THE RATE OF SPERM TRAVEL IN CATTLE

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INTRODUCTION

The rate of mammalian sperm travel is a question of both scientific and direct practical importance. The extablishment of this fact is fundamental to a more thorough understanding of the physiology of reproduction. The apparent short functional life of the mammalian reproductive cells indicates that the optimum time for mating is relatively short. The increasing practice of artificially inseminating female animals as a means of controlling certain genital diseases, increasing the rate of conception, and extending the influence of proven sires has created an additional need for information regarding the physiology of reproduction. Few observations have been made concerning the time of ovulation or the rate at which spermatozoa travel in the genital tract of the female.

Through experience, animal breeders have arrived at a variety of opinions as to the opportune time for mating animals. Many breeders have practiced multiple servicing of the female as a means of insuring conception. This practice tends to exhaust the sire and limit his use to fewer females. With improved conception rates the animal producer may plan the lamb or calf crop to a greater economic advantage. Many valuable animals are discarded from the herd as shy breeders. A better understanding of the factors governing fertility and those causing irregularities in breeding animals will lessen this economic loss. A knowledge of the optimum time for breeding females would enable the animal breeder and inseminator to spread the utility of sires to the maximum extent. Shy and uncertain breeders might be made to reproduce regularly. There exists considerable divergence of opinion in regard to the factors

affecting fertility and conception. This study was conducted in an effort to obtain further fundamental information regarding the rate of sperm travel and the factors affecting it.

REVIEW OF LITERATURE

Rate of Sperm Travel

The literature contains much discussion but little information concerning the speed at which mammalian sperm travel. Widely different rates have been observed in the time required for sperm to reach the infundibulum. Beshlebnov (3) found bull sperm in the ovarian end of the fallopian tubes 4 hours after insemination and in one case only 1 3/4 hours were required. Hartman and Ball (17) reported rat sperm in the distal end of the horn 100 seconds after copulation. Parker (27) stated that 4 hours were required for the rabbit sperm to reach the infundibulum. Evans (9) found dog sperm in the oviduct 25 seconds after ejaculation by the male. Phillips and Andrews (28) located sheep sperm in the ovarian end of the fallopian tubes, in a minimum time of 30 minutes after insemination. Green and Winters (13), in studies on sheep, reported the time required for sperm to traverse the tract to be 5 to 6 hours. Lewis (23) obtained sperm from the oviduct of the sow 7 hours after copulation. Long and Evans (24) state that 4 hours are required for the mouse sperm to reach the distal end of the oviduct.

Viability of Sperm

The ability of sperm to survive in the genital tract as well as in vitro is a problem of practical importance. Inasmuch as the rate of sperm travel and the time of ovulation seem quite variable, it is of prime importance to know how long after ejaculation the sperm cells will remain capable of fertilizing the ovum. The factors which affect the viability of sperm have long been the subject of controversy.

Motility of Sperm in the Tract: Feiling (10) contends that motility of sperm is the only criterion of fertility. Beshlebnov (3) found 50 per cent of the spermatozoa to be motile in the cow after 24 hours, a few motile spermatozoa after 30 hours, and none motile after 40 hours. Lewis (23) found live sperm in the sow after 41 1/2 hours. However, the average time of survival was 18 to 25 hours. Parker (27) reported live rabbit sperm in the female tract after 30 hours. Green and Winters (13) state that, in general, sheep sperm do not live more than 24 hours in the tract, and Andreev (1) found live bull sperm in the female tract after 24 hours.

Morphology and Viability: Numerous morphological abnormalities have been observed in sperm. Some workers have evaluated sperm samples on the basis of the per cent of normal spermatozoa present. Voloskov (35) reported 13 different morphological abnormalities in horse sperm. He stated that 70 per cent normal sperm gave a conception rate of 68 to 80 per cent while samples having 48 to 52 per cent normal sperm gave a conception rate of only 40 to 53 per cent. He believes that abnormal sperm heads are due to excessive sexual activity while abnormal tails are due to pathological conditions in the testes. Rodolfo (31) isolated 3 types of sperm from the boar. Type I had a normal head and tail, type II had a protoplasmic drop on the neck, and type III had the drop situated on the middle of the tail. He believes these 3 types represent 3 stages of development. He stated that type I predominated in the semen. Studies on sheep sperm by Comstock and Brady (6) revealed a significant positive correlation of the liveability of sperm with the length of head and the number of spermatozoa per cubic m.m.

Effect of pH on Viability: Workers have endeavored to ascertain the optimum pH range for the survival of sperm. The pH of the sperm sample is thought by some, to be an indication of the viability of the sperm therein. Katziolos (18) found bull sperm samples ranging in pH from 6.39 to 7.81 with a mean of 6.89 ± .06. He reports a negative correlation between high pH and the number of spermatozoa in the sample, and a slightly positive correlation between high pH and duration of life. Schneerson (32) concluded that the optimum vitality of bull sperm is attained at a pH of 5.8 to 6.6. Using a potentiometer, Sergin (33) reported the average pH of sperm as follows: bull, 6.74; ram, 7.08; rabbit, 7.20; stallion, 7.23; boar, 7.57; and man, 7.79. He also stated that the buffering capacity of sperm is lower than that of blood. Hammond (15) believes that high acidity is an indication of a greater number of spermatozoa per volume unit due to the CO2 given off by sperm. He also states that the semen is usually much higher in acidity than the female tract.

