

From the Department of Reproductive Physiology and Pathology,
Veterinary College of Norway, Oslo.

STUDIES ON REPRODUCTION IN THE GOAT

I. THE NORMAL GENITAL ORGANS OF THE NON-PREGNANT GOAT

By

Olav Lyngset

The goat, *Capra hircus*, is one of the oldest domesticated animals. The domestication probably took place in Turkestan sometime in the 5th millennium B.C. Of the two wild species, *Capra aegagrus* and *Capra falconeri*, *Capra aegagrus* is considered to be the most probable ancestor of most of the tame goats (*Berge* 1953). The goat is a typical mountain and flock animal, and as a domestic animal it has not been much appreciated or valued. The expression "the poor man's cow" is characteristic of the position it has occupied in comparison with the other domesticated animals. Little work has been done with breeding and the improvement of the race. There are no breeds of goats that in production or usefulness are comparable to the most refined breeds within the other species of domesticated animals. As far as size is concerned the goat should be well suited as an experimental animal, but it is rarely used in investigations or for experimental purposes. In most text books on veterinary medicine, regardless of the subject discussed, sheep and goats are mentioned as a single entity. In cases where experimental examinations have been necessary they are usually carried out on sheep. It is hardly correct in all situations to draw direct parallels between these two animal species.

The morphology of the genital organs of the goat receives little mention in text books or special publications. The only biometrical study of the sex organs of the goat which appears to have been done comes from India. *Basu et al.* (1961) examined 85 sex organs from goats of which 74 were pregnant. The authors

report the size of the various parts of the organs and, although not thus indicated, it is natural to assume that these figures are based on organs from non-pregnant animals, 11 in all. *Hadi* (1964—65) examined 45 genital organs from non-pregnant goats. The organs were amputated caudally to the cervix and the biochemical data include only the cervix and those parts of the genital tract

Table 1. Earlier biometrical observations on the genital organs of the female goat (cm and g).

Part of organ	Mean values					Authors	
Right ovary	length	1.37 ^a	1.54 ^b	1—1.8 ^c	1.5 ^d	1.5 ^e	a. <i>Hadi</i> (1964—65)
	width	0.73 ^a	0.83 ^b	1—1.8 ^c			b. <i>Basu et al.</i> (1961)
	depth	0.95 ^a	1.12 ^b				c. <i>Kock</i> (1963)
	weight	1.02 ^b					d. <i>Ellenberger & Baum</i> (1943)
Left ovary	length	1.40 ^a	1.54 ^b				e. <i>Nickel et al.</i> (1960)
	width	0.72 ^a	0.86 ^b				
	depth	0.85 ^a	1.12 ^b				
Right Fallop. tube	length*	22.50 ^a	14—16 ^c	14—16 ^d	14—15 ^e		
Left Fallop. tube	length*	23.68 ^a	14—16 ^c	14—16 ^d	14—15 ^e		
Right uterine horn	length	12.10 ^b	21—29 ^d				
Left uterine horn	length	11.91 ^b	21—29 ^d				
Corpus uteri	length	1.39 ^a	1.96 ^b	1.5—1.9 ^d			
Cervix	length	2.49 ^a	4.09 ^b	5—6 ^c	3.5—6 ^d	3.0 ^e	
	breadth	1.28 ^a					
Vagina	length	7.80 ^b					
Vestibulum	length						
Rima vulvae	length						

* Length of Fallopian tube includes that of uterine horn.

which lie cranially to the cervix. Table 1 contains a survey on the measurements of various parts of the genital organs of the goat which have been reported in the literature.

In an attempt to obtain a better knowledge of the physiology and pathology of reproduction in the goat, a number of examinations have been undertaken in this field since 1963. In 1964 a study of the sex organs of goats, based on material from slaughterhouses, was started. The primary intention with the study was

to obtain a survey on the frequency of pathological changes in the genital tract. Later a biometrical evaluation of the different parts of the organs and the recording of the functional activity of the ovaries were included. A total number of 1020 genital organs were examined whereof 397 were from goats in various stages of pregnancy. A survey on the examinations performed on normal, non-pregnant sex organs follows.

