,434 |
| Average number of ova | 13·36 | 16·47 | 14·63 |
| Number of litters | 54 | 35 | 89 |
| Piglets born (alive and still-born):— | | | |
| Total Number | 429 | 337 | 766 |
| Average No. | 7·94 | 9·63 | 8·61 |
| Ova unaccounted for at parturition:— | | | |
| Average Number | 5·42 | 6·84 | 6·02 |
| Average Per Cent. Number | 40·57 | 41·53 | 41·15 |
| Normal piglets born:— | | | |
| Total Number | 390 | 296 | 686 |
| Average Number | 7·22 | 8·46 | 7·71 |
| Ova not resulting in normal piglets:— | | | |
| Average Number | 6·14 | 8·01 | 6·92 |
| Average Per Cent. Number | 45·96 | 48·63 | 47·30 |

*Atrophy of the Embryo between 26 Days of Pregnancy and Parturition.*

By calculating the mean number of normal embryos at 26 days of pregnancy from the data in Table 45, and by utilising the date for the number of normal piglets at birth appearing in Table 50, it becomes possible to arrive at an estimate of the incidence of atrophy between the 26th day of pregnancy and parturition. As the results in Table 45 show a higher degree of atrophy at the 60th and probably at the 48th hour, of service in Large Blacks and at the 36th hour in Large Whites, the data of these periods were omitted from the particulars presented in Table 51.

TABLE 51.

*Estimated Atrophy Between 26 Days of Pregnancy and Parturition in Large Blacks and Large White Pigs.*

| | Large Blacks. | Large Whites. | Large Blacks. and Large Whites. |
|---|---|---|---|
| Normal embryos at 26 days of pregnancy: | | | |
| Number of individuals | 40 | 30 | 70 |
| Number of embryos | 338 | 365 | 703 |
| Mean number of embryos | 8·45 | 12·17 | 10·04 |
| Normal piglets at parturition: | | | |
| Number of litters | 54 | 35 | 89 |
| Total number of piglets | 390 | 296 | 686 |
| Mean number of piglets | 7·22 | 8·46 | 7·71 |
| Normal embryos at 26 days of pregnancy: | | | |
| Mean number | 1·23 | 3·71 | 2·33 |
| Mean Per Cent. Number | 14·56 | 30·48 | 23·21 |

Considerable breed differences are indicated. The estimated mean number of normal embryos at 26 days of pregnancy, which fail to be represented by normal piglets at birth, amounts to 1·23 in Large Blacks and 3·71 in Large Whites. This involves an estimated incidence of atrophy between the two intervals of 14·56 per cent. in Large Blacks and 30·48 per cent. in Large Whites.

*Farrowing Over Day and Night.*

As the hour of parturition was recorded in the majority of instances, it is possible to determine whether, according to the limited number of observations available, any preference exists for the day or night period for the event to occur. The results show that over the two breeds, out of a total of 89 farrowings, 49 occurred between the hours of 7 p.m. and 6 a.m. (night) and 40 between 7 a.m. and 6 p.m. (day). The Chi-squared test shows that no significant difference exists between these two totals.

*The Gestation Period.*

The frequency distribution of the duration of gestation is shown in Table 52 (*a*) and additional information in Table 52 (*b*).

TABLE 52.

*Frequency Distribution of the Period of Gestation in Large Black and Large White Pigs.*

(*a*)

| Class Interval, (Days). | Frequencies. | |
|---|---|---|
| | Large Blacks. | Large Whites. |
| 111 | 5 | 0 |
| 112 | 5 | 7 |
| 113 | 13 | 10 |
| 114 | 10 | 12 |
| 115 | 3 | 10 |
| 116 | 4 | 9 |
| 117 | 0 | 2 |
| 118 | 0 | 3 |
| TOTAL | 40 | 53 |

(*b*)

| | | |
|---|---|---|
| Number of individuals | 40 | 53 |
| Mean duration of gestation, days | 113·35 | 113·66 |
| Standard deviation | 1·42 | 1·42 |

Calculation shows the standard deviation of the difference to be 0·733, hence the breed mean difference is non-significant. In Large Blacks the mode is 113 days and the range 111 to 116 days and in Large Whites the mode is 114 days and the range 112 to 118 days.

*Migration of the Embryo.*

Actual transference of the fertilized ovum from one cornu to the other can only be assumed if the number of embryos carried in any one cornu exceeds the relative number of corpora lutea. Such a condition may, however, be confounded by the existence of one or more multiovular follicles or twinning on the relevant side. As such phenomena appear to be of rare occurrence (Corner, 1921, 1923), these probabilities have been ignored and each corpus luteum assumed to represent an ovum at the time of conception. All females, slaughtered at about 26 days of pregnancy in the optimum service period studies, have been used as material for this study. Out of 61 Large Black sows and out of 44 Large White sows, 21 instances were discovered in each breed in which migration of the embryo appears to have occurred. The data are presented in Table 53.

TABLE 53.

*Migration of the Embryo.*

| Sow No. | Left Cornu. | | | Right Cornu. | | |
|---|---|---|---|---|---|---|
| | No. of Embryos in Excess of No. of C.L. | C.L. No. | No. of Embryos. | No. of Embryos. | C.L. No. | No. of Embryos in excess of No. of C.L. |
| Large Blacks. | | | | | | |
| 32........ | — | 8 | 6 | 6 | 5 | 1 |
| 34........ | — | 15 | 6 | 4 | 3 | 1 |
| 45........ | — | 10 | 7 | 4 | 1 | 3 |
| 48........ | 1 | 5 | 6 | 8 | 9 | — |
| 55........ | — | 7 | 3 | 7 | 4 | 3 |
| 60........ | — | 8 | 6 | 6 | 5 | 1 |
| 110........ | 1 | 3 | 4 | 5 | 11 | — |
| 116........ | — | 7 | 5 | 7 | 6 | 1 |
| 118........ | — | 8 | 6 | 5 | 4 | 1 |
| 123........ | 1 | 7 | 8 | 8 | 10 | — |
| 126........ | — | 9 | 2 | 4 | 0 | 4 |
| 130........ | 4 | 1 | 5 | 4 | 9 | — |
| 132........ | — | 8 | 6 | 7 | 6 | 1 |
| 137........ | — | 7 | 5 | 4 | 3 | 1 |
| 138........ | — | 8 | 4 | 8 | 4 | 4 |
| 157........ | — | 9 | 5 | 6 | 5 | 1 |
| 160........ | 1 | 3 | 4 | 5 | 8 | — |
| 161........ | — | 10 | 7 | 6 | 5 | 1 |
| 188........ | — | 13 | 4 | 5 | 0 | 5 |
| 191........ | — | 9 | 4 | 6 | 4 | 2 |
| 221........ | 1 | 6 | 7 | 5 | 9 | — |
| Large Whites. | | | | | | |
| 18........ | 1 | 4 | 5 | 3 | 6 | — |
| 71........ | 1 | 9 | 10 | 4 | 9 | — |
| 73........ | 2 | 7 | 9 | 6 | 9 | — |
| 77........ | — | 10 | 7 | 5 | 4 | 1 |
| 79........ | 2 | 7 | 9 | 7 | 12 | — |
| 82........ | — | 12 | 6 | 9 | 7 | 2 |
| 96........ | — | 15 | 8 | 8 | 3 | 5 |
| 98........ | 2 | 6 | 8 | 6 | 8 | — |
| 103........ | 1 | 8 | 9 | 8 | 9 | — |
| 113........ | 3 | 1 | 4 | 6 | 9 | — |
| 116........ | — | 9 | 7 | 7 | 6 | 1 |
| 118........ | 1 | 3 | 4 | 4 | 9 | — |
| 135........ | — | 9 | 5 | 9 | 7 | 2 |
| 142........ | 2 | 8 | 10 | 7 | 9 | — |
| 143........ | — | 11 | 5 | 10 | 5 | 5 |
| 149........ | — | 8 | 4 | 6 | 4 | 2 |

Calculation shows that, for Large Blacks and Large Whites respectively, out of 61 and 47 cases examined 34·4 per cent. and 36·4 per cent. showed migration, and of these 28·6 per cent. and 56·3 per cent. occurred from the right to the left cornu and 71·4 per cent. and 43·7 per cent. from left to right. All cases in which the number of embryos in the two cornua differ by one only were considered as being similar to those in which the numbers are identical. On this basis the data reveal that equalisation of the numbers of embryos have been achieved in 11 out of 21 (52·4 per cent.) instances in Large Blacks, and in 4 out of 14 (25 per cent.) instances in Large Whites. Transfer in certain instances appears to have assumed considerable proportions, involving as many as 4 and even 5 embryos (vide Large Blacks Nos. 126, 138, 188 and Large Whites Nos. 96, 143). Furthermore, it has to be pointed out that migrations in various instances appear to have continued beyond the stage of equilibrium, producing considerable unbalance in numbers on the two sides. Such cases are shown in the following individuals: Large Blacks Nos. 55, 126, 138 and Large White No. 143.

*The Temperature of the Sow in Oestrus.*

It will be observed from Appendix 6, Table I, that the majority of sows were temperatured at each mating. All single temperature records are those taken immediately prior to service. In a limited number of instances two readings are shown, the first being that preceding, the second just after, service. Vaginal temperatures were taken with an ordinary clinical thermometer. The animals were housed most of the time, except for short periods while being fed or when idling in their exercising yard.

The 24 hours of the day were divided into four equal six hour periods, starting from 6·01 p.m. The temperature records were classed under each interval according to the hour of service. Particulars abstracted from Appendix 6, Table I, are presented in Appendix 6, Table V, and a summary of the data, together with the analysis of variance, appear in Table 54.

TABLE 54.

*Mean Vaginal Temperatures (°F) of Large Black and Large White Sows in Oestrus Taken at Sixhour Intervals Over the 24 Hours of the Day.*

| | NIGHT. | | | | DAY. | | | |
|---|---|---|---|---|---|---|---|---|
| | 6·01 p.m.–12·00 midnight. | | 12·01–6·00 a.m. | | 6·01 a.m.–12·00 noon. | | 12·01–6·00 p.m. | |
| | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. | Large Blacks. | Large Whites. |
| n................ | 27 | 8 | 9 | 5 | 25 | 15 | 21 | 17 |
| Mean (breeds)...... | 102·4 | 102·4 | 102·1 | 102·7 | 101·9 | 102·1 | 101·9 | 102·6 |
| Mean (both breeds). | 102·4 | | 102·3 | | 102·0 | | 102·3 | |
| Mean (both breeds) day and night).... | 102·4 | | | | 102·2 | | | |
| Mean (general)..... | 102·2 | | | | | | | |

TABLE 54 (*continued*).

*Analysis of Variance.*

| Component. | D.F. | Sum Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| Breeds.................. | 1 | 2·83 | 2·83 | 4·96 | ss |
| Periods................. | 3 | 3·63 | 1·21 | 2·12 | ns |
| Interaction............. | 3 | 9·68 | 3·23 | 5·67 | SS |
| Error................... | 119 | 68·32 | 0·57 | — | — |
| TOTAL........... | 126 | 84·46 | — | — | — |

Although the analysis of variance seems to indicate that differences in temperature are not independent of breeds, the significance of the differences obtained is very doubtful, as shown by the fact that the calculated values fall short of the 5 per cent. level of P.

