A Study of the Duration of Motility of Spermatozoa in the Different Divisions of the Reproductive Tract of the Merino Ewe.

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INTRODUCTION.

In a previous paper the authors (1932) discussed the vitality of spermatozoa in the genital tract of the Merino ewe, with special reference to its practical application in breeding. During that series of experiments it became apparent that the spermatozoa survived longer in the cervix than in the other divisions of the reproductive tract in the Merino ewe. It appeared that the secretions of the vagina and the divisions of the genital tract cranial to the cervix were, in comparison with the cervix, definitely unfavourable to the life of spermatozoa. In the cervix alone did the secretion appear to be favourable. It was therefore suggested that the cervix of the Merino ewe acts as a reservoir for spermatozoa, where they are maintained under favourable conditions pending ovulation and the arrival of an available ovum in the Fallopian tube.

The present experiments were undertaken to ascertain whether, by isolating spermatozoa in the uterine horns and the Fallopian tubes, an accurate estimate of the duration of their vitality in the different divisions of the reproductive tract could be made; that is to observe, from a point of view of motility, whether the secretions from the vagina, uterus, uterine horns, and Fallopian tubes act detrimentally as compared with the secretion of the cervix.

LITERATURE.

Although a considerable amount of work has been done on the vitality of the spermatozoon in laboratory animals, especially the rabbit, the guinea pig, and the rat, the literature is not rich in references to work done on sheep. No references can be found to the particular aspect now under consideration, namely the motility of the sperms at different levels of the reproductive tract.

The literature relevant to the vitality of the spermatozoon in the genital tract has been discussed by the authors in the paper referred to above, so that it is considered unnecessary to repeat the discussion in detail here.

Hammond and Asdell (1926) have shown that there is some unfavourable influence on the vitality of rabbit spermatozoa by the female genital secretion. These authors point out that spermatozoa taken from the male epididymis retain their vitality for three days, while those taken from the vagina of the female after copulation retained their fertilizing power for only 30 hours. Walton Hammond and Asdell (1928) found that spermatozoa collected from the epididymis of the killed rabbit retained their fertilizing power longer when kept in vitro than those collected from the vagina immediately after copulation. Yocem (1929) has studied the life of the spermatozoon in the genital tract of the female guinea pig and rat during oestrus and also during the interoestrous
period. He found that in the guinea pig sperms artificially inseminated during the oestrous period survived somewhat longer than those inseminated during the interoestrous period. In the case of insemination during oestrus, motility was maintained for 41.5 hours in guinea pigs and 12.5 hours in rats. The duration of life of the sperms artificially injected during the interoestrous period was 36 hours in the guinea pig. The sperms of rat semen injected into guinea pigs survived only 4.5 hours, and guinea pig sperms into rats only 11 hours.

Löw (1902) has observed in the case of rats that the vaginal secretion of the female is unfavourable to the life and the motility of spermatozoa, while the uterine secretion is favourable.

Sabotta's (1895) observations on the mouse have shown that the greater majority of the sperms in the uterus are non-motile 6 to 10 hours after coitus. Kugota (1929) made observations on the influence of uterine secretions on the life and motility of the spermatozoa of the mouse during different periods of the oestrous cycle. He concluded that the secretions had different influences at different periods. He says:

"In der zweiten Periode wirkt er höchst günstig. Diese Wirkung beginnt schon in der ersten Periode und ist in der dritten Periode plötzlich sehr gering. Diese Einwirkung auf die Lebensdauer der Spermatozoen scheint um so günstiger zu sein, je stärker der Uterus­saft konzentriert ist. In der vierten Periode und im Dioestrum können wir weder eine günstige noch eine nachteilige Wirkung finden."

The division into five periods was made by Kugota according to the microscopic appearance of vaginal smears and sections of the vaginal wall.

Hammond (1930) working with rabbits has shown that sperms taken from the vagina and maintained outside the body at different temperatures may retain fertility at 35° C. for 14 hours; at 10° C. for 96 hours, and at 0° C. for 16 hours. Walton (1930) also working with rabbits, in co-operation with Hammond, has taken sperms from the epididymis of the male and maintained them outside the body at different temperatures. His results regarding fertility were more or less similar to those of Hammond. Above body-temperature the spermatozoa were rapidly destroyed; at 37° C. to 40° C. the maximal survival was about 13 hours. There was an increasing prolongation of survival as the temperature was lowered until a maximum of about 7 days at 15° C. was reached.

