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STUDIES ON REPRODUCTION IN THE GOAT

III. THE FUNCTIONAL ACTIVITY OF THE OVARIES OF THE GOAT*)

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The functional activity of the ovaries implies the frequency of ovulation in the two ovaries. This frequency has been thoroughly investigated in most uniparous domesticated mammals. In several species the one ovary has been found to be more active than the other.

In the cow it has previously been demonstrated that the right ovary is more active than the left. *Reece & Turner* (1938) investigated the ovarian activity in sexually immature heifers, in sexually mature heifers and in pregnant cows. In sexually immature heifers these authors found the largest follicles in the right ovary in 73.5 % of the cases. In the sexually mature heifers they found the corpus luteum in the right ovary in 60.2 % of the animals. In 59 pregnant cows the corpus luteum was found in the right ovary in 39 (66.1 %). *Rajakoski* (1960) found a significantly higher number of follicles ≥ 5 mm in the right ovary than in the left. On the other hand, both ovaries contained the same number of follicles of an approximate size of 1 mm.

In the mare, *Andrews & McKenzie* (1941) and *Asdell* (1946) and *Hancock* (1948) report that the left ovary is the most active. *Arthur* (1958) investigated 792 organs from mares. In his material he found 347 cases with a corpus luteum in the left ovary. This made up 52.2 % of the total number of corpora lutea.

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Casida et al. (1966) published the results of an investigation where they had especially studied the inequality in function of the right and left ovaries of the ewe. In 351 ewes where only one follicle had ovulated, the corpus luteum in 61.8 % of the cases was localized in the right ovary. More than one follicle had ovulated in 325 ewes; from these were derived a total of 667 corpora lutea. Of these 55.5 % were situated in the right ovary.

Taneja (1959) found that in the goat ovulation took place in the right ovary in 55.4 % of the cases. *Basu et al.* (1961) found corresponding values in their material. The ovulation took place most frequently in the right ovary (58 %).

The present work is based on a larger material than in earlier publications regarding these conditions in the goat. The purpose with this study was to obtain more decisive evidence of the functional activity of the ovaries of the goat. Some of the results have been published in a preliminary report (*Lyngset* 1966a).

MATERIALS AND METHODS

The material included in this work is based on the examination of genital organs of goats collected at slaughterhouses. The collection of the organs has been described earlier (*Lyngset* 1968). No information regarding the animals before slaughtering is available. The material consists of 366 organs from pregnant animals with 596 functional corpora lutea of pregnancy, and 171 organs from non-pregnant animals with 190 corpora lutea periodica. Ovulation is recorded by the presence of corpora lutea. In studying the frequency of ovulation the ovaries are compared in pairs.

RESULTS

A greater activity has been found in the right than in the left ovary. A total of 786 corpora lutea were recorded and of these 448 or 57.0 % were found in the right ovary. A small difference was found between the organs of pregnant and non-pregnant animals with respect to the frequency of ovulation. In pregnant goats 57.45 % of the corpora lutea were found in the right ovary as compared with 55.79 % in the non-pregnant goats. In cases where only one follicle had ovulated this was in the right ovary in 62.34 % of the cases.

The frequency of ovulation in the right and left ovary in 227 single pregnancies is listed in Table 1. Of these there are 149

Table 1. The incidence of ovulation (c.l.) in right and left ovary in single pregnancies.

Number of single pregnancies	277	
1 c.l. in corresponding ovary	88	38.77 %
2 c.l. in corresponding ovary	30	13.22 %
1 c.l. in each ovary	20	8.81 %
2 c.l. in corresponding and		
1 c.l. in opposite ovary	4	1.76 %
1 c.l. in opposite ovary	61	26.87 %
2 c.l. in opposite ovary	22	9.69 %
2 c.l. in opposite and		
1 c.l. in corresponding ovary	1	0.44 %
3 c.l. in opposite ovary	1	0.44 %

cases where only one follicle has ovulated. This corresponds to 65.64 %. These 149 cases can be divided thus: 56 (37.58 %) where the ovulation had occurred in the right ovary and the foetus was located in the right uterine horn, 32 (21.48 %) with the corpus luteum in the left ovary and the foetus in the left horn, 37 (24.83 %) with the corpus luteum in the right ovary and the foetus in the left horn and 24 (16.11 %) with the corpus luteum in the left ovary and the foetus in the right horn. From this will be seen that in 59.06 % of the cases the ovum has been produced by the ovary of the side in which the foetus is situated. In as many as 40.94 % the ovulation occurs in the ovary opposite to the uterine horn in which the foetus lies.

Two or more ova has been discharged in 78 of 227 single pregnancies. This corresponds to 34.36 % of the total number. There were 30 cases with two corpora lutea in the ovary which corresponded to the placement of the foetus, 22 cases with two corpora lutea in the opposite ovary, 20 cases with one corpus luteum in each ovary, four cases with two corpora lutea in the corresponding ovary and one in the opposite ovary, one case with two corpora lutea in the opposite and one corpus luteum in the corresponding ovary, and one case with three corpora lutea in the opposite ovary.

