THE ANATOMICAL STUDIES OF THE STOMACH OF THE GOAT I. THE POST-NATAL DEVELOPMENT OF THE STOMACH WITH SPECIAL REFERENCE TO THE WEANING AND PROLONGED SUCKLING

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I. THE POST-NATAL DEVELOPMENT OF THE STOMACH WITH SPECIAL REFERENCE TO THE WEANING AND PROLONGED SUCKLING

By

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Introduction

Although detailed observations have been made on the anatomy of the stomach of the ox, only scant attention has been paid to that of the goat. In view of the fact that most investigations concerning the digestion of the ruminants are made with the goat, it is necessary to obtain further and precise informations on the anatomy of the stomach of the goat.

According to Sisson (1) the stomach of the ruminant consists of four parts, rumen, reticulum, omasum and abomasum, and takes its form early in fetal life. The former three parts are oesophageal sacculations covered with stratified squamous and non-glandular epithelium, while the abomasum has a simple columnar and glandular one, and is termed the 'true stomach'. The relative sizes of these four parts of the ox vary with age, in correlation with the nature of food. In the new-born calf the rumen and reticulum together are about half as large as the abomasum, and in ten or 12 weeks this ratio is reversed. At four months the rumen and reticulum together are about four times as large as the omasum and abomasum together.

The development of the four parts of the stomach of the ox above mentioned is closely related with the change of food, since the reversion of the ratio of stomach volume takes place just at the time of weaning. However very littile is known about the mechanism of the post-natal development of the stomach correlating with changes of food.

Yoshikawa(2) studied the anatomy of the digestive organs of the so-called 'Kiso horse', a breed of horse peculiar to the Kiso district in Japan, and reported that its caecum and colon are extraordinary large, lying in the right half of the abdominal cavity, and that this unusual arrangement of the large

intestines may be due to the nature of food, since the 'Kiso horse' is usually fed on forage. His results suggest that the stomach and intestines of herbivorous animals such as the horse and ox may be directly affected by the nature of the food.

The present investigation deals with the post-natal development of the stomach of the goat with special reference to the effect of food at the time of weaning, to obtain more and detailed knowledge on the functional anatomy of the stomach of ruminating domestic animals.

Materials and Methods

31 young goats of Saanen breed of various age, from new-born to 72 days, were used. All of them were killed by cutting the carotid vein without anaesthesia. The general arrangement of the stomach together with other digestive organs was observed immediately after their death. The age, body weight and other details are given in Table 1.

Table 1. Materials used.

Stage	Age (Days)	Body weight (kg.)	Food	No. of individuals
I	1	2.3	Milk	025
	2	2.8	,,	027
II	3	2.1	,,	023
	4	2.1	,,	024
	4	2.1	,,	026
III	2	—	,,	311
	9	1.7	,,	017
	10	2.8	,,	013
IV	16	2.5	,,	012
	16	7.1	,,	028
V	25	2.8	,,	005
VI-A	32	6.0	,,	021
	35	7.2	,,	011
	36	3.3	,,	296
	38	7.7	,,	291
VI-B	37	2.5	Grass	297
	40	7.6	,,	292
	ca40	6.8	,,	287
	ca40	3.2	,,	288
	ca40	3.5	,,	810
	ca40	5.0	,,	811
VII-A	53	5.5	Milk	003
	61	7.6	,,	293
	72	5.6	,,	007
VII-B	ca50	6.8	Grass	814
	53	5.1	,,	002
	58	3.2	,,	294
	60	5.3	,,	004
	64	5.0	,,	018
	66	3.8	,,	016
	68	7.5	,,	022

Results

As shown in Table 1, the animals were divided into nine groups according to their ages and food. The descriptions of each stage are as follows:

1. Results obtained for the suckling goats.

I. 1–2 days suckling group (Figs. 1–2).

The rumen: It is very small and lies in the upper side of the abdominal cavity. To the left its anterior extremity is separated from the reticulum by the rumino-reticular groove (Sulcus ruminis reticularis) at a point opposite to the ninth or tenth rib, while to the right it is connected with the reticular groove (Sulcus reticuli) at a point opposite to the eighth intercostal space. The posterior extremity of the rumen is divided into dorsal and ventral blind sacs by the deep posterior groove (Sulcus ruminis caudalis). The posterior dorsal blind sac reaches a short distance before the point opposite to the third lumblar vertebra, and the ventral one at the point opposite to the twelfth rib or the first lumblar vertebra. Accordingly a straight line which connects both ends of these two sacs passes dorso-ventrally and forward to the anterior ventral angle of the adbominal cavity (Fig. 1).

The reticulum: It lies just before the rumen and is connected with the anterior extremity of the dorsal sac of the rumen. Its parietal or diaphragmatic surface (Facies diaphragmatica) lies against the diaphragm and liver at a point opposite to the sixth or seventh rib. A part of the left lobe of the liver lies between the diaphragm and reticulum. As mentioned above, the reticulum is separated from the rumen backward by the rumino-reticular groove and reticular groove. Ventrally and backward it is also connected with the upper part of the omasum by a very short narrow neck (Collum omasi), and ventrally it is in contact with the anterior part of the body of the abomasum (Fig. 2).