These experiments were done with the object of testing the effects of temperature on spermatozoa, and the work of both authors is confirmatory, but on analysing their results from a point of view of the present work, it is evident that the spermatozoa taken from the vagina by Hammond were less vital than those taken from the epididymis by Walton.

Hutschenreiter (1915) has shown that motility of spermatozoa of the stallion has usually ceased after 4 hours in the vagina of healthy mares during oestrus, while in the uterus sperms survived up to 10 hours. He found that spermatozoa survived somewhat longer in the vagina during the interoestrous period than during oestrus.

Quinlan, Maré, and Roux (1932) have shown that spermatozoa live longer in the cervix than in the other divisions of the genital tract in the merino ewe. These authors have further observed that sperms obtained from the ram without having come into contact with vaginal secretion survive longer in vitro than sperms taken from the vagina after normal copulation. The maximum time of survival of spermatozoa, taken from the vagina of sheep immediately after
copulation, and kept in sterile pipettes at room temperature appears to be about 48 hours; while in semen taken from the same ram without admixture with vaginal secretion and kept under similar environmental conditions, the spermatozoa have survived 56 hours.

In the case of the human sperm it appears to be recognised that the duration of life varies in the different divisions of the female genitalia. Giles (1919) states that spermatozoa in the vagina die within one hour after coitus; in the cervical canal they may be found 2 to 5 days after coitus; in the fundus they are frequently found 24 hours after coitus and occasionally after several days. More cranially, that is in the Fallopian tubes, their normal behaviour is unknown. Haussman (1879) and Hühner (1913), quoted by Giles, maintain that the life of the sperm in the vagina is not longer than a few hours. Hühner (1913) has shown that living sperms have been found in the cervical canal after 15 to 24 hours only in 11.6 per cent. of cases; after 2 to 5 days in 20 per cent. of cases, and after 1 to 12 hours in 45.9 per cent. of cases. The same author's examination for sperms in the uterus have shown living spermatozoa in 27 per cent. of cases after 1 to 12 hours; in 16.7 per cent. after 15 to 24 hours, and in 6.3 per cent. after 2 to 7 days.

**METHOD.**

The work was carried out during the months of November, 1931, and February, 1932, at the School of Agriculture, Middelburg, Cape Province. The rams used, namely W. 31, T. 413, and T. 417, had been extensively employed by the authors in previous experiments (1931, 1932). Their fertility records were known to be highly satisfactory, as is shown in Table II. They were in good, hard, breeding condition during the time these observations were being carried out. The ewes were full-mouth sheep selected from the flock at the School. They were in good, breeding condition and appeared to be clinically normal. Their previous breeding record was known.

The ewes were tested twice daily for oestrus, at 6 a.m. and 5 p.m., with vasectomised teasers.

Only sheep which allowed copulation without restraint were used for observation. The sheep to be used were brought to the Laboratory immediately before service was allowed. Three services were allowed each ewe. The services followed in rapid succession and were completed in less than 15 minutes. Immediately afterwards the ewe was caught and the hind extremity elevated. Two samples of semen were withdrawn in sterile glass pipettes, which were introduced along the ventral wall of the vagina to its cranial extremity. The amount of semen collected varied from about 1 to 1.5 cm. in each pipette.

After collection of the semen the sheep were taken to the theatre for operation. The wool had been shorn from the left flank prior to service, so that as little time as possible was lost between copulation and actual insemination into the uterus and Fallopian tubes. When observations were first begun several sheep were operated upon after copulation before withdrawal of the semen. The vulvar lips were clamped to retain the semen during operation. The ejaculate was withdrawn only when the uterus was exposed. All these results have been disregarded in this series of observations, as it was considered that the semen had been too long in contact with vaginal secretion before final injection into the selected site in the genital tract, namely, the apex of the uterine horn and the Fallopian tube.
The sheep were anaesthetised by an intrajugular injection of chloral hydrate (10 per cent. with 0.9 per cent. saline solution). The amount of chloral hydrate injected is graduated according to the weight of the sheep. This method of anaesthesia is highly successful. It has been used very extensively in this country for major surgery in sheep. [De Kock and Quinlan (1927); Quinlan, Mare and Roux (1930).]