The calculated general breed mean is 102·1 °F. for Large Blacks and 102·4 °F. for Large Whites. The over-all mean temperature is shown to be 102·2 °F. The range is 100·0° to 104·5 °F., 82·5 per cent. of cases falling in the 101·1° to 103·0 °F. range class. One individual showed a temperature of 105·2 °F., but as this appeared to be abnormally high, her temperature was omitted from the range data.

With regard to the temperatures before and after service, the data show that a rise was recorded in every instance, the mean increase over 34 observations in Large Blacks being 0·80 °F. and the range 0·3° to 1·8° F. The three only observations available for Large Whites show similar tendencies. These increases could in no instance be associated with infertility.

*Discussion.*

Thirteen authors have been reviewed with regard to the period at which pigs should be mated for optimum results. Of these only four have based their recommendations on data obtained from actual experimental work. The other writers, generally, assume that ovulation in the pig occurs somewhere during the second day of oestrus and that the fertilizable life of the spermatozoon is limited. Mating should therefore be timed so as to provide a fresh supply of active male cells at the top of the tubes as the ova are liberated. Furthermore, they argue that breeding should not be delayed till the last stages of oestrus because the viable life of the ovum is very short and that such matings may therefore be barren. Theoretically, this hypothesis appears very sound, but the argument must stand or fall principally on one aspect in the mechanism of reproduction, namely, whether or not the vitality of the spermatozoon, in the female genital tract, is as limited as has been generally assumed hitherto.

Lewis (1911) found that 80 per cent. of the spermatozoa were dead 16 hours or more after mating and that live spermatozoa were present in only 5 cases out of 19 sows, killed 22½ to 24 hours after mating. The results yielded by this technique would appear to be extremely unreliable, as the data that accrued from the work on the optimum service period will confirm. As has already been shown, ovulation in the Large White breed occurs between the 18th and 36th hour, and in the Large Black breed only between the 42nd and the 54th hour, of oestrus. Yet, notwithstanding this condition, out of 15 Large White and out of 11 Large

Black females, mated at the zero hour of oestrus, only two failed to conceive out of each breed group. Furthermore, the data show that the mean number of embryos obtained from services at the zero hour does not differ from those obtained at apparently more optimum periods. The doubtful value of such results is further revealed by the work of Krallinger and Schott (1933). These authors mated sows the first hour after the onset of oestrus and obtained litters comparable to those from services allowed only on the second day. Such results, obtained from practice, therefore seem to negative the findings of Lewis and unmistakenly prove that the fertilizable life of spermatozoa within the female genital tract must be quite 48 to 54 hours, as is the case in the Large Black breed. Consequently, the method of searching for motile spermatozoa in the genital tract of the sow at set intervals after mating would appear to yield unreliable results. The technique does not provide acceptable data for the assumption that, in the pig, mating should not be allowed during early oestrus as such services may be barren, due to a lack of viable spermatozoa at the period of ovulation.

Haring's (1937) claim that the viable life of spermatozoa rarely exceeds 24 hours is based on the finding that, if sows are mated within 12 hours after the onset of oestrus and again 24 hours later, the greatest number of piglets born are from second matings. As ovulation, according to him, occurs at about the 24th hour and is completed at the 36th hour of oestrus, he concluded that spermatozoa from the first service had lost their vitality at the period of ovulation. A two-fold objection against this work would seem to be indicated. Firstly, his experiment was not planned to show whether a single service allowed within 12 hours after the onset of oestrus would be barren or not. No provision had been made for such single matings to serve as controls. Secondly, the introduction of a fresh supply of semen 24 hours after the first confounds the issue. It is quite conceivable that, if fresh and old spermatozoa were to surround the ovum simultaneously, impregnation would more easily be affected by the fresh germ cells. This condition may arise even though those male cells which arrived first may still be perfectly capable of fertilizing the ovum. The literature does not mention whether all first services were performed by the same boar or not. If the same boar had been used, the probability exists that his germ cells might have been of a low vitality, as spermatozoa from different boars may vary considerably (Marshall and Hammond, 1937). McKenzie (1932), employing an exactly similar technique to Haring, demonstrated that in 8 out of 13 such double matings, pregnancies resulted from first matings only. This finding is therefore at variance with that of Haring's. The great disparity between the results of these two authors could probably best be explained on the basis of decided differences between the longevity of the spermatozoa *in utero* between the boars used. Also, McKenzie's gilts might, as a breed, have ovulated at a much earlier period than the sows used by Haring. This study has shown that significant breed differences exist with regard to the period of ovulation.

With regard to the optimum period to breed pigs, Haring (1937) recommended the second day, or about 24 to 40 hours after the beginning of oestrus, as the largest number of fertilizable ova will then be available. McKenzie and Miller (1930 *b*) and McKenzie (1932) stated that too early matings might be barren and recommended double services to procure large litters. It is of importance to note that all three authors followed the same plan. They mated sows during the early stages of oestrus and again a second or third time at specified intervals after the first, using differently-coloured boars at each mating. Although their results vary somewhat, their conclusions are similar. A very serious objection has to be brought forward at this stage against their technique. Their work merely demonstrated that certain piglets resulted from particular services allowed at definite intervals during oestrus, but there is no evidence as to litter size consequent to those particular matings. For instance, in Haring's table, the fact that out of a total of 10 piglets, 4 resulted from a first mating allowed 12 hours after the onset of oestrus, does not prove that the number of piglets from the first mating need necessarily have been no larger than four. No provision had been made to pit the one service period against another and then to compare actual litter size resulting from the practices followed. Furthermore, the fact that piglets are born from a first or second service only, or that the litter is mixed, is doubtful evidence as to the priority that should be accorded any one of the systems of breeding recommended. The deliberate mixing of " stale " and fresh semen might provide misleading information. As indicated above, the spermatozoa introduced by the last services may very probably have an advantage over their more exhausted, and therefore less motile, competitors in the impregnation of ova. That, however, does not prove beyond doubt that the older cells are incapable of achieving maximum fertilization of the available ova. Also, the fertilizing abilities of the germ cells from one boar might be of a much superior quality than that from another, although the literature affords no evidence on this aspect.

The present study was an attempt to improve on the technique employed by the authors discussed above. The procedure adopted was to assess the size of litter at 26 days of pregnancy in terms of the number of embryos, instead of the number of piglets delivered at term. It is fully realised that a number of objections might be advanced against this method. The most important would seem to be that litter size at 26 days of pregnancy is not a true reflection of the ultimate number of piglets that would have been delivered at birth. Furthermore, an additional objection arises from the fact that all embryos, whether normal or atrophic, were considered in total litter size. Other workers have shown that atrophy in the pig is a normal phenomenon and may assume considerable dimensions (Hammond, 1921; Machens, 1915; Haring, 1937; Corner, 1921, 1923; etc.).

With regard to the first objection raised above, it might be argued that the atrophic factors, responsible for the reduction of litter size between 26 days of gestation and parturition, will react with equal severity on all litters sired at the various intervals. Consequently, the total number of embryos at 26 days should be a reliable reflection of litter size at birth anyway. An exception to this, it would appear, exists for matings allowed during the last stages of oestrus, namely, at the 48th and 60th hour intervals in Large Whites and Large Blacks respectively, as will be discussed below. Secondly, the inclusion of both normal and atrophic foetuses at 26 days in total litter size was resorted to intentionally. It was desired, in addition, to determine the fertilizing powers of the spermatozoa, admitted at the different periods during oestrus, at as early a period during gestation as was practically possible. Disregarding, therefore, those embryos which atrophy and are resorbed in the very early stages of pregnancy, an all-inclusive embryo count at the 26th day would be a much more reliable index of such fertilizing abilities of the male cells than litter size at term. Effective litter size at the 26th day stage, with the exclusion of atrophic embryos, will be considered in the discussions below. Also, the additional information which accrued from the adoption of this plan, without seriously detracting from the main object of this study, further justified the procedure.

The application of statistical methods to the data clearly shows that an optimum time to mate pigs within the oestrus period could not be demonstrated, at least not if the object be to obtain the highest degree of fertilization of the available ova. Within the breeds the differences between the mean numbers of embryos for the various service intervals are insignificant at the 5 per cent. level. The White breed is considerably more fertile than the Black breed. Even though the interval mean differences fail to reach significance, it is of importance to note that, in both breeds, the mean number of embryos at the 12-hour period is greater than that at any other period. This indicates that breeding at that stage might possibly be just slightly more favourable than at other intervals.

The above finding is rather unexpected and is not in agreement with the generally accepted view, propagated for many years, that pigs should be bred at about the second day of oestrus. The disparity revealed between the results of this study and those of other workers (Haring, McKenzie, McKenzie and Miller) could possibly be explained by differences in technique. Those authors failed to show real differences in litter size between early and late services. They based their conclusions, as to the advisability of breeding at about the second day of oestrus, mainly on the evidence afforded by the constitution of litters resulting from matings performed by differently-coloured boars at various periods during oestrus. The probability of the introduction of error by such a procedure has already been discussed. From the available literature it would appear that Krallinger and Schott (1933) were the only workers who mated sows once only at specified times during oestrus and compared the mean litter size at birth. They showed that 46 pregnancies, resulting from services within the first hour of oestrus, yielded a mean litter size of 9·8. Of 348 matings, allowed on the day following the appearance of oestrus, a mean litter size of 10·05 was obtained. The difference, they found, was not significant. The findings of the present study is therefore in agreement with that of these two authors.

This aspect in fertility was also approached from a different angle. By using a fertility index, that is, the number of embryos calculated as a percentage of the relative number of corpora lutea, the analysis of the data yielded identical conclusions to those discussed above. This, incidentally, also shows that the fertilizing powers of spermatozoa remain unimpaired *in utero* up to 48 to 54 hours, the period of ovulation in Large Blacks.

The conclusions arrived at in the preceding paragraphs have to be qualified in two respects before a decision could be arrived at with regard to an optimum service period.

Firstly, examination of the number of clearly atrophic embryos occurring at the different service intervals (Table 45) reveals that, if breeding is delayed until towards the end of the oestrous period, the number of atrophic cases is increased above the normal. For Large Blacks this applies to the 60th and probably to the 48th hour of oestrus, and for Large Whites to the 36th hour, the respective times when the metoestrous phase for these two breeds is due. As shown previously, ovulation is completed at 54 hours in Large Blacks and at 36 hours in Large Whites. If, therefore, mating be delayed till the 60th hour in Large Blacks, the youngest crop of ova would be at least 6 hours old and the oldest 12 hours. If delayed till the 36th hour in Large Whites, the ages of the ova would range from 0 to 18 hours. Egg cells of such ages, could certainly be classed as " stale ". These results therefore show that, in the pig, ova remain fertilizably viable for 12 to 18 hours but, if fertilized, the zygote is subject to aberrations and early death to an abnormal degree, even during the first quarter (26 days) of gestation. Unhappily it was not possible to obtain further information as to what would happen if gestation were allowed to run its full course. The available information, however, indicates that litter size would be significantly reduced if breeding were delayed till the end of the oestrous period. In Large Blacks this would occur if mating be delayed till after the end of the second day and, in Large Whites, till after the end of the first day, of oestrus. The rising incidence of atrophic conditions in the embryo, concomitantly with the ageing of the ovum from which it derives, would appear to confirm for this species the similar results established for the guinea pig by Blendau and Young (1939). These authors showed that, in the guinea-pig, developmental abnormalities, death and abortion of the embryo and reduced litter size, follow inseminations after the egg has attained the age of 8 hours and more. These conditions they ascribed to the age of the egg at the time of fertilization; the early stages in development being mainly affected.

