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COMPARATIVE MORPHOLOGICAL STUDIES ON THE INTESTINAL GLANDS OF THE COLON AND RECTUM OF SOME DOMESTIC ANIMALS

(With 3 Tables and 12 Figures)

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دراسات مورفولوجية مقارنة على الغدد المعوية فى القولون والمستقيم فى بعض الحيوانات المستأنسة

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فى هذا البحث تم دراسة الغدد المعوية للقولون والمستقيم هستولوجيا ومورفومتريا فى عدد خمسة من كل من الكلاب والماعز والحمير من كلا الجنسين ومختلف الأعمار بالاضافة الى عدد خمس حيوانات اخرى من كل نوع تم استخدامها للماسح الالكترونى. وقد اظهرت الدراسة ان الغدد المعوية لقولون ومستقيم الكلب من النوع الأنبيبى المستقيم البسيط معظمها ذو نهايات كبيرة يعطيها شكل الحواجل . ولوحظت هذه الغدد منفصلة عن الطبقة العضلية المخاطية بالطبقة الحبيبية .اما الغدد المعوية فى الماعز فكانت ملتوية نسبياً ومرتكزة على الطبقة العضلية المخاطية مما أدي الي تميز هذه الطبقة بالمظهر التوهدى. وكانت الغدد المعوية فى الحمار من النوع الأنبيبي المستقيم البسيط وتنتهى نسبياً بعيداً عن الطبقة العضلية المخاطية .اختلف عمق الغدد المعوية للقولون والمستقيم بين الأنواع موضع الدراسة، فكان ٥٢١,٦٣ إلى ٥٧٢,٥٨ ميكرون فى الكلب ، ٤١٨,٦٧ إلى ٥٢٤,١٩ ميكرون فى الماعزو ٤٥٣,٣٣ الى ٤٨٤,٣٤ ميكرون فى الحمار .وتراوح عمق الغدد المعوية للمستقيم ما بين ٤٨٩,٢٢ ، ٣٧٨,٧١ و ٤٣٧,٧٠ ميكرون فى الثلاث حيوانات المذكورة على التوالى .اما قطرها فى قولون الكلب فتراوح من ٦١,٠٣ إلى ٦٣,٤٥ ميكرون ،وفى قولون الماعز من ٥٢,٣٣ إلى ٥٣,٧٦ ميكرون وفى قولون الحمار من ٥٦,٠٢ الى ٥٦,٨١ ميكرون. بينما كان فى المستقيم ٥٩,٦٥ ميكرون ، ٥٦,٦٧ ميكرون و ٤٨,٣٨ ميكرون فى الكلب ، الماعز والحمار على التوالى. اظهرت الدراسة كذلك ان الغدد المعوية للقولون والمستقيم فى الحيوانات موضع الدراسة كانت مبطنة بالخلايا الفرشية ، الخلايا الكأسية وقليل من الخلايا غير المميزة فى قاع الغدة. وتراوحت نسبة الخلايا الكأسية مابين ٥٦,١٣% إلى ٥٨,٨٥% من بطانة الغدد المعوية للقولون فى الكلب. بينما كانت قليلة

نسبيا فى الماعز والحمار وبلغت ٥٥,٠٢% إلى ٥٧,٩٨% و ٤٤,١٠% إلى ٤٥,٠٧% على التوالى.اما فى المستقيم فكانت نسبة الخلايا الكأسية عالية فى الكلب عن مثيلتها فى الماعز والحمار .أوضح الميكروسكوب الإلكترونى الماسح التوزيع المنتظم لفتحات الغدد المعوية على السطح المخاطى للقولون والمستقيم فى الحيوانات موضع الدراسة. وكانت هذه الفتحات مثلثة الشكل فى الكلب، أما فى الماعز والحمار فكانت دائرية ، بيضاوية ، مثلثة ونجمية.

SUMMARY

The morphology of the intestinal glands of the colon and rectum was studied in 10 dogs, 10 goats and 10 donkeys of both sexes and of different ages by using light and scanning electron microscope. The intestinal glands (crypts of Lieberkuehn) of the colon and rectum of the dog were of the simple straight tubular type, mostly with enlarged bases giving them flask-shaped appearance. They were separated from the muscularis mucosa by the Stratum granulosum. In the goat, they were slightly tortuous and rested directly on the muscularis mucosa giving it a pitted appearance. In the donkey, they were typical simple straight tubular in type terminating slightly apart from the muscularis mucosa. The depth of the intestinal glands of the colon measured about 521.63 ± 16.83 to 572.58 ± 22.36 µm in the dog, 418.67 ± 5.42 to 524.19 ± 9.82 µm in the goat and 453.33 ± 3.18 to 484.34 ± 6.16 µm in the donkey. The intestinal glands of the rectum were shorter and measured 489.22 ± 17.15, 378.71 ± 8.15 and 437.70 ± 3.21µm in depth in the three mentioned animals, respectively. The intestinal glands of the colon and rectum of the studied animals were lined with brush cells, goblet cells and few undifferentiated cells at the crypt bottom. In the dog, the goblet cells constituted about 56.13% to 58.85 % of the lining of the intestinal glands of the colon. Whereas, in the goat and donkey they were relatively fewer and ranged from 55.02% to 57.98% and 44.10% to 45.07%, respectively. In the colon, the proportion of the intestinal glands to the connective tissue lamina propria was higher in the dog than in the goat and donkey. This proportion was comparatively lower in the rectum. Scanning electron microscopical investigation revealed that the openings of the intestinal glands were regularly distributed upon the mucosa of the colon and rectum of all examined animals. In the dog, they were uniformly triangular in shape. However, in the goat and donkey, the openings were rounded, oval, triangular and star in shape.

Key words: *Intestinal glands, scanning electron microscope, colon, rectum, dog, goat, donkey*

INTRODUCTION

The intestinal glands (Crypts of Leiberkuehn) were studied histologically and morphometrically in the small and large intestine of ruminants (Lackhoff, 1983; Ludwig, 1986) as well as by scanning electron microscope in the cecum of some domestic animals (Wille, 1975) and in the equine ileocecal junction (Kotze and Soley, 1990). The morphometrical and scanning electron microscopical features of the intestinal glands of the dog, goat, and donkey were lacking in the available literature. Therefore this work aims to study the intestinal glands in the colon and rectum histologically, morphometrically and by using scanning electron microscope in three species of animals representing Carnivora (dog), Ruminantia (goat) and Equidae (donkey).