MATERIAL AND METHODS

Out of a total of 623 sex organs from non-pregnant goats which were examined, the biometrical observations in the present paper comprise 221 organs. Only organs where no pathological changes could be macroscopically observed were used. No information regarding the animals was available. Immediately after exvisceration in the slaughterhouse the organs were placed in plastic bags and deep-frozen for transport to the laboratory. They were either examined immediately on reception or placed in the freezing room until examination. Before examination the organs were thawed in tap water (temperature 5—10°C). They were examined as quickly as possible after thawing and were left in water from the time they were thawed until they were examined. A few organs were examined immediately after exvisceration. A slide rule (Somet) with a nonius scale was used for the measurement of the length, breadth and thickness of the ovaries and for the measurement of the corpora lutea and follicles.

The ovaries were dissected clean and during measurement lay on a level slab. Their length was determined as the maximal distance from pole to pole along an axis parallel to the ovarian mesenterial attachment. The breadth was measured as the greatest distance along an axis vertical to the longitudinal axis, and the thickness as the greatest distance along an axis at right angles to the other two axes.

The corpus luteum was enucleated and the diameter was measured after enucleation as the largest diameter when the organ lay with its own weight on a level slab. The follicles in most cases were measured in situ and only those clearly visible on the surface were measured. In a few cases the follicles were dissected free and the diameter measured directly.

The other parts of the organs were measured with a metal tape measure on which a sliding marker was mounted to make

reading easier and more accurate. The oviducts and the uterine horns were dissected free from the ligaments and placed on a level slab without being stretched.

The Fallopian tubes were measured from the Infundibulum tubae to Ostium uterinum tubae. The uterine horns were dissected and their length measured internally from the bifurcation to Ostium uterinum tubae. The length of the uterine body was measured from the bifurcation to the internal os of the cervix. The length of the uterine body, cervix, vagina and vestibule were also measured on the dissected organ. The organs were sliced dorsally. The thickness of the cervix and the length of the Rima vulvae were measured before dissection. The vagina was measured from the external cervical os (Os externum cervix uteri) to the junction with the vestibule, and the vestibule from the vaginovestibule junction to the clitoris. The clitoris was not measured in the normal material. The ovaries and corpora lutea were weighed on a Mettler scale with an accuracy of ± 30 mg.

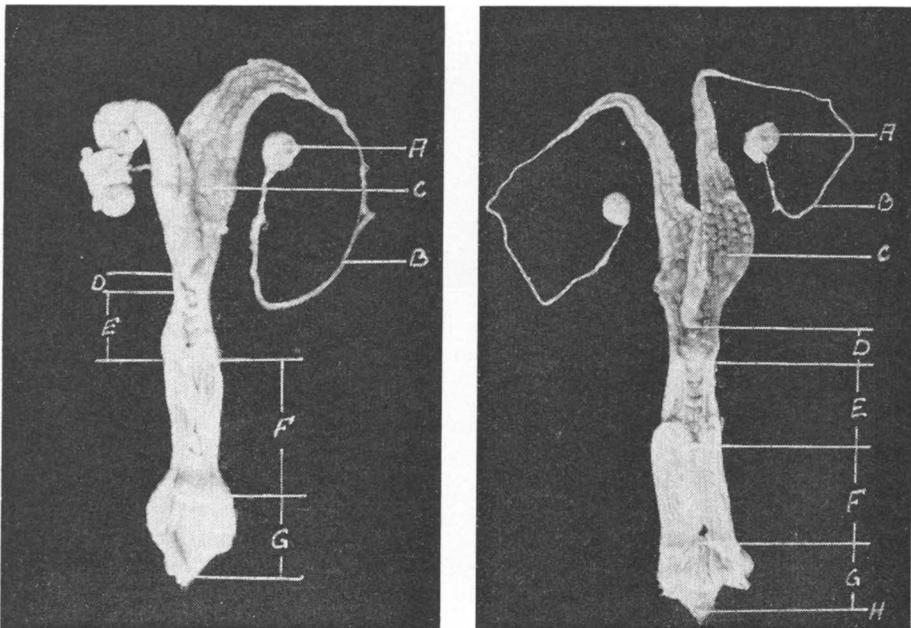


Figure 1. The genital organs of the non-pregnant goat.
A. Ovary, B. Fallopian tube, C. Uterus, D. Corpus of uterus, E. Cervix,
F. Vagina, G. Vestibulum, H. Clitoris.