The omasum: It is very small and lies in the middle part of the abdominal cavity opposite to the eighth or ninth rib. It is also connected with the abomasum as well as with the reticulum, but is not in contact with the rumen.

The abomasum: It is very large and occupies the lower half of the abdominal cavity. Forward it faces the diaphragm at a point opposite to the sixth or seventh rib, though a part of the left lobe of the liver is located between them. The body of the abomasum extends backward and then turns dorsally at a point opposite to the third or fifth lumblar vertebra according to the degree of its fullness. Ventrally it lies directly on the abdominal floor, and dorsally it is related to the small intestine covered with the greater omentum. Its greater curvature faces the left flank passing ventrally and backward.

As mentioned above, the reticular groove begins at the point opposite to the eighth rib or eighth intercostal space and a short distance to the left of

the median plane and passes almost vertically.

The intestines: The duodenum, beginning at the pylorus, first passes dorsally and forward, and then forms a S-shaped curve (Anas sigmoidea). Next it extends backward and then turns forward forming the illiac flexture. The remainder of the small intestines run in numerous coils forming a sort of festoon surrounding the colon (Fig. 2).

The coils of the colon are solid and may be regarded as a cylinder, the convex side of which faces to the left and sometimes ventrally. The caecum becomes in contact with the upper part of the right flank at a point opposite the fourth or fifth lumblar vertebra, and extends backward and almost horizontally, the blind end of which lies just before the pelvic inlet. This blind end of the caecum is subject to variation in its position, i. e., it sometimes turns downward or laterally.

The intestine, as a whole, chiefly occupies the left half of the abdominal cavity except the S-shaped part of the duodenum, which is in contact with the right side of the posterior ventral blind sac of the rumen (Fig. 1).

The liver: Its right and middle lobes cover the rumen, reticulum and omasum dorsally and laterally under the right ribs as well as the right costal portion of the diaphragm. Dorsally they also cover the anterior part of the abomasum. The posterior part of the abomasum together with its pyloric part is not covered by the liver, but is directly in contact with the right flank and the right costal portion of the diaphragm. As already mentioned, the left lobe of the liver lies in the anterior end of the abdominal cavity, and is related to the diaphragm as well as the diaphragmatic surface of the reticulum and abomasum.

The spleen: It is relatively large compared with the rumen. Therefore, its visceral surface is widely related to the vestibule and dorsal sac of the rumen.

II. 3–4 days suckling group (Figs. 3-4).

The rumen: It begins to develop, and the ventral sac extends backward to a point opposite to the third lumblar vertebra. The dorsal sac of the rumen, however, still remains unstretched beyond the third lumblar vertebra. Accordingly the straight line which connects both ends of these two sacs becomes almost vertical to the long axis of the body. On the other hand, the rumen strectches downward to the middle of the abdominal cavity and its bottom partially comes in contact with the abomasum (Fig. 3).

The positions of the rumino-reticular groove and reticular groove are the same as those in Stage I, namely, the former opposes the ninth or tenth rib, and the latter the eighth intercostal space.

The reticulum: It becomes a little larger, its parietal surface lying against the diaphragm and a part of the left lobe of the liver at a point opposite to

the seventh intercostal space or eighth rib. It is also connected with the omasum as already mentioned (Fig. 4).

The omasum : It shows no remarkable changes in its size and position, but it is now in contact with the right side of the ventral sac of the rumen, since the latter extends downward towards the omasum.

The abomasum : It is related with the left lobe of the liver at a point opposite to the seventh intercostal space or eighth rib just as in the case with the reticulum. It is still large and occupies the lower half of the abdominal cavity (Fig. 4).

The intestines : As a result of the extension of the rumen, the S-shaped curve of the duodenum is now related to the right anterior groove (Sulcus ruminis cranialis dexter) of the rumen.

The size and position of the caecum and colon show no remarkable change, and the latter is cylindrical as before. The intestines, as a whole, are still found in the upper posterior part of the abdominal cavity.

The liver : The posterior blind sac of the rumen is now uncovered by the liver, and is in direct contact with the right flank. The left lobe of the liver is found between the stomach and diaphragm as before.

The spleen : It is now only related to the vestibule and the anterior half of the dorsal sac of the rumen, since its growth is relatively small compared with that of the rumen (Fig. 4).

III. 7–10 days suckling group (Fig. 5).

The rumen : The ventral sac of the rumen extends backward beyond the dorsal one and ends at a short distance before the fourth lumblar vertebra. Accordingly the straight line which connects both ends of these two sacs passes almost vertically and slightly backward. Meanwhile the rumen extends downward and its ventral sac is now in contact with the abomasum laterally as well as dorsally. Namely, it is now related to the left dorsal part of the body of the abomasum (Fig. 5).

The rumino-reticular groove lies between the eighth and ninth rib, and passes almost parallel to them. The reticular groove lies against the ninth or tenth rib.

The reticulum : The parietal surface of it still lies against the diaphragm as well as the left lobe of the liver at a point opposite to the seventh rib or seventh intercostal space. Otherwise no remarkable change in its size and position is observed.

