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Dept. of Anatomy and Histology,
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MORPHOLOGICAL AND MORPHOMETRICAL STUDIES ON THE TUNICA MUSCULARIS OF THE COLON AND RECTUM OF SOME DOMESTIC ANIMALS

(With 3 Tables, 3 Histograms and 4 Plates)

By

H. BADAWI; YOUSRIA A. ABDEL-RAHMAN; A.O. SALEM and A.A. MOHAMMED

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دراسات مورفولوجية ومورفومترية على الرداء العضلي للقولون والمستقيم في بعض الحيوانات المستأنسة

حلمي بدوي ، يسرية عبدالغني عبدالرحمن ، أحمد عمر سالم ، عبدالمهيمن مصطفى محمد

تم في هذا البحث دراسة الرداء العضلي للقولون والمستقيم مورفولوجيا ومورفومتريا في عدد خمسة حيوانات بالغة سليمة ظاهريا من كل من الكلاب والماعز والحمير من كلا الجنسين ومختلف الأعمار. وقد أظهرت الدراسة أن هذا الرداء يتكون من طبقتين من العضلات الملساء . كانت الطبقة الدائرية الداخلية السميكة في قولون الكلب والماعز ترتبط مع الطبقة الطولية الخارجية الرفيعة بواسطة الألياف الشبكية فيما عدا الأماكن التي بها ضفيرة مايسنرز فقد لوحظ وجود بعض الألياف البيضاء والمرنة . هذه الألياف المرنة قد شوهدت في الرداء العضلي لقولون الكلب ، وكانت غائبة في قولون الماعز. أما في قولون الحمار لوحظ أن الطبقتين العضليتين تكونان مختلفتين في السمك ومنفصلتين بواسطة الحاجز البين عضلي. زاد سمك الطبقة الخارجية الطولية الرفيعة مكونة أشرطة معوية في القولون المستعرض والهابط . هذه الأشرطة لوحظ أنها غنية بالألياف المرنة مقارنة بالأجزاء الأخرى من القولون. كان الرداء العضلي لقولون الماعز أقل سمكا عنها في الحيوانات تحت الدراسة حيث تراوح سمكه من ٢٤١,١٤ ميكرون ± ١٠,٤٣ إلى ٢٨٩,٩٩ ميكرون ± ٦,٠٨ عند التلافيف الجاذبة والقولون الهابط على التوالي. بينما في الكلاب بلغ سمكه ٨٢٨,٢٠ ميكرون ± ٩٢,٥٠ إلى ٨٢٩,٦٩ ميكرون ± ٤٣,٧٢ في القولون الهابط والمستعرض على التوالي. وقد وجد أنه بالرغم من إختلاف سمك الرداء العضلي للأجزاء المختلفة لقولون الحمار إلا أنها أكثر سمكا من مثيلاتها في الحيوانات موضع الدراسة حيث بلغت ١٥٢١,٤٩ ± ١٥٣,٣١ عند الشريط المعوي المساريقي. أما في المستقيم وجد أن الرداء العضلي في الكلب

والحمار يتكون من طبقة دائرية رفيعة وطبقة طولية سميكة تنفصلان بواسطة الحاجز البين عضلي . أما في الماعز فكان الرداء العضلي أقلهما سمكا (٢٩١,٤٤ ميكرون ± ١٠,٥٤) بينما كان أكثرهم سمكا في الحمار (٢٠٧٠,١٧ ميكرون ± ١٧,٥١). كانت الألياف المرنة قليلة في الرداء العضلي لمستقيم الكلب والحمار وغائبة في الماعز. وقد نوقشت نتائج البحث وعلاقتها بالدور الممكن للرداء العضلي في تكوين الصورة النهائية للمادة البرازية في الحيوانات موضع الدراسة.

SUMMARY

The Tunica muscularis of the colon and rectum of the dog, goat and donkey was studied morphologically and morphometrically. It composed of two layers of smooth muscle fibers. In the dog and goat, the thick inner circular layer was joined with the thin outer longitudinal one by reticular fibers, except at the places of myenteric plexus, where few collagenous and elastic fibers were observed. The latter was demonstrated in the colon of the dog and absent in goat. In the donkey, the 2 muscular layers were of variable thickness and constantly separated by inter-muscular septum. The thin outer longitudinal layer became thickened forming the Taeniae coli in the transverse and descending colon. The Tunica muscularis of the colon of the goat was the thinnest of the studied animals, where it ranged from 241.14 µm ± 10.43 to 289.99 µm ± 6.08 at the centripetal gyri and descending colon, respectively. While, in the dog it measured 828.20 µm ± 92.50 to 829.69 µm ± 43.72 in the descending and transverse colon, respectively. Although, the Tunica muscularis of the colon of the donkey was of variable thickness within its different parts, it was the thickest of the studied animals where it measured 1521.49 µm ± 153.31 at the meseneric band of the descending colon. In the rectum, the Tunica muscularis of the dog and donkey was composed of thin inner circular and thick outer longitudinal muscular layers separated by inter-muscular septum. The Tunica muscularis of the goat was the thinnest (291.44 µm ± 10.54 in thickness) while that of the donkey was the thickest of the studied animals (2070.17 µm ± 17.51). The elastic fibers were fewer in the Tunica muscularis of the rectum of the dog and donkey and absent in that of the goat. The obtained results were discussed in relation to the possible role of the Tunica muscularis in the formation of the final form of the fecal matter in the animals under investigation.