RESULTS

1. *General observations*

A photograph of the genital tract of an adult goat is presented in Fig. 1. The organ has been opened and the uterine horns and tubes dissected free from the ligaments. The various parts of the organs — the ovaries, the tubes, the uterine horns with the body of the uterus, the cervix, the vagina, the vestibule with the clitoris — are marked.

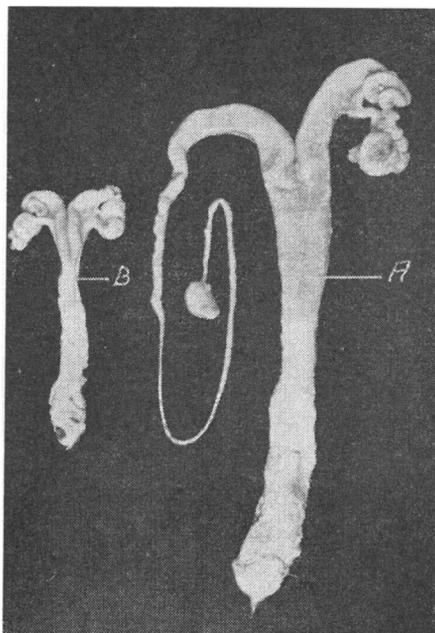


Figure 2. A. The genital organs of a multipar goat. B. The genital organs of a nullipar goat (about 9 months old).

Fig. 2 shows the genital organs of an adult goat placed beside the organs from a young, nulliparous goat. The difference in size is considerable. The young goat is slaughtered in its first sexual season, 8—9 months old.

When compared with the cow the ovaries of the goat are relatively large. Text books usually describe them as being round or oval (*Ellenberger & Baum 1943, Nickel et al. 1960*) and this is the most common type, but they can have very different shapes and appearances. Usually the longest axis of the ovary is parallel to the mesenteric attachment, but they may also be spherical or

have their longest axis at a different angle to the attachment. Fig. 3 shows a number of ovaries with different morphology. Some of the most common shapes of the ovaries are: Heart-shaped, long and narrow, many-sided and almost horseshoe-shaped. In some cases they are almost completely adhered to the bursa. In these cases it is impossible to separate the bursa from the ovary. This does not necessarily have any significance as far as ovulation and the reception of the egg in, and its transport through, the tubes are concerned.

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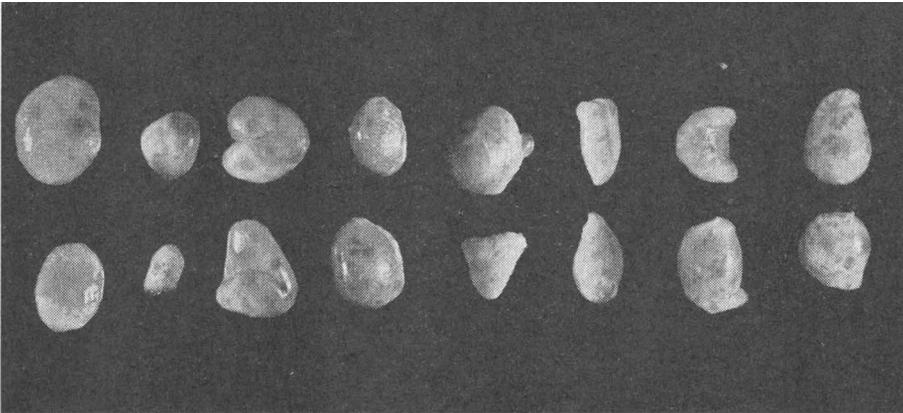


Figure 3. The morphology of the ovaries of the goat. * An ovary with 1—2 mm long thread-like connective tissue fibres on the surface.

The ovaries are smooth and shiny with a colour and consistency which is dependent upon their condition — whether they are active, containing follicles or corpora lutea, or inactive. The ovaries that contain many small follicles have a spongy appearance. The large follicles are prominent on the surface with a bluish tinge. In cases where several large follicles are found, the ovary may resemble a cluster of grapes. The presence of corpus luteum in the ovary gives it a pale pink appearance. One or more corpora lutea can fill an ovary so completely that it may be difficult to identify any interstitial tissue. Corpus luteum in the ovary will also increase its size. In a few cases the surface of the ovary was covered with small, 1—2 mm long, thread-like, very resilient connective tissue fibres. An example of such an ovary is marked * in Fig. 3.