The present study has shown that all matings allowed at the zero hour of oestrus resulted in the lowest mean number of atrophic embryos. At the time of fertilization the spermatozoa, introduced at the onset of oestrus, must have been 48 to 54 hours old in the case of Large Blacks and 18 to 36 hours in the case of Large Whites. Such conditions, therefore, indicate that developmental abnormalities of the embryo are not a consequence of impregnation of fresh ova by "stale" spermatozoa. Similar results have been reported for other species of animals by Dunn (1927), Riddle and Behre (1921) and Hammond and Asdell (1926).

Secondly, the probabilities of fertile matings at the different intervals are of major importance and cannot be ignored in practice. The results have shown that, after the onset of oestrus, breeding of the sow should not be postponed beyond the middle of the second day, for Large Blacks, and beyond the end of the first day, for Large Whites, as the incidence of abortive matings rises steeply after these respective periods.

The fact that no significant differences obtain between the mean number of ova that become fertilized as a result of successful matings allowed during any interval of the oestrous period, cannot therefore be accepted as evidence that it is immaterial when sows are mated. The established condition that the number of atrophic embryos increases and the rate of conception decreases as oestrus advances, therefore shows that breeding operations must be confined to the early stages of the receptive state of the sow for optimum results. For Large Blacks, with a mean duration of oestrus of 49·9 hours, breeding should be confined only to the first day. The generally accepted view that the egg retains its vitality for a very short period in all species of animals (Lewis, 1911; Knaus, 1931; etc.) is fully borne out by the present study. It has been shown that, in Large Blacks, ovulation occurs from the 48th to the 54th hour and, in Large Whites, from the 18th to the 36th hour of oestrus. Reference to Table 46 will show that, in Large Blacks, the percentage of successful matings up to the 36th hour is still 80·6, then suddenly declines to 53·1 at the 48th hour and to only 14·8 at the 60th hour. At 60 hours the ages of the ova would range from 6 to 12 hours. The low level of only 14·8 per cent. of pregnancies, obtained for this interval, would therefore undoubtedly have resulted from the fertilization of the most recent crop of ova, about 6 hours old at the time of service. The low percentage of 53·1 of pregnancies at 48 hours, shows that disappointing results follow even in those instances where breeding and liberation of ova just about synchronise. As ovulation in the Large White breed occurs from the 18th to the 36th hour, that is over a period of 18 hours, that interval is considerably longer than in the former breed. Nevertheless, successful matings are only assured if confined up to 6 hours after the expected onset of ovulation, that is, up to the 24th hour. The percentage of pregnancies declines from 87·5 at 24 hours to 63·6 at 36 hours, and to 28 at 48 hours. The results for both breeds, therefore, show that mating should be allowed during that period which precedes the onset of ovulation, if the highest rate of pregnancies is to be obtained. The optimum period, both in respect of effective litter size and of conception rate, is confined to the first 36 hours of oestrus in Large Blacks and to the first 24 hours in Large Whites. The advice, tendered by the majority of writers, that breeding should be delayed till the second half of the oestrous period, could therefore not be supported by the results of the present study.

The cause for differences in fertility between breeds of pigs and between ages within the breeds, is fundamentally the same, namely differences in the mean numbers of ova maturing at each ovulation period. If the data for the two breeds be considered jointly, there appears to be no doubt that pigs shed significantly larger numbers of eggs with advancing age. The results show an over-all mean number of corpora lutea of 14·12 at 7—8 months and 16·17 at 17—57 months of age, that is, an increase in basic fertility of 14·52 per cent. over the stipulated age-spread. These results are therefore in agreement with those of Harris (1916), Hammond (1914), etc.

The rare condition in which the number of embryos exceed the relevant number of corpora lutea, as reported by Corner (1921, 1923), has been confirmed by the present study. Out of a total of 102 observations over both breeds, embryo counts were in excess in only three instances. A further seven instances were recorded in which the number of embryos and corpora were identical. The incidence of such relationships would undoubtedly be higher if observations could have been carried out at a much earlier stage of gestation than has been possible in this study.

As has been shown above, the correlation between the embryo number and the relevant number of corpora lutea is highly significant. Hence, appreciable differences between the number of eggs shed at different ovulations will be directly reflected in the relative litter sizes. The data reveal surprising variations in ova number produced at consecutive ovulations. Calculation has further shown that no correlation exists between these two variables, so that an estimate as to a sow's fertility, based on the number of corpora lutea of a single ovulation, could be most misleading. Differences of 8 to 9 corpora are not uncommon and in one instance the disparity amounted to as much as 24 and in another to 16. Corner (1923) estimated that about 70 per cent. of the original number of ova are represented by live piglets at birth. On this basis, an individual such as Large Black No. 23 (Appendix 6, Table IV), may deliver only 5 or 6 piglets if mated during the period when she matured 8 ova. On the other hand, if she were mated at the next period, when 24 ova were produced, she might have had a litter of 17 or 18 piglets. This condition, therefore, shows that it would be dangerous to estimate the fecundity of a sow on the evidence of any one litter only; she should be given at least a second chance if her first litter was disappointingly small.

Corner (1923) found that at the third week of pregnancy (13 to 21 days) 26·6 per cent. of ova were missing. That finding agrees very closely with that of the present study, which shows that 28·17 per cent. of ova could not be accounted for at 26 days of pregnancy. Corner also estimated that about 30 per cent. of ova never resulted in living young. The available data show that 45·96 per cent. and 28·63 per cent. of ova, in Large Blacks and Large Whites respectively, fail to give rise to viable young at birth.

According to Corner (1921), 7·43 per cent. and 4·25 per cent. of embryos are degenerate at 20 and 30 days of pregnancy respectively and, in a further study (1923), he found that at the third week, 4·7 per cent. were abnormal. Disregarding all data for Large Black sows served at the 48th and 60th hour intervals and for Large Whites served at the 36th hour interval, calculation shows that, in the former breed, 9·86 per cent. and, in the latter breed, 4·19 per cent. of ova are abnormal at the 26th day of pregnancy. The figure for the Large Black breed is therefore almost identical with that of Corner's for the 30th day of gestation, but that for Large Blacks is more than double that for Large Whites. The literature supplies no data relative to the incidence of atrophy between the 26th day of pregnancy and parturition. A calculated estimation, based on the available material, shows that, for Large Blacks, this amounts to 14·56 per cent. and, for Large Whites to 30·48 per cent. It has further been shown that in Large Blacks 9·09 per cent., and in Large Whites 12·16 per cent., of all piglets born were still-born, which figures are rather higher than Krizenecky's estimate of 6·99 per cent. McKenzie (1928) and Hughes *et al.* (1928) have shown that sub-optimal treatment of pregnant sows may lead to increased atrophy of the embryo. As all sows received identical treatment in these studies, the higher incidence of degenerates obtaining in the Large Black breed at the 26th day must be ascribed to other causes than those arising from under-nourishment. This may be due either to an inherent breed difference or to genetic factors carried by the particular blood-line, predisposing the embryos to degeneration and death at an early age in the Large Blacks. Subsequent to this stage of gestation, however, death of the embryo and the number of still-born piglets occur at a considerably higher rate in Large Whites than in Large Blacks. Corner (1921) thinks that overcrowding, especially during the latter half of gestation, is an important but not the only factor inducing degeneration. Hammond (1921) considers that in domesticated animals production has outstripped nutrition. Both views, therefore, indicate that death of the embryo will tend to be accentuated with increased litter size. Hence, the greater fecundity of the Large White breed of pig is probably the basic cause of the greater incidence of degeneration of the embryo subsequent to the 26th day of gestation and of the larger number of still-births, as revealed by these studies.

The mean number of corpora lutea (and hence the number of ova shed), including all ages, have been shown to be 13·54 and 16·70 for Large Blacks and Large Whites respectively. Furthermore, the number of corpora lutea and the number of embryos at the 26th day of pregnancy have been shown to be highly correlated. Atrophy in Large Whites, subsequent to the 26th day amounts to 30·48 per cent. against 14·56 per cent. in Large Blacks. Also, in Large Whites, 12·16 per cent. of piglets are still-born against 9·09 per cent. in Large Blacks. Yet, notwithstanding these conditions, effective litter size in Large Whites is still greater than in Large Blacks, namely, 8·46 as against 7·22. A mean difference of 3·16 ova between the two breeds is thus responsible for a mean difference of 1·24 live piglets at birth. From this it follows that fecundity in the sow is to a great extent governed by the number of ova liberated. Any endeavour to increase litter size in breeds with a low fertility through selection and breeding, cannot therefore easily be dissociated from an attempt to increase the number of eggs that ripen at each oestrus. On the other hand, the results have shown that, on an average, 47·3 per cent. of ova available for fertilization fail to develop into viable pigs at birth. If, therefore, the many factors, responsible for non-impregnation of the ovum and for developmental abnormalities subsequent to fertilization, could be effectively eliminated, fecundity in the pig would be almost doubled without any increase in the number of female germ cells produced. Those factors are, however, as yet but vaguely understood. Hammond (1921) has indicated that the factors which control the number of eggs which develop to reach birth-size have the greatest influence on fertility in domestic animals; this opinion is fully supported by the results discussed above. The Large White is today recognised as the most prolific of all breeds of pigs. As the evidence indicates that those factors postulated by Hammond are as prevalent in this breed as in others, its present-day status must be ascribed to its inherent genetic ability to mature large numbers of ova. This condition will undoubtedly be the direct result of selection based on large litters, applied over many generations. Any further improvement in this respect must necessarily be slow. It seems clear that considerable advances in fecundity would therefore most readily accrue if further research could reveal and show how to control those factors responsible for death during intra-uterine development.

The gestation period for the two breeds is almost identical, namely, 113·66 days for Large Whites and 113·35 days for Large Blacks. These figures agree very closely with those supplied by other authors (Zorn and Krallinger, 1930; Carmichael and Rice, 1920; etc.). The constancy of this period, as McKenzie (1928) remarked, is truly remarkable. The breed differences in modes and ranges should be considered as tentative in view of the limited number of observations.