The genital apparatus was exposed through a laparotomy in the left flank. The left uterine horn and left Fallopian tube were withdrawn. At first the intention was to isolate the left horn and the left tube by ligation and subsequent section. After a couple of trials this method of operation had to be abandoned, as impracticable. In the case of the tube the operation produced no pathological change in the mucosa, but the horn, as a closed sac (having been ligated and sectioned cranially and caudally), became filled with fluid so that the environment of the sperms between injection and examination could not be regarded as normal. This procedure had to be modified so that the normal conditions of the right side of the genital tract, which was used as a control, were simulated as closely as possible. The left tube was cut close to the uterine extremity in a small artery forceps and crushed. It was ligated with fine silk on either side of the forceps. The forceps was then removed and the tube sectioned in the crushed area. During the application of the ligatures care was taken that blood vessels in the mesosalpinx were not included.

The semen was now transferred to the tube by introducing the pipette deeply into it through the abdominal ostium and blowing out the semen. The introduction of semen into the horn was done by puncturing the left horn close to its apex with the point of the pipette. The semen was then blown into the lumen of the horn.

The semen was in every case controlled microscopically for activity of the spermatzoa at the time of injection. Further it was retained and examined from time to time for survival of the sperms in vitro. After injection of the semen the uterus was replaced in position. The laparotomy wound was closed by suturing the peritoneum and muscles with No. 1 cat-gut, and the skin with No. 2 suture silk. The sheep were then placed in a shed to await the time of observation. All the sheep had fully recovered from the effects of anaesthesia after 3 hours.

The sheep were killed by bleeding at intervals of 6, 9, 12, 15, 18, and 24 hours after operation. The abdomen was opened through a prepubic mid-ventral incision and the different compartments of the genitalia immediately clamped off with suitable forceps so as to prevent wandering of spermatzoa on the right or control side of the reproductive tract after death of the animal. The genitalia were not removed from their attachments. The different divisions were then opened, fresh preparatory were made on glass slides and immediately covered with a cover slip. The microscopic observations for living sperms were all carried out in the natural secretion.

The preparations were immediately submitted to microscopic examination for living spermatzoa. Smears were also made and later examined for morphological changes.

It is realised that this method of examination presents disadvantages since it does not simulate the normal environmental conditions within the genitalia. However, there was little chance of sperms which were alive at the time of slaughter failing to survive the short interval between the death of the sheep and microscopic examination. It is taken, therefore, that dead sperms
seen on microscopical examination of fresh preparations were actually dead before the secretions containing them were removed from the genitalia. The examinations were done at the Grootfontein School of Agriculture, at room temperature which varied between 72° F. and 84° F. where the observations were carried out.

The results of the experimental observations are summarised in Table I. They are, however, of sufficient interest to discuss them in some detail first.

The sheep used for observation of the spermatozoa six hours after operation was about 24 hours in oestrus when served. The ovary had not ovulated at the time of slaughter.

Living sperms were found in all divisions of the genitalia both on the operated and control sides. There was, however, a greater percentage of living sperms in the control side; in the horns 68 per cent. as compared with 44 per cent., and in the tubes 40 per cent. as compared with 21 per cent. In the vagina only about 10 per cent. of the sperms were motile. In the cervix spermatozoa were very plentiful; about 55 per cent. being motile. The pars indivisa of the uterus contained relatively few sperms in comparison with the cervix; 71 per cent. were motile.

The sheep used for observation of the spermatozoa nine hours after insemination was about nine hours in oestrus when served. The ovary had not yet ovulated at the time of slaughter. Sperms were numerous in the vagina; about 50 per cent. were motile. Sperms in the cervix were also very numerous, 90 per cent. being motile. A few motile sperms were seen in the pars indivisa. A few non-motile sperms were seen in the control horn; no motile sperms were seen. Spermatozoa were very rare in the operated horn; only two intact sperms were seen of which one was sluggishly motile. No sperms were seen in the control Fallopian tube. Sperms were rare in the operated tube, only about 5 per cent. of those seen being motile. The explanation of the rarity of spermatozoa in the cranial divisions of the genitalia appears to be that they had not yet gone forward from the cervix.

The sheep used for observation of the spermatozoa 12 hours after insemination was about 22 hours in oestrus at the time of service. The ovary had not yet ovulated at the time of slaughter.