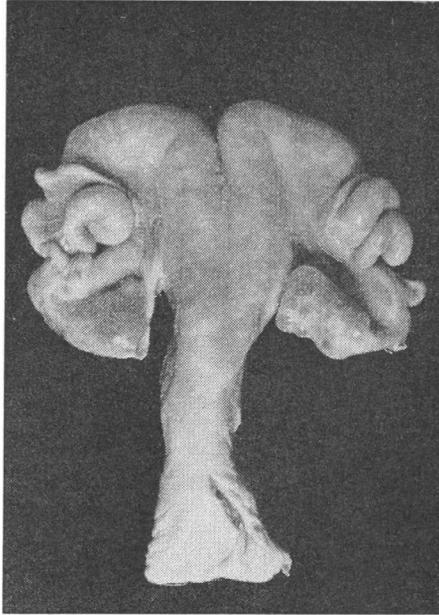


Figure 4. The uterus of the goat showing the spiral form of the uterine horns.

The tubes are relatively long and sinuous. The uterine horns are long and coiled. This is clearly shown in Fig. 4. The formation of a spiral is more marked than in the cow. On dissection the mucous membrane is found to be smooth and shiny and often covered with some mucus. The caruncles are very distinct even in nulliparous animals. Greyish-black to black pigmentation, especially of the caruncles, but also of the intercaruncular endometrium, can now and again be seen. This pigmentation can include the whole uterine mucous membrane. Fig. 5 shows an organ where it is the caruncles mainly that are pigmented. In this study complete or partial pigmentation of the uterine mucous membrane has been found in 5—10 % of the material. *Nickel et al.* claim that this pigmentation is very usual in the sheep and that it occurs very rarely in the goat. In the present material the pigmentation seems to occur relatively frequently. Pigmentation has not been recorded in juvenile, nulliparous animals, but the material contains few animals in this category. Neither is pigmentation seen in pregnant animals. In the sheep this pigmentation occurs in all phases

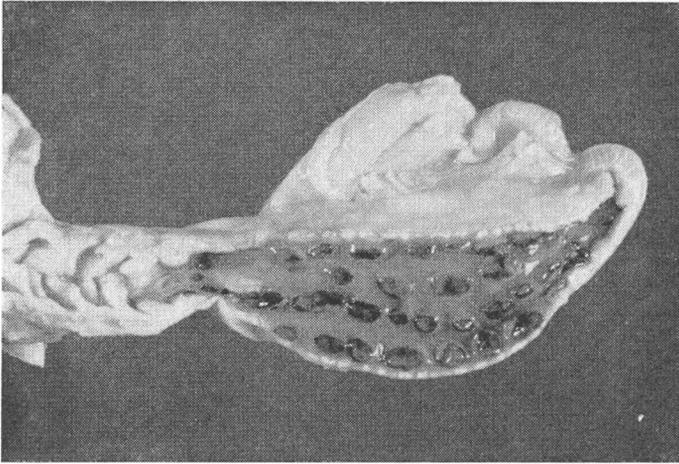


Figure 5. The uterus of a goat with black pigmentation of the caruncles.

of the oestrous cycle, in juvenile, sexually mature and pregnant animals. The pigment is assumed to be melanin (*Nickel et al.*).

The body of the uterus is short, 0.5—3.5 cm, and joins with the cervix which feels firm and fibrous and in consistency is quite different from the rest of the organ. The cervix is divided up by 5—8 transversal folds. These folds close the cervical canal so that it is only possible to pass a catheter 0.5 cm into the canal. The appearance of the external uterine orifice or portio vaginalis varies a great deal with age and with the stage of the cycle, and there are also large individual variations.

In most cases the portio vaginalis protrudes tap-like into the vagina. In some individuals the tap-like formation is very pronounced, but in others it is simply continuous with the bottom of the vagina. In some cases the outer orifice is lobular with a dorsal and ventral lip, but in most cases there are no definite divisions or lobules. It is possible to a certain degree to determine the stage of the cycle with the help of a vaginal speculum (*Lyngset*, unpublished).

Black pigmentation may also occur in the mucous membrane of the vestibule, just as in the mucous membrane of the uterus. It can occur in spots or involve only a part of the vestibule, but often the whole of the vestibule and the clitoris is pigmented. Fig. 6 shows a case where most of the mucous membrane is pigmented.