The omasum : As a result of the downward extension of the rumen, the omasum is now in contact with the right side of the anterior ventral blind sac of the rumen, and opposes the tenth or eleventh rib at a half level of the abdominal cavity. It is small as before.

The abomasum : It still occupies the lower half of the abdominal cavity.

Forward it lies against the diaphragm and the liver at a point opposite to the seventh rib or the seventh intercostal space, as in the case of the reticulum.

The intestines: The coils of the colon are cylindrical as before (Fig. 5). Otherwise, no noticeable change in their size and position is observed.

The liver and spleen: No remarkable change is found in their size and position.

IV. 16 days suckling group (Figs. 6–7).

The rumen: Its development is notable. The ventral sac of the rumen extends to a point opposite to the fourth lumblar vertebra, but the dorsal one still ends at a short distance beyond the third lumblar vertebra. Accordingly the straight line which connects both ends of them now inclines strongly backward and dorso-ventrally. Downward the ventral sac of the rumen now extends to almost the lower one-third level of the abdominal cavity, and is related widely to the upper and left wall of the body of the abomasum, though the pyloric part of the latter, when filled, is not in contact with it (Fig. 7).

The reticular groove opposes the ninth or tenth rib, and as a result of the extension of the rumen it inclines dorso-ventrally and somewhat backward. The rumino-reticular groove lies against the eighth intercostal space.

The reticulum: It begins to extend and its parietal surface lies against the diaphragm at a point opposite to the seventh rib, though a small part of the left lobe of the liver still remains between them.

The omasum: It is small as before, and is related to the abomasum and to the right of the vestibule of the rumen (Fig. 7).

The abomasum: It is still large and occupies the lower half of the abdominal cavity, its pyloric part lying against the fourth lumblar vertebra just behind the posterior blind sac of the rumen.

The intestines: The S-shaped curve of the duodenum lies to the right longitudinal groove of the rumen (Sulcus ruminis dexter), while some part of the small intestine is related to the right of the ventral sac of the rumen. The remainder of the intestines is found limited in the posterior upper part of the abdominal cavity. The coils of the colon is now discoidal rather than cylindrical.

The liver and spleen: The development of the liver and spleen is relatively small compared with that of the stomach. A very small part of the liver still remains between the diaphragm and reticulum as well as abomasum. The spleen now only covers the vestibule of the rumen.

V. 25 days suckling group (Figs. 8–9).

The rumen: It shows further development and its dorsal sac extends backward nearly to a point opposite to the fifth lumblar vertebra, while the ventral one to a point opposite to the sixth lumblar vertebra. Downward the ventral sac reaches about the lower one-third level of the abdominal cavity,

and is related dorsally to the left flank and abomasum (Fig. 8).

The rumino-reticular groove lies parallel to the eighth intercostal space, while the reticular groove opposes the ninth or tenth rib and inclines obviously backward.

The reticulum: It somewhat extends forward, and its parietal surface is now in direct contact with the diaphragm at a point opposite to the sixth intercostal space or the seventh rib.

The omasum: It is still small, but due to the extension of the rumen, it is now related to the right of the vestibule of the rumen.

The abomasum: It is moved aside to the left by the extension of the rumen, but is still large lying on the abdominal floor. Its pyloric part, when filled, lies against the third to the fifth lumblar vertebra, and dorsally it is widely in contact with the left posterior ventral coronary groove of the rumen (Sulcus coronarius ventralis caudalis), and ventrally with the left flank (Fig. 9).

The intestines: As already described in the Stage IV, the S-shaped curve of the duodenum is related to the right longitudinal groove of the rumen covered with some part of the jejunum as well as the greater omentum. The rest of the intestine lies chiefly to the right of the median plane, though a part of the jejunum and ilium still remains to the left. This part of the small intestine is in contact with the rumen and abomasum as well as the left flank. The coils of the colon is flattened and is discoidal rather than cylindrical.

The liver and spleen: The liver, as a whole, moves to the right of the median plane, and its left lobe is scarcely found between the reticulum and diaphragm. Accordingly the reticulum together with the abomasum is in direct contact with the diaphragm (Fig. 9).

The spleen is now attached to a small area of the dorsal curvature of the rumen at a point opposite to the eleventh to thirteenth rib.

2. Results obtained for the prolonged suckling and the post-weaning goats.

The goats from 30 to 72 days old were divided into two groups according to the nature of food, and noticeable difference of the anatomy of their stomach was found. These two groups are as follows:

A. Suckling group. The animals of this group were fully fed with hot market milk two times a day using a glass cylinder provided with a rubber cap at its end. They were kept within a pen to prevent them from eating other foods.

B. Post-weaning group. The animals of this group were pastured and allowed to graze all day long.

VI-A. 32-38 days prolonged suckling group.

The rumen: Its development is greatly reduced. Its dorsal sac ends at a point opposite to the fifth lumblar vertebra, while the ventral sac at a point opposite to the sixth lumblar vertebra. Ventrally it lies on the abdominal floor, while forward it is related to the anterior part of the body of the abomasum which lies on the anterior half of the abdominal floor.

The rumino-reticular groove lies against the eighth or ninth rib, and the reticular groove against the ninth or tenth rib.