Genital Conditions: Weber (36) found blood and urine to have a harmful but non-toxic effect on sperm. Hammond (15) reports that retention of the placenta causes inflamation of the uterus and in turn the spermatozoa are attracted to the leucocytes and becomes agglutinated. He also states that inflamation of the os. uteri may prevent the opening of the cervix during oestrus, and cause incomplete liquifaction of the mucous, thereby making sperm travel difficult or impossible. Seymour (34) found live but sluggish human sperm in the cervix 111 hours after insemination. Kozlova (20) and others contend that normal vaginal secretions have an unfavorable influence on the longevity of spermatozoa.

Viscosity of Mucous: Noticeable differences in the viscosity of

mucous from the female tract have been observed. Workers have attempted to ascertain the effect this factor exerts on spermatozoa. Beshlebnov (3), working with cows not in heat, found sperm in the ovarian end of the fallopian tubes, but all were immobile and abnormal after 10 to 15 hours. Novoselov (26) made viscosimeter readings on samples of bull sperm and mucous from the cervix of cows in dioestrus. He found the average viscosity of the mucous to be much greater than that of the sperm and concluded that sperm introduced into the cervix during dioestrus would cease progressive motion and die. Hammond (15) reports that 72 hours after the end of the heat period the mucous becomes opaque with leucocytes and corpusles. Weber (36), working with a 20 per cent agar solution, found a viscous solution to be more suitable than a fluid solution for maintaining the normality and motility of sperm.

Effect of Temperature on Viability: It has been demonstrated by some that temperature shocks are to be avoided in handling sperm. Observations on the optimal temperature for sperm survival have been quite consistent. Studies on the effect of temperature on bull sperm by Weber (36) gave survival results as follows: 0°C - 96 hours, 5 to 12°C - 209 hours, 18 to 22°C - 40 hours, and 38°C - 8 hours: Gunn (14) concluded that 4°C was the optimal temperature for the survival of sheep sperm; Atabek (2) reported goat sperm to be very sensitive to temperature and recommended that it should be kept at body heat.

Effect of Sunlight: Lewis (23) demonstrated that sunlight had a detrimental effect on boar sperm.

Optimal Dosage of Sperm: There is some information in the literature regarding the amount of semen necessary to insure conception.

Kozlova (20) reports that .2 c.c. of semen placed in the cervix gave the same conception rate in cows as 4.0 c.c. placed in the vagina. Kufarev (21) using .5 c.c. of bull semen in the cervix obtained conception results equal to that of natural mating, however, when only .2 c.c. of semen was used the conception rate decreased 8 per cent.

Dilution of Sperm: Most workers are of the opinion that the viability of sperm is decreased with dilution, however, some have obtained desirable results with diluted sperm. Working with 524 mares, Kedrov (19) obtained the following results: Undiluted sperm gave a conception rate of 57.25; diluted 4 times gave a rate of 59.88; diluted 8 times gave a rate of 46.87. Hatziolos (18) found that undiluted bull sperm survived longer than sperm diluted with Ringers, Tyrode or Russian glucose. Working with pigs, Rodin and Lipatov (30) obtained the best results with a 4 times dilution. Weber (36) found the Russian gluco-phosphate diluent to be the most satisfactory for bull sperm.

Effect of Oestrus on the Genital Tract

Numerous investigators have expressed their belief that the condition of the genital tract is a major factor affecting the fertility of females. Many irregularities of the genital tract and their effect on fertility have been observed. Green and Winters (13) report that the stage of oestral cycle has no effect on the rate of sperm travel in sheep.

Oestral Cycle Changes: The normal oestral cycle of the cow is about 20 days. The duration of oestrus is known to vary. Hammond (15) reported cows remaining in heat from 6 to 30 hours with an average of 16 hours. Mirskaja and Salzmann (25) found the average duration of heat in

mares to be 5.65 days. Corner and Amsbaugh (8) found that the duration of oestrus in the sow was about 3 days. Hammond (15) reported ewes in heat from 3 to 51 hours with an average of 27 hours.

According to Hammond (15), the mechanism of the oestral cycle consists of a delicate balance between the internal secretion of the anterior pituitary and the 2 ovarian secretions, oestrin and progestrone, produced from the follicle and corpus luteum, respectively. The follicle stimulating hormone and the lutenizing hormone secreted by the pituitary cause follicle development, ovulation and the formation of the corpus luteum.

Oestrin gives rise to heat symptoms, which are swollen vulva, dilated cervix and mucous production in the uterus and cervix. Under the influence of progestrone the cervix becomes tightly closed and the secretion of the mucosa becomes dry and sticky, a condition presumably unfavorable for the ascent of sperm.

The Time of Ovulation

The time at which the follicle erupts and the ova is released is of great importance in determining the opportune time for mating. Although there are some variations in the reports as to the time of ovulation, most workers are in agreement that it occurs just before or soon after the end of oestrus. Gotze (12) contends that ovulation may occur in the mare without heat, and heat may occur without ovulation.