Key words: *Colon, rectum, Tunica muscularis, fecal matter, dog, goat, donkey.*

INTRODUCTION

The Tunica muscularis of the large intestine consists of an inner circular and outer longitudinal smooth muscle fibers separated by inter-muscular septum containing the myenteric plexus. In guinea pig, rabbit, pig, horse and man modification of the outer longitudinal muscular layer occurs to form flat muscular bands containing elastic fibers called Taeniae coli (Sloss, 1954; Sisson, 1975; Gabella, 1983; Telford and Bridgman, 1995). Breazile (1971) added that the haustra produced by the Taeniae coli assist in mixing the materials within the large intestine and are particularly important in the horse and pig since these herbivorous animals have no rumen to digest dietary cellulose. The muscular coat produces peristalsis which involves both the circular and longitudinal muscle layers and serves to squeeze the digesta (Drazner, 1985 and Currie, 1988). The circular layer performs segmental contraction (Drazner, 1985) while the longitudinal layer produces a pendular or propulsive contraction (Pace, McCashland and Landolt, 1965; Schottelius and Schottelius, 1973 and Currie, 1988). From the available literature the Tunica muscularis of the colon and rectum of the domestic animals received little attention. In this work the morphology and morphometry of the Tunica muscularis of the colon and rectum of the dog, goat and donkey will be explored. The purpose of this study will be an aid to correlate the role of the Tunica muscularis in the formation of the different final forms of the fecal matter of the studied animals.

MATERIALS and METHODS

Five large intestine of dog, goat and donkey each of both sexes and different ages were obtained from the dissecting room and were perfused through the cranial and caudal mesenteric arteries with Bouin's fixative. The specimens were collected from the segment of the colon concerned with formation of the final form of the fecal matter (descending colon in dog and donkey and centrifugal gyri of the ascending colon in the goat). In addition, the preceeding segment (transverse colon in dog and donkey and centripetal gyri in the goat, in which the content is semifluid) and the rectum as storage place were also used.

These specimens were rapidly rinsed in normal physiological saline for removal of the intestinal contents and then immersed in the same fixative used for further 24 hours. Thenafter they were processed for paraffin embedding. 5 µm thick paraffin sections were stained with H&E (Harris, 1900), Crossmon's trichrome (Crossmon, 1937), Verhoeff's haematoxylin (Verhoeff, 1908) and Gomori's reticulin (Gomori, 1937).

Morphometric studies were carried out using Leica Q 500 MC Image analyser. The thickness of the Tunica muscularis as well as its layers was measured in each animal on fifteen fields along the histological sections. The total wall thickness of the different parts of the colon and rectum of the studied animals was calculated by summation the thickness of the different layers (Mohammed, 1997).

The measurements were statistically analysed using *SAS* international computer program (1990).

RESULTS

A) Colon:

The Tunica muscularis of the colon of the dog, goat and donkey was composed of an inner circular and outer longitudinal layers of smooth muscle fibers. In the dog (Plate I, Fig. 1) and goat (Plate II, Fig. 1 & 2), the thick inner circular and thin outer longitudinal muscular layers were joined together with reticular fibers except at the places of the myenteric plexus, where few collagenous and elastic fibers were observed. The latter appeared as few fine fibers especially in the inner circular layer in the colon of the dog, while in the goat, they could not be demonstrated (Plate II, Fig. 2). In the donkey, the inner circular and outer longitudinal muscular layers were of variable thickness and constantly separated by inter-muscular connective tissue septum (Plate III, Fig. 1-4). The latter was formed mainly of collagenous (Plate IV, Fig. 1) and elastic fibers (Plate III, Fig. 3) and contained the myenteric plexus as well as blood vessels. The inner circular layer was thick at the inter-taenial region of the transverse (Plate III, Fig. 1) and descending colon as well as at the semilunar folds (Plate III, Fig. 1&2). While, the outer longitudinal layer became thicker at the inter-taenial region (Plate III, Fig. 2).

The muscular coat of the colon of the donkey contained variable amounts of elastic fibers. They were few and dispersed within the inner muscular layer of the transverse colon (Plate III, Fig. 3) as well as that of

the semilunar fold of the descending one. The outer longitudinal muscular layer of the mesenteric (Plate III, Fig. 4) and anti-mesenteric bands (Plate III, Fig. 5) was extremely rich in elastic fibers than the inner circular layer. These elastic fibers ran parallel to the longitudinal axis of the muscular layer. In addition, these taeniae showed abundant blood capillaries (Plate IV, Fig. 1 & 2).

The average thickness of the Tunica muscularis of the transverse and descending colon of the dog was nearly equal, where they reached about 829.69 µm ± 43.72 and 828.20 µm ± 92.50, respectively. This muscular coat represented about 46.74% and 46.47% of the total wall thickness of the transverse and descending colon. The Stratum circulare constituted about 2.45 and 1.66 times the thickness of Stratum longitudinale at the level of transverse and descending colon, respectively (Table 1, Hist.1, 2& 3).

In the goat, the muscular coat was thinner where it measured 281.15 µm ± 7.97 and 289.99 µm ± 6.08 in thickness at the transverse and descending colon, respectively. The thickness of the inner circular layer was 187.51 µm ± 5.46 at the transverse and 195.79 µm ± 3.84 at the descending one. The outer longitudinal muscular layer was nearly of the same thickness along the transverse and descending colon, where it reached 93.63 µm ± 3.72 and 94.19 µm ± 3.72, respectively. The Tunica muscularis represented about 31.93% of the total wall thickness of the transverse colon and 33.01% of that of the descending one. The inner circular layer constituted 2.0 and 2.09 times the outer longitudinal one of the before mentioned segments (Table 2, Hist. 1,2& 3).

However, in the donkey the Tunica muscularis of the colon was the thickest of the studied animals. This muscular coat varied considerably in thickness at the different parts of the colon especially its outer longitudinal layer. The Tunica muscularis was 1067.74 µm ± 12.40 in thickness within the inter-taenial region of the transverse colon. It was formed of thick inner circular (617.73 µm ± 9.98) and thin outer longitudinal (356.99 µm ± 7.81) layers, representing about 48.74% of the total wall thickness. While, at the taeniae the latter layer was increased in thickness greatly (Plate III, Fig. 2) to reach 861.19 µm ± 21.52. Within the descending colon the variation in the thickness of the Tunica muscularis was clear. It was of minimal thickness (793.83 µm ± 19.91) at the semilunar folds and saccules, consisting of thick inner circular layer (528.97 µm ± 17.59) and thin outer longitudinal one (190.88 µm ± 2.34). In this region, the Tunica muscularis formed about