The reticulum: Its extension is reduced or almost stopped just as in the case of the rumen.

The omasum: It is small as before and related to the right of the vestibule of the rumen at a point opposite to the ninth to tenth rib.

The abomasum: As mentioned above, the abomasum lies on the abdominal floor. Dorsally it is related to the ventral sac of the rumen and forward it is in direct contact with the diaphragm at a point opposite to the sixth intercostal space. The pyloric part of the abomasum is related to the right of the posterior ventral coronary groove of the rumen.

The intestines, liver and spleen: Their arrangement and size are the same as those of the previous stage (Stage V).

VII-A. 53-72 days prolonged suckling group (Fig. 10).

The stomach: The general situation and size of the rumen, reticulum and omasum are similar to those of Stage VI, though the rumen shows little growth and reduces its size gradually day by day. The abomasum shows variation in its position according to its fullness. When filled, it occupies most of the lower half of the abdominal cavity (Fig. 10), while when empty, its pyloric part turns somewhat forward and is related to the right anterior groove of the rumen.

Other organs: The arrangement and size of the intestines, liver and spleen show no remarkable change from those of Stage VI-A.

VI and VII-B. 37-68 days post-weaning group (Figs. 11-12).

The rumen: It increases in size and volume so rapidly after the weaning that it occupies the left half as well as the lower part of the right half of the abdominal cavity. Its left surface (Parietal surface) is in direct contact with the left flank. Backward it extends almost to the pelvic inlet. The rumino-reticular groove lies parallel to the sixth or eighth rib (Fig. 11).

The reticulum: It develops remarkably and its diaphragmatic surface is in contact with the diaphragm at a point opposite to the fifth rib or sixth intercostal space.

The omasum: It increases in volume slightly, but is small even after two months.

The abomasum: It reduces in volume remarkably. When it is filled, its

pyloric part lies before the ventral posterior coronary groove, while when empty, it is related to the right anterior groove of the rumen. The abomasum, as a whole, lies to the right of the rumen with the exception of the anterior part of its body (Figs. 11–12).

The intestines: Most of the intestines lies to the right of the median plane, chiefly in contact with the right surface of the dorsal sac of the rumen, though a terminal part of the small intestine lies laterally and backward to the left of the posterior extremity of the rumen. The coils of the colon become flattened and are now discoidal. They lie almost in the median plane and opposite to the twelfth rib to the fourth lumblar vertebra (Fig. 12).

The liver and spleen: The liver is related to the right of the four parts of the stomach, and its visceral surface nearly faces to the left dorso-ventrally. Namely, its left lobe lies ventrally and forward, while the right lobe together with the caudal one dorsally and backward.

Discussion

The post-natal development of the stomach which is described as above will be discussed as follows:

1. The post-natal development of the rumen.

The extension of the rumen takes place backward and dorso-ventrally, and to the left, i.e., the rumen which is attached to the anterior roof of the abdominal cavity in the new-born goats extends gradually backward and downward, and after 25 days the posterior end of its ventral sac reaches almost the pelvic inlet, its dorsal curvature lying to the left of the abomasum at the lower one-fifth level of the abdominal cavity. After the weaning the rumen shows a marked development and occupies nearly three-fourths of the abdominal cavity. In 40 to 60 days the general situation of the stomach is nearly the same as those of the adult individuals.

The post-natal development of the rumen just stated may be explained as follows:

First, the anterior extremity of the rumen together with the reticulum is connected with the terminal portion of the oesophagus, accordingly the rumen is always fixed or contracted forward and upward by the oesophagus. Second, the rumen is related dorsally to the spleen and diaphragm, and is firmly attached to them by two ligaments, Ligamentum gastro lineale and Lig. gastro phrenicum. The rumen, as a whole, is therefore attached to the roof and anterior wall of the abdominal cavity, but is free ventrally and backward. After all, these are the reasons why the rumen extends backward and downward, since it is free in those directions.

2. The post-natal development of the reticulum and omasum.

The development of the reticulum takes place a little later than that of

the rumen, and is most remarkable after the weaning. As shown in Table 2, the anterior face of the reticulum, the pariatal surface, extends forward from stage to stage. Namely, it lies against the fifth or sixth rib after the weaning, while in the new-born animals it lies at a point opposite to the sixth or seventh rib.

Table 2. The position of the parietal surface of the reticulum in the abdominal cavity.

Stage	Age in days	Position in the abdominal cavity
I	1–2	6th rib–7th rib
II	3–4	7th int. sp.*–8th rib
III	7–10	7th rib–7th int. sp.
IV	16	7th rib
V	25	6th int. sp.–7th rib
VI–VII A	32–72	6th int. sp.–7th rib
VI–VII B	37–68	5th rib–6th rib

* Intercostal space

The extension of the reticulum mentioned above takes place in correlation to that of the rumen, thus resulting in a change in position of the reticular groove as well as the rumino-reticular groove. This change in position is shown in Table 3.

Table 3. The position of the reticular groove and rumino-reticular groove in the abdominal cavity.