Brewster (4) found ovulation occurring in cattle on the average 13 1/2 hours after the end of heat. According to Hammond (15), Gerasimova (11) found ovulation occurring in cows about 27 hours after the beginning of heat. Working with cows, Andreev (1) found ovulation occurring

30 to 40 hours after the onset of heat. Beshlebnov (3) mated cows while in heat and reported ovulation in 4 cases from 21 to 26 hours following service and in 5 cases from 22 to 30 hours after service. Working with dairy heifers, Werner, Casida, and Rupel (37) observed the average time of ovulation to be 11 1/2 hours after the end of oestrus with a range of 2 1/4 to 22 3/4 hours. Reports on the mare by Mirskaja and Salzmann (25) indicate ovulation on the average 3.84 days after the onset of heat. Lewis (23) states that the sow ovulates near the end of oestrus. Green and Winters (13) report that ovulation in the ewe occurs late in the heat period, as the animal is passing from heat. Studies on humans by Kurzrok (22) indicate that ovulation usually occurs 13 to 15 days after the onset of menstruation. Long and Evans (24) reported ovulation in rate as occurring just prior or soon after the end of oestrus. Young, Meyers and Dempsey (38), working with guinea pigs, state that ovulation occurs within 1 hour of the end of the heat period.

Viability of Ovum

A knowledge of the viability of the ova after liberation is equally as important as the survival of the sperm cells in determining the optimum time for mating. Little is known regarding the physiology of the ovum, due to the difficulty of obtaining ova from the genital tract and the inability to observe its physiological processes after possession is accomplished. Conclusions regarding the viability of the ovum cannot be made until techniques have been improved and numerous observations made.

Observations to date, indicate considerable variation in differ-

ent species regarding the duration of life of the unfertilized egg. Parker (27) reported the duration of life of the rabbit ovum to be 2 to 4 hours. Corner (7) states that degeneration of the pig ovum began about 7 days after ovulation while Lewis (23) states that the sow ovum retains its viability only a few hours after being liberated. Hartman (16) gives the following length of time as the duration of life of the ovum after liberation: Rabbit, 4 or 5 hours; human, 24 hours; and the mouse and opposum, 24 hours.

Uterine Contractions

It is generally agreed among workers that the mammalian spermatozoan travels through the female genital tract under it's own motile power. However, Evans (9), by the use of a uterine fistula, found that the bitch forced sperm through the tract by a series of abdominal strainings at the time of copulation. Beshlebnov (3) suggests that the migration of sperm in the cow is aided by uterine contractions. He inseminated cows in heat with dead (heated) sperm and was able to recover some of the sperm in the horns and tubes.

SCOPE OF INVESTIGATION

An attempt was made to obtain information pertaining to the rate of spermatozoan travel in cattle and the factors affecting spermatozoan travel. Data was obtained with the following objectives:

(a) To determine the effect of the following factors on spermatozoan travel in the genital tract of cattle:

(1) Effect of age of cattle:

(2) Effect of type of cattle:

(3) Effect of stage of oestrus:

(4) Effect of previous parturitions:

(5) Effect of abnormalities and conditions of the genital tract:

(6) Effect of uterine contractions.

(b) To determine the average length of the genital tract in:

(1) Cows

(2) Heifers

EXPERIMENTAL PROCEDURE

Animals used: The cows used in this experiment were obtained from the college herds of beef and dairy cattle. All of the animals used were known to be negative reactors to tuberculosis and Bang's disease tests. All cows were artificially inseminated with the semen from one bull. The 10 year old Jersey bull used was known to produce a high per cent of motile and normal spermatozoa.

Handling of Semen: All samples of semen were collected in a sterile artificial vagina to prevent contamination. Each sample, with the exception of Case no. 16, was checked soon after collection and observed to be above 90 per cent normal and motile. Inseminations were made in every case within 1 hour from the time of collection of the semen. The semen was kept at body temperature from the time of collection until used. The semen samples used for determining the effect of uterine contractions were killed by heating at 55° C. for 5 minutes.

Method of Insemination: All of the cows reported in this investigation were inseminated by the use of a glass speculum, capillary tube, and a rubber pressure bulb. Precautions were taken to inseminate all cows alike. In so far as possible the semen was placed in the vaginal half of the cervix. Cases 20, 21, and 22 were inseminated by placing the spermatozoa into the uterine body. The glassware was warmed to body temperature before being used.

Amount of sperm used: The amount of semen used varied with different cases. The samples used averaged 2.7 c.c. with the lower limit being 1.0 c.c. This variation was not intentional but due to the amount of semen available for the insemination. No attempt was made to compare

results with dosage of sperm used as previous work reported by Kufarev (21) indicate that 0.5 c.c. of semen placed in the cervix gave maximum conception rates.

Collection of Samples: The time allowed for spermatozoa travel varied from 155 to 593 minutes. The time reported was the interval of time between insemination and sectioning of the tract. Each tract was sectioned as soon as possible after slaughtering and in every case within 45 minutes after slaughter and before the body temperature of the animal had materially decreased.