MATERIAL and METHODS

This study was carried out on the large intestine of clinically healthy ten dogs, ten goats and ten donkeys of both sexes and different ages (Tab. 1, 2 & 3). The specimens were obtained from the dissecting room.

For light microscopical investigation five large intestine of each species were perfused through the cranial and caudal mesenteric arteries with Bouin's fixative. Pieces were taken from the ascending, transverse and descending colon as well as the rectum. The specimens were rapidly rinsed in normal physiological saline, immersed in the same fixative used and processed for paraffin embedding. 5 µm thickness paraffin sections were stained by H & E and combined alcian blue - PAS (Mowry, 1956).

Different measurements were carried out on the intestinal glands of the studied animals each using Leica Q 500 MC Image analyser. These measurements were statistically analysed by using *SAS* international computer program (1990). They were done in the following manner:

1- Depth of the intestinal gland from its opening at the epithelial surface till its base was measured in longitudinal sectioned fifteen crypts.
2- Diameter of the intestinal glands was calculated from fifteen typical cross sectioned crypts.
3- Percentage of goblet cells in the intestinal glands to the total epithelial cell lining was calculated from fifteen longitudinal sectioned crypts.
4- Percentage of the intestinal glands to the connective tissue Lamina propria mucosae was calculated in five fields of the histological section.
5- Thickness of the Lamina propria mucosae was calculated from fifteen fields.

For scanning electron microscopical examination samples were taken from the parts of the large intestine as already mentioned for the light microscopy from the rest of the animals under investigation. The samples were fixed in 5% glutaraldehyde in 0.1 M phosphate buffer pH 7.2 for 24 hours at 4° C, dehydrated in alcohol followed by amyl acetate and critically-point dried with liquid Co_2. They were sputter-coated with gold and examined in a JEOL 5400 LV scanning electron microscope.

RESULTS

The crypts of Lieberkuehn of the dog were simple straight tubular glands with mostly enlarged bases giving them flask-shaped appearance (Fig. 1 & 2a, b). The blind ends of the Gll. intestinales were separated from the muscularis mucosa by a thin layer containing different types of leukocytes referred as Stratum granulosum (Fig. 3). In the goat, the intestinal glands were simple tubular slightly tortuous. They extended through the entire thickness of the lamina propria with their blind ends resting directly on the muscularis mucosa resulting in its pitted appearance (Fig. 4 & 5a, b). However, in the donkey, the crypts of Lieberkuehn were typical simple straight tubular glands and terminated slightly apart from the muscularis mucosa (Fig. 6a, b).

The intestinal glands of the colon and rectum of the studied animals occupied mostly the whole thickness of the lamina propria. In the dog, these glands exhibited its maximum depth in the ascending colon then decreased gradually towards the rectum. The depth of these glands was 572.58 µm ± 22.36 in the ascending colon, 551.11µm ± 21.58 in the transverse colon, 521.63 µm ± 16.83 in the descending colon and 489.22 ± 17.15 µm in the rectum. The diameter of these crypts was 63.45 µm ± 1.2, 61.03 µm ± 1.42, 61.37 µm ± 0.93 and 59.65 µm ± 0.97 in the ascending, transverse, descending colon and rectum, respectively (Tab. 1). In the goat, these glands were short and measured 524.19 µm ± 9.82 in depth in the ascending colon, 435.31 µm ± 2.71, 418.67 µm ± 5.42 and 378.71µm ± 8.15 in the transverse and descending colon as well as in the rectum, respectively. The diameter of these crypts were 53.76 µm ± 1.35 in the ascending colon. It reached 49.17 µm ± 1.03 in the transverse colon, 47.46 µm ± 1.17 in the descending one and 48.38 µm ± 1.21 in the rectum (Tab. 2). In the donkey, the depth of these intestinal glands measured 484.34 µm ± 6.16 in the ascending, 472.29 ± 3.81 in the transverse and 466.68 µm ± 2.86 in the descending colon. In the rectum, it reached 437.70 µm ± 3.21 (Tab. 3). The diameter of the intestinal glands was 55.83 ± 1.16 in the ascending, 56.81 µm ±

1.09 in the transverse and 56.02 μm ± 0.56 in the descending colon as well as 56.67 μm ± 0.92 in the rectum (Tab. 3). The percentage of the intestinal glands to the connective tissue lamina propria was 61.68%, 64.94%, 65.44% and 63.69% in the ascending, transverse and descending colon as well as the rectum of the dog, respectively. In the goat, this proportion reached 52.52% in the ascending, 56.66% in the transverse and 56.18% in the descending colon. However, in the rectum the proportion was 65.04%. In the donkey, this proportion was fewer, where it reached 45.25% in the ascending, 47.73% in the transverse, and 44.45% in the descending colon as well as 40.50% in the rectum.

The Gll. intestinales of the colon and rectum of the investigated animals were lined with simple columnar epithelial cells with striated border, goblet cells and undifferentiated cells. The striated border of the columnar cells decreased in height in the direction of the crypt bottom (Fig. 1). The goblet cells were the most predominant cell type and revealed strong positive reactivity with alcian blue and periodic acid Schiff (Fig. 7). The undifferentiated cells observed at the crypt bottom show mitotic figures (Fig. 3 & 8). They appeared as low columnar-shaped cells with slightly basophilic cytoplasm. Lymphocytes as well as eosinophil leukocytes were observed within the lining of the intestinal glands.

In the dog, the goblet cells represented about 56.13%, 57.45%, 58.85% and 59. 75% of the total cell count of the intestinal glands of the ascending, transverse and descending colon as well as the rectum, respectively (Tab. 1). In the goat, they formed about 57.98% of the total cell count of the ascending colon. In the transverse, descending colon and rectum these cells constituted about 55.02%, 55.03% and 55.55%, respectively (Tab. 2). However, in the donkey, the goblet cells represented about 45.07% of the total cell count of the intestinal glands in the ascending and transverse colon, 44.10% in the descending colon and 43.38% in the rectum (Tab. 3).