Stage	Age in days	Position	
		Reticular groove	Rumino-reticular groove
I	1–2	8th int. sp.*	9th rib–10th rib
II	3–4	8th int. sp.	9th rib–10th rib
III	7–10	9th rib–10th rib	8th rib–9th rib
IV	16	9th rib–10th rib	8th int. sp.
V	25	9th rib–10th rib	8th rib–9th rib
VI–VII A	32–72	9th rib–10th rib	8th rib–9th rib
VI–VII B	37–68	8th rib–9th rib	6th rib–8th rib

* Intercostal space

As shown in Table 3, the rumino-reticular groove lies at a point opposite to the eighth or ninth rib before weaning, but against the sixth or eighth rib after weaning. On the other hand, it opposes the eighth or ninth rib even after two months in the prolonged suckling goats.

The reticular groove lies against the ninth or tenth rib passing dorso-ventrally and almost vertically before the weaning, while it opposes the eighth or ninth rib and inclines backward after weaning. As already mentioned, these changes in position of the grooves show that the extension of the reticulum is chiefly made towards the anterior surface of the abdominal cavity,

since the development of the rumen resists the backward extension of the reticulum.

The development of the omasum is the slowest of those of the four parts of the stomach. Even after 68 days the omasum seems to be contracted and almost functionless. Generally it lies against the ninth or tenth rib to the right of the median plane, relating to the other three parts of the stomach.

3. The post-natal development of the abomasum.

In the new-born goats the abomasum is large and lies on the abdominal floor. It gradually reduces in volume and moves to the right of the median plane closely relating with the extension of the rumen. Meanwhile the anterior end of the abomasum, the fundus, is partly attached to the omasum and reticulum. The abomasum is, therefore, fixed upward and forward by them.

The pyloric part of the abomasum joins the duodenum at the pylorus and passes forward to the visceral surface of the liver, since the latter is connected with the bile duct at the second bend of the S-shaped curve. On the other hand, the lesser omentum is attached along the area of adhesion of the omasum to the abomasum, the pyloric part of the abomasum and the first part of the duodenum.

After all, the abomasum may be regarded as fixed by the omasum, reticulum and duodenum at both ends of it, though the pyloric part of the abomasum is relatively free owing to the flexibility of the first part of the duodenum. This must be the reason why the abomasum in filled condition is allowed to extend backward along the long axis of the abdominal cavity almost to the pelvic inlet, and why it tends to move forward to the visceral surface of the liver in empty condition.

In addition to this, the extension of the rumen to the left and the movement of the liver to the right also affect the movement of the abomasum mentioned above. The movement of the liver will be discussed in the next section.

4. The post-natal movement of the liver.

In the new-born goats, the liver lies between the stomach and the diaphragm on both sides of the median plane. Then it gradually moves to the right of the median plane and in 16 to 25 days its left lobe lies limited in the lower right portion of the abdominal cavity.

The movement of the liver just stated seems to support the post-natal movement of the pyloric part of the abomasum, since the abomasum is indirectly connected with the liver dorsally and forward. On the other hand, this movement of the liver to the right may be regarded as a result of the extension of the stomach forward and to the left.

5. The post-natal development of the omentum.

In the new-born goats the rumen is contracted and is not in contact with the abomasum. The greater omentum, therefore, descends from the right and left longitudinal grooves of the rumen and ends along the second part of the duodenum, the greater curvature of the abomasum, the liver and the first part of the colon. As a result of the post-natal development of the rumen, the abomasum is related to the right of it after weaning. Accordingly the greater omentum in the post-weaning goats passes first laterally to the right and then ascends on the right side of the rumen, consisting of two parts, the superficial layer and the deep layer. The superficial layer corresponds to the right part of the greater omentum in the new-born goats, while the deep layer to the left part of it.

6. The post-natal development of the intestines.

In the new-born goats the intestines are chiefly situated in the left half of the abdominal cavity, but after weaning they move to the right dorsal portion of the abdominal cavity, because the rumen extends downward and laterally to the left and occupies most of the left half of the abdominal cavity extending considerably into the right half.

It is noticed that the coils of the colon in the suckling goats are solid and are rather cylindrical than discoidal, and that they become flattened in the post-weaning animals. The results mentioned above will be explained as follows:

First, as a result of the extension of the rumen, the cylindrical coils of the colon come in contact with its right posterior portion. Second, the coils are then compressed laterally by the rumen and become flattened and discoidal after weaning.

The cylindrical coils of the colon in the suckling goats seem to have a close relation to the spirals of the colon of the swine. To support the view just stated, Yoshikawa and Tanaka (3) found that the large intestines of the herbivorous domestic animals have a close relation embryologically. Thus it appears probable that the colon of the ruminants is essentially the same as that of the non-ruminating animals such as the swine.

The caecum lies to the right of the coils of the colon in early post-natal stages and then extends backward, almost horizontally to the pelvic inlet, though variation in its position is found in some individuals. No remarkable change is found in its position after weaning.

7. The post-natal development of the stomach after the prolonged suckling.

As shown in Stages VI–VII A, the prolongation of the suckling causes a noticeable difference in the development of the stomach. This will be briefly described as follows:

First, the extension of the rumen together with the reticulum is reduced or stopped, while the abomasum remains large and lies directly on the abdominal floor. Accordingly the rumen lies to the right of the abomasum, and is scarcely in contact with the abdominal floor. Second, as a result of the reduction of the development of the rumen and reticulum mentioned above, the reticular groove and the rumino-reticular groove remain in the position of 25 days goat, which is already described in section 2.