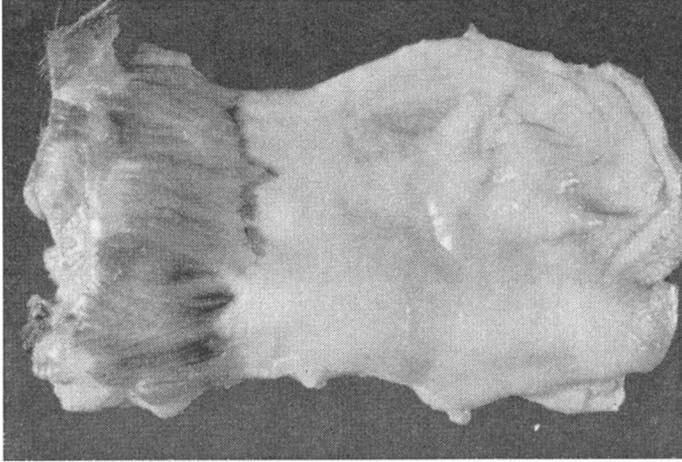


Figure 6. Vestibulum of a goat with black pigmentation.

The intensity of the pigmentation varies somewhat as shown in the figure. The colour in the mucous membrane stops along a sharp line at the junction of the vestibule and vagina. It has not been possible to find any description in the literature of this form of pigmentation in the goat. In this material the frequency of pigmentation of the vestibule was found to be about 1 %. This type of pigmentation hardly has any special significance and must almost be characterized as a normal but rare condition. Similar pigmentation was not observed in the vagina. It is peculiar that this pigmentation should occur in the vestibule, but not in the vagina. Whether or not melanin, as described in the uterus of the sheep, is the factor here is not known.

The clitoris in the goat does not protrude far out of the Fossa clitoridis and normally should not be visible between the lips of the vulva.

2. Results of the measurements

Table 2 contains the results of the measurements of the various organs. The table includes the number of organs measured, the average measurement and the standard deviation. There is some variation in the number of measurements undertaken for each organ and there are especially few for the length of the tubes.

Table 2. Biometrical observations on the genital organs of the normal non-pregnant goat (cm and g).

		No. of obs.	Mean	s
Right ovary	length	220	2.21	0.39
	width	220	1.67	0.34
	depth	220	1.15	0.26
	weight	216	2.37	0.37
Left ovary	length	218	2.14	0.40
	width	218	1.62	0.33
	depth	218	1.12	0.30
	weight	218	2.14	0.34
Right uterine horn	length	161	23.12	5.23
Left uterine horn	length	162	23.84	5.30
Corpus uteri	length	156	1.36	0.18
Cervix	length	166	5.73	0.35
	breadth	160	1.60	0.19
Vagina	length	123	7.30	0.38
Vestibulum	length	109	3.59	0.20
Rima vulvae	length	59	1.73	0.21
Right Fallop. tube	length	10	19.71	4.41
Left Fallop. tube	length	10	19.87	4.30

It will be of interest to observe the size of the ovaries, and how this is dependent on the presence of one or more corpora lutea. Table 3 shows the average length, breadth, thickness and weight of the right and left ovary, without corpus luteum present,

Table 3. Variation in the size of the ovaries in relation to the number of corpus luteum (c.l.) in cm.

		No c.l.		One c.l.		Two c.l.	
		no. of obs.	mean value	no. of obs.	mean value	no. of obs.	mean value
Right ovary	length	114	2.09	81	2.30	25	2.45
	width	114	1.53	81	1.80	25	1.91
	depth	114	1.04	81	1.25	25	1.29
	weight	111	1.91	80	2.81	25	3.00
Left ovary	length	135	2.02	71	2.30	12	2.59
	width	135	1.54	71	1.70	12	1.94
	depth	135	1.04	71	1.22	12	1.49
	weight	136	1.81	70	2.53	12	3.50

Table 4. Diameter and weight of the corpus luteum (cm and g).

Corpus luteum (c.l.)		No. of obs.	Mean	s
c.l. in right ovary	diameter	106	1.35	0.26
	weight	69	0.75	
c.l. in left ovary	diameter	84	1.32	0.22
	weight	51	0.76	
c.l. in both ovaries	diameter	190	1.33	
	weight	120	0.76	
One c.l. in right ovary	diameter	81	1.36	
Two c.l. in right ovary	diameter	25	1.25	
One c.l. in left ovary	diameter	72	1.31	
Two c.l. in left ovary	diameter	12	1.32	

and with one and two corpora lutea present. The size of the corpus luteum — the diameter and weight, can be seen in Table 4. The table gives the results for the left and right ovary individually and together. The size of the corpus luteum in cases with one or two respectively in the same ovary is also shown.