Migration of the embryo from one cornu to the other, as demonstrated by Warwick (1926), and Küpfer and Quinlan (1926), has been confirmed by these studies. Transference of the embryo may be a very normal phenomenon but, without resorting to Warwick's or Küpfer and Quinlan's technique of semi-spaying sows, it is impossible to establish such a condition unless the number of embryos actually exceeds the relative number of corpora lutea on any one side. It does, however, seem clear that the object of migration is to equalise the number of embryos in the two cornua, as in all instances in which transference was demonstrable, such occurred from the side carrying the larger number of corpora lutea to the one carrying the lesser number. The objective of equalisation is, however, not always achieved and the mechanism involved does not appear to be infallible; unbalance has resulted in several instances in which the process was clearly overdone. It would appear that once the migratory action is set in motion, effective control of the movement is lacking. A clear indication of such a condition is well illustrated by the following two instances. In Large White No. 143 ten embryos and 5 corpora lutea appear on the right side, whereas the left side carried only 5 embryos and 11 corpora lutea. In the case of Large Black No. 126, the left side with 9 corpora lutea carried only 2 embryos whereas the right side with no corpora lutea carried 4 embryos. By and large, however, reasonable success is actually achieved by relieving the heavier-bearing horn of the uterus of its unequal burden.

The recording of the temperatures of sows immediately prior to services was intended solely as a check on the normal condition of the animals at the time of mating. No systematic attempt was made to correlate variations in body temperatures with those of diurnal atmospheric changes. The temperature of the normal sow during interoestrus, under the climatic conditions of the Western Transvaal, could therefore not be indicated. However, the available results show that no convincive significant mean differences could be demonstrated for body temperatures of the sow in oestrus, if the data be considered in six-hour intervals. It is, of course, probable that hourly records would have yielded more reliable information. These periodic records seem to indicate that the sow, not exposed to the direct rays of the sun, is in possession of a sufficiently effective heat regulatory mechanism to enable her to maintain an even state of body heat, notwithstanding diurnal variations in atmospheric temperatures. Harder's (1937) finding that minimum and maximum body temperatures obtain in the early morning and late afternoon respectively, could therefore not be substantiated under the prevailing conditions. The breeds do not appear to differ significantly. The over-all mean temperature of 102·2° F. agrees very closely with the 102·4° F. as supplied by Palmer (1917), but disagrees slightly with the mean of 103·3° F., according to Smith (1907).

## *Summary and Conclusions.*

1. The mean percentages of conception, resulting from services at 12 hour intervals during oestrus, were similar from 0 to 36 hours in Large Blacks and from 0 to 24 hours in Large Whites; thereafter highly significant declines, typical for each breed, follow.

2. Differences between the mean numbers of ova that become fertilized, as a result of successful matings allowed at any time during oestrus, are non-significant. The incidence of atrophy of the embryo is accentuated if services are delayed until towards the end of oestrus. In Large Blacks this condition arises if pregnancies result from matings occurring at the 60th and probably at the 48th hour, and in Large Whites at the 36th hour, of oestrus.

3. Atrophy of the embryo as a result of impregnation by " stale " spermatozoa does not occur.

4. The optimum period to breed pigs is dependent on the duration of oestrus. Best results are secured from matings occurring at any period during the first 36 hours of oestrus in Large Blacks and during the first 24 hours of oestrus in Large Whites.

5. The influence of age on fertlity is due to an increase in the number of ova shed with advancing age: over the Large Black and Large White breeds the mean number of ova at 7-8 months is 14·12 and at 17-57 months is 16·17.

6. The condition seems to be rare in which the number of embryos exceeds the relative number of corpora lutea.

7. The number of ova shed by a sow at consecutive ovulations are uncorrelated.

8. Of the ova liberated 28·17 per cent. cannot be accounted for at the 26th day of pregnancy and 41·15 per cent. cannot be accounted for at parturition; 47·3 per cent. of ova fail to give rise to living young at birth.

9. Over-crowding appears to be a cause of atrophy of the embryo.

10. The mean number of ova shed (including all ages) is 13·54 and 16·70 in Large Blacks and Large Whites respectively.

11. The mean number of normal embryos at 26 days of pregnancy is 8·45 and 12·17 in Large Black and Large White pigs respectively.

12. The estimated incidence of atrophy of the embryo between the 26th day of pregnancy and parturition amounts to 14·56 per cent. and 30·48 per cent. in Large Blacks and Large Whites respectively.

13. The mean number of normal piglets delivered at birth is 7·22 in Large Blacks and 8·46 in Large Whites.

14. The mean number of still-born piglets is 0·72 (9·09 per cent.) in Large Blacks and 1·17 (12·16 per cent.) in Large Whites.

15. No preference is shown for farrowings to occur during the day or night.

16. The mean duration of gestation is 113·35 days in Large Blacks and 113·66 days in Large Whites; the mean difference is non-significant.

17. Migration of the embryo could be demonstrated in 34·4 per cent. and in 36·4 per cent. of cases in Large Blacks and Large Whites respectively.

18. Mean body temperatures of the sow in oestrus, taken at six-hour intervals over the 24 hours of the day, do not differ significantly; the mean over-all temperature is 102·2° F. and the range is 100·0 to 104·5° F., 80·4 per cent. of cases falling in the 101·1 to 103·0° F. class.

---

# PART 5.

## VIII. Studies on the Boar.

### *Observation* 6.

*The Deposition of Semen by the Boar in the Genital Tract of the Sow During Coitus.*

*Object.*

The object was to determine in which compartment of the genital tract of the sow the boar deposits his semen during coitus.

*Material and Method.*

Four Large Black gilts, one Large Black and one Large White boar were employed as material. Mating was performed either in a serving crate or "free" as each case demanded. The duration of each service was timed in minutes and seconds. Immediately at the termination of coitus the gilt was killed with a "humane" killer and, as soon as all involuntary reflex movements had ceased, she was opened and the different compartments of the genital tract isolated by tying off with pieces of twine. The genitalia were then removed to the laboratory, each compartment opened in turn and examined for the presence of semen. The interval between coitus and examination did not exceed 15 minutes. The volume of semen contained in the cornua was determined by "milking" into a measuring cilinder. In the case of one gilt, the cervix, with the gelatinous fraction inclusion, was photographed for record purposes. In two instances scrapings from the walls of the fallopian tubes were examined microscopically in order to determine the extent of penetration of the spermatozoa.

*Literature.*

McKenzie *et al.* (1938) thought that the main function of the great volume of semen is to wash the ejaculate into the uterus and that semen is deposited well into the cervix. The gelatinous fraction of the ejaculate, coming chiefly toward the end of coitus, they state, is probably intended to seal the cervix and forestall the loss of semen. However, they claim that normal services resulted from boars with both the seminal vesicles and Cowper's gland removed, showing that the "bouchon vaginal" is not indispensible. The time required for ejaculation is not affected by the frequency of ejaculations. Phillips (1935) quoted a communication from McKenzie to the effect that the male germ cells reach the middle of the tubes in 3·1 hours and the ovaries in 5 hours. Rodolfo (1934) showed that spermatozoa reach the tubes within 40 minutes after artificial insemination and stated that this is possible only because of the pressure exerted by the volume of semen, as the cells cannot by themselves wiggle their way through 160 mm. of cornua in that period.

*Results.*

Details of the results obtained in each of the four gilts appear in Appendix 7.

Examination of the genital tract immediately after coitus reveals that in all four instances the cornua were flooded with semen, the volume varying from 13 to 112 c.c. per cornu, according to whether coitus was accompanied by much spilling of semen or not. In the three instances in which the contents were carefully measured, the total volume of semen, carried by the two cornua, was: 31 c.c. in gilt No. 56, 32 c.c. in gilt No. 62 and 217 c.c. in gilt No. 102. Considerable quantities of the ejaculate were wasted in the two first instances.

In the case of gilt No. 56, much semen was wasted during coitus and no vaginal plug was found in the cervix. In gilt No. 62 a considerable overflow was noticed during the act but a gelatinous plug was produced, broken into two portions, measuring 3·5 and 5·5 cm. each. In the other two gilts, Nos. 58 and 102, served by a Large Black and a Large White boar respectively, no overflow of semen occurred during service. In both instances a large and unbroken gelatinous plug was produced, measuring 16 cm. in the former and 14 cm. in the latter case. The plugs were securely lodged in the cervices, completely closing the passage. In one instance this body measured 2·5 cm. in diameter (Vide Photo No. 7).

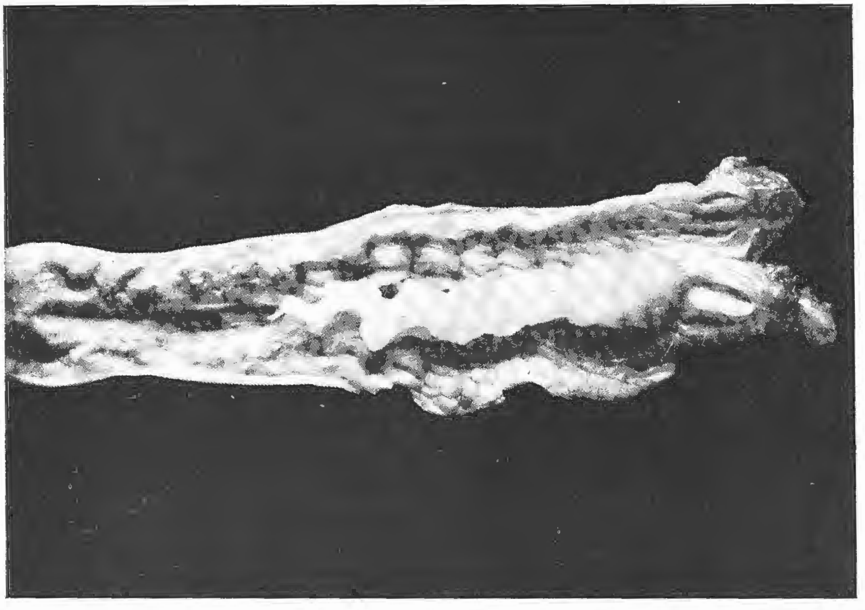

PHOTO No. 7.—Opened cervix showing " bouchon vaginal ".

*Discussion.*

The results show that, in the pig, semen is deposited directly into the pars indivisa during copulation. From here, presumably, the ejaculate is transported to the cornua, either through mere pressure of the large volume of liquid (as suggested by McKenzie *et al.* and Rodolfo), or otherwise through peristaltic action of the uterine walls, or through both. McKenzie's communication that spermatozoa reach the middle of the tubes only after 3·1 hours and the ovaries after 5 hours, is not supported by the results of this study. However, Rodolfo's finding that the germ cells reach the tubes within 40 minutes, has been well substantiated. It would appear that if the object of the exceedingly large volume of semen is to irrigate the uterus and serve as a medium of transportation of the spermatozoa, then that object is very effectively achieved. This is shown by the finding in one sow in which live male cells were recovered from the apices of the fallopian tubes, 15 minutes after coitus. It is therefore clear that it is impossible for spermatozoa to lie in wait for the ova at the top of the tubes within 15 minutes after completion of the sexual act.

It would appear that if undue spilling of semen occurs, a gelatinous plug is either not formed or is only partially produced, as was the case in both instances in which considerable wastage of semen resulted. In both instances in which no overflow occurred, the plug was found unbroken, firmly held by the rugae of the cervix. There appears to be no doubt that the object of this gelatinous fraction of the ejaculate is to seal the uterine canal in order to forestall wastage of semen, as suggested by McKenzie *et al.* However, as numerous fertile matings were observed to have been accompanied by considerable waste of the gelatinous fraction, and in which the formation of the "bouchon vaginal" was therefore improbable, its presence is certainly not indispensible, as mentioned by McKenzie and co-workers.