8. General considerations.

From the results mentioned above, it will be noticed that the remarkable changes in the size and arrangement of the stomach together with other digestive organs take place at the time of weaning. These changes involve the extension of the reticulum, the contraction and translocation of the abomasum, the flattening of the coils of the colon and the translocation of the small intestines and liver to the right half of the abdominal cavity, closely associated with, or more preferably, in direct relation to, the extension of the rumen.

On the other hand, the development of the rumen mentioned above is greatly advanced by the weaning, while it is reduced or almost stopped by the prolonged suckling. This shows that the post-natal development of the stomach of the goat before and after weaning is strongly affected by the nature of food, viz., the weaning produces a marked development of the rumen, but the prolonged suckling resists it. In other words, the anatomical characters of the stomach, i. e., the relative size and arrangement of the four divisions of the stomach, are the direct indications of their feeding. It is also noticed that the prolongation of the suckling from 53 to 72 days causes the contraction of the rumen and sometimes results in the misgrowth or death of the animals, and that the forced weaning before 16 days also causes almost a similar relation.

At any rate, the results mentioned above shows that the most suitable time of the weaning is from 16 to 25 days. To support the view just stated, it is noticed that the extension of the rumen reaches the maximum in 16 to 25 days of suckling, and that the prolonged suckling over 25 days does not give the normal development of the stomach and the growth of the animals, especially the suckling from 53 to 72 days causes the misgrowth or death of the animals as already stated.

The conclusions mentioned above are also supported by the results obtained for the ratio and capacity of the four divisions of the stomach, which will be reported in another paper.

Summary

18 goats from new-born to 72 days of suckling and 13 from 37 to 68 days of post-weaning were dissected and the size and arrangement of their stomachs together with other digestive organs were observed, and the findings are summarized as follows:

1. In the new-born goats the rumen is very small and lies attached to the anterior roof of the abdominal cavity. It gradually extends backward and downward, and in 25 days it almost reaches the pelvic inlet. After weaning in 25 to 32 days, the rumen shows a marked development and in 40 to 68 days it occupies nearly three-fourths of the abdominal cavity as that of the adult.

2. The development of the reticulum takes place a little later than that of the rumen, and is most remarkable after weaning. The extension of the reticulum is chiefly made forward to the anterior surface of the abdominal cavity, since the development of the rumen resists its backward extension. The development of the omasum is the slowest of the four parts of the stomach. Even after 68 days of post-weaning it seems to be contracted and almost functionless.

3. In the new-born goats the abomasum is very large lying on the abdominal floor. It gradually reduces in volume and moves to the right of the median plane, closely relating with the extension of the rumen. The pyloric part of the abomasum changes its position according to its fullness. After weaning the abomasum, as a whole, lies to the right of the anterior groove of the rumen.

4. In the new-born goats the liver lies between the stomach and diaphragm on both sides of the median plane. It gradually moves to the right and after 16 days its left lobe lies limited to the lower right part of the abdominal cavity.

5. In the new-born goats the intestines are chiefly situated in the left half of the abdominal cavity, but after weaning they move to the right half of the cavity, since the rumen extends downward and laterally to the left.

6. It is noticed that the coils of the colon in the suckling goats are cylindrical rather than discoidal, and that this cylinder of the colon becomes flattened after weaning. It is suggested that the nature of this cylinder of the colon in the suckling goats may be the same as that of the spirals of the colon of the swine.

7. In the new-born goats the greater omentum descends from the right and left longitudinal grooves of the rumen almost vertically. In the post-weaning goats it passes first laterally to the right and then ascends on the right side of the rumen.

8. The prolongation of the suckling resists the extension of the rumen,

while the weaning from 16 to 25 days results in a remarkable extension of the rumen. Forced weaning before 16 days often results in the misgrowth of the rumen.

9. From the results mentioned above, it is concluded that the post-natal development of the stomach of the goats before and after weaning is directly affected by the nature of food, and that the anatomical characters of the stomach of the young goats differ in different feedings.

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Explanation of Figures

Plate I

Fig. 1. New-born goat (No. 025). Left side view. The rumen is very small and is attached to the roof of the abdominal cavity. The left lobe of the liver lies between the diaphragm and the stomach.

Fig. 2. 2 days suckling goat (No. 027). Right side view. The liver and the right lobe of the lung are removed. The rumen is not in direct contact with the abomasum. No intestines are found to the right of the stomach except the first part of the duodenum.

Fig. 3. 3 days suckling goat (No. 024). Left side view. The rumen and reticulum begin to develop, and the straight line which connects both ends of the dorsal and ventral sacs passes vertically.

Fig. 4. 4 days suckling goat (No. 023). Left side view. The ventral sac of the rumen is partly in contact with the abomasum. The blind end of the caecum passes dorso-ventrally and almost vertically.