41.89% of the total wall thickness. The maximal thickness was observed at the mesenteric and anti-mesenteric bands of the descending colon, where it measured about 1521.49 µm ± 153.31 and 1485.89 µm ± 96.90, respectively. The average thickness of the inner circular layer was 562.32 µm ± 27.41 at the mesenteric and 515.51 µm ± 13.83 at the anti-mesenteric band. The outer longitudinal layer was thick forming the taeniae (dorsal and ventral bands), which had approximately the same thickness. It reached 816.66 µm ± 131.6 and 816.4 µm ± 80.25 in thickness, respectively. The muscular coat constituted about 62.10% of the total wall thickness at the level of the mesenteric band and 60.37% of that of the anti-mesenteric one. The inner circular layer formed about 1.73, 2.77, 0.74 and 0.65 times the outer longitudinal one at the transverse, semilunar fold, mesenteric and anti-mesenteric band of the descending colon, respectively (Table 3, Hist.1, 2& 3).

B) Rectum:

Unlike that of the colon, the Tunica muscularis of the rectum of the dog (Plate I, Fig. 2) and donkey (Plate IV, Fig. 3) consisted of thin inner circular and thick outer longitudinal smooth muscle fiber layers separated by inter-muscular septum. In the goat, the inner circular layer was thicker than the outer longitudinal one (Plate II, Fig. 3). The connective tissue layer was formed mainly of collagenous and elastic fibers and contained blood vessels and nerve cells and fibers of the myenteric plexus. The former fibers were observed surrounding the muscular bundles especially the outer longitudinal layer and communicated with those of the inter-muscular septum and Tunica serosa (Plate I, Fig. 2; Plate II, Fig. 3 and Plate IV, Fig.3). Few fine elastic fibers were observed within the muscular layers of the rectum of the dog (Plate I, Fig. 3) and donkey (Plate IV, Fig. 4) as well as the inter-muscular septum of the goat, (Plate II, Fig. 4).

The Tunica muscularis of the rectum of the dog measured about 786.06 µm ± 34.05 and formed about 48.17% of the total wall thickness. Its circular layer was 331.10 µm ± 23.39, while the Stratum longitudinale measured 415.06 µm ± 31.79 in thickness. The former layer represented about 0.82 time the outer one (Table 1, Hist. 1,2,3). In the goat, this tunica was also thinner than that of the dog, where it measured 291.44 µm ± 10.4 in thickness and constituted about 34.01% of the total wall thickness. The average thickness of the thick inner layer reached 160.29 µm ± 4.39, while the thin outer longitudinal was 92.94 µm ± 5.28 in thickness. Consequently, the Stratum circulare constituted

about 1.74 times the outer longitudinal layer (Table 2, Hist. 1, 2, 3). The Tunica muscularis of the rectum of the donkey was the thickest, where it measured 2070.17 µm ± 17.51 and constituted about 55.29% of its total wall thickness. The inner circular layer was 907.90 µm ±28.28 in thickness and the outer longitudinal one was 987.00 ± 24.4. The former layer was constituted 0.92 time the outer one (Table 3, Hist. 1,2,3).

DISCUSSION

The present investigation revealed that the Tunica muscularis of the colon of the dog and goat was arranged into thick inner circular and thin outer longitudinal smooth muscle fiber layers in between them the Plexus nervorum myentericus. These results are in accordance with that mentioned by Trautmann and Fiebiger(1957) and Liebich(1990) in the dog and ruminant as well as Evans(1993) in the dog.

In the donkey, the Tunica muscularis contained in addition a thick inter-muscular connective tissue septum, which contained the myenteric plexus. The Tunica muscularis of the transverse colon of the donkey was composed of thick inner circular and thin outer longitudinal smooth muscle fiber layers at the inter-taenial region as that of dog and goat. The outer longitudinal muscular layer of the transverse and descending colon of the donkey was thickened forming the taeniae. In the horse, similar results were recorded in the transverse (Burns, 1992; Dyce, Sack and Wensing, 1996) and the descending colon (Trautmann and Fiebiger, 1957; Sisson, 1975; Schummer and Nickel, 1979; Banks, 1993; Stinson and Calhoun, 1993).

The Taeniae coli were observed also in a variety of species including pig (Sloss, 1954; Stinson and Calhoun, 1993), man (Copenhaver, Kelly and Wood, 1978; Leeson, Leeson and Paparo, 1988 and Telford and Bridgman, 1995), rabbit (Gabella, 1983 and Houssainy, 1996) and guinea pig (Gabella, 1976).

The Tunica muscularis of the rectum possesses in addition to the muscular layers a well-developed inter-muscular connective tissue septum. In the dog, the muscular layer was thicker than that of the colon, where it constituted about 48.17% of the total wall thickness. The thickening occurred in the outer longitudinal muscular layer as mentioned by Trautmann and Fiebiger (1957) and Banks (1993) in the same animal. In the rectum of the goat, the Tunica muscularis was relatively thicker (34.01%), due to the presence of an inter-muscular C.

T. septum. However, in the donkey it was thicker than that of the dog and goat, where it constituted about 55.29% of the total wall thickness. This is due to the increased thickness of both inner and outer muscular layers. These results simulated that mentioned by Trautmann and Fiebiger (1957), Schummer and Nickel (1979), Banks (1993) and Stinson and Calhoun (1993) in the horse. While, Sisson (1975) stated that the increased thickness of this tunic in the rectum of the horse is due to the outer longitudinal muscular layer.

The elastic fibers were few in the Tunica muscularis of the colon and rectum of the dog and absent in those of the goat. Trautmann and Fiebiger (1957) stated that they are hardly demonstrable in the muscular coat of goat and sheep. In the donkey, these fibers were more numerous specially in the Taeniae coli simulating that mentioned by Trautmann and Fiebiger (1957), Schummer and Nickel (1979), Stinson and Calhoun (1993), Liebich (1990) in the horse and pig, Sloss (1954) in the pig and Gabella (1983) in the rabbit.