Table 2 shows the frequency of ovulation in the right and left ovary in multiple pregnancies. In almost 50 % of the twin pregnancies both follicles developed from the same ovary. This occurred a total of 67 times, 36 times in the right ovary and 31 times in the left. In 40.44 % of the cases one follicle had ovulated in each ovary. In five cases there was only one corpus luteum

Table 2. The incidence of ovulation (c.l.) in right and left ovary in twin and triple pregnancies.

Number of twin pregnancies	136	
2 c.l. in one ovary	67	49.26 %
1 c.l. in each ovary	55	40.44 %
3 c.l. in one ovary	2	1.47 %
2 c.l. in one ovary and		
1 c.l. in the other	6	4.41 %
2 c.l. in each ovary	1	0.74 %
Only one c.l.	5	3.68 %
Number of triple pregnancies	3	
1 c.l. in one ovary and		
2 c.l. in the other	2	
Only 2 c.l.	1	

in a twin pregnancy. Among the three triple pregnancies there was one case where only two corpora lutea were found.

In a number of cases some of the ova will not be fertilized or else will die at an early stage of development. In Table 3 the number of cases of "ovum loss" or early foetal death is recorded. In the present material of organs from pregnant animals with multiple ovulations, 443 corpora lutea have been found, 87 or 19.6 % of the ova have not been fertilized or have been lost at an early stage of foetal development.

In 52 out of 120 cases (43.3 %) the one embryo had died when two ovulations had occurred in the same ovary, while in

Table 3. The incidence of ovum loss.

Total number of ova lost	87	
Single pregnancies with:		
2 c.l. in one ovary	52	59.77 %
1 c.l. in each ovary	20	22.99 %
3 c.l. in one ovary	1	1.15 %
2 c.l. in one ovary and		
1 c.l. in the other	5	5.75 %
Twin pregnancies with:		
3 c.l. in one ovary	2	2.30 %
2 c.l. in one ovary and		
1 c.l. in the other	6	6.90 %
2 c.l. in each ovary	1	1.15 %
Number of organs with one embryo lost	80	
Number of organs with two embryos lost	7	

only 20 out of 75 cases (26.7 %) when one ovum had been shed from each ovary. Of 138 cases with two ovulations in the right ovary, 33 or 23.91 % were lost. Out of 102 cases with two ovulations in the left ovary, 19 or 18.63 % were lost.

DISCUSSION

As discovered earlier by *Taneja* (1959) and *Basu et al.* (1961) the right ovary is also the most active in the goat. There is good agreement between the results reported by the authors mentioned and those found in this material. In this material an average of 57 % of the ovulations have occurred in the right ovary. In cases of multiple ovulations there appears to be a greater tendency for the first of these ovulations to occur in the right ovary (62.34 %). The ova which are shed later in the same follicular phase are more evenly distributed between the two ovaries. This observation has also been made in the sheep by *Casida et al.* (1966).

In all of our domesticated ruminants the right ovary is more active than the left. The small ruminants appear to be much alike as far as the relative functional activity of the right and left ovary is concerned.

In this material a maximum of three ovulations (three corpora lutea) from the same ovary has been recorded. With a maximum of three ovulations from each ovary it should be theoretically possible for 15 combinations of ovulations in the ovaries to occur. Quite a number of these combinations have occurred. In single pregnancies where only one follicle has ovulated, this ovum will erupt on the same side as the foetus is implanted in most of the cases (59.06 %), as would be expected. But in a surprisingly large number (40.94 %) the ovum will be shed from the opposite ovary.

It was most interesting to observe that in half of the twin pregnancies both corpora lutea were found in the same ovary. It was reasonable to expect that one ovum would have been shed from each ovary. The latter was the case in 40 % of the cases in this material. There seems to be a marked tendency in the goat to develop two mature follicles in the same ovary, in the same follicular phase. The same tendency does not seem to be present in the sheep according to *Casida et al.* The number of observations of triple pregnancies in this material is too small to justify any statement regarding the frequency of the various combinations of ovulations.

Some cases were also recorded where more foetuses were found than there were corpora lutea present in the ovaries. In five cases (3.68 %) of the twin pregnancies only one corpus luteum was found. Similarly, in one case of triple pregnancy only two corpora lutea were present in the ovaries. The sex was recorded in two of the pairs of twins. In one case both of the foetuses were male and in the other both were female. The triplets were all males. Six cases are presented here with one more foetus than the number of corpora lutea thus suggesting identical twins. On reviewing the literature it has not been possible to find any observations regarding identical twins in goats. *Assherton* (quoted by *Witten & Ferguson* 1948) in a sheep found a blastocyst with two distinct ectodermal masses lying within the trophoblast. This should indicate that identical twins in sheep do occur.

No additional precise observations of identical twins in the sheep seem to have been made. *Morley* (1948) estimates the occurrence of one-egg twins in the sheep to a maximum of 2 %. He arrives at this figure by evaluating the frequency of twins of the same sex in relation to twins of the opposite sex. If more pairs of twins of the same sex should occur, this should indicate the presence of identical twins. In the goat a frequency of 51.7 % of pairs of twins with the same sex has previously been found (*Lyngset* 1966b).