Scanning electron microscopical examination of the mucosa of the colon and rectum of the animals under investigation revealed regular distribution of the openings of the intestinal glands. In the dog, they appeared triangular in shape. Each triangular-shaped opening was circumferntially surrounded by 3 to 5 cell layers of brush and few goblet cells. Therefore, the glandular openings appeared as units separated from each other by shallow grooves (Fig. 9a & b). In the goat and donkey, the openings of the intestinal glands were also regularly distributed at the mucosa of the colon and rectum without definite demarcation between them and the inter-cryptal region (Fig.

10). The openings of these intestinal glands were rounded, triangular, oval and star- shaped (Fig. 11a-c& 12 a-d).

DISCUSSION

Both light and scanning electron microscopical observations of the colon and rectum of the studied species revealed different forms of the intestinal glands. The dog possessed simple straight tubular glands with mostly enlarged bases giving them flask-shaped appearance similar to that observed by MARTIN (1906) in the same animal. STROMBECK and GUILFORD (1991) in the dog and cat and EVANS (1993) in the dog described them as simple straight tubular glands. In agree with TRAUTMANN and FIEBIGER (1957) the crypts of Lieberkuehn of the goat appeared as simple tubular slightly tortuous glands. In the donkey, they were typical simple straight tubular glands simulating that described by TRAUTMANN and FIEBIGER (1957), EL - HAGRI (1967), SCHUMMER and NICKEL (1979) and BANKS (1993) in the domestic animals as well as WILSON and WILSON (1983), COPENHAVER, KELLY and WOOD (1978) and FAWCETT (1994) in man.

In the present study, the colonic intestinal glands extended deeper in the lamina propria with their blind ends terminating at variable levels from the muscularis mucosa. In the dog, they were separated from the muscularis mucosa by the Stratum granulosum. However, in the goat, the intestinal glands ranged from 418.67 to 524.19 µm in depth and rested directly on the muscularis mucosa resulting in its pitted appearance. On the other hand, MARTIN (1906) and SCHUMANN (1907) found that the depth of the intestinal glands ranged from 238 to 357 µm in the goat and from 258 to 391µm in the sheep. In the donkey, they ranged from 453. 33 to 484.34 µm in depth and terminated slightly apart from the muscularis mucosa. In the horse the depth of the intestinal glands ranged from 225 µm to 449 µm (MARTIN, 1906; SCHUMANN, 1907). In the colon of man, the depth of the intestinal glands was 0.5 mm (LEESON, LEESON and PAPARO, 1988; FAWCETT, 1994; KRAUSE and CUTTS, 1994) or 0.4 mm to 0.6 mm (TELFORD and BRIDGMAN, 1995).

The present investigation showed that the depth of the intestinal glands of the rectum was shorter than that of the colon, where they measured 489.22, 378.71 and 437.70 µm in the dog, goat and donkey, respectively. In man they ranged from 0.7 mm (FAWCETT, 1994; KRAUSE and CUTTS, 1994) to 0.75 mm (LEESON et al., 1988).

Variation in the depth of the intestinal glands of the large intestine of the animals under investigation is due to the variations in the thickness of the lamina propria enclosing them, where there is a direct relation between the depth of these glands and the thickness of the lamina propria.

The diameter of the intestinal glands of the colon varied among the studied animals. It was wider in the dog (61.03 to 63.45μm) than in the goat (47.46 to 53.76μm) and in the donkey (55.83 to 56.81μm). The diameter of the rectal intestinal glands was narrow, where it reached 59.65, 48.38 and 56.67 μm in dog, goat and donkey, respectively. MLADENOWITSCH (1907) mentioned that the diameter of the rectal intestinal glands of the domestic animals ranged from 32 to 65 μm. Variation in the diameter of the intestinal glands may be species-dependent.

The proportion of the intestinal glands to the connective tissue lamina propria varied considerably among the studied species as well as within the colon and rectum of the same animal. They constituted 61.68% to 65.44%, 52.52 % to 56.66% and 44.45% to 47.73% in the colon of the dog, goat and donkey, respectively. The percentage was lower in the rectum than in the colon. The intestinal glands lead to increase the surface area and consequently the corresponding functions.

The intestinal glands of the colon and rectum of the studied animals were lined with brush cells, goblet cells as well as few undifferentiated cells at the crypt bottom. These results simulate that mentioned by TRAUTMANN and FIEBIGER (1957) and LIEBICH (1990) in the domestic animals, SLOSS (1954) and MICHEL (1989) in the pig as well as HAM (1974), COPENHAVER et al (1978), FAWCETT (1994), KRAUSE and CUTTS (1994) and TELFORD and BRIDGMAN (1995) in man. The undifferentiated cells w observed undergoing mitosis as mentioned by COPENHAVER et al. (1978), CORMACK (1987), MICHEL (1989), BANKS (1993) and TELFORD and BRIDGMAN (1995).

The histochemical observation revealed that the lining goblet cells produced both acidic and neutral mucin as stated by MICHEL (1989) and HOUSSAINY (1996). The mucus secretion is stimulated by direct contact between the gland cells and luminal content (GANONG, 1975). This secretion is alkaline with a pH ranged from 7.5 to 8.0 in the domestic animals (BREAZILE, 1971) or 8.3 to 8.4 in man (FENTON, 1960). It plays a significant role in protection of the mucosa against both the mechanical irritations caused by the developing feces (JENSEN and COLORADO, 1980; WILSON and WILSON, 1983; KRAUSE and CUTTS, 1994) and acids produced by the bacterial action on food remnants (FENTON, 1960; FLOREY, 1962;

BREAZILE, 1971). It also binds the fecal materials together (JENSEN and COLORADO, 1980), lubricates them and consequently facilitate their propulsion (FLOREY, 1962; JENSEN and COLORADO, 1980; ROSS and REITH, 1983; WILSON and WILSON, 1983; BURROWS, 1986).