Abbreviations

1, Rumen ; 2, Reticulum ; 3, Omasum ; 4, Abomasum ; 5, Oesophagus ; 6, Pyloric part of abomasum ; 7, Duodenum ; 8, Jejunum ; 9, Ilium ; 10, Coils of colon ; 11, Caecum ; 12, Colon ; 13, S-shaped curve of duodenum ; 3-13 rb, 3rd-13th rib ; 3Lb, 3rd lumblar vertebra ; Kl, Left kidney ; Kr, Right Kidney ; L, Lung ; Li, Liver ; Od, Deep layer of greater omentum : Os, Superficial layer of greater omentum ; R, Porta hepatis ; Rg, Rumino-reticular groove ; Rt, Reticular groove.

Plate I

Figs. 1-4

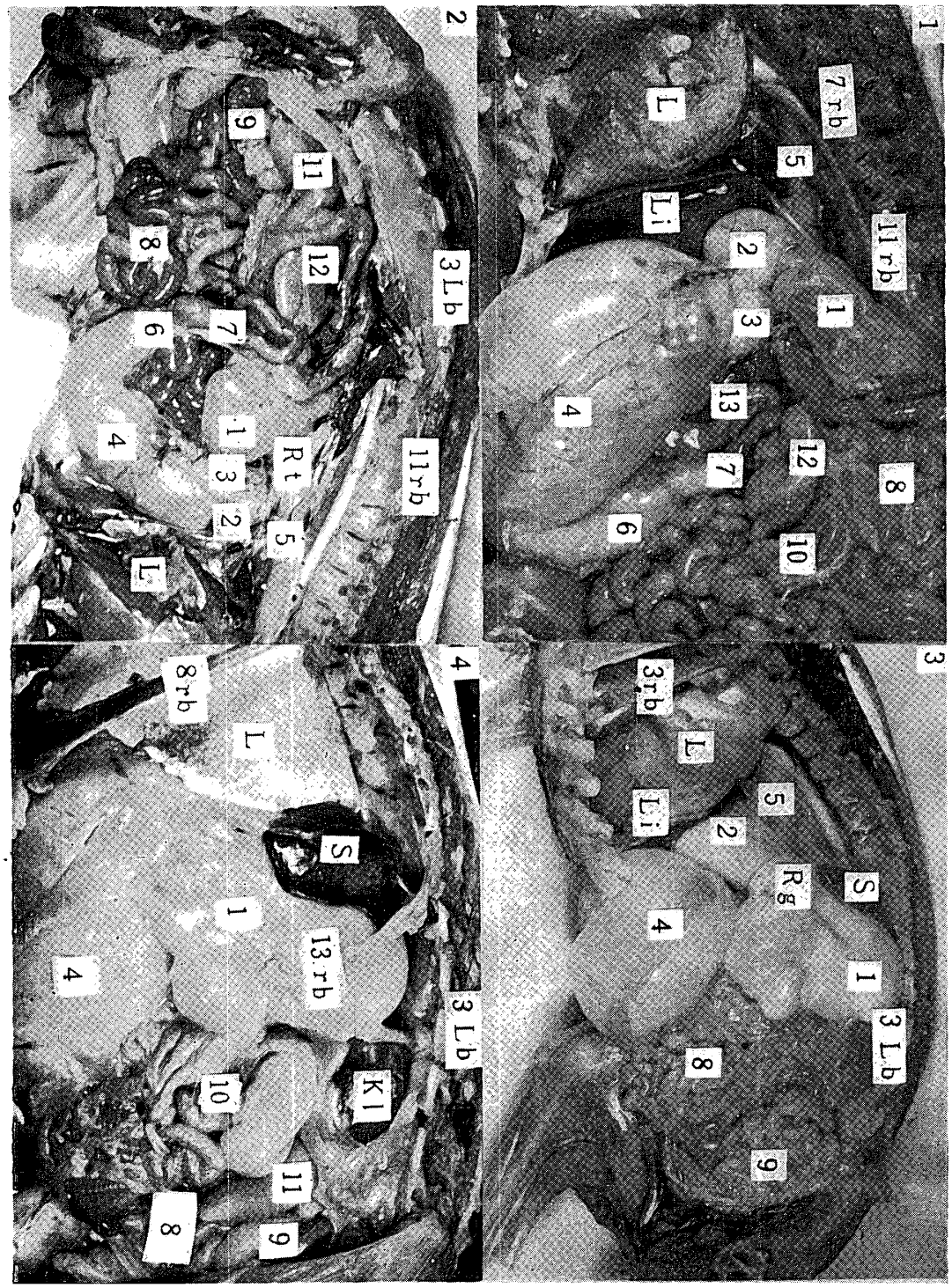

Plate II

Fig. 5. 9 days suckling goat (No. 017). Left side view. The abomasum is still large and lies on the abdominal floor. The coils of the colon are cylindrical, and its axis runs to the left ventrally.

Fig. 6. 16 days suckling goat (No. 028). Right side view. The liver is turned upward. The abomasum occupies the lower half of the abdominal cavity, and its pyloric part reaches the pelvic inlet.

Fig. 7. 16 days suckling goat (No. 028). Right side view. The liver and the greater omentum are removed. The rumen extends backward and is widely in contact with the abomasum. The straight line which connects both ends of two sacs of the rumen now passes dorso-ventrally and backward.