The question can be raised as to whether the occurrence of twin foetuses, even of the same sex, but with only one corpus luteum in the ovaries, is a criterium strong enough to establish that cases of one-egg twins occur.

Polynuclear ova and polyovular follicles occur in the goat (*Harrison* 1948). *Harrison* says: "A striking characteristic of the goat ovary is the presence of polynuclear ova and polyovular follicles". These should then theoretically be able to generate several foetuses. The polynuclear ova are mainly confined to the primordial stage of the oocyte, but are found in follicles containing two or three layers of granulosa cells. In only one case out of many thousands of polyovular follicles this follicle had developed beyond the primordial stage and reached a size of 550 μ . This was a two-ova follicle where one ovum showed signs of degeneration.

In another work, *Harrison* (1962) claims that only one case (the wild rabbit) has been described with a polyovular follicle

which has reached full maturity and ruptured. The great majority of these follicles atrophy or all except one of the ova die. The finding of two foetuses with only one corpus luteum can therefore in all probability be taken as an indication of the occurrence of identical twins.

In 87 cases, the number of corpora lutea surpassed the number of foetuses. These corpora lutea were macroscopically alike in appearance and can with certainty be said to be corpora lutea and not luteal cysts.

No remnants of foetuses or foetal membranes were to be found. In cases of early foetal death in the cow the foetus and the foetal membranes will not be completely absorbed, there will always be obvious remnants (*Phillipsen 1967*). Whether the situation is the same in the goat is not known. A definite tendency to the loss of one ovum when two are shed from the same ovary has been found. There can be several reasons for this. The second ovum to ovulate can be "weaker" than the first or the timing of ovulation in relation to mating can play a part. In the case of the goat it is not known how much time elapses between the first and the second ovulation when these take place in the same ovary. The second follicle may rupture so late in relation to mating that conception is disturbed. There also appears to be a higher death rate among ova shed from the right ovary (23.91 %) than those shed from the left one (18.63 %). This is just the opposite to what was found in sheep by *Casida et al.* These authors found a loss of ova of 35.5 % when they were shed from the right ovary and 40.6 % when they were from the left ovary.

The frequency of "ovum loss" in the goat has previously been studied by *Taneja*. In an investigation of 161 organs from pregnant goats he found that 2.4 % of the ova had been lost. *Dutt* (1954), in his material of sheep, found a 30 % loss of the embryo. *Casida et al.* found a similar frequency. A loss of 19—20 % of the embryos will be an important factor as far as the reduction of fertility in a goat stock is concerned.

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SUMMARY

1. A study of the functional activity in the ovaries was undertaken on 366 organs from pregnant goats and 171 organs from non-pregnant goats. The ovulations were recorded by the presence of corpora lutea in the ovaries.
2. The right ovary appears to be the most active in the goat, since 57 % of the ovulations occurred in the right ovary. In cases of multiple ovulations there appears to be a greater tendency for the first of these ovulations to occur in the right ovary (62.34 %).
3. In almost 50 % of twin pregnancies both ova will be shed from the same ovary.

4. In six cases, five twin pregnancies and one triplet pregnancy, only one, respectively two corpora lutea were found. This can in all probability be taken as an indication of the occurrence of identical twins.
5. The incidence of "ovum loss" or early embryonic mortality was found to be 19.6 %.

ZUSAMMENFASSUNG

Untersuchungen über die Reproduktion bei Ziegen.

III. Die funktionelle Aktivität in den Ovarien der Ziege.

1. Eine Untersuchung der funktionellen Aktivität in Ovarien wurde an 366 Organen von trächtigen und 171 Organen von nichtträchtigen Ziegen vorgenommen.
Die Ovulationen wurden durch Anwesenheit von Corpora lutea in den Ovarien registriert.
2. Auch bei der Ziege scheint das rechte Ovarium am aktivsten zu sein, da 57 % der Eier vom rechten Ovarium gelöst waren.
3. Bei Zwillingträchtigkeiten entstammen in fast 50 % der Fälle beide Eier demselben Ovarium.
4. Es wurden 6 Fälle von eineiigen Zwillingen registriert.
5. Die Frequenz von „Ovum loss“ oder frühem Tod der Frucht war 19,6 %.

SAMMENDRAG

Undersøkelser over reproduksjon hos geit.

III. Den funksjonelle aktiviteten i ovariene hos geit.

1. Det er foretatt en undersøkelse av den funksjonelle aktiviteten i ovariene ved undersøkelse av 366 organer fra drektige og 171 organer fra ikke drektige geiter. Ovulasjonene er registrert ved tilstedeværelse av corpora lutea i ovariene.
2. Høyre ovarium synes å være det mest aktive også hos geit, idet 57 % av eggene er løsnet fra høyre ovarium.
3. Ved tvillingdrektheter vil i nesten 50 % af tilfellene begge eggene løsne fra samme eggstokk.
4. Det er registrert 6 tilfeller av eneggete tvillinger.
5. Frekvensen av „ovum loss“ eller tidlig fosterdød er funnet å være 19,6 %.

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