## *Observation 7.*

## *The Duration of Coitus.*

*Object.*

The object was to determine the duration of coitus.

*Material and Method.*

While these observations were in progress numerous matings had to be allowed. A service record was kept for each boar reflecting dates of service and duration of coitus. Occasionally a boar dismounted before completion of the act, coitus being completed in two or more stages. In those instances the duration was taken as the sum of the different periods.

*Literature.*

According to Rodolfo (1934) the duration of coitus in the boar is 5 to 8 minutes. He stated that as this species yields the largest volume of semen of all farm animals, it cannot be mated as intensively as the ram. Marshall and Hammond (1937) gave this period as 10 to 20 minutes. Hammond (1940) says coitus lasts 3 to 25 minutes and that the boar should not be disturbed during the act if the full quota of semen is to be ejaculated. Kronacher (1927) states that the sexual act lasts up to 10 minutes. According to McKenzie *et al.* (1938), this period occupies 10 minutes, with a range of 3 to 25 minutes.

*Results.*

The service records of the different boars used in these observations are presented in Appendix 7, Table I. From these it will be observed that only on rare occasions were boars used at intervals of less than two days.

It was thought that the interval of rest between services might have a bearing on the duration of coitus. Correlation coefficients between these two variables were calculated, the results showing that the coefficients for each breed are non-significant. (For Large Blacks $r = 0 \cdot 007$; for Large Whites $r = 0 \cdot 1003$). The data for the two Large White boars, Nos. P. 65 and P. 145, were omitted from the calculations owing to the small number of observations available.

The data for both breeds were further analysed by variance analysis to determine the degree of difference between the durations of coitus for the different boars. The results show that boars differ highly significantly in respect of this period. Table 55 and Figure 17 supply further information on the duration of coitus.

TABLE 55.

*The Duration of Coitus in Large Black and Large White Boars.*

| | Large Blacks. | Large Whites. |
|---|---|---|
| Number of observations | 244 | 124 |
| Mean in seconds | 310·9 | 248·2 |
| Standard deviation | 108·92 | 92·67 |
| Coefficient of variation | 35·03 | 37·34 |

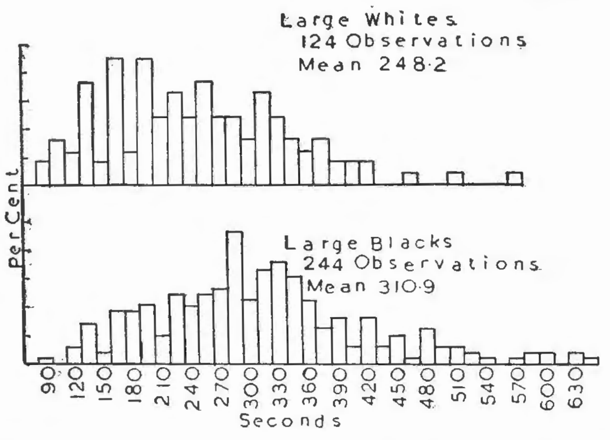


FIG. 17.—Frequency distribution of the duration of coitus.

The results show that, for Large Blacks, the mean duration of coitus is 5 minutes 11 seconds and for Large Whites 3 minutes 8 seconds, the mean difference being highly significant ($t = 6 \cdot 78$. For $n = 366$, $P = \cdot 01$, $t = 2 \cdot 58$). Figure 17 shows the frequency distribution of the duration of coitus, arranged in 15 second class-intervals. The mode is poorly expressed in both breeds, especially for Large Whites, but would appear to be at 285 seconds (4 min. 45 sec.) for Large Blacks. The variation is considerable for both breeds, the range being 90 to 645 seconds (1 min. 30 sec. to 10 min. 45 sec.) for Large Blacks and 90 to 570 seconds (1 min. 30 sec. to 9 min. 30 sec.) for Large Whites.

*Discussion.*

The finding by McKenzie *et al.* (1938) that no correlation exists between the period of inactivity and the duration of coitus, is supported by the present study. Highly significant individual and breed differences have been revealed. Considerable differences obtain between the various authors in regard to the length of this period. With the exception of McKenzie and co-workers, the references supply no experimental data for their statements. Working with Chester Whites and Duroc Jerseys, McKenzie *et al.* (1938) found the mean duration of coitus to be 10 minutes with a range of 3 to 25 minutes. They failed to mention breed differences but, as the durations recorded above for Large Blacks and Large Whites show decided differences, it seems clear that the disagreement between the present finding and that of the American workers should be ascribed to real breed differences. With regard to ranges, both breeds show a minimum of 1 minute 30 seconds and maxima of 10¾ minutes and 9½ minutes for Large Blacks and Large Whites respectively. These figures also differ considerably from those of the majority of authors in other countries.

*Observation* 8.

*The Frequency of Services if the Boar is Allowed to Mate at Will.*

*Object.*

In this study it was the object to determine how often a boar will perform the sexual act if allowed free access to a sow in oestrus.

*Material and Method.*

Two Large White boars, P.64 and P.65 and two Large Black sows, Nos. 38 and 61, served as material. The boars were 17 months old, both being active and fertile. When the boar was penned with his sow the latter was already well in oestrus. Attendants were on duty night and day. A lantern was used over night to provide only sufficient light to observe the behaviour of the boars. The time of each service or attempted service was recorded. The duration of coitus was recorded only in the case of P.65. The observation on each boar was terminated when it was considered that his sow was going into metoestrus. Unfortunately no other in-oestrous sows were available to continue each observation over a longer period.

*Literature.*

Rodolfo (1934) advised that boars should not be mated more often than once a day for more than two days in succession. He found that by the third day the number of spermatozoa falls far below the average of that in a light mating programme. He claimed that it is not wise to use a boar before he is 10 months old and not intensively before he is two years of age. Marshall and Hammond (1937) recommended that boars of 9 to 15 months should be used only occasionally and that boars should not run with the sows, as exhaustion on one sow may lead to refusal to serve others subsequently. Asdell (1934) advises farmers to use boars of 8 to 9 months sparingly and not more than once a day on 12 to 15 sows per season, and at one year they can be used 25 to 30 times per season, gradually increasing to 50 to 60 times at the age of 2 to 3 years. McKenzie *et al.* (1938) showed that, for ejaculations occurring every 48 hours or longer, the volume of semen remains near or above 200 c.c. per ejaculate over periods of 7 to 10 days, with a range of 125 to 500 c.c., the total number of spermatozoa exceeding 20 billion and abnormalities not exceeding 100 per 1,000. Repeated services at intervals of 24 hours or less, however, reduce semen volume to below

200 c.c. and the count to 2 to 5 billion, abnormalities increasing to more than 200 per 1,000 after two or three days. Two of three boars, used at 12 hour intervals, temporarily lost their desire to mate after the third or fourth service. The first ejaculate, following a long rest, has a high total sperm count, but abnormal forms approach or exceed 200 per 1,000. A consistent relationship exists between abnormality counts and duration of motility, especially during frequent ejaculations. They concluded that yearling boars should not be mated more often than once in 24 hours and that best results might be expected at 48 hour intervals, if the season is to extend over a period of two weeks or more. Chester White and Duroc Jersey boars were used as material.

*Results.*

Particulars for each boar are presented in Table 56.

TABLE 56.

*Frequency of Uncontrolled Services by the Boar if Allowed Free Access to the Sow.*

Large White boar P.64

| Date. | Time. | Interval in Hours. | Order of Service. |
|---|---|---|---|
| 3.11.41 | 4·30 p.m. | — | 1 |
| | 7·15 p.m. | 2·75 | 2 |
| | 7·59 p.m. | 0·73 | 3 |
| | 8·10 p.m. | 0·18 | 4 |
| 4·11·41 | 1·45 a.m. | 5·58 | 5 |
| | 4·51 a.m. | 3·10 | 6 |
| | 6·32 a.m. | 1·68 | 7 |
| | 8·00 a.m. | 1·47 | 8 |
| | 12·10 p.m. | 4·17 | 9 |
| | 6·00 p.m. | 5·83 | 10 |
| | 9·20 p.m. | 3·33 | * |
| 5.11.41 | 6·03 a.m. | 8·72 | 11 |

*Unsuccessful attempts at service.

Large White boar P.65

| Date. | Time. | Interval in Hours. | Order of Service. | Duration of Coitus. Min. | Sec. |
|---|---|---|---|---|---|
| 15·11·41 | 2·00 p.m. | — | 1 | 2 | 20 |
| | 4·00 p.m. | 2·00 | 2 | 3 | 32 |
| | 6·00 p.m. | 2·00 | * | — | — |
| 16·11·41 | 12·30 a.m. | 6·50 | 3 | 4 | 0 |
| | 2·30 a.m. | 2·00 | * | — | — |
| | 2·50 p.m. | 12·33 | 4 | 4 | 0 |
| | 3·15 p.m. | 0·42 | * | — | — |
| | 5·55 p.m. | 2·67 | * | — | — |
| 17·11·41 | 12·05 a.m. | 6·17 | * | — | — |
| | 3·30 p.m. | 15·42 | 5 | 0 | 30 |
| 18·11·41 | 4·15 a.m. | 12·75 | * | — | — |
| | 5·15 a.m. | 1·00 | 6 | 3 | 50 |
| | 11·15 a.m. | 6·00 | * | — | — |
| | 12·15 p.m. | 1·00 | 7 | 3 | 15 |

*Unsuccessful attempts at service.

P.64 performed 11 matings over a period of $37\frac{1}{2}$ hours with one unsuccessful attempt towards the end. In the case of P.65, 7 successful matings occurred over a period of almost 3 days, interpolated with 7 unsuccessful attempts. Unfortunately in this case the sow proved slightly too weak to carry the boar at each mounting, so that the information is incomplete. If, however, the intervals between actual matings only be considered, the data show no tendency to an increase in the intervals of rest towards the end. In fact the sixth and seventh services are separated by the second shortest interval, the shortest being between the first and second. The data for P.64 also do not reveal any proof of a lengthening of the rest period between matings as the number of copulations increases, with the probable exception of the last interval, which occurred after a previous unsuccessful attempt. Furthermore, the periods of rest after unsuccessful services do not indicate a quicker return to the sow if compared to the intervals between successful matings and the succeeding attempts. There would appear to be no significant differences between the duration of coitus as the number of services increases.

*Discussion.*

Researches on the effects of the frequency of ejaculation on semen have been mainly confined to two aspects, namely, the volume per ejaculate and the morphology of the spermatozoa (Rodolfo, 1934; McKenzie *et al.*, 1938). These workers have demonstrated that the volume of semen decreases and abnormality counts increase as the mating program is intensified. Their general conclusion is that mature boars should not be used more often than once every two days. Apart from the effects on these two qualities of semen, it would be both interesting and of practical value to know what influence a heavy mating regimen would have on actual fertility as reflected by litter size. No data relative to the pig and bearing directly on this aspect, could be traced from the literature. If, however, we are to infer from the conclusions of these authors that continued matings with a greater frequency than once every two days might adversely influence fertility in the boar, then the results of this observation are an indication of the consequences that will follow any system of uncontrolled mating, especially if a large number of sows are to be bred within a short breeding season. Considering the amount of energy spent by the boar during coitus, it is surprising to find that one male at least was capable of performing the act eleven times in just over one and a half days.