With respect to the capability of the elastic fibers for expansion about 150 times its original size (Liebich, 1990), it is acceptable that these fibers give the muscular coat more elasticity. The latter provide the Tunica muscularis a greater resistance against the mechanical stress exerted by the luminal content upon the wall and consequently they act as shock absorber for stretch or compression. The presence of numerous elastic fibers within the muscular coat of the colon of the donkey is necessary to counteract the greater mechanical stress exerted by the large fecal balls upon the wall. However, in the goat the small fecal pellets necessitate mild mechanical stress and in accordance elastic fibers were not observed.

The Taeniae coli of the donkey contained numerous blood capillaries. They are few in these of guinea pig (Gabella, 1976). Gabella (1983) stated that the absence of blood capillaries in the rabbit Taeniae coli suggests that the tissue is an unfavourable environment that does not attract or does not support growing capillaries. He added also that the abundance of elastic fibers constitutes a hindrance to the growth of capillaries. The present finding disproves this suggestion, where the Taeniae coli of the donkey were highly vascularised to accommodate the adopted function.

The circular layer of the Tunica muscularis performs rhythmic segmental contraction. This type of contraction takes the form of phasic constrictions of the wall for a short distance which results in local

mixing of the luminal content, bringing them in direct contact with the absorptive surface (Fenton, 1960; Pace et al., 1965; Ganong, 1975 and Currie, 1988). Drazner (1985) added that the segmentation offers resistance against the propulsive activity, allowing time for maximal reabsorption and for storage and drying of the fecal matter.

The outer longitudinal layer of the Tunica muscularis produces a pendular or propulsive contraction. It is a rhythmic cycles of shortening and lengthening of the longitudinal muscluar layer which plays a role not only in mixing the luminal contents (Pace et al., 1965; Currie, 1988) but also for pushing them in anal direction (Schottelius and Schottelius, 1973). On the other hand, Drazner (1985) and Currie (1988) stated that the peristalsis involves both the circular and longitudinal muscle layers and serves to squeeze the digesta.

Breazile (1971) stated that the presence of Taeniae and Haustra provide the cecum and colon of horse and pig with different motility patterns from those of ruminants and carnivores. They include, localized segmenting contractions in which the Haustra are alternately compressed and expanded as well as pendular movement caused by contraction of the taeniae and functions in mixing of the internal content. Innervation of the inner and outer layers of the Tunica muscularis was carried out by the myenteric plexus (Krause and Cutts, 1994).

The proportion of the inner circular layer to the outer longitudinal one of the Tunica muscularis was relatively higher in the colon than in the rectum. In the latter this proportion was reversed. This reflect the relatively dominant role played by the inner circular layer in the colon than in the rectum, in which the outer longitudinal layer is needed for pushing the stored feces during defecation.

The above mentioned facts revealed that, there is a direct relation between the thickness of the muscular coat of the colon and rectum of the studied animals from one side and the total wall thickness, diameter of these parts and the volume of the contained fecal matter from the other side. This relation may explain that the colon and rectum of the donkey with their wider diameter need thicker muscular coat. This is needed to exert a greater role not only for the passage of the voluminous contents but also for their exposure to the mucosal surface for more absorption in comparison with those of the goat and dog.

The colon of the studied animals exhibited remarkable interspecies difference in the formation of the characteristic form of the feces. Within the descending colon of the donkey the received semifluid

fecal matter from the transverse colon was kneaded and rolled into its characteristic ball forms between two successive semilunar folds. This is achieved by the aid of the segmental contraction, alternating compression and expansion of the thick inner circular muscular layer (2.77 times the outer one). Contraction of the outer longitudinal layer opens these valvular folds and pushes the formed fecal balls with the aid of contraction of the taeniae in anal direction. This explains the high vascularity observed in the colic bands.

On the other hand, the received semifluid fecal matter from the centripetal turns of the colon of the goat was divided into fecal pellets within the centrifugal turns by the aid of the segmental contraction of the circular layer as well as the presence of transversely oriented folds. On the contrary, the colon of the dog possessed neither semilunar nor transverse folds (Mohammed, 1997) so, it may be suggested that the segmental contraction of the circular layer has a little role in dividing the contents into smaller units, which appeared in the form of columns.

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LEGENDS

Plate I:

Fig. 1: Photomicrograph of the descending colon of the dog showing the inner circular (a_1) and outer longitudinal layers (a_2) of the Tunica muscularis. Intestinal glands (G), submucosa (b), Tunica serosa (c), myenteric plexus (arrow), green coloration of collagenous fibers. Trichrome X 40.

Fig. 2: Photomicrograph of the Tunica muscularis of the rectum of the dog showing inner circular (a_1), outer longitudinal (a_2) and inter-muscular septum (b). Tunica serosa (c), collagenous fibers (arrow), myenteric plexus (arrowhead). TrichromeX 100.

Fig. 3: Photomicrograph of the Tunica muscularis of the rectum of the dog showing elastic fibers (arrow) within the inner circular (a_1), outer longitudinal (a_2) and inter-muscular septum (b). Myenteric plexus (asterisk). Verhoeff's X250.

Plate II:

Fig. 1: Photomicrograph of a centripetal turn of the colon of the goat showing thick inner circular (a_1), thin outer longitudinal (a_2) of the Tunica muscularis, myenteric plexus (arrow), submucosa (b), mesothelium (arrowhead), subserosa (double arrow). Trichrome X 160.

Fig. 2: Photomicrograph of the transverse colon of the goat showing elastic fibers (arrowhead) around the myenteric plexus (arrow), thick inner circular (a_1) and thin outer longitudinal (a_2) layers of the Tunica muscularis. Verhoeff's X 250.

Fig. 3: Photomicrograph of the rectum of the goat showing inner circular (a_1), outer longitudinal (a_2) and inter-muscular septum (b) of the Tunica muscularis. Mesothelium (arrow), subserosa (asterisk). TrichromeX 100.

Fig. 4: Photomicrograph of the rectum of the goat showing elastic fibers (arrow). Inter-muscular septum (a), inner circular (b_1), outer longitudinal (b_2) muscular layers, subserosa (c), mesothelium (arrowhead). Verhoeff's X 160.