The goblet cells constituted 56.13% to 58.85% of the lining of the intestinal glands of the colon of the dog. However, they were relatively few in the goat and donkey, where they reached 55.02% to 57.98 and 44.10% to 45.07%, respectively. In the rectum, the percentage of goblet cells was higher in the dog than in the goat and donkey. This agrees with that reported by MOE (1955) and LIEBICH (1990) who mentioned that, the carnivores possess more goblet cells than herbivores. This may explain that the dog is in need of large quantity of mucus for more lubrication and consequently facilitating the passage of harder feces, that contains nearly 18% water (DRAZNER, 1985). In sheep and horse the fecal matter contains 68% and 75% water respectively (SWENSON, 1977).

The brush cells lining the intestinal glands of the colon of the studied animals were in reversed relation to the goblet cells. They were fewer in dog in comparison with goat and donkey. The latter animal possessed the higher proportion of brush cells. These cells play a significant role in fluid (water) absorption (HAM, 1974; COPENHAVER et al., 1978; LEESON et al., 1988) as well as Na^+, Cl^- and vitamins (BANKS, 1993). The latter author added that, cellulose digestion and the subsequent absorption of its digestive products occur in the cecum and colon of horse and related animals. This fact may explain the higher proportion of brush cells in the donkey than in the dog, where greater absorptive capacity is needed for the absorption of the digested cellulose products.

Scanning electron microscopical investigation of the mucosa of the colon and rectum of the studied animals revealed a regular distribution of the openings of the intestinal glands, simulating that observed in the cecum of the pig and cow (WILLE, 1975) and in the equine ileocecal junction (KOTZE and SOLEY, 1990). However, in the cecum of horse and goat the openings were irregularly distributed (WILLE, 1975).

In the dog, the openings of the intestinal glands of the colon and rectum were uniformly triangular in shape. They appeared as units separated from each other by shallow grooves, which may be due to folding, shrinking or compression of the mucosa (KOTZE and SOLEY, 1990). This groove showed similarity with that of rat colon (SCHIFF, MOORE and KETELS, 1980). However, in the goat and donkey, the intestinal gland openings appeared rounded-, oval-, triangular-, or star-shaped. WILLE (1975) observed that the

gland openings were rounded or oval in the cecum of the goat and dome - shaped in that of sheep. He attributed this variation to be species-bounded.

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LEGENDS

Fig. 1: Photomicrograph of the mucosa of the ascending colon of the dog showing straight tubular gland with flask-shaped base (asterisk). Simple columnar epithelium with striated border (arrows), goblet cells (arrowheads). H&E X 160.

Fig. 2a&b: Scanning electron micrographs of the mucosa of the ascending colon of the dog showing straight tubular glands with enlarged base (a). High magnification of the marked area (b). Side view.

Fig. 3: Photomicrograph showing mitosis within the undifferentiated cells (arrows) of the intestinal glands of the ascending colon of the dog. Stratum granulosum (a), inner circular (b_1) and thick outer longitudinal (b_2) layers of the muscularis mucosa. H&E X 250.

Fig. 4: Photomicrograph of the mucosa of the descending colon of the goat showing tubular slightly tortuous glands (Ig). Epithelium mucosae (arrowheads), pitted appearance (arrows). H&E X 160.

Fig. 5a&b: Scanning electron micrographs of the mucosa of the descending colon of the goat showing tubular slightly tortuous glands (double arrow), impressions in the muscularis mucosa (asterisks), cut base of the glands (arrows). Side view.

Fig. 6a: Photomicrograph of the descending colon (semilunar fold) of the donkey showing intestinal glands (Ig). Goblet cells (arrows), brush cells (arrowheads), undifferentiated cells with mitosis (thick arrow), muscularis mucosa (a), submucosa (b). H & E X 160.

Fig. 6b: Scanning electron micrograph of the mucosa of the descending colon (Haustra) of the donkey showing the straight tubular intestinal glands. Side view.

Fig. 7: Photomicrograph of descending colon of the donkey (Haustra) showing positively stained goblet cells of the intestinal glands. AB- PAS X 160.

Fig. 8: Photomicrograph showing mitotic division within the undifferentiated cells of the intestinal glands of the descending colon (thick arrow). H & E X 400.

Fig. 9a&b: Scanning electron micrographs of the mucosal surface of the descending colon of the dog showing triangular-shaped intestinal gland openings (asterisks). Goblet cells (arrows), shallow groove (arrowheads).

Fig. 10: Scanning electron micrograph of the mucosa of the descending colon of the donkey showing intestinal gland openings (arrowheads) and inter-cryptal region (asterisks).

Fig. 11a-c: Scanning electron micrographs of the rounded- (a), triangular- (b) and star- (c) shaped intestinal gland openings of the descending colon of the donkey. Brush cells (arrows) goblet cells (arrowheads), mucus released from goblet cells (thick arrows).

Fig. 12a-c: Scanning electron micrographs of the luminal surface of the descending colon of the goat showing rounded-(a), triangular-(b) and oval- (c) shaped intestinal gland openings. Brush cells (arrows) and goblet cells (arrowheads).

Fig. 12d: Scanning electron micrograph of the luminal surface of the rectum of the goat showing star- shaped intestinal gland opening. Numerous goblet cells (arrowheads), brush cells (arrows), mucus discharged from a goblet cell (thick).