## ADDITIONAL STUDIES.

### (a) *Differences in Potential Fertility Between Daughters of Different Boars.*

*Object.*

The object was to determine whether any significant differences exist in potential fertility, as revealed by the number of corpora lutea, between groups of sisters sired by different boars.

*Material and Method.*

Females slaughtered for the studies in the optimum service period and for the morphological changes of the ovary were used for this observation. It is proposed to analyse the data with regard to the number of corpora lutea in the ovaries of groups of full and half sisters sired by different boars. For this purpose a limited number of daughters of five Large Black and six Large White boars were available, in each group of which, it will be observed, certain females appeared as full sisters.

*Results.*

Particulars in respect of daughter groups appear in Appendix 7, Table II and variance analyses, together with the group means, are presented in Tables 57 (*a*) and (*b*).

TABLE 57.

(*a*)

*Variance Analyses: The Number of Corpora Lutea in the Ovaries of Groups of Sisters of Large Black and Large White Females.*

| Component. | D.F. | Sum. Squares. | Mean Square. | F. | Significance. |
|---|---|---|---|---|---|
| LARGE BLACKS. | | | | | |
| Boars.................. | 4 | 286·767 | 71·692 | 116·76 | SS |
| Error................... | 59 | 36·217 | 0·614 | — | — |
| TOTAL........... | 63 | 322·984 | — | — | — |
| LARGE WHITES. | | | | | |
| Boars.................. | 5 | 732·984 | 146·597 | 135·5 | SS |
| Error................... | 77 | 83·281 | 1·082 | — | — |
| TOTAL........... | 82 | 816·265 | — | — | — |

(*b*)

*The Mean Number of Corpora Lutea in Different Daughter Groups.*

LARGE BLACKS.

| | U.88. | U. 32. | U. 2020. | P. 15. | U. 1786 |
|---|---|---|---|---|---|
| No. of daughters......... | 13 | 10 | 25 | 9 | 5 |
| Mean number of corpora lutea.................. | 11·54 | 13·20 | 13·40 | 13·44 | 13·57 |

LARGE WHITES.

| | P. 64. | B. Founder. | B. 391. | P. 61. | du Preez. | B. 155. |
|---|---|---|---|---|---|---|
| Number of daughters. | 20 | 16 | 23 | 7 | 11 | 6 |
| Mean number of corpora lutea | 15·95 | 16·38 | 17·39 | 17·71 | 18·64 | 18·83 |

The analyses show that, in both breeds, the mean differences between daughter groups are highly significant. The least significant differences as between pairs of boars were calculated, all possible combinations being considered, with the following results: In Large Blacks the number of corpora lutea of the daughters of only one boar, namely U.88, differ significantly from those of the groups of daughters of all other boars, the differences between the latter groups being non-significant. In Large Whites the daughter groups of P. 64, B. Founder, and B. 391 differ highly significantly between themselves and against the remaining three groups; the daughters of P. 61 being merely significantly different only from the daughters of B. 155, the differences between the remaining groups being non-significant.

*Discussion.*

Probably because of the relatively natural high fecundity obtaining in the sow, there would appear to have been no incentive up to now for workers to have studied the influence of the boar on the fecundity of his daughters, as no relevant data could be traced from the available literature.

As effective litter size in sows is greatly confounded by the manifold factors governing atrophy of the embryo, it is clearly difficult to gauge the influence of the boar on the fertility of a limited number of his daughters. Comparative studies on the abilities of different boars to transmit high fertility to their progeny could of course only be determined effectively if relatively large numbers of daughters of each could be tested out on a litter size basis. However, litter size is closely correlated to the number of ova shed. The number of corpora lutea, carried by groups of daughters of various boars, could therefore reasonably be employed as a basis for a comparative study of their transmitting powers in respect of this character.

The potential fertility, based on corpora lutea counts, of groups of daughters of certain boars have been compared statistically. As the numbers of individuals per group are limited, the conclusions arrived at should be regarded as tentative. The results show that, in Large Blacks, the daughter groups of four out of five boars failed to reveal any statistically significant differences and that the daughters of only one boar had a mean corpora lutea count which was significantly less than that of all other daughter groups. The condition for Large Whites is rather different as, between the daughter groups of six boars, the mean corpora lutea count of one only did not differ significantly from that of only two other groups. From the data it would appear that, in this latter breed, boars differ highly significantly in respect of their powers to influence the fertility of their daughters. The breed differences revealed should in all probability be ascribed to the greater measure of genetic homozygosity obtaining in the Large Black breed, owing to the considerable degree of line-breeding practised with this material as against almost continuous outbreeding in the Large Whites.

### (*b*) *Some Observations on the Sexual Behaviour of the Boar.*

A few general remarks on the boar, accumulated during the progress of these observations, might be of interest and some value.

During the warm summer months it was a matter of common occurrence to find entire and vasectomised boars ("teasers") extremely inactive during the hot hours of the day. This condition at times was so pronounced that they completely refused to pay any attention to the females while testing of oestrus was carried out. Considerable improvement was obtained by throwing a bucket of cold water over the boar shortly before his admittance to the sows.

The ability of a boar to locate a sow in oestrus or in pro-oestrus is surprising. An active and experienced male will, when confronted by a large number of females, pick out those in a receptive state without much waste of time and immediately transfer his attentions to them. A very common habit among boars is frequent urination when in the presence of the sows. The following are among the most common performances through which a boar usually goes before he will mount the sow in oestrus: continuous "chewing" or grinding of the teeth, foaming at the mouth accompanied by a movement of the jaws which is best described as a yawn. He will sniff at the genitals of the female, poke his nose between her hind legs and, with a sudden jerk, lift her hind quarters into the air. A particularly favourite habit is to nose the sow in her flanks and to persist in this action for a considerable period at times. He may now resort to friendly biting of the sow's ears or to placing his nose against that of the sow's, producing at the same time a continuous series of grunts. It is usual for the male to mount only after having gone through all or some of these preliminaries and after having apparently satisfied himself that the sow is in a receptive state. It is, however, not unusual to find a boar attempting to mount a sow not in oestrus. On occasions a boar will be particularly active and will follow a sow wildly through the pen while he continues to mount her notwithstanding the most obvious protestations on the sow's part. It was customary to keep one such boar in solitary confinement and to confront him with sows in pro-oestrus or metoestrus, which the regular "teasers" refused to mount. No matter how active a boar might be, after a few days of regular and active "teasing" he grows tired, loses interest and has to be removed from the presence of the females and rested. To maintain the boar's interest in the sows, he has to be allowed an occasional service. No difficulty was ever experienced to accustom boars to work in the serving crate.

Although no attempt was made to determine the age of sexual maturity in the boar, experience has shown that this period is subject to wide variations. One Large Black gilt conceived to her full brother when he was not yet fully six months old. Another, Large Black P.88, at the age of 10 to 11 months, refused to pay any attention to females intensely in oestrus. A third boar, Large White P.111, also 10 to 11 months old, readily served sows and was used as a very vigorous "teaser" at that age. Generally speaking, it would appear that sexual maturity in the boar is reached at a somewhat later stage than in the gilt.

## *Summary and Conclusions.*

1. Semen is deposited directly into the uterus during coitus and spermatozoa reach the cranial extremety of the fallopian tubes within 15 minutes after mating.

2. The mean duration of coitus is 5 minutes 11 seconds in Large Blacks and 3 minutes 8 seconds in Large Whites, the mean difference being highly significant. Varying periods of inactivity of the boar and the duration of coitus are uncorrelated.

3. Of two Large White boars, allowed free access to sows in oestrus, one mated 7 times during $34\frac{1}{4}$ hours and the other 11 times during $37\frac{1}{2}$ hours.

4. Differences between boars in respect of their abilities to influence basic fertility in their daughters, could be demonstrated in certain instances only.

5. The sexual behaviour of the boar is discussed.

## ACKNOWLEDGMENTS.

The writer wishes to express his sincere thanks and appreciation to Mr. W. F. Buys, Stockman, and to Messrs. J. J. du Toit and J. M. Latsky, both formerly Assistant Stockmen, of the Potchefstroom College of Agriculture, for the services rendered by them and for their loyal support during the years that these studies were being carried out.

Thanks are due to Dr. D. G. Haylett of the University of Pretoria, and more especially to Dr. A. R. Saunders, formerly of this Institution and now Assistant Director of Agricultural Education and Research, and to Mr. F. X. Laubscher, Research Officer, for their invaluable advice and guidance and unfailing courtesy at all times, in the preparation of the statistical data.

In conclusion the author wishes to convey his particular indebtedness to Dr. John Quinlan, Division of Veterinary Services, Onderstepoort, for his patient and constructive guidance in carrying out this investigation. Without him this work would have been impossible.

### REFERENCES.

As this study was carried out during the war years of 1939-45, great difficulty was experienced in obtaining certain publications. The writer was consequently obliged to rely on "review" abstracts and, in the case of a number of instances, the facts could only be obtained indirectly from quotations in relevant publications.

AITKEN, W. A. (1926). The Oestrous Cycle of the Mare. *Vet. Practitioner's Bull.*, Vol. 8, No. 1.

ALLAN, J. A. (1939). When to Mate Sows. *Farmer and Stock Breeder*, No. 7.

ALLAN, EDGAR; KNOUTZ, W. B., AND FRANCIS, B. F. (1924). Selective Elimination of Ova in the Adult Ovary. *The Anatomical Record*, Vol. 27.

ANDERSON, W. S. (1922). Vitality of Spermatozoa. *Kent. Agric. Exp. Sta.*, Bull. 239.

ANDERSON, J. (1938). Ovulation in the Ewe. *J. Agr. Sc.*, Vol. 28, pt. I.

ANDERSON, J. (1944). The Periodicity and Duration of Oestrus in Zebu and Grade Cattle. *J. Agr. Sc.*, Vol. 34, pt. 2.

ANDREWS, F. N., AND McKENZIE, FRED F. (1941). Estrus, Ovulation and Related Phenomena in the Mare. *Univ. Mo. Agr. Sta. Res. Bull.* 329.

ASDELL, S. A. (1934, 1938). *Cornell Extension Bull.* 305, June 1934; reprinted 1938.

BERTRAM, H. A. (1926). Über die Wurfgrösse beim veredelten Landschwein. *Züchtungskunde*, 1, pp. 256-269. Quoted by Buchanan Smith, 1930.

BISSCHOP, J. H. R. (1945). Personal communication.

BLENDAU, R. J., AND YOUNG, W. C. (1939). The Effects of Delayed Fertilization on Development of the Guinea Pig Ovum. *Amer. J. Anat.*, Vol. 64, p. 303.

BONSMA, J. C. (1945). Personal communication.

BONSMA, F. N., AND OOSTHUIZEN, P. M. (1935). Milk Production in Large Black Sows and its Importance in Relation to the Production of Baconers. *South African Jour. Sc.*, Vol. 32, p. 360.

CARMICHAEL AND RICE (1920). Quoted by Krallinger (1937).