No spermatozoa were seen in the vagina; some disintegrated remains were present. Sperms in the cervix were very numerous; about 40 per cent. were motile. In the pars indivisa of the uterus sperms were infrequent; about 58 per cent. were motile. In the control horn sperms were infrequent; about 70 per cent. were motile. Sperms were difficult to find in the operated horn; only two motile sperms were seen. In the normal tube spermatozoa were infrequent, but about 90 per cent. of those seen were motile. No motile sperms were present in the operated horn; a few non-motile intact sperms were present.

The sheep used for observation of the spermatozoa fifteen hours after insemination was about 15 hours in oestrus at the time of service. The ovary had not yet ovulated at the time of slaughter.
About 2 per cent. of the sperms seen in the vagina were sluggishly motile. Spermatozoa in the cervix were very numerous; about 93 per cent. were motile. In the pars indivisa sperms were fairly numerous; about 50 per cent. being motile. In the normal horn spermatozoa were fairly frequent; about 25 per cent. were motile. A few non-motile sperms were seen in the operated horn; no motile sperm was seen. Sperms were rare in the control tube; only two motile sperms were seen. A few dead and disintegrated sperms only were seen in the operated tube.

The sheep used for observation of the spermatozoa eighteen hours after insemination was about 16 hours in oestrus at the time of service. The ovary had not yet ovulated at the time of slaughter.

Disintegrated sperms were seen in the vagina; one very sluggishly motile sperm was seen. Spermatozoa were numerous in the cervix; about 47 per cent. were motile. There was little difference in the frequency of the sperms in the control and operated horn; motility was sluggish in those seen which were still alive. In the control horn sperms were infrequent; only one of those seen was motile. Sperms were infrequent and mostly non-motile in the operated horn; one motile sperm only was seen. Some non-motile sperms were seen in the normal tube. Only disintegrated remains were present in the operated tube.

The sheep used for observation of the spermatozoa twenty-four hours after insemination was about 14 hours in oestrus at the time of service. The ovary had ovulated at the time of slaughter. No spermatozoa were present in the vagina or in the divisions of the genitalia above the cervix. In the operated horn and tube there was no trace of spermatozoa. Sperms were fairly frequent in the cervix; about 10 per cent. showing motility.

A control operation was performed on sheep 0·312, Table I, to ascertain if anaesthesia and puncture with insertion of the pipette to the tube and horn without ligature would have any detrimental effect on the genitalia and consequent unfavourable influence on the spermatozoa. The sheep used for this observation was about 17 hours in oestrus at the time of insemination. The ovary had not yet ovulated at the time of slaughter 18 hours later.

There was one motile sperm seen in the vagina. Sperms were frequent in the cervix; 70 per cent. being motile. In the pars indivisa the sperms were not nearly so frequent as in the cervix; about 40 per cent. were motile. The spermatozoa in the genitalia cranial to the pars indivisa were equally numerous on the operated and control sides; just under 50 per cent. showing motility.

Table I shows in summarised form the results of the observations:

Table II shows the breeding records of the three rams used for obtaining spermatozoa:
<table>
<thead>
<tr>
<th>Ewe No</th>
<th>Period in oestrus</th>
<th>Rams used</th>
<th>Time elapsed since service and operation</th>
<th>How Examined</th>
<th>Compartments of Genitalia Examined</th>
<th>Fallopian Tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.311</td>
<td>±18 hrs.</td>
<td>3 W. 31 x 1 T. 413 x 1 T. 417 x 1</td>
<td>6 hours (not ovulated)</td>
<td>F.</td>
<td>+ (10%) + (55%) + (71%) + (68%) + (44%)</td>
<td>++ (21%)</td>
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<tr>
<td>0.33</td>
<td>±9 hrs.</td>
<td>3 W. 31 x 1 T. 413 x 1 T. 417 x 1</td>
<td>9 hours (not ovulated)</td>
<td>F.</td>
<td>+ + (50%) + + (90%)</td>
<td>+ + (70%)</td>
</tr>
<tr>
<td>0.259</td>
<td>±22 hrs.</td>
<td>3 T. 413 x 1 T. 417 x 1</td>
<td>12 hours (not ovulated)</td>
<td>F.</td>
<td>0</td>
<td>+ (40%) + (75%)</td>
</tr>
<tr>
<td>0.239</td>
<td>±13 hrs.</td>
<td>3 W. 31 x 1 T. 413 x 1 T. 417 x 1</td>
<td>15 hours (not ovulated)</td>
<td>F.</td>
<td>+ (2%) + + (80%) + (50%)</td>
<td>+ (25%)</td>
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<tr>
<td>0.16</td>
<td>±16 hrs.</td>
<td>3 W. 31 x 1 T. 431 x 1 T. 417 x 1</td>
<td>18 hours (not ovulated)</td>
<td>F.</td>
<td>+ (4%) + (40%)</td>
<td>Sperms very rare, one motile sperm seen</td>
</tr>
<tr>
<td>0.293</td>
<td>±14 hrs.</td>
<td>3 W. 31 x 2 T. 417 x 1</td>
<td>24 hours (not ovulated)</td>
<td>F.</td>
<td>+</td>
<td>+</td>
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<tr>
<td>0.312</td>
<td>±17 hrs.</td>
<td>2 T. 413 x 1 T. 417 x 1</td>
<td>18 hours (not ovulated)</td>
<td>F.</td>
<td>+ +</td>
<td>+ +</td>
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++ = 75 to 100 per cent. motile,
+++ = 50 to 75 per cent. motile,
++ = 25 to 50 per cent. motile,
+ = 1 to 25 per cent. motile,
0 = Non-motile sperms only,
- = No sperm seen,
F = Fresh preparations,
S = Stained preparations.
## Study of Duration of Motility of Spermatozoa

<table>
<thead>
<tr>
<th>First Service</th>
<th>Second Service</th>
<th>Third Service</th>
<th>Total</th>
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<tbody>
<tr>
<td>Ram No.</td>
<td></td>
<td></td>
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<tr>
<td>T. 413</td>
<td>T. 417</td>
<td>W. 31</td>
<td>Total</td>
</tr>
<tr>
<td>Number Fertilised</td>
<td>Number Fertilised</td>
<td>Number Fertilised</td>
<td>Number Fertilised</td>
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<tr>
<td>Number Not Fertilised</td>
<td>Number Not Fertilised</td>
<td>Number Not Fertilised</td>
<td>Number Not Fertilised</td>
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<td>Percentage Fertilised</td>
<td>Percentage Fertilised</td>
<td>Percentage Fertilised</td>
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<td>25</td>
<td>22</td>
<td>26</td>
<td>74</td>
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<tr>
<td>48</td>
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<td>20</td>
<td>62</td>
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<tr>
<td>84.6</td>
<td>89.6</td>
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<td>22</td>
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<tr>
<td>92.3%</td>
<td>92.0%</td>
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<tr>
<td>93.1%</td>
<td>93.0%</td>
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This table presents the data on the duration of motility of spermatozoa across different services, with columns indicating the number and percentage of spermatozoa that were fertilised, and those that were not.
DISCUSSION.

From the literature available of work done on laboratory animals, namely the rabbit, guinea pig, and the mouse it appears that non-specific genital secretions have a definite detrimental influence on the life of spermatozoa [Yochem (1929)]. Further, it appears that admixture with female genital secretions curtails the duration of fertilising vitality, and the duration of motility of the sperm as compared with contact with the male secretion [Hammond and Asdell (1926); Walton, Hammond and Asdell (1928)].

The female genital secretions are more favourable to spermatozoa during oestrus than during the interoestrous period. The unfavourable influence of the secretions of the vagina in comparison with the secretions of the uterus on the motility of sperms has been noted by Löw (1902), in the case of the mouse and Hutschenreiter (1915) in the case of the mare. Kugota (1929) has shown that the secretion of the uterus has a varying influence on the spermatozoa at different periods during the oestrous cycle.

There appears to be no doubt, in the case of sheep, that the sperm does not as a rule survive contact with vaginal secretion for more than 12 hours. Occasionally isolated motile sperms may be seen up to 18 hours or even 24 hours following coitus, but this is exceptional. Spermatozoa in the cervix survive up to 48 hours. This indicates that there is a different influence in the different compartments [Quinlan, Maré and Roux (1932)]; in one division it is more favourable to spermatozoan life than in the others.

In the case of the human species the summary of Giles (1919) indicates that sperms survive longer in the cervix than in the uterus and vagina.