Table 1: Showing the measurements of the intestinal glands of the colon and rectum of the dog

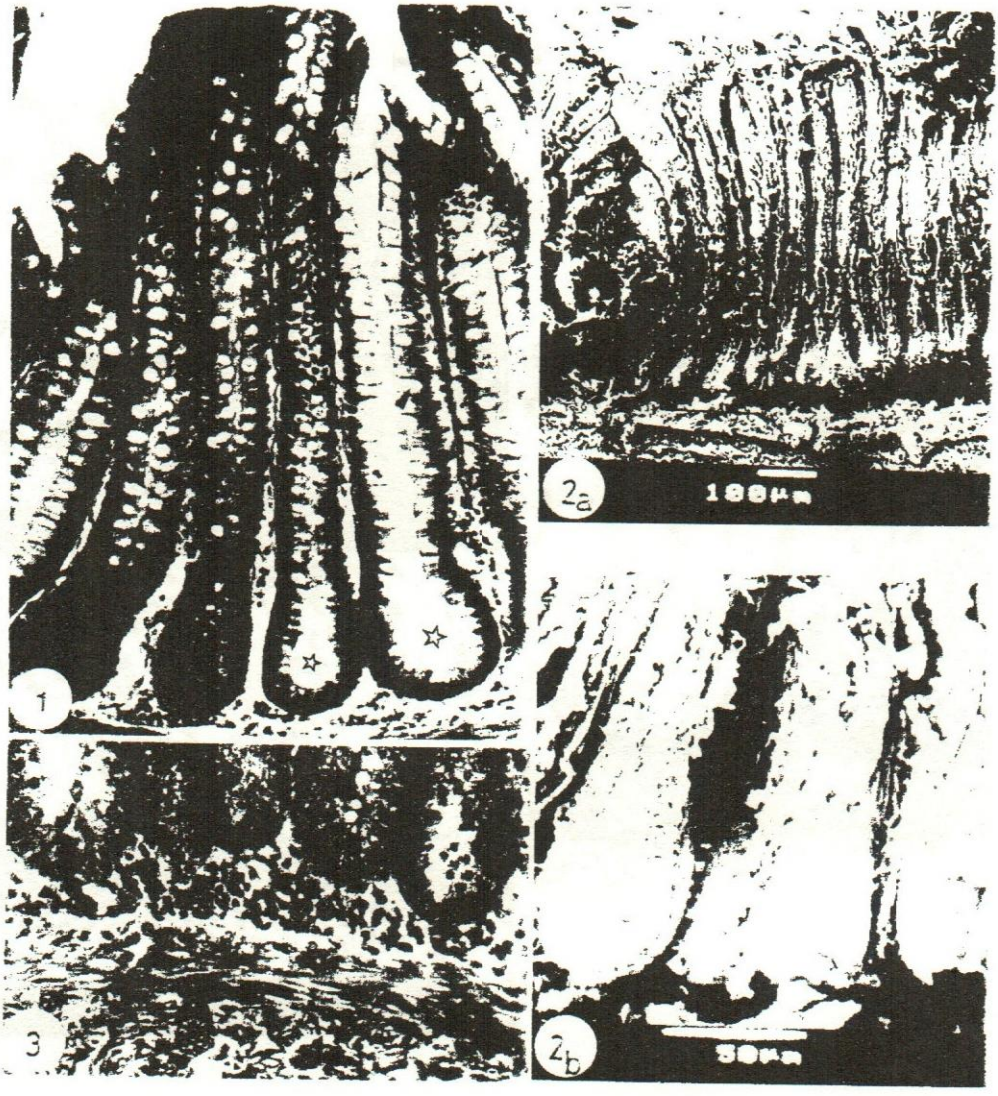
Number	1	2	3	4	5	
Sex Male (M) or Female (F)	M	M	F	F	M	Mean ± S.E
Age (Year)	4	5	3	2.5	3	
Colon ascendens						
Thickness of Lamina propria mucosae (µm)	579.72	600.25	698.60	562.74	588.79	606.02 ± 21.40
Depth of the Glandula intestinales (µm)	545.30	563.63	670.20	530.69	553.10	572.58 ± 22.36
Diameter of the Glandula intestinales (µm)	59.03	66.42	62.44	66.12	63.25	63.45 ± 1.2
Percentage of goblet cells to the total cell count in the Glandula intestinales	56.53	57.26	54.67	53.81	58.41	56.13
Percentage of the Glandula intestinales to the C.T. lamina propria	63.56	65.74	55.78	58.92	64.43	61.68
Colon transversum						
Thickness of Lamina propria mucosae (µm)	573.68	563.83	686.18	529.79	581.48	586.99 ± 23.54
Depth of the Glandula intestinales (µm)	532.40	533.25	640.20	493.4	556.30	551.11 ± 21.58
Diameter of the Glandula intestinales (µm)	63.23	60.40	62.90	56.45	62.32	61.03 ± 1.42
Percentage of goblet cells to the total cell count in the Glandula intestinales	57.50	59.20	54.67	54.61	61.31	57.45
Percentage of the Glandula intestinales to theC.T. lamina propria	64.84	68.49	63.19	62.85	65.32	64.94
Colon descendens						
Thickness of Lamina propria mucosae (µm)	564.05	540.26	594.56	483.91	577.50	552.06 ± 17.21
Depth of the Glandula intestinales (µm)	555.63	492.45	551.62	461.96	546.52	521.63 ± 16.83
Diameter of the Glandula intestinales (µm)	60.00	59.77	64.69	60.19	62.19	61.37 ± 0.93
Percentage of goblet cells to the total cell count in the Glandula intestinales	59.5	62.2	56.67	55.61	60.31	58.85
Percentage of the Glandula intestinales to the C.T. lamina propria	59.80	66.38	66.56	70.22	64.23	65.44
Rectum						
Thickness of Lamina propria mucosae (µm)	518.52	538.49	470.60	445.08	572.26	508.99 ± 20.51
Depth of the Glandula intestinales (µm)	501.47	513.39	468.70	426.22	536.31	489.22 ± 17.15
Diameter of the Glandula intestinales (µm)	59.84	61.22	59.94	55.94	61.31	59.65 ± 0.97
Percentage of goblet cells to the total cell count in the Glandula intestinales	60.56	61.39	56.57	57.81	62.46	59.75
Percentage of the Glandula intestinales to the C.T. lamina propria	62.22	60.53	66.80	65.69	63.23	63.69

Table 2: Showing the measurements of the intestinal glands of the colon and rectum of the goat