Plate III:

Fig. 1: Photomicrograph of the transverse colon of the donkey showing thick inner circular (a_1), thin outer longitudinal layers (a_2) of the Tunica muscularis and inter-muscular septum (b). Collagenous fibers (Green color). submucosa (c), Tunica serosa (d). TrichromeX 100.

Fig. 2: Photomicrograph of the taeniae of the transverse colon of the donkey showing inner circular (a_1), outer longitudinal (a_2), taenia (a_3) and inter-muscular septum (b). Submucosa (arrow), Tunica serosa (asterisk). H&E X 40.

Fig. 3: Photomicrograph of the transverse colon of the donkey showing elastic fibers (arrowhead). Inner circular (a_1), outer longitudinal (a_2), inter-muscular septum (b), myenteric plexus (arrow), subserosa (c), mesothelium (double arrow). Verhoeff'sX 100.

Fig. 4: Photomicrograph of the descending colon (mesenteric band) of the donkey showing the elastic fibers (arrow). Inner circular (a_1), outer longitudinal (a_2) and inter-muscular septum (b). Verhoeff'sX 160.

Fig. 5: Photomicrograph of the descending colon (anti-mesenteric band) of the donkey showing elastic fibers (arrow). Outer longitudinal muscular layer (a), subserosa (b), mesothelium (double arrow). Verhoeff's X 250.

Plate IV:

Fig. 1: Photomicrograph of the descending colon (anti-mesenteric band) of the donkey showing taenia, (a_1), inner circular layer (a_2) and inter-muscular septum (b). Tunica serosa(arrow). TrichromeX 40.

Fig. 2: Photomicrograph showing numerous blood capillaries (arrow) within the mesenteric band of the descending colon of the donkey. H & E X 250.

Fig. 3: Photomicrograph of the rectum of the donkey showing the collagenous fibers within the submucosa (a), inner circular (b_1), outer longitudinal (b_2) and inter-muscular septum (c).Tunica mucosa (d), fat cells (asterisk). Trichrome X 10.

Fig. 4: Photomicrograph showing elastic fibers (arrow) within the inner circular (a) and inter-muscular septum (b) of the Tunica muscularis of the rectum of the donkey. Verhoeff's. X 160.

Table 1: Showing the measurements in µm of the Tunica muscularis of the Colon and Rectum in the dog.

Number Sex Male (M) or Female (F) Age (Year)	1 M 4	2 M 5	3 F 3	4 F 2.5	5 M 3	Mean ± S.E
A-Colon transversum						
Tunica muscularis (thickness)	669.09	805.34	845.02	856.32	972.66	829.69 ± 43.72
Stratum circulare (Sc)	497.53	544.37	595.35	638.86	639.25	583.07 ± 24.68
Stratum longitudinale (Sl)	171.56	260.97	249.67	217.46	333.41	246.61 ± 23.86
Ratio of Sc to Sl	2.90	2.09	2.38	2.94	1.92	2.45
Total wall thickness	1592.16	1719.02	1983.32	1778.88	1881.66	1791.01 ± 60.03
Percentage of the tunica muscularis to the total wall thickness	42.024	46.849	42.606	48.138	51.692	46.74
B- Colon descendens						
Tunica muscularis (thickness)	653.98	708.93	630.67	1003.79	1143.62	828.20 ± 92.50
Stratum circulare (Sc)	355.84	450.84	391.85	693.61	679.81	514.39 ± 64.39
Stratum longitudinale (Sl)	298.14	258.09	238.81	310.18	463.81	313.81 ± 35.49
Ratio of Sc to Sl	1.19	1.75	1.64	2.24	1.47	1.66
Total wall thickness	1659.30	1590.56	1561.57	1839.79	2088.98	1748.04 ± 87.66
Percentage of the tunica muscularis to the total wall thickness	39.413	44.571	40.386	54.560	54.745	46.47
C-Rectum						
Tunica muscularis (thickness)	781.26	876.10	661.78	757.33	853.85	786.06 ± 34.05
Stratum circulare (Sc)	394.55	334.43	250.94	351.75	323.82	331.10 ± 23.39
Stratum intermusculare	34.12	43.50	42.41	36.21	43.27	39.9 ± 1.97
Stratum longitudinale (Sl)	352.59	498.17	368.43	369.37	486.76	415.06 ± 31.79
Ratio of Sc to Sl	1.12	0.67	0.68	0.95	0.67	0.82
Total wall thickness	1828.96	1746.41	1440.66	1495.93	1661.45	1634.68 ± 65.68
Percentage of the tunica muscularis to the total wall thickness	42.716	50.166	45.936	50.626	51.392	48.17

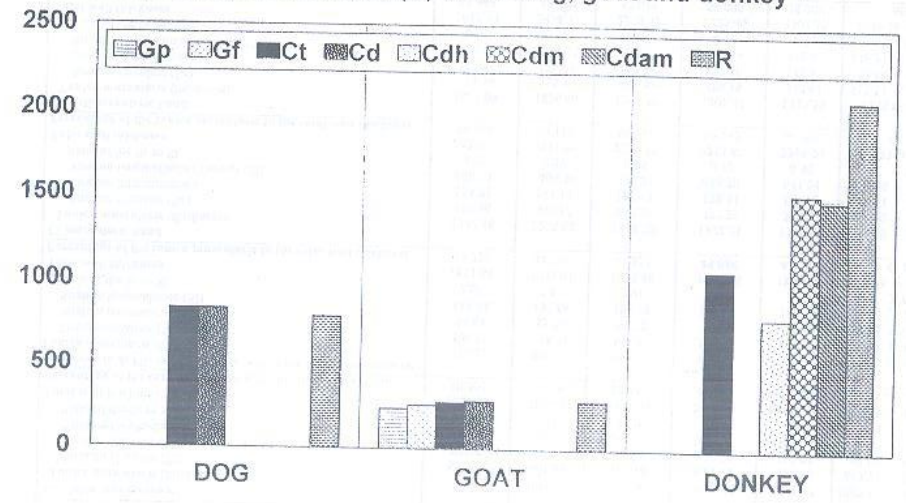
Table 2: Showing the measurements in µm of the Tunica muscularis of the Colon and Rectum in the goat