The literature is scanty in reference to the influence of genital secretions on spermatozoa when their survival in the different divisions of the reproductive tract is studied. The point is, however, not without practical importance in breeding.

If, as the authors suggest, the cervix is the natural habitat of the spermatozoa in the ewe, while awaiting the arrival of an available ovum, a healthy condition of this portion of the reproductive tract is of the utmost importance in conception. Cervicitis does not appear to be a common condition in sheep, but its incidence in cattle is frequent. The uterine cervices of the bovine and the ovine have an anatomical similarity and it is highly probable that both perform similar physiological functions in relation to the spermatozoa.

It is evident from the previous work of Quinlan, Maré and Roux (1932) that the vagina is not the natural habitat of the spermatozoa of the ewe after copulation. They lose motility within a few hours in this part of the genital passage. The vagina appears to act only as a portal of entrance to the ostium uterinum.

The cervix would appear to be the portion of the female reproductive tract physiologically adapted to act as the natural habitat of spermatozoa while awaiting the arrival in the Fallopian tube of an ovum available for impregnation. Its secretion appears to be highly favourable to the life of the sperms. They remain numerous and active in this division even up to 48 hours after copulation.

It appears, in view of the relative infrequency of spermatozoa in the pars indivisa of the uterus, the uterine horns, and the Fallopian tubes, that the cervical reservoir is called upon for a constant small supply of sperms as long as any survive there. From the observations made in a very large number of ewes there appears to be no swarming forward of sperms to the tubes following copulation.
STUDY OF DURATION OF MOTILITY OF SPERMATOZOA.

The results of the present series of experiments indicate that sperms which become located in the uterus, uterine horns, and the Fallopian tubes do not survive longer than 10 to 12 hours in these situations. If the uterine horns and tubes were the natural habitat of sperms why do not those placed there and isolated remain alive for longer than 10 to 12 hours?

So far as one can see from the operation there results no pathological change in the genital tract to account for the rapid death of spermatozoa transferred to the Fallopian tube and uterine horn, compared with those from the same ejaculation which become located in the cervix.

It is maintained that the few live sperms which were found in the operated horn after the 12th hour are not any remaining from those injected into its apex, but rather some which have come forward from the cervix, similar to the condition prevailing on the non-operated, control side. That the operation of manipulation and injection is harmless is definitely proved in the case of the control experiment on sheep 0·312, Table I, where the conditions in both sides of the genitalia were similar at slaughter, 18 hours after insemination.

CONCLUSIONS.

1. A study has been made of the motility of the spermatozoa of three highly fertile rams in the different divisions of the reproductive tract of normal Merino ewes.

2. The end-point of motility of spermatozoa in the vagina appears to be about 12 hours. The majority have ceased to be motile before the 12th hour; very occasional sluggishly motile sperms are present up to 18 and even 24 hours.

3. Spermatozoa may be numerous and actively motile in the cervical canal 24 hours after copulation.

[The present series of experiments extended only to the 24th hour, but previous experiments carried out by the authors (1932) have shown that living spermatozoa may be found in the cervix 48 hours after copulation.]

4. Spermatozoa injected into the lumen of the apex of the uterine horn do not survive contact with the uterine secretion for more than 12 hours. In fact the end-point of motility appears to be about the 9th hour.

5. Spermatozoa injected into the isolated Fallopian tube through its ovarian opening do not retain motility for more than a few hours; 21 per cent. were motile after 6 hours; 5 per cent. after 9 hours; no motile sperms were seen after 12 hours.

6. The secretion of the vagina is unfavourable to the motility of spermatozoa.

7. The secretion of the cervix is more favourable than that of the other divisions of the genitalia to the life of spermatozoa.

8. The secretion of the uterus and Fallopian tubes is unfavourable to spermatozoa artificially transferred to these situations without passage through the cervix.

9. The cervical canal appears to be the natural habitat of spermatozoa while awaiting the arrival of an available ovum; small numbers of sperms are constantly passing forward through the uterus to the uterine horns and the Fallopian tubes. Under favourable conditions the cervix acts as a depot for spermatozoa from which there is a constant issue of activity motile sperms to the cranial divisions of the reproductive tract.
10. The injury to the Fallopian tube and uterine horn by the operation did not prevent sperms from acting normally, as shown by a control operation following normal copulation.

LITERATURE.