Number Sex Male (M) or Female (F) Age in years	1 M 1.5	2 M 2	3 F 3	4 M 2.5	5 F 5	Mean ± S.E
Colon ascendens (Gyri centripetalis)						
Thickness of Lamina propria mucosae (µm)	467.47	498.55	521.11	496.46	514.01	499.52 ± 8.27
Depth of the Glandula intestinales (µm)	483.78	533.61	548.62	521.38	533.56	524.19 ± 9.82
Diameter of the Glandula intestinales (µm)	54.86	49.19	52.26	56.00	56.52	53.76 ± 1.35
Percentage of goblet cells to the total cell count in the Glandula intestinales	60.26	54.59	60.00	57.17	57.88	57.98
Percentage of the Glandula intestinales to the C.T Lamina propria	47.36	49.19	56.81	52.38	56.87	52.52
Colon transversum						
Thickness of Lamina propria mucosae (µm)	413.28	410.75	414.47	410.85	412.76	412.34 ± 1.79
Depth of the Glandula intestinales (µm)	431.51	426.01	438.46	436.85	443.73	435.31 ± 2.71
Diameter of the Glandula intestinales (µm)	45.16	49.43	51.66	51.13	48.49	49.17 ± 1.03
Percentage of goblet cells to the total cell count in the Glandula intestinales	55.15	53.21	52.46	58.46	56.18	55.02
Percentage of the Glandula intestinales to the C.T lamina propria	57.84	55.89	57.27	59.68	52.61	56.66
Colon descendens						
Thickness of Lamina propria mucosae (µm)	378.13	401.76	392.32	386.96	401.36	392.11 ± 4.04
Depth of the Glandula intestinales (µm)	398.63	428.23	418.23	414.16	434.12	418.67 ± 5.42
Diameter of the Glandula intestinales (µm)	44.06	48.43	46.08	51.11	47.63	47.46 ± 1.17
Percentage of goblet cells to the total cell count in the Glandula intestinales	56.15	54.13	52.61	57.12	55.14	55.03
Percentage of the Glandula intestinales to the C.T lamina propria	53.89	63.23	55.73	54.23	54.28	56.18
Rectum						
Thickness of Lamina propria mucosae (µm)	347.39	344.66	371.18	374.38	336.65	354.85 ± 6.74
Depth of the Glandula intestinales (µm)	364.51	376.01	394.46	403.85	354.73	378.71 ± 8.15
Diameter of the Glandula intestinales (µm)	51.37	46.36	45.53	51.33	47.32	48.38 ± 1.21
Percentage of goblet cells to the total cell count in the Glandula intestinales	55.50	56.60	53.23	56.70	55.73	55.55
Percentage of the Glandula intestinales to theC.T. lamina propria	56.23	59.43	54.64	54.46	55.42	56.04

Table 3: Showing the measurements of the intestinal glands of the colon and rectum of the donkey