DISCUSSION

When the measurements of the size of the genital organs of the goat here undertaken (Table 2) are compared with earlier reported values a certain discrepancy is found. The measurement values in this material for all dimensions of the ovaries are higher than those given by *Basu et al.* (1961) and *Hadi* (1964—65). While *Hadi* reports an average length of the right ovary of 1.37 cm, a length of 2.21 cm has been found in the present material, a difference of almost 1 cm. The explanation for this great difference must be that the breed of goat from which *Hadi's* material is collected is of a smaller size than the breeds from which this material is gathered. None of the authors referred to in Table 1 have defined what they mean by the terms length, breadth and thickness of the ovaries. In this material it is by no means always the case that the length of the ovary quoted represents the largest dimension. As already mentioned the morphology of the ovaries varies greatly, and in many cases the breadth may be greater than the length.

The usual anatomy text books do not mention any difference in the size of the two ovaries. *Basu et al.* found the length and breadth of the two to be the same while the left ovary was a little broader than the right. *Hadi* found that the left ovary was somewhat longer than the right while the other dimensions were greatest in the right one. In this material the right ovary was found to be a little larger than the left in all dimensions. The difference is not statistically significant.

There are several indications that the right ovary in the goat is the most active (*Taneja 1959, Basu et al., Lyngset 1968*). It seems quite natural that the most active organ of a pair will also be the larger. In cattle where the right ovary is also shown to be the most active, *Reece & Turner (1938)* among others found the weight of the right ovary to be higher than the left. In this material the right ovary also proved to be heavier than the left, the means being 2.37 g and 2.14 g respectively, but the difference is not significant.

Taneja and *Basu et al.* found in their material that the foetuses are most frequently located in the right uterine horn. *Basu et al.* also found that the right uterine horn was somewhat larger than the left.

In this material, however, the left uterine horn is longer than the right, the means being 23.84 cm and 23.12 cm respectively. This is in agreement with *Hadi's* results. It was presumed that the right horn would be the largest since it is functionally the most active. The difference in size of the two horns of the uterus is not statistically significant.

The body of the uterus is short in the goat, the mean length being 1.36 cm. The cervix, on the other hand, is long, an average of 5.73 cm. This figure agrees well with that given by *Kock (1963)*. In this material the length of cervix is greater than that reported for slaughter heifers by *Drennan & Macpherson (1966)*.

In the present study the vagina and vestibule were measured independently which does not seem to have been the usual practice in other works. The division between the vagina and the vestibule is very distinct, and measuring does not present any technical problems. The average length of the vagina is 7.30 cm and of the vestibule 3.59 cm. The tubes were also measured, although not very many of them. The average of the right and left tube is 19.71 cm and 19.87 cm respectively.

As expected, the size of the ovaries is dependent upon the

presence of corpus luteum. This is shown in Table 3. The ovaries increase in size if they contain one or more corpora lutea. When there are two corpora lutea in the same ovary, the left is larger than the right, but the number of observations made in this group are few. Table 4 shows the size, diameter and weight of the corpus luteum. There is no statistically significant difference in the size of the corpus luteum whether localized in the right or the left ovary. It would be natural to suppose that when there are two corpora lutea in the same ovary these would on the average be smaller than when only one is present. This does not seem to be the case since the difference is not statistically significant.

The method of measurement used is obviously open to criticism. Measurement of such flexible material as organs will always present great difficulties. The measurements here are made according to strictly defined rules and following a carefully standardized method so as to reduce errors to a minimum. Each measurement quoted is an average of two measurements. The most serious objection to the method must involve the deep-freezing and subsequent thawing of the organs. This method is used by *Cowan & Macpherson* (1966) in a study of the sex organs from sows. These authors did not discuss the possible effect of freezing and thawing on the organs and thereby on the measurements. It must therefore be assumed that they did not consider that freezing and thawing had any effect on the results. In order to make it at all possible to collect and work-up a representative material on the goat the method used was the only alternative. Freezing and thawing does not seem to have any significant effect on the size and shape of the organ. Since it is of prime importance in this connection that the organs are not allowed to dry out they were frozen and stored in plastic bags.