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
A- Gyri centripetales						
Tunica muscularis (thickness)	217.44	273.97	244.66	257.10	212.54	241.14 ± 10.43
Stratum circulare (Sc)	166.34	198.69	176.59	185.75	152.78	176.03 ± 7.05
Stratum longitudinale (Sl)	51.10	75.28	68.07	71.35	59.76	65.11 ± 3.87
Ratio of the Sc toSl	3.26	2.64	2.59	2.60	2.56	2.73
Total wall thickness	869.65	960.70	934.08	923.17	877.36	912.99 ± 15.45
Percentage of the tunica muscularis to the total wall thickness	25.003	28.518	26.198	27.850	24.225	26.36
B- Gyri centrifugales						
Tunica muscularis (thickness)	271.59	251.23	251.88	271.56	269.99	263.25 ± 4.27
Stratum circulare	176.40	165.45	174.35	188.80	176.42	176.28 ± 3.33
Stratum longitudinale	95.19	85.78	77.53	82.76	93.57	86.97 ± 2.96
Ratio of the SctoSl	1.85	1.93	2.25	2.28	1.89	2.04
Total wall thickness	899.51	888.03	862.09	894.15	932.33	895.22 ± 10.03
Percentage of the tunica muscularis to the total wall thickness	30.193	28.291	29.217	30.371	28.959	29.41
C-Colon transversum						
Tunica muscularis (thickness)	263.01	304.38	275.69	262.76	299.90	281.15 ± 7.97
Stratum circulare	171.51	202.94	187.44	176.63	199.05	187.51 ± 5.46
Stratum longitudinale	91.50	101.44	88.25	86.13	100.85	93.63 ± 2.84
Raio of thes Sc to Sl	1.87	2.00	2.12	2.05	1.97	2.00
Total wall thickness	871.23	909.54	874.74	853.18	890.44	879.83 ± 8.49
Percentage of the tunica muscularis to the total wall thickness	30.188	33.465	31.517	30.798	33.680	31.93
D- Colon descendens						
Tunica muscularis (thickness)	299.71	311.56	278.94	283.66	276.06	289.99 ± 6.08
Stratum circulare (Sc)	210.63	202.10	189.24	187.23	189.76	195.79 ± 3.84
Stratum longitudinale	89.08	109.46	89.70	96.43	86.30	94.19 ± 3.72
Ratio of the Sc to Sl	2.36	1.85	2.11	1.94	2.20	2.09
Total wall thickness	872.98	922.54	861.57	872.29	861.42	878.16 ± 10.17
Percentage of the tunica muscularis to the total wall thickness	34.332	33.772	32.376	32.519	32.047	33.01
E- Rectum						
Tunica muscularis (thickness)	337.74	280.29	282.78	272.11	284.29	291.44 ± 10.54
Stratum circulare (Sc)	179.34	157.59	158.49	151.78	154.27	160.29 ± 4.39
Stratum Intermusculare	42.31	38.56	36.56	34.80	38.80	38.21 ± 1.12
Stratum longitudinale (Sl)	116.09	84.14	87.73	85.53	91.22	92.94 ± 5.28
Ratio of the Sc to Sl	1.54	1.87	1.81	1.77	1.69	1.74
Total wall thickness	914.75	837.78	858.15	841.36	827.00	855.81 ± 13.91
Percentage of the tunica muscularis to the total wall thickness	36.922	33.456	32.952	32.342	34.376	34.01

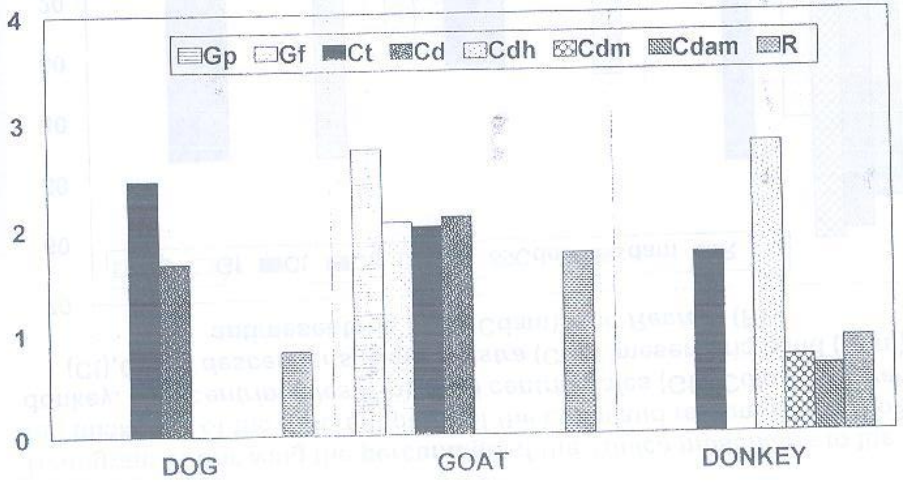
Table 3: Showing the measurements in μm of the Tunica muscularis of the Colon and Rectum in the donkey