The entire genital tract was removed from the body and the excess tissue cut away allowing the tract to attain it's maximum length in a horizontal position on a table. Data was recorded on the length of the fallopian tube, uterine horn, uterine body and cervix. One tube was sectioned into 3 equal lengths and one horn into 2 equal lengths. The remaining horn and tube was retained until the other samples had been checked satisfactorily under the microscope. All apparent abnormalities of the tract were recorded.

Each section was flushed thoroughly with a 0.9 N. physiological saline solution. Flushings were made by inserting the tip of a finely pointed glass tube in the end of the section and forcing the flushing solution through with the aid of a rubber bulb. Flushings were collected in sterile test tubes, labeled and sealed at once.

Examination of Flushings: Extensive preliminary experiments were carried out prior to the beginning of this investigation, in an effort to separate the spermatozoa from the flushing solution and the tract debris. It was found that flushings could be centrifuged at the rate of

3100 R. P. M. or at a relative centrifugal force of 2133.4 for 12 minutes, thereby forcing the spermatozoa and the debris into the lower tip of the centrifuge tube. A finely pointed capillary tube was used to obtain the material from the tip of the centrifuge tube. This material was spread thinly over the surface of a slide and observed microscopically for the presence of spermatozoa. Positive identification of each spermatozoan was ascertained by observation under 440 times magnification. No attempts were made to estimate the per cent of live spermatozoa or the total number in the sample. The presence of a single spermatozoan was considered as positive evidence of spermatozoan travel. Positive identification of trichomonads was made by Dr. C. F. Clark of the Pathology Section.

OBSERVATIONS

Case no. 1. This Guernsey, age 72 months, was off-heat when inseminated. The sperm had traveled 48.0 cm. (center 1/3 of fallopian tube) in 200 minutes or at the rate of 1:4.16. Her breeding record showed one calf dropped 27 months prior to slaughter. She was mated to 4 different fertile bulls during 11 regular heat periods following her last and only calf. She was treated for severe granular vaginitis 43 months prior to slaughter. Twelve months before slaughter she was treated for a mild case of cervicitis. This cow had no history of retained corpus luteum.

Case no. 2. This Shorthorn, age 112 months, was in heat when inseminated. The sperm had traveled 55 cm. (center 1/3 of fallopian tube) in 268 minutes or at the rate of 1:4.87. Records showed her to be a regular breeder, having dropped 6 calves. The last calf came 54 days prior to slaughter and was 6 weeks premature.

Case no. 3. This Hereford (virgin), age 15 months, was in heat when inseminated. The sperm had traveled 51.5 cm. (ovarian 1/3 of the fallopian tube) in 255 minutes or at the rate of 1:4.95.

Case no. 4. This Brown Swiss, age 48 months, was in heat when inseminated. The sperm had traveled 58.0 cm. (ovarian 1/3 of fallopian tube) in 330 minutes or at the rate of 1:5.68. Breeding records showed that she had dropped one calf 18 months prior to slaughter. A large cyst was ruptured on the right ovary 12 months prior to slaughter.

Case no. 5. This Jersey, age 69 months, was in heat when inseminated. The sperm had traveled 54 cm. (uterine 1/3 of fallopian tube) in 310 minutes or at the rate of 1:5.74. She had dropped 5 calves, the third of which was a 5 months aborted fetus. She was a regular breeder. This

cow was culled due to mastitis infection.

Case no. 6. This Shorthorn (virgin), age 18 months, was off-heat when inseminated. The sperm had traveled 57 cm. (ovarian 1/3 of fallopian tube) in 360 minutes or at the rate of 1:6.31.

Case no. 7. This Shorthorn (virgin), age 16 months, was in early heat when inseminated. The sperm had traveled 40 cm. (uterine 1/3 of fallopian tube) in 265 minutes or at the rate of 1:6.62.

Case no. 8. This Angus, age 60 months, was in heat when inseminated. The sperm had traveled 45 cm. (ovarian 1/2 of uterine horn) in 345 minutes or at the rate of 1:7.66. Breeding records revealed 3 calves, the last of which was dropped 2 months before slaughter. No breeding attempts had been made following the last calf.

Case no. 9. This Hereford, age 144 months, was off-heat when inseminated. The sperm had traveled 71.5 cm. (center 1/3 of fallopian tube) in 551 minutes or at the rate of 1:7.70. Her breeding record showed 9 calvings with one pair of twins. The last calf was dropped 14 months and 13 days prior to slaughter and the last breeding date was 6 1/2 months prior to the slaughtering date. The left horn was enlarged and contained the residue of a re-absorbed fetus.

Case no. 10. This Shorthorn, age 156 months, was off-heat when inseminated. The sperm had traveled 19 cm. (os. 1/2 of uterine horn) in 155 minutes or at the rate of 1:8.15. Her breeding record showed 11 calves, the last of which was dropped 28 days prior to slaughter. The uterine walls were somewhat thick and distended and contained a bloody fluid having an obnoxious odor.

Case no. 11. This Angus (virgin), age 12 months, was off-heat

when inseminated and the sperm had traveled 28 cm. (uterine 1/3 of fallopian tube) in 240 minutes or at the rate of 1:8.57.