CHRISTENSEN, F. W.; THOMPSON, O. A., AND JORGENSON, L. (1926). Prolificacy of Sows and Mortality of Pigs. *North Dakota Agr. St. Bull.* 194.

COLE, H. H.; HOWELL, C. E., AND HART, G. H. (1931). The Changes Occurring in the ovary of the Mare during Pregnancy. *Anat. Rec.*, Vol. 49, No. 3.

COLE, H. H., AND MILLER, R. F. (1932). Data on Reproduction in the Sheep. *Anat. Rec.*, Vol. 52, Suppl., p. 49. Quoted by James Anderson (1938).

CORNER, G. W. (1915). *Carnegie Institute, Washington; Contributions to Embryology*, Vol. 2, No. 5, pp. 69-94.

CORNER, G. W. (1921). Cyclic Changes in the Ovaries and Uterus of Swine and Their Relations to the Mechanism of Implantation. *Carnegie Institute, Washington; Contributions to Embryology*, Vol. 13, pp. 117-146.

CORNER, G. W. (1923). The Problem of Embryonic Pathology in Mammals with Observations on Intra-uterine Mortality in the Pig. *Amer. J. Anatomy*, Vol. 31, No. 5.

CORNER, G. W., AND AMSBAUGH, A. E. (1917). Oestrus and Ovulation in Swine. *Anat. Records*, Vol. 12, No. 2, pp. 287-291.

DAVIDSON, H. R. (1930). Reproductive Disturbances Caused by Feeding Protein-deficient and Ca-deficient Rations to Pigs. *J. Agric. Sc.*, Vol. 20, pp. 233-264.

DAVIDSON, H. R. (1939). Before Farrowing is the Time. *Fmr. and Stk. Brd.*. Dec. 19, 1939.

DETTWEILER AND MÜLLER (1924). Lehrbuch der Schweinezucht. Parry, Berlin.

DUNN, L. C. (1927). Selective Fertilization in Fowls. *Poultry* Sc., Vol. 6, p. 201. Quoted by Hammond (1941).

DU TOIT, P. J.; MALAN, A. I., AND ROETS, G. (1935). A study of the Mineral Content and Feeding Value of Natural Pastures in the Union of South Africa. *Onderstepoort J.*, Vol. 5, No. 1.

EVANS, H. M., AND BISHOP, R. S. (1923). The Production of Sterility with Nutritional Regimens Adequate for Normal Growth and its Cure with Other Foodstuffs. *J. Metabolic Research*, Vol. 3, p. 223.

FARMER AND STOCK BREEDER (1940). 54: 189. Contains the record of a sow which produced 3 litters of 8, 13 and 17 piglets, respectively, in one year.

MORRISON, F. B. (1936). Feeds and Feeding, 20th Edition. C. N. Caspar Co. Book Emporium, Milwaukee, Miss.

GRÖNER, H. (1941). Über den Umfang der Fruchtbarkeit und Säuglingssterblichkeit beim Schwein im Zusammenhang mit Zucht u. Haltung. Dissertation, Vet. Med. Fak., Univ. Berlin Reviewed in *Animal Breeding Abstracts*, Vol. 2, No. 3, 1943.

GRANT, R. (1933). Studies on the Physiology of Reproduction in the Ewe. *Trans. Roy. Soc. Edinb.*, Vol. 58, No. 1, 1933-34.

HAMMOND, JOHN (1914). On Some Factors Controlling Fertility in Domestic Animals. *J. Agric. Sc.*, Vol. 6, pt. 3.

HAMMOND, JOHN (1917). On the Causes Responsible for the Developmental Progress of the Mammary Gland in the Rabbit during the Latter Part of Pregnancy. *Proc. Roy. Soc.*, B. Vol. 89.

HAMMOND, JOHN (1921). Further Observations on the Factors Controlling Fertility and Foetal Atrophy. *J. Agric. Sc.*, Vol. 11, Pt. 4.

HAMMOND, JOHN (1927). The Physiology of Reproduction in the Cow. Cambridge University Press, London.

HAMMOND, JOHN (1928). Die Kontrolle der Fruchtbarkeit bei Tieren. *Züchtungskunde*, Vol. 3, p. 523. Quoted by Hammond & Walton (1934).

HAMMOND, JOHN (1930). The Effect of Temperature on the Survival in Vitro of Rabbit Spermatozoa obtained from the Vagina. *J. Exp. Biol.*, Vol. 7, No. 2.

HAMMOND, JOHN (1931). Information on the optimum service period in the horse, in a personal communication to Quinlan (1931).

HAMMOND, JOHN (1934). The Fertilization of Rabbit Ova in Relation to Time. *J. Exp. Biol.*, Vol. 11, No. 2, pp. 140-161.

HAMMOND, JOHN (1940). Farm Animals. Edward Arnold & Co., London.

HAMMOND, JOHN (1941). Fertility in Mammals and Birds. *Biological Review,* Vol. 16, p. 165.

HAMMOND, JOHN, AND ASDELL, S. A. (1926). The Vitality of the Spermatozoa in the Male and Female Reproductive Tracts. *Brit. J. Exp. Biol.,* Vol. 4, p. 155.

HAMMOND, JOHN, AND WALTON, A. (1934). Notes on Ovulation and Fertilization in the Ferret. *J. Exp. Biol.,* Vol. 11, No. 3.

HARDER, HANS-JÜRGEN (1937). Untersuchungen über die Hauttemperatur des Schweines mit dem Termo-Element. Inaugural Dissertation, Tierärztliche Hochschule, Hannover, pp. 1—46.

HARING, F. (1937). Der Einfluss des Begattungszeitpunktes während des Rauschzeit beim Schwein auf dem Befruchtungserfolg und das Geslechtsverhältnis der Ferkel. *Züchtungskunde,* Bd. 12, Heft I.

HARRIS (1916). American Naturalist, 50, No. 593.

HEAPE, W. (1900). The Sexual Season of Mammals and the Relation of the Pro-oestrum to Menstruation. *Quarterly J. Microscopical Science,* No. 173, N.S., Nov. 1900.

HUGHES, J. S., AUBEL, C. E., AND LIENHARDT, H. F. (1928). The Importance of Vitamin A and Vitamin C in Swine Rations. *Agr. Exp. Sta. Kansas, Tech. Bull.* 23, June 1928.

JOHANSSON, IVAR (1929). Statistischer Untersuchungen über die Fruchtbarkeit der Schweine. *Ztschr. Tierzucht.,* 15, 49—86. Quoted by Buchanan Smith (1930).

JOHANSSON, IVAR (1931). Problems in Breeding for High Prolificacy. *Pig Breeders Annual,* Vol. 11 (1931-32), pp. 80—87.

KIRILOV, V. S. (1937). Problems in Animal Husbandry (Translated Summary) No. 3, 1937.

KNAUS, H. (1931). Über den Zeitpunkt der Konzeptionsfähigkeit des Weibes. *Münchener Med. Wochenschr.,* No. 9, 27 Feb., 1931.

KRALLINGER, H. F. (1932). Der Rhythmus in der Rausche der Schweine. *Arch. Tierernährung u. Tierzucht,* Vol. 8, No. 3, 1932.

KRALLINGER, H. F. (1937). Geschlechtsleben u. Fortpflanzung des Hausschweines. *Forschungsdienst,* Band 3, Heft 10, 11, 12.

KRALLINGER, H. F., AND SCHOTT, A. (1933). Untersuchungen über Geschlechtsleben u. Fortpflantzung der Haustiere II: der Einfluss der Decktermines innerhalb der Rausche der Schweine auf ihre Fruchtbarkeit u. das geschlechtsverhältnis der Nachkommen. *Arch. Tierernährung und Tierzucht,* Vol. 9, No. 1, 1933, pp. 41—49.

KRIZENECKY, J. (1935). Quoted by Krallinger (1937).

KRIZENECKY, J. (1942). Ist die Trächtigkeitsdauer eine individuell verschiedene Eigenschaft der Sau? *Z. Tierz. Züchtbiol.,* Vol. 51.

KRONACHER, C. (1927). Allgemeine Tierzucht, 4. Abteilung, S. 304/5.

KÜPFER, M. (1920). Denschr. Schweiz. Natur. Gesel., 56. Quoted by Hammond (1927).

KÜPFER, M. (1928). The Sexual Cycle of Female Domesticated Mammals. *13th and 14th Reports of the Director of Veterinary Education and Research,* pt. 2, 1928.

KÜPFER, M. AND QUINLAN, J. (1926). Personal communication by Quinlan.

LANGLET, J. F. (1934). Fruchtbarkeitsleistungsprüfungen bei Ebern. *Z. Schweinezucht,* H. 4, p. 62.

LEWIS, L. L. (1911). The Vitality of Reproductive cells. *Okl. Agr. Exp. Sta. Bull.* 96.

LONG, J. A., AND EVANS, H. M. (1922). The Oestrous Cycle in the Rat and its Associated Phenomena. *Memoirs of the University of California,* Vol. VI.

MACHENS, A. (1915). Fruchtbarkeit und Geslechtsverhältnis beim Veredelten Landschwein. *Berl. Tierärtzl. Wchschr.,* Vol. 31, pp. 559—62. Quoted by Buchanan Smith (1930).

MARCOTTY (1914). *Arch. f. Gynaek.,* Vol. 103, p. 63.

MARSHALL, F. H. A. (1922). The Physiology of Reproduction. Longmans, Green & Co., London.

MARSHALL, F. H. A., AND HAMMOND, J. (1937). Fertility and Animal Breeding. *Min. of Agric. & Fisheries, London, Bull.* 32.

MASLOV, B. V. (1938). Svinoplemhoz, No. 809. Reviewed in *Animal Breeding Abstracts,* Vol. 8, No. 1, 1940.

McKENZIE, F. F. (1924). Correlations of External Signs and Vaginal Changes with the Ovarian Cycle in Swine. *Anat. Rec.,* Vol. 27.

McKENZIE, F. F. (1926). The Normal Oestrous Cycle in the Sow. *Univ. Mo. Res. Bull.* 86.

McKENZIE, F. F. (1928). Growth and Reproduction in Swine. *Mo. Agr. Exp. Sta. Res. Bull.* 118.

McKENZIE, F. F. (1932). Optimum Time to Breed Gilts. *Miss. Agr. Exp. Sta. Bull.* 285.

McKENZIE. K. J. J., AND MARSHALL, F. H. A. (1912). On Ovariotomy in Sows; with Observations on the Mammary Glands and Internal Organs. *J. Agr. Sc.* Vol. 4, pt. 4, 1912.

McKENZIE, F. F., AND MILLER, J. C. (1930*a*). Heat and Size of the Vulva in Swine. *Mo. Agr. Exp. Sta. Bull.* 285.

McKENZIE, F. F., AND MILLER, J. C. (1930*b*). Optimum Time to Breed Swine. *Mo. Agr. Exp. Sta. Bull.* 285.

McKENZIE, F. F.; MILLER, J. C., AND BAUGUESS, L. C. (1938). The Reproductive Organs and Semen of the Boar. *Univ. Mo. Res. Bull.* 279.