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
A- Colon transversum:						
Tunica muscularis (thickness)	1122.53	1056.63	1053.63	1059.48	1046.45	1067.74 ± 12.40
Stratum circulare (Sc)	657.15	601.64	617.78	620.33	591.76	617.73 ± 9.98
Stratum Intermusculare	83.18	90.78	72.62	106.69	111.82	93.02 ± 6.50
Stratum longitudinale (Sl)	382.20	364.21	363.23	332.46	342.87	356.99 ± 7.81
Ratio of the Sc to Sl	1.72	165	1.70	1.87	1.73	1.73
Total wall thickness	2227.11	2196.80	2174.32	2184.26	2169.84	2190.47 ± 9.18
Percentage of the tunica muscularis to the total wall thickness	50.403	48.099	48.458	48.505	48.227	48.74
B- Haustria & Plicae semilunaris coli of the Colon descendens:						
Tunica muscularis (thickness)	736.52	800.16	802.90	867.83	761.74	793.83 ± 19.91
Stratum circulare (Sc)	496.34	516.74	548.41	595.65	487.69	528.97 ± 17.59
Stratum intermusculare	54.84	85.76	67.71	75.40	86.21	73.98 ± 5.27
Stratum longitudinale (Sl)	185.34	197.66	186.78	196.78	187.84	190.88 ± 2.34
Ratio of the Sc to Sl	2.68	2.61	2.94	3.03	2.60	2.77
Total wall thickness	1851.68	1932.91	1927.48	1924.76	1832.94	1893.93 ± 19.07
Percentage of the tunica muscularis to the total wall thickness	39.778	41.397	41.655	45.088	41.558	41.89
C- mesenteric band						
Tunica muscularis (thickness)	1332.48	2205.82	1368.72	1322.51	1377.93	1521.49 ± 153.31
Stratum circulare (Sc)	496.96	660.12	569.30	497.20	588.07	562.32 ± 27.41
Stratum intermusculare	154.81	141.14	129.15	138.81	148.62	142.51 ± 3.91
Stratum longitudinale (Taenia) (Sl)	680.73	1404.56	670.27	686.50	641.24	816.66 ± 131.6
Ratio of the Sc to Sl	0.73	0.47	0.85	0.72	0.92	0.74
Total wall thickness	2235.01	3145.98	2270.52	2213.68	2268.99	2426.83 ± 161.08
Percentage of the tunica muscularis to the total wall thickness	59.619	70.116	60.282	59.743	60.729	62.10
D- antimesenteric band						
Tunica muscularis (thickness)	1671.09	1826.46	1294.89	1301.42	1335.58	1485.89 ± 96.9
Stratum circulare (Sc)	531.76	564.40	482.61	486.18	512.61	515.51 ± 13.83
Stratum intermusculare	158.81	178.91	152.36	132.50	146.61	153.84 ± 6.82
Stratum longitudinale (Taenia) (Sl)	980.52	1083.15	659.92	682.74	676.36	816.54 ± 80.25
Ratio of the Sc to Sl	0.54	0.52	0.73	0.71	0.76	0.65
Total wall thickness	2615.74	2834.73	2270.57	2225.40	2302.36	2449.76 ± 104.10
Percentage of the tunica muscularis to the total wall thickness	63.886	64.432	57.029	58.480	58.009	60.37
E- Rectum						
Tunica muscularis (thickness)	2074.73	2072.42	2117.39	2087.71	1998.60	2070.17 ± 17.51
Stratum circulare (Sc)	936.14	870.14	912.11	881.12	940.18	907.90 ± 28.28
Stratum intermusculare	170.41	156.10	185.16	196.17	168.28	175.22 ± 6.24
Stratum longitudinale (Sl)	968.18	1046.18	1020.42	1010.42	890.14	987.00 ± 24.4
Ratio of Scto Sl	0.96	0.83	0.89	0.87	1.05	0.92
Total wall thickness	3983.44	3989.91	3568.51	3927.42	3334.32	3760.72 ± 118.1
Percentage of the tunica muscularis to the total wall thickness	52.084	51.942	59.336	53.157	59.940	55.29

Histogram 1: Showing the thickness of the Tunica muscularis of the *Gyri centripetales* (Gp), *Gyri centrifugales* (Gf), *Colon transversum* (Ct), *Colon descendens* (Cd), *Houstra* (Cdh), mesenteric band (Cdm), antimesenteric band (Cdam) and *Rectum* (R) of the dog, goat and donkey



Histogram 2: Showing the ratio of *Stratum circulare*(Sc) to the *Stratum longitudinale* (Sl) of the *Tunica muscularis* of the different parts of the colon and rectum in dog, goat and donkey. *Gyri centripetales* (Gp), *Gyri centrifugales* (Gf), *Colon transversum* (Ct),*Colon descendens* (Cd), *Haustra* (Cdh), mesenteric band (Cdm), antimesenteric band(Cdam), and *Recum* (R)



Histogram 3: Showing the percentage of the *Tunica muscularis* to the total wall thickness of the different parts of the colon and rectum in dog, goat and donkey. *Gyri centripetales* (Gp), *Gyri centrifugales* (Gf), *Colon transversum* (Ct),*Colon descendens* (Cd), *Haustra* (Cdh), mesenteric band (Cdm), antimesenteric band(Cdam), and *Rectum* (R)