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SUMMARY

1. A study of 221 genital organs from non-pregnant goats is reported.
2. The ovaries of the goat are relatively large. They are usually round or oval-shaped, but other shapes frequently occur (heart-shape or almost horseshoe-shape).
The size, shape and consistency will vary with the presence of follicles or corpora lutea. The average weight of the two ovaries is found to be 2.37 g for the right one and 2.14 g for the left.
3. The uterine horns are long with a pronounced spiral formation. The uterine body is short, 0.5—3.5 cm. Complete or partial black pigmentation of the uterine mucous membrane is found in 5—10 % of the material.
4. The average length of the cervix is found to be 5.7 cm. The cervix is divided by 5—8 transversal folds.
5. The average length of the vagina and vestibule combined is about 11 cm. A black pigmentation of the mucous membrane of the vestibule, involving all or only part of it, is observed.
6. The size of the corpus luteum is recorded. There is no difference in the size of the corpus luteum whether it is located in the left or right ovary or whether there are one or two corpora lutea present in the same ovary.

ZUSAMMENFASSUNG

Untersuchungen über die Reproduktion bei Ziegen.

I. Die Genitalorgane bei normalen nichtträchtigen Ziegen.

1. Eine Untersuchung von 221 Genitalorganen von normalen nichtträchtigen Ziegen ist vorgenommen worden.

2. Die Ovarien der Ziege sind relativ gross. Die Form ist gewöhnlich rund oder oval, jedoch kommen andere Formen häufig vor (herzförmig, annähernd hufeisenförmig). Die Form, Grösse und Konsistenz hängt von der Anwesenheit von Follikeln und Corpora lutea ab. Die Durchschnittsgewichte der beiden Ovarien betragen 2,37 g für das rechte und 2,14 g für das linke Ovarium.
3. Die Gebärmutterhörner sind lang und ausgesprochen spiralförmig. Corpus uteri ist kurz, 0,5—3,5 cm. Bei 5—10 % des untersuchten Materials wurde eine völlige oder partielle schwarze Pigmentierung der Uterusschleimhaut festgestellt.
4. Die durchschnittliche Länge von Zervix betrug 5,7 cm. Zervix wird von 5—8 querlaufenden Falten eingeteilt.
5. Die gesamte Länge von Vagina und Vestibulum ist durchschnittlich 11 cm. Es wurde eine Schwarzpigmentierung der Schleimhaut von Vestibulum beobachtet. Die Pigmentierung kann entweder die ganze Schleimhaut oder nur Teile derselben umfassen.
6. Die Grösse von Corpus luteum wurde registriert. Es zeigte sich, dass die Grösse des Corpus luteum unabhängig davon ist, ob dieses sich um rechten oder linken Ovarium befindet oder ob ein oder zwei Corpora lutea im selben Ovarium zugegen sind.

SAMMENDRAG

Undersøkelser over reproduksjonen hos geit.

I. Genitalorganer hos normale ikke drektige geiter.

1. Det er foretatt en undersøkelse av 221 genitalorganer fra normale ikke drektige geiter.
2. Ovariene hos geit er relativt store. Formen er vanligvis rund eller oval, men andre former forekommer hyppig (hjerteformet, tilnærmet hestekoformede).
Form, størrelse og konsistens vil variere med tilstedeværelse av follikler og corpora lutea. Gjennomsnittsvektene for de to ovariene er funnet å være 2,37 g for det høyre og 2,14 g for det venstre.
3. Uterushornene er lange med uttalt spiralform. Corpus uteri er kort, 0,5—3,5 cm. Det er funnet hel eller delvis svart pigmentering av uterusslimhinnen i 5—10 % av materialet.
4. Det er funnet en gjennomsnittlig lengde av cervix på 5,7 cm. Cervix deles opp av 5—8 tverrgående folder.
5. Vagina og vestibulum har tilsammen en lengde på ca. 11 cm i gjennomsnitt. Det er iaktatt en svartpigmentering av slimhinnen i vestibulum. Pigmenteringen kan omfatte hele eller bare deler av slimhinnen.
6. Størrelsen av corpus luteum er registrert. Det er ingen forskjell i størrelsen av corpus luteum om det er lokalisert i høyre eller venstre ovarium, eller om det er ett eller to corpora lutea tilstede i samme ovarium.

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