Fig. 8. 25 days suckling goat (No. 005). Left side view. The rumen develops remarkably and its ventral sac almost reaches the pelvic inlet. The abomasum is large as before and is related to the rumen dorsally and to the left.

Plate II

Figs. 5–8

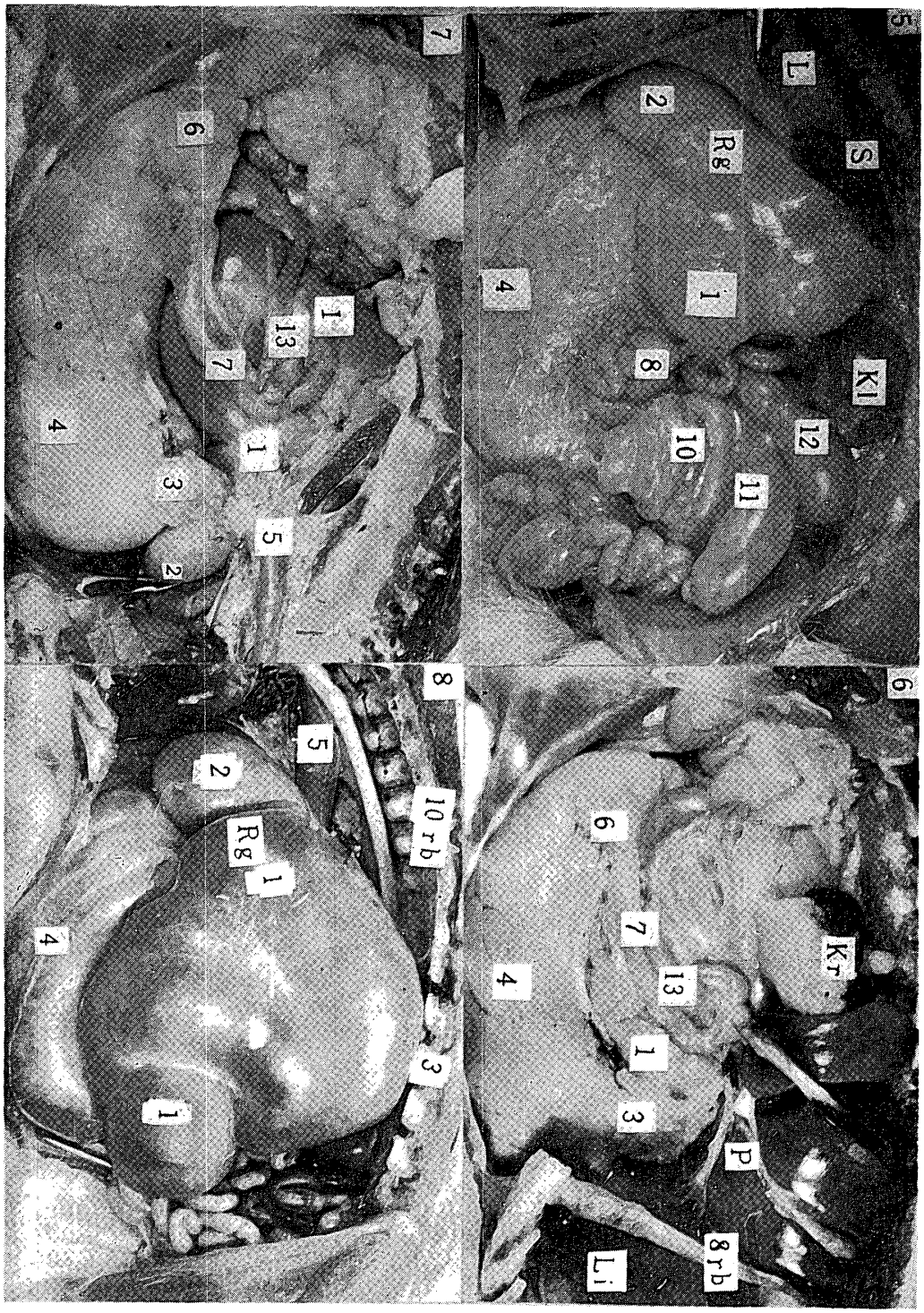

Plate III

Fig. 9. 25 days suckling goat (No. 005). Left side view. The rumen is turned upward. The omasum is small. The S-shaped curve of the duodenum lies just behind the Porta hepatis.

Fig. 10. 72 days prolonged suckling goat (No. 007). Left side view. The relatively small rumen is turned upward. The abomasum is very large and lies on the abdominal floor. Its pyloric part lies just before the pelvic inlet.

Fig. 11. 53 days post-weaning goat (No. 002). Right side view. The rumen is very large and occupies the lower half as well as the left part of the upper half of the abdominal cavity. The abomasum is small and is related to the right ventral sac of the rumen.

Fig. 12. 64 days post-weaning goat (No. 018). Left side view. The rumen is turned upward. The coils of the colon are discoidal and lie to the right of the rumen. The abomasum is relatively small and lies on the anterior part of the abdominal floor.

Plate III

Figs. 9–12