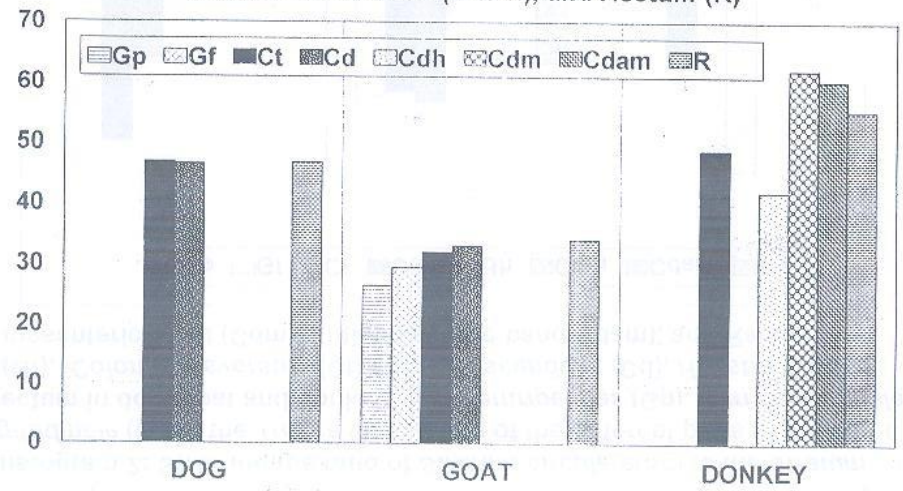
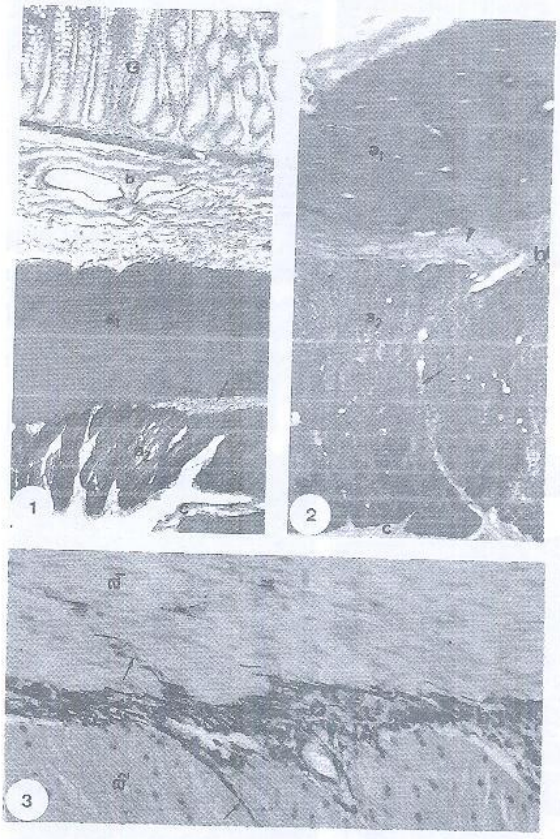


Plate I



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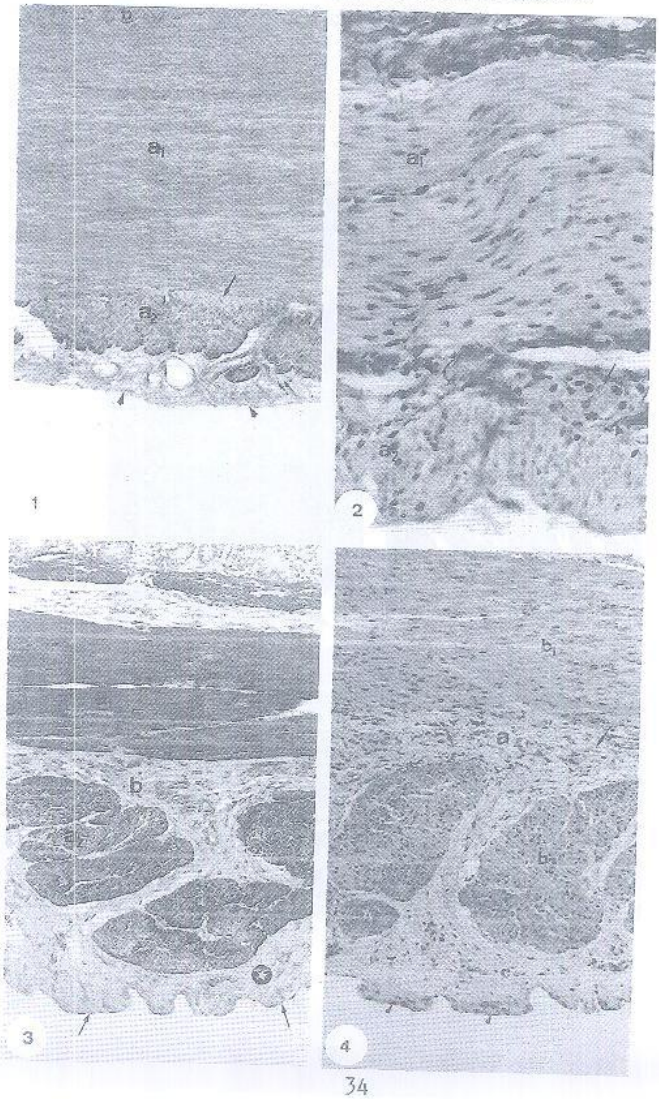

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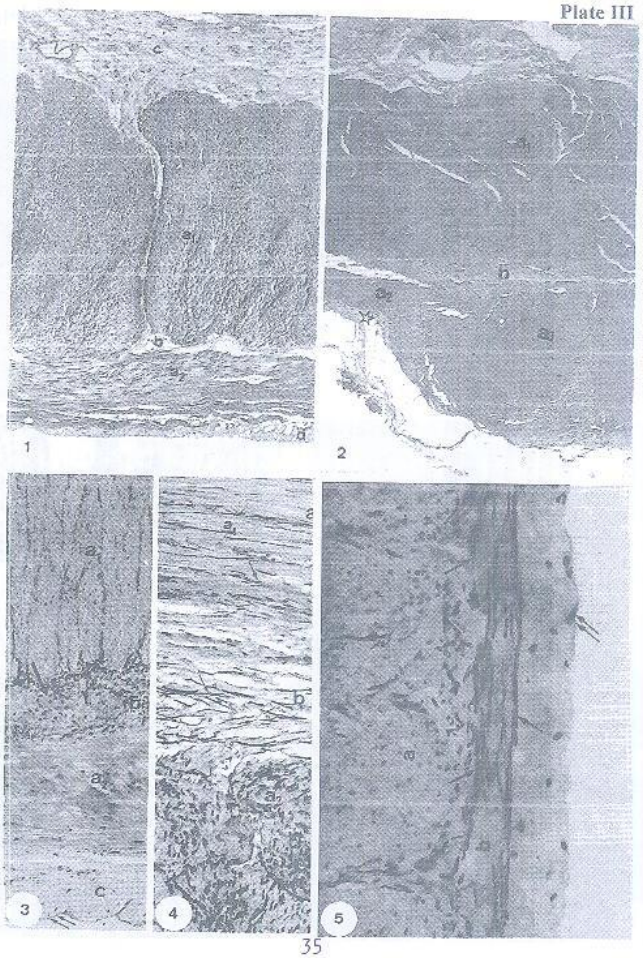

Plate IV