Case no. 12. This Ayrshire, age 42 months, was in heat when inseminated. The sperm had traveled 23 cm. (os. 1/2 of uterine horn) in 200 minutes or at the rate of 1:8.69. Records revealed this cow was a regular breeder, having dropped 2 calves, the last of which came 4 months prior to slaughter. Flushings from the uterine body and horns were quite bloody. She was bred 39 days prior to slaughter, conceived, and the corpus luteum was squeezed out 5 days prior to the slaughtering date. The uterus was quite bloody and indications of recent abortion were obviously apparent.

Case no. 13. This Hereford (virgin), age 13 months, was off-heat when inseminated and the sperm had traveled 35 cm. (ovarian end of uterine horn) in 307 minutes or at the rate of 1:8.77. This heifer had occupied the same lot as no. 16. No breeding attempts had been made. These samples were slightly infested with trichomonads.

Case no. 14. This Shorthorn (virgin), age 20 months, was off-heat when inseminated. The sperm had traveled 39.9 cm. (uterine 1/3 of fallopian tube) in 355 minutes or at the rate of 1:8.89.

Case no. 15. This Hereford (virgin), age 11 months, was off-heat when inseminated and the sperm had traveled 14.5 cm. (os. 1/2 of uterine horn) in 352 minutes or at the rate of 1:24.27. The absence of a corpus luteum, follicle or follicle scar was noted on the ovaries. This beef heifer had been on full-feed and was showing a high degree of finish.

Case no. 16. This Shorthorn (virgin), age 13 months, was in heat when inseminated and the sperm was found only in the os. uteri after 172 minutes. Records revealed that no breeding attempts had been made. The

heifer occupied a lot with several young steers and heifers. The samples were heavily infested with living organisms which were positively identified as trichomonads by 3 members of the Pathology Department.

Case no. 17. This Ayrshire, age 36 months, showed no signs of heat when inseminated. The sperm were found only in the os. uteri and uterine body after a time of 593 minutes. This heifer had never calved and ovulated only after repeatedly massaging the ovaries. The ovaries were massaged regularly and the corpora lutea squeezed out when found over a period of 22 months. When ovulation did occur, oestral symptoms were not apparent. The left ovary was cystic. The left horn of the uterus was totally absent. The os. uteri and uterine body were full of a heavy, viscous, gelatin-like mucous.

Case no. 18. This Shorthorn, age 10 months, was off-heat when inseminated. Sperm could not be found in any of the samples. The time between insemination and the sectioning of the genital tract was 323 minutes. This sample of sperm was not observed for motility and normality until 5 hours after collection. It had been kept at body temperature. The spermatozoa were dead but of normal morphology.

Case no. 19. This Shorthorn, age 110 months, was off-heat when inseminated. Sperm could not be found in any of the flushings after 265 minutes were allowed for travel. Her breeding record showed 6 calves, the last of which was dropped 91 days before slaughter. A heavy, viscous mucous was found in the os. uteri and uterine body when examined after slaughter.

Case no. 20. This Jersey, age 95 months, was in heat when inseminated. The sperm sample was killed by heating at 55° for 5 minutes before inseminating the cow. Sperm could not be found in any of the samples after

435 minutes were allowed for travel. This cow had dropped 5 calves, requiring an average of 3 services per conception. An extremely heavy flow of watery mucous was observed at the time of insemination, otherwise she was normal. This cow was culled due to mastitis infection.

Case no. 21. This crossbred heifer, age 16 months, was off-heat when inseminated with dead (heated) sperm. The sperm were found only in the os. uteri after a time of 240 minutes. The tract appeared to be normal and no previous breeding attempts had been made.

Case no. 22. This Angus cow, age 129 months, was in heat when inseminated with dead (heated) sperm. Sperm could not be found in any of the samples after 230 minutes were allowed for travel. Records revealed that she had been a regular breeder until 10 months before slaughter, at which time she dropped a dead calf. During this 10 months period she had come in heat and been bred regularly, but failed to conceive. Flushings from the uterine horn, uterine body, and os. uteri were heavily contaminated with a firm, lumpy pus. The left ovary was cystic and there was no indication of a follicle or erupted follicle pit on either ovary.

RESULTS

Table 1. The Results of Sperm Travel Studies.

Case No.	Age (mo.)	Oestrus*	Tract Length (cm.)	Travel Distance (cm.)	Time** (minutes)	Rate*** of Travel	
1	72	-	56.0	48.0	200	4.16	
2	112	x	63.5	55.0	268	4.87	
3	15	x	51.5	51.5	255	4.95	
4	48	x	58.0	58.0	330	5.68	
5	69	x	72.0	54.0	310	5.74	
6	18	-	57.0	57.0	360	6.31	
7	16	x	55.0	40.0	265	6.62	
8	60	x	68.0	45.0	345	7.66	
9	144	-	82.0	71.5	551	7.70	
10	156	-	56.4	19.0	155	8.15	
11	12	-	41.5	28.0	240	8.57	
12	42	x	63.5	23.0	200	8.69	
13	13	-	65.0	35.0	307	8.77	
14	20	-	52.5	39.9	355	8.89	
15	11	-	44.0	14.5	352	24.27	(a)
16	13	x	47.4	6.5	172	26.46	(b)
17	36	-	57.3	7.0	593	84.71	(c)
18	12	-	48.5	0.0	323	0.0	(d)
19	110	-	66.5	0.0	265	0.0	(e)
20	95	x	62.0	0.0	390	0.0	(f)
21	16	-	60.0	0.0	240	0.0	(g)
22	129	x	66.5	0.0	230	0.0	(h)

* x indicates heat: - indicates off-heat.
** Time from insemination to sectioning of the tract.
*** Minutes required for sperm to travel 1 cm.