Number Sex Male (M) or Female (F) Age (Year)	1 F 8	2 M 11	3 F 14	4 F 6	5 M 11	Mean ± S.E
Colon ascendens						
Thickness of Lamina propria mucosae (µm)	495.32	489.52	508.63	516.42	481.69	498.35 ± 5.64
Depth of the Glandula intestinales (µm)	481.03	473.01	492.50	506.50	468.61	484.34 ± 6.16
Diameter of the Glandula intestinales (µm)	57.60	54.43	58.42	57.31	51.38	55.83 ± 1.16
Percentage of the goblet cells to the total cell count in the Glandula intestinales	42.36	44.63	45.81	47.25	44.69	45.07
Percentage of the Glandula intestinales to C.T. lamina propria	42.97	45.81	46.21	48.12	43.28	45.27
Colon transversum						
Thickness of Lamina propria mucosae (µm)	487.56	476.45	486.58	504.49	480.66	487.15 ± 4.28
Depth of the Glandula intestinales (µm)	471.35	463.30	473.68	487.59	465.53	472.29 ± 3.81
Diameter of the Glandula intestinales (µm)	53.83	54.75	58.44	59.59	57.42	56.81 ± 1.097
Percentage of the goblet cells to the total cell count in the Glandula intestinales	48.55	44.47	43.98	41.04	47.32	45.07
Percentage of the Glandula intestinales to C.T. lamina propria	46.80	46.81	47.16	53.34	44.53	47.73
Colon descendens						
Thickness of Lamin propria mucosae (µm)	471.74	467.26	469.92	454.04	470.46	466.68 ± 2.86
Depth of the Glandula intestinales (µm)	457.61	455.61	456.95	439.18	465.97	453.33 ± 3.18