MILLS, C. A. (1932). Geographic Variations in the Female Sexual Functions. *Amer. J. Hygiene,* Vol. 25, No. 2, 593—600.

MILLS, C. A. (1937). Geographic and Time Variations in Body Growth and Age at Menarche. *Human Biology,* Vol. 9, No. 1.

MILLS, C. A., AND SENIOR, F. A. (1930). Does Climate Effect the Human Conception Rate? *Arch. Intern. Med.,* Vol. 46, pp. 921—929.

MUMFORD, F. B.; HOGAN, A. G., AND McKENZIE, F. F. (1926). Fecundity in Swine. The Effect of Age, the Normal Oestrous Cycle and the Cycle as Influenced by Unfavourable Dietary Conditions. *Univ. Mo. Agr. Exp. Sta. Bull.* 236.

NORDBY, J. E. (1929). Sterility in Boar Responsible for Reduced Size of Litter. *J. Amer. Vet. Med. Ass.,* Vol. 74, pp. 911—914.

OESTERMEYER, A. (1934). Zuchtbuchstudien über die Vererbung der Fruchtbarkeit und des Ferkelreichtums beim Hausschwein. *Südd. Landw. Tierzucht,* Vol. 28, 1934. Quoted by Haring (1937).

OGLE, C. L. (1934). Climatic Influence on the Growth of the Male Albino Mouse. *Amer. J. Physiol.* Vol. 107/635.

OGLE, C. L. (1936). Germinal Response (in Male Mice) to Environmental Conditions. *Amer. J. Phys.* Vol. 117, No. 2.

OGLE. C. L., AND MILLS, C. A. (1933). Adaptation of Sexual Activity to Environmental Stimulation. *Amer. J. Physiology,* Vol. 105, p. 76.

PALMER, C. C. (1917). Effects of Muscular Exercise and the Heat of the Sun on the Blood and Body Temperature of Normal Pigs. *J. Agric. Res.,* Vol. 9, p. 167.

PAPANICOLAOU, G. N., AND STOCKARD, C. R. (1919). Effect of Underfeeding on Ovulation and the Oestrous Rhythm in Guinea Pigs. *Proc. Roy. Soc. Exp. Biol. Med.,* Vol. 17, 1919—20, p. 143.

PHILLIPS, RALPH W. (1935). Infertility of Males After Prolonged Rest. *Amer. Soc. An. Prod.,* 1935.

PINCUS, G. (1936). The Eggs of Mammals. MacMillan. London.

PINCUS, G., AND ENZMAN, E. V. (1932). Fertilization in the Rabbit. *J. Exp. Biol.,* Vol. 9, 403.

QUINLAN, J. (1932). The Vitality of the Spermatozoon and the Liberated Ovum in Domestic Animals. *J. South Afric. Vet. Med. Assn.*, Vol. 3, 1932, pp. 1—7.

QUINLAN, J., AND MARÉ, G. S. (1931). The Physiological Changes in the Ovary of the Merino Sheep in South Africa and their Practical Application in Breeding. *17th Report. Dir. Vet. Serv. and An. Indus.* U. of S.A.

QUINLAN, J.; MARÉ, G. S., AND ROUX, L. L. (1932). The Vitality of the Spermatozoa in the Genital Tract of the Merino Ewe, with Special Reference to its Practical Application in Breeding. *18th Report Dir. of Vet. Serv. and An. Indst.*, Aug., 1932.

QUINLAN, J.; BISSCHOP, J. H. R., AND ADELAAR, T. F. (1941). Bionomic Studies on Cattle in the Semi-arid Regions of the Union of South Africa. IV. The Ovarian Cycle of Heifers during Summer. *The Onderstepoort Journal,* Vol. 16., Nos. 1 and 2, 1941.

QUINLAN, J.; MYBURGH, S. J., AND DE VOS, D. (1941). The Hydrogen-Ion Concentration of the Vaginal Secretion of Merino Sheep during Oestrus, Dioestrus and Pregnancy, with some Remarks on its Influence on Sex-Determination, and the Influence of the Vaginal Temperature at the Time of Mating on Conception. *The Onderstepoort Journal,* Vol. 17, Nos. 1 and 2, 1941, pp. 105—114.

RIDDLE, O., AND BEHRE, E. H. (1921). Studies on the Physiology of Reproduction in Birds: IX. On the Relation of Stale Sperm to Fertility and Sex in Ring Doves. *Amer. J. Physiol.* Vol. 57, p. 228. Quoted by Hammond (1941).

RIDGWAY, ROBERT (1912). Colour Standards and Colour Nomenclature. A. Hoen & Co., Baltimore, M. D.

ROBSON, J. M. (1940). Recent Advances in Sex and Reproductive Physiology. 2nd Edition. J. & A. Churchill Ltd., London.

RODOLFO, A. (1934). The Physiology of Reproduction in Swine. *Phil. J. Sc.*, Feb., Sept., Oct., 1934.

ROUX, L. L. (1936). Sex Physiology of Sheep. *Onderstepoort J.*, Vol. 6, No. 2.

SAUNDERS, R. A. (1942). Field Experiments at Potchefstroom. A Summary of Investigations Conducted during the Period 1903—1940. *Science Bull.* No. 14, Dept. of Agr., South Africa.

SCHMALTZ, R. (1921). Das Geschlechtsleben der Haussäugetiere. 3 Aufl., Scholtz, Berlin. Quoted by Krallinger (1937).

SCHMIDT, J. (1929). Schweinezucht. Verlag P. Parry, Berlin.

SCHMIDT, J. (1937). Praktische Wichtige Ergebnisse neuer Züchtungsversuche. *Z. Schweinezucht.* 44.

SEBATANI, (1908). Quoted by Krallinger (1937).

SELYE, H., AND McKEOWN, T. (1934*a*). Production of Pseudopregnancy by Mechanical Stimulation of the Nipples on the Ovary and the Sexual Cycle. *Proc. Soc. Exp. Biol. Med.*, Vol. 31, pp. 683—687.

SELYE, H., AND McKEOWN, T. (1934b). The Effect of Mechanical Stimulation of the Nipples on the Ovary and the Sexual Cycle. Quoted to be in the press.

SELYE, H., AND McKEOWN, T. (1934*c*). Further Studies on the Influence of Suckling. *Anat. Record,* Vol. 60, 1934, pp. 323—332.

SIMPSON, Q. J. (1912). Fecundity in Swine. *Amer. Breed. Rept.* Vol. 8, pp. 261—66.

SINCLAIR AND SYROTUCK (1928). Age as a Factor in Swine Reproduction. *Scientific Agriculture,* Vol. 8, April 1928, p. 492. Quoted by Krallinger (1937).

SMITH, F. (1907). Veterinary Physiology, 3rd Edition. Bailliere, Tindall & Cox, London.

SMITH, BUCHANAN (1930). Litter Size, is it Inherited? *Pig Br. Annual.* Vol. 10, 1930—31, pp. 46—52.

STRUVE, J. (1911). Die Perioden der Brunst bei Rindern, Schweinen und Pferden. *Fühlings Landwirtschaft. Ztg.*, LX.

SUTTON, T. S. (1941). The Role of Nutrition in Reproduction. *J. Amer. Vet. Med. Assoc.*, Jan., 1941.

VON ECKSTAEDT, VITZTHUM (1928). Fruchtbarkeitsuntersuchungen an Schweinen unter besonderer Berücksichtigung der Inzuchtverhältnisse. Quoted by Buchanan Smith (1930).

WALTON, A., AND HAMMOND, J. (1928). Observations on Ovulation in the Rabbit. *The British J. Exp. Biology,* Vol. 6, No. 2, Dec. 1928.

WARWICK, B. L. (1926). Intra-uterine Migration of Ova in the Sow. *Anat. Rec.*. Vol. 33, pp. 29—33.

WARWICK, B. L. (1927). What Factors Determine the Number, Size and Weight of Newborn Pigs? *Wisc. Agr. Exp. Sta. Bull.* 396, pp. 64—67.

WENTWORTH, E. N., AND AUBEL, C. E. (1916). Inheritance of Fertility in Swine. *J. Agr. Res.,* Vol. 5, 1916, pp. 1145—1160.

YAMANE, J., AND NORIYOSHI MAKITA (1934). The Influence of Season on the Fertility of Berkshire Pigs in North Formosa. *J. Soc. Tropic. Agric.,* Vol. 6, pt. 3, 1934.

YATES, F. (1934). Contingency Tables Involving Small Numbers and the $X^2$ Test. *Suppl. J. Roy. Stat. Soc.,* Vol. 1, pp. 217—235.

ZORN, W. (1927). Frühreife, Futterwertung, Fruchtbarkeit u. Wüchsigkeit der Ferkel. *Deutsch Landw. Tierzucht,* H. 9. Quoted by Krallinger (1937).

ZORN, W.; KRALLINGER, H. F., AND SCHOTT, A. (1933). Untersuchungen zur züchterischen Bewertung der Fruchtbarkeit und des Vierwochengewichtes by weissen Edelschweinen. *Züchtungskunde,* Vol. 8, 1933, pp. 433—50. Quoted by Krallinger (1937).

ZORN, W., AND KRALLINGER, H. F. (1930). Quoted by Krallinger (1937).

---

## APPENDIX 1.

OBSERVATION 1 (*a*).

*The Morphological Changes of the Ovary During Dioestrus.*

This appendix gives descriptive details of the ovaries of pigs slaughtered every three days during the dioestrous cycle. The different three-day intervals were reckoned from the beginning of oestrus. Six such intervals were recorded, the sixth interval thus falling on the 18th day of the dioestrous cycle. One Large Black and one Large White female were slaughtered at each three-day interval. Numerical particulars, such as weights and dimensions of ovaries, numbers of corpora lutea and Graafian follicles, appear in Table I of this appendix.

*Group I. Three days After the Beginning of Oestrus.*

*Large Black No.* 234.

Onset of oestrus, 21.5.44, 9 a.m.; slaughtered 24.5.44, 7.30 a.m.

Oestrus had already terminated at the time of slaughter. The corpora lutea I have a pale purplish vinaceous colour (Ridgway, 1912). All corpora stand out prominently from the ovary. The points of rupture show very clearly as bright red papillae. Vascularisation is very faint. The shape is mostly spherical but some are conically inclined. On section each corpus contains a dark red blood clot. The corpora lutea II are firm, solid bodies, creamy yellow externally and on section, but three in the left and one in the right ovary are slightly bluish-coloured on section. Only 4 Graafian follicles can be seen on the left ovary and 5 on the right ovary, all 1 mm. in diameter. These follicles are colourless.

*Large White No.* 157.

Onset of oestrus, 19.2.43, 6 p.m.; slaughtered 22.2.43, 4 p.m.

The colour of the corpora lutea I ranges from pale purplish vinaceous to dark red, the majority being of the latter type. The shape varies from distinctly conical to spherical. Points of rupture show clearly. Three corpora were much larger than the rest, measuring 13 to 14 mm. On section each of these latter has a dark red blood clot inclusion. The other corpora are lighter coloured on section and their central cavities contain a light red fluid. One follicle in the right ovary is cystic and had failed to rupture, diameter 15 mm. Its colour is light red. On puncture a light red fluid escapes which immediately sets to a