(a) Full-fed beef heifer with no previous heat.

(b) Heavy trichomonad infestion.

(c) Abnormal genital tract. (Absence of 1 uterine horn)

(d) Sperm sample not checked promptly. (Dead after 5 hours)

(e) Heavy mucous flow observed at time of insemination.

(f) Heated sperm used. (Uterine contraction studies)

(g) Heated sperm used. (Uterine contraction studies)

(h) Heated sperm used. (Uterine contraction studies)

Effect of Age of Cattle: In an effort to study the effect of age on the rate of spermatozoa travel, accurate ages by months, were recorded for each animal. Abnormal cases, 15 to 22 inclusive, are excluded from Table 2. The correlation between age (x) and the rate of spermatozoa travel (y) was found to be rxy = -.223 for the animals in heat and rxy = -.119 for those not in heat. These correlation coefficients show that age has very little if any effect on the rate of spermatozoan travel.

Table 2. Effect of Age on the Rate of Sperm Travel.

Animals in heat

Case no.	Age (months) (x)	Rate of Travel (y)	Correlation Coefficient
3	15	4.95	
7	16	6.62	
12	42	8.69	
4	48	5.68	
8	60	7.66	
5	69	5.74	
2	112	4.87	
			rxy = -.223

Animals off-heat

Case no.	Age (months) (x)	Rate of Travel (y)	Correlation Coefficient
11	12	8.57	
13	13	8.77	
6	18	6.31	
14	20	8.39	
1	72	4.16	
9	144	7.70	
10	156	8.15	
			rxy = -.119

Effect of Type of Cattle: The effect of type on the rate of spermatozoan travel is shown in Table 3. These results suggest a difference in the rate of spermatozoa travel between the beef type and the dairy type cows. Inasmuch as no data is available on dairy type heifers, this comparison was made on mature cows only. Although the oestrus factor is variable and the numbers are small, there seems to be a marked difference between the types shown. Case no. 19 was excluded due to a genital abnormality and cases 20 and 22 were used to check another factor.

Table 3. The Effect of Type of Cattle on the Rate of Spermatozoa Travel in Cows.

Case No.	Breed	Oestrus	Rate of Travel	Average Rate
2	Shorthorn	x	4.87	
8	Angus	x	7.66	
9	Hereford	-	7.70	
10	Shorthorn	-	8.15	
				7.09
1	Guernsey	-	4.16	
4	Brown Swiss	x	5.68	
5	Jersey	x	5.74	
12	Ayrshire	x	8.69	
				6.06

Effect of Stage of Oestrus: Animals of various ages were slaughtered in heat and off-heat in an attempt to determine the effect of the stage of oestrus on the rate of spermatozoa travel. Here again the numbers are small but marked differences are shown in the heifer groups (I and II) as to the stage of oestrus. In group II, the sperm traveled only 69.35 per cent as fast as was observed for the heifers in heat. However, it should be noted that there is almost no difference shown in cow groups III and IV. The fastest rate of travel observed in the entire group was in case 1., a 6 year old cow not in heat. Table 4

indicates that heat may be responsible for an increase in the rate of travel in heifers and has little or no effect in mature cows.

Table 4. The Effect of Oestrus and Previous Parturition on the Rate of Sperm Travel

Group No.	No. of Animals	Case Numbers*	Oestrus	Average Rate	
Heifers I	2	3,7	x	5.68	
" II	4	6,11,13,14	-	8.13	
					7.31
Cows III	5	2,4,5,8,12	x	6.52	
" IV	3	1,9,10	-	6.67	
					6.57

*Heifers number 15,16,18, and 21 and cows number 17,19,20 and 22 are excluded.

Effect of Parturition: The average rate of sperm travel in 6 heifers was 7.31 while the rate observed in 5 cows was 6.57. These figures alone would indicate a difference due to parturition, with the faster rate for the cow group. However, since oestrus has been shown to be responsible for an increase in the heifers and to have no effect in the cows, it appears that parturition has a hindering effect on the rate of spermatozoa travel when the animals compared are all in heat. When the animals were not in heat the genital tract in the heifers was less suitable for sperm travel than was observed in cows.

Effect of Abnormalities and Conditions of the Genital Tract: Several genital abnormalities and irregularities were observed. In this study, it was not possible to obtain a complete history of each abnormal genital tract. No attempt was made to ascertain the exact predisposing factors responsible for the irregular conditions found. However, all of the apparent unusual conditions of the genital tract were recorded in an effort to determine what effect they might have on the rate of spermatozoa

travel.