Diameter of the Glandula intestinales (µm)	53.85	55.77	56.46	56.28	57.73	56.02 ± 0.562
Percentage of goblet cells to the total cells in the Glandula intestinales	45.35	43.25	44.09	43.68	45.51	44.10
Percentage of the Glandula intestinales to C.T lamina propria	42.40	45.36	43.99	45.14	45.36	44.45
Rectum						
Thickness of Lamina propria mucosae (µm)	456.79	440.93	456.27	445.70	445.12	448.96 ± 2.86
Depth of the Glandula intestinales (µm)	445.74	446.61	428.67	433.73	433.76	437.70 ± 3.21
Diameter of the Glandula intestinales (µm)	58.23	57.63	52.84	56.23	58.43	56.67 ± 0.92
Percentage of goblet cells to the total cells in the Glandula intestinales	45.98	44.85	43.25	41.30	41.53	43.38
Percentage of the Glandula intestinales to of C.T. lamina propria	43.56	35.42	41.56	38.12	43.85	40.50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2b
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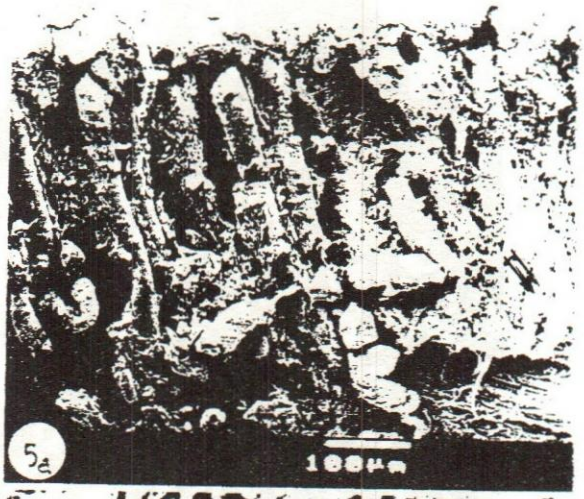
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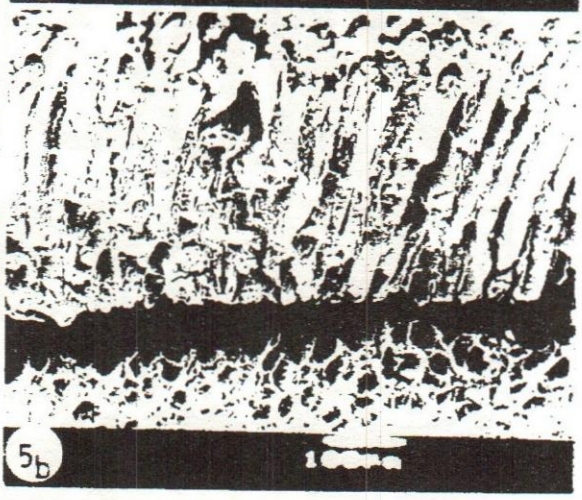
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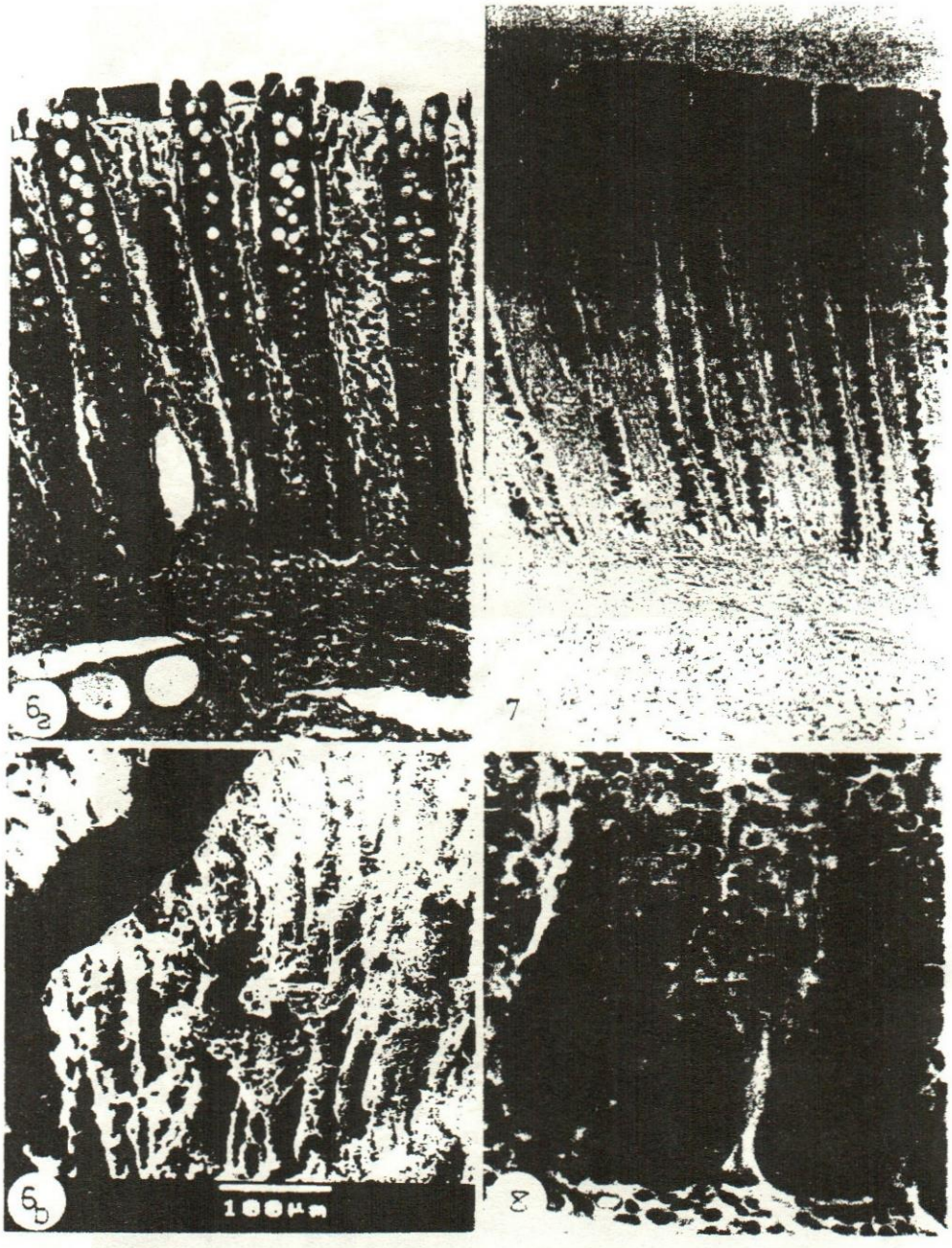
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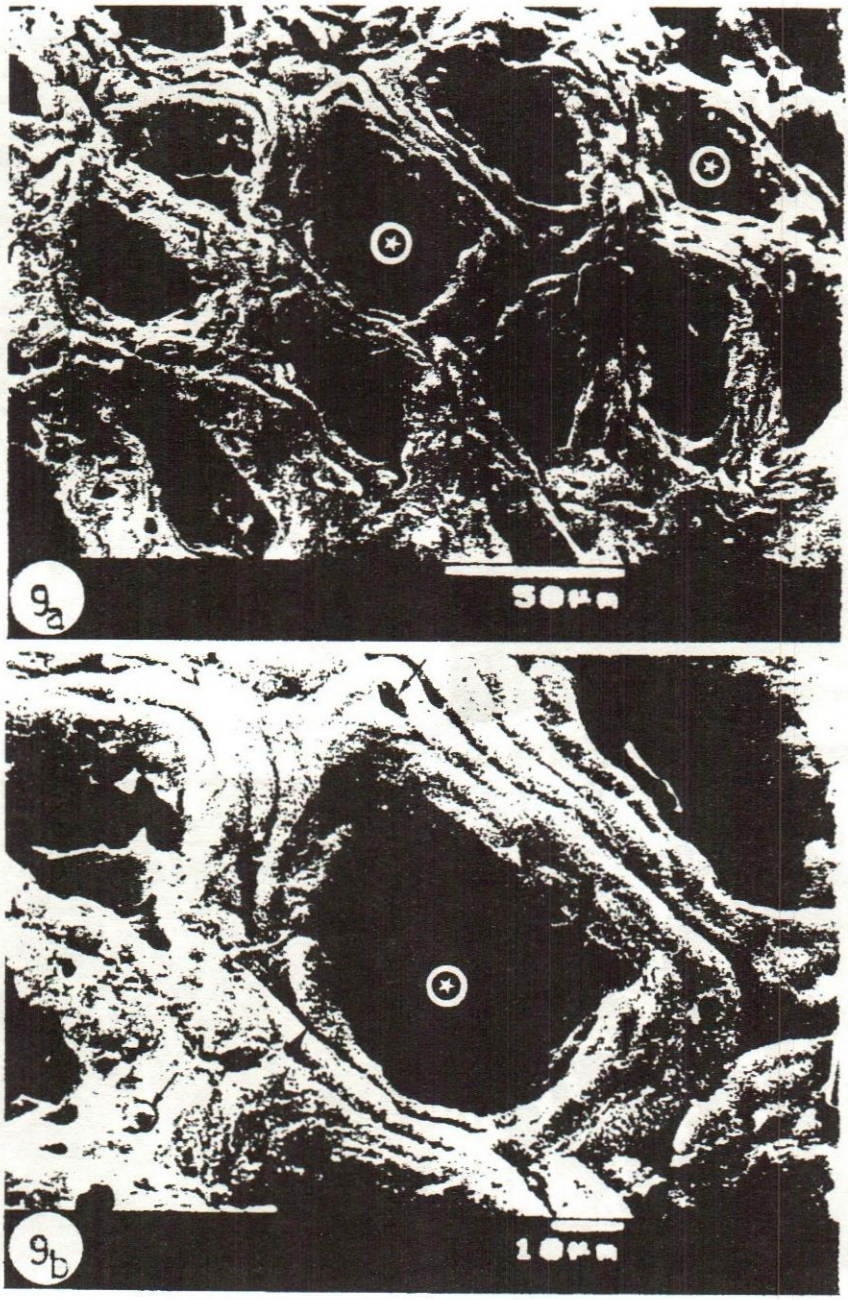
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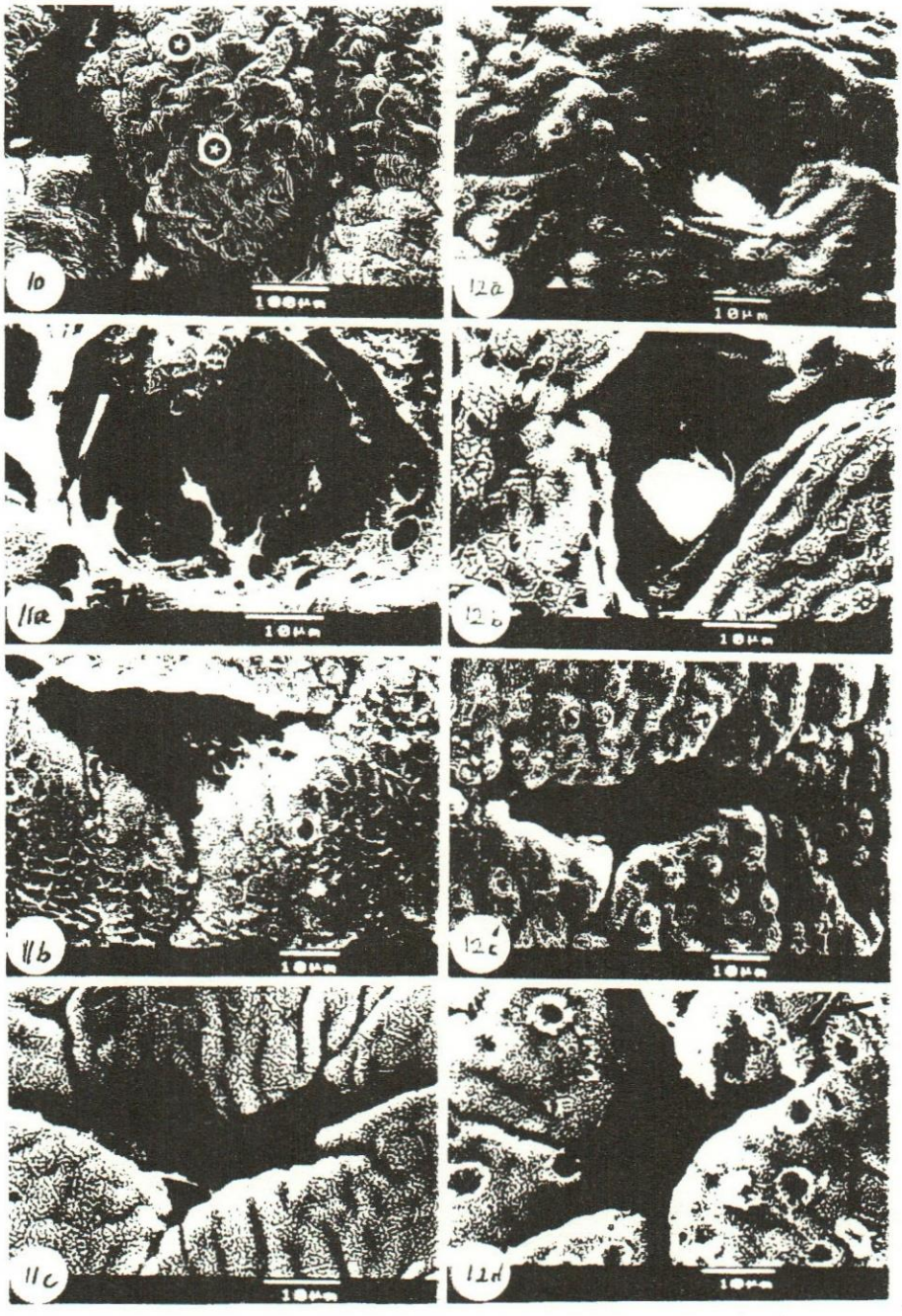
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