The following case histories indicate the condition of the genital tract, the available genital and breeding history, and the subsequent effect on the rate of sperm travel.

Case no. 15. This beef heifer possessed a high degree of finish. Records revealed no previous heat periods and this was substantiated by ovarian observations. The rate of sperm travel was 24.27.

Case no. 10. This aged cow was slaughtered 26 days after a normal parturition. The uterine walls were somewhat thick and distended and contained a bloody fluid having an obnoxious odor. The rate of sperm travel was 8.15.

Case no. 9. This aged cow was last bred 6 1/2 months prior to slaughter. The left uterine horn contained the residue of a re-adsorbed fetus. The rate of sperm travel was 7.70.

Case no. 12. This young cow was last bred 33 days prior to slaughter, conceived, and the corpus luteum was squeezed out 5 days before slaughter. The uterus was irritated and bloody and indications of recent abortion were apparent. The rate of sperm travel was 8.69.

Case no. 13. This heifer was slightly infested with trichomonads. The rate of sperm travel was 8.77.

Case no. 16. This heifer was heavily infested with trichomonads. Sperm were found only in the os uteri.

Case no. 17. This 3 year old heifer ovulated only after repeatedly massaging the ovaries and then gave no symptoms of oestrus. The left ovary was cystic and the left uterine horn was totally absent. The os uteri and uterine body were full of heavy viscous, gelatin-like mucous.

Sperm were found only in the os uteri and uterine body.

Case no. 20. This aged cow was a regular breeder and her last calf was dropped 91 days prior to slaughter. A heavy, viscous mucous was found in the os uteri and uterine body on examination after slaughter. Spermatozoa could not be found in any of the flushings.

Effect of Uterine Contractions: An attempt was made to determine if uterine contractions occured in cattle and if so what effect they had on the rate of spermatozoa travel. Three animals were inseminated with dead (heated) sperm and observed in the same manner as were the other cases. The time reported includes the time interval between insemination and slaughter. Table 5 indicates that uterine contractions probably do not occur in cattle. Further studies must be conducted before the presence or effect of this factor can be definitely established.

Table 5. The Effect of Uterine Contractions on the Rate of Spermatozoa Travel

Case No.	Oestrus	Travel (Distance) (cm.)	Time (Minutes)	Rate of Travel
19	x	0.0	390	0.0
21	-	0.0	240	0.0
22*	x	0.0	230	0.0

*Cystic ovary and pus formation in genital tract.

Average Length of Genital Tracts from Cows and Heifers: The approximate length of the genital tract of an animal should be known before attempting to predict the optimal time for breeding. Table 1 shows the length of the genital tract of each animal slaughtered. In Table 6 the animals have been grouped according to parturition. A wide range of lengths were observed for each group. From these values it was

found that the average length of the tracts from the cows was significantly longer than the average length of the tracts from the heifers. On the average the cow tracts were 12.25 cm. or 18.90 per cent longer than the tracts from the heifers.

Table 6. Average Length of Genital Tracts from Cows and Heifers

Group	Number of Animals	Maximum Length (cm.)	Minimum Length (cm.)	Average* Length (cm.)
Cows	11	82.0	56.0	64.95 ± 2.27
Heifers	11	65.0	41.5	52.70 ± 2.13

*Measured from the vaginal end of the os uteri to the base of the infundibulum.

DISCUSSION

That age has very little if any effect on the rate of sperm travel is shown by the insignificant correlation values obtained in Table 2. If all of the normal cases, regardless of the stage of oestrus were combined into one table the correlation values would not be significant.

The results show that the rate of sperm travel in beef type cows was 83.47 per cent as fast as that of the dairy type cows. One factor which may have been responsible for this difference was the higher degree of finish of the beef type animals. It was noted, upon slaughter, that the cows in high condition exhibited a large amount of internal fat and that the genital organs were usually imbedded in fatty tissue.

From these data it seems that the stage of oestrus has no effect on the rate of sperm travel in cows, which is in agreement with results reported in ewes by Green and Winters (13). However, in heifers out of heat the sperm travel was 69.86 per cent as fast as that observed for the heifers in heat. This may be attributed to the fact that the genital tract in heifers is dilated only during heat, thereby permitting the sperm to travel in a more capacious tract. Once parturition has occured the genital tract of the cow becomes fully developed and the tract remains somewhat open and distended, regardless of the stage of oestrus.

The results shown in Table 4 concerning the effect of parturition on the rate of sperm travel, are meager but indicate that when animals are in heat the rate of travel is faster in heifers. The rate of travel for cows in heat was 87.11 per cent as fast as was observed for the corresponding group of heifers. Inasmuch, as oestrus has been shown to be responsible for an increase in rate in the heifers, and to have no

effect in cows, the difference shown between groups II and IV is attributed to oestrus rather than parturition. The difference between groups I and III may be the result of a change in toxicity, acidity, or mucous viscosity due to parturition. Further work is necessary to determine the influence of parturition on sperm travel and what factors are responsible for the different results.

The results shown previously in this paper indicate the irregularities and the nature of the genital abnormalities observed and their effect on sperm travel.

One beef heifer in high condition and without previous heat gave an unusually slow rate of travel. It is possible that the sperm had penetrated the genital tract as far as would be possible even though more time had been allowed. This case indicates what might occur in any immature, non-functional tract.

Another tract contained an unusual amount of bloody fluid, yet the rate of travel was about normal, which bears out Weber's (36) contention that blood has only a slight effect on the viability of sperm.

The left uterine horn of case no. 9 contained the residue of a re-adsorbed fetus, however, the rate of travel was comparable to that of the normal cows and spermatozoa were isolated from the central section of the Fallopian tube. This would indicate, in the event that ovarian function was normal, that fertilization might occur while the residue of a dead fetus was being carried.

In case no. 12, recent abortion and the presence of excessive blood in the tract did not reduce the rate of travel materially from that of the normal cows. Thus, it seems possible for spermatozoa to

ascend in a genital tract that is in a highly irritated and disturbed condition.

Two cases of trichomonad infestion were found in supposedly virgin heifers. The heavily infested tract was not conducive to sperm travel. However, the other tract, yielding only a few live organisms gave almost average results. Rees and Garlick (29) report that severe infestion of trichomonads may prevent conception but the majority of infested animals conceive normally and abort the fetus later.

In case no. 17, the left uterine horn was absent and the left ovary cystic. A waxy, gelatin-like plug was found in the os uteri and the uterine body. It was apparently impossible for spermatozoa to penetrate the genital tract of this animal. Case no. 20, also exhibited an unusually viscous mucous in the os uteri and uterine body. Here again, it appeared that the semi-solid, waxy mucous of the genital tract was unsuitable for spermatozoa movement.

Thus it was found that any diseased or abnormal condition of the genital tract that resulted in severe irritation, intoxication, or extremely viscous mucous production impeded or prohibited the normal travel of spermatozoa.

Sufficient animals were not available to satisfactorily determine the occurrence or effect of uterine contractions. Results shown in Table 5 indicate that uterine contractions do not occur in cattle. This is not in agreement with the results obtained by Beshlebnov (3). Further work is necessary before the presence or influence of this factor can be definitely established.

Data obtained in this study indicate that the genital tract in

cattle is not fully developed until after the first parturition. Considerable variation was observed for the different ages, however, the average lengths of the tracts from the cows were significantly longer than the average length of the tracts from the heifers. These findings are in agreement with Hammond (13), who states that the female tract in cattle develoges much during the first pregnancy.

Many factors affecting the rate of spermatozoa travel in animals have been reported by other workers. However, most workers contend that the two chief factors are, the activity of spermatozoa and the condition of the genital tract. In this experiment the activity of the spermatozoa used did not vary significantly. The following variations in the rate of travel are attributed to unobserved conditions of the genital tract. By multiplying the minimum and maximum rates observed in apparently normal cows, times the average length of the genital tract it is estimated that the approximate time required for spermatozoa to reach the infundibulum ranges from 4.5 to 9.5 hours. In a similar manner, it is estimated that heifers in heat require 4.3 to 5.8 hours, while the time required for heifers out of heat ranged from 5.5 to 7.8 hours. These figures are not in complete harmony with the results obtained by Beshlehnov, (3): He reported a minimum time of 1.75 hours with the average for all cattle at about 4.5 hours. However, a wide range of variations were reported by Cole (5), and Phillips and Andrews (20) in the time required for sperm to reach the infundibulum in ewes.

SUMMARY AND CONCLUSIONS

1. Data indicate that age has no effect on the rate at which sperm travels in the genital tract of cattle.

2. The rate of travel in beef type cows is considerably slower than that observed in the dairy type cows.

3. The rate of travel in heifers off-heat was 69.8% as fast as that observed for the heifers in heat.

4. Sperm traveled almost as fast in the off-heat cows as it did in the cows in heat. From this it is concluded that the reproductive tract of the mature cow gives no special response during heat that would tend to accelerate the advance of sperm.

5. It was found that markedly diseased or abnormal conditions of the genital tract were usually accompanied by an extremely heavy mucous which tended to inhibit or obstruct the movement of sperm.

6. The presence of excessive blood in the tract exerted only a slight influence on the progress of the sperm.

7. Results from the 3 cases observed indicate that uterine contractions either do not occur or have no effect on the rate of sperm travel.

8. The shortest time in which sperm were found in the upper end of the tube was 5 hours and 30 minutes in mature cows.

9. The shortest time in which sperm were found in the upper end of the tube was 4 hours and 15 minutes in heifers.

10. On the average, approximately 7 hours is required for sperm to reach the infundibulum of the cow according to this data.

11. On the average, approximately 6 hours is required for sperm

SUMMARY AND CONCLUSIONS (Con't)

to reach the infundibulum in heifers in heat and about 7 1/4 hours for the heifers off-heat according to this data.

12. Sperm suspended in a .9 N. physiological saline solution can be concentrated by centrifuging at a relative force of about 2100 times gravity for 12 minutes.

13. The average length of the genital tract is significantly longer in animals having had at least one parturition.

14. From this study, it is concluded that the condition of the female genital tract is a major factor affecting the rate of sperm travel in cattle.

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