RESEARCH ARTICLE

Gross Morphometry of Large Intestine in Postnatal Age Groups of Indian Domestic Pig (*Sus scrofa domesticus*)

Tejaswini Nagilla[1*], Rajendranath Nalla[1], Ranjith Kumar Sundari[2], Jayasri Akkaldevi[3]

Abstract

The present study on gross morphometry of large intestine was conducted on different postnatal age groups (Group I piglets, 0-4 weeks, Group II weaners, 4-10 weeks and Group III adults, above 10 weeks, n=6 each) of Indian domestic pig. The large intestine of pig grossly appeared as a complex sacculated tube with caecum, colon and rectum attached to the dorsal wall of the abdominal cavity. The gross morphometrical observations revealed a significant increase in the length and diameter of all the segments of large intestine with advancing age. The total length of the large intestine increased from 107.58±11.27 cm in Group-I to 379.26±23.97 cm in Group-III. The length and diameters of the caecum increased significantly with age. The ascending colon showed characteristic centripetal and centrifugal turns. The total length of ascending colon increased from 80.53±10.28 cm in Group I to 164.97±8.48 cm in Group II and 287.83±20.67 cm in Group III. Similarly, significant ($p<0.05$) increase in the length and diameter of the transverse colon, descending colon and rectum were observed during postnatal growth. Among the colonic segments, the ascending colon showed the greatest length, whereas the rectum exhibited the greatest diameter in adult animals. The length of ascending colon and the diameter of rectum increased significantly ($p<0.05$) from Group I to Group III.

Key words: Caecum, Colon, Gross morphometry, Large intestine, Pig, Postnatal age, Rectum.

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Introduction

The pigs are highly adaptable and rapidly growing species that may be attractive for small and marginal farmers for rearing. They are primarily reared for meat production, although their skin, fat and other by-products also have considerable economic value (Urmila *et al.,* 2019; Thomas *et al.,* 2021 and Singh *et al.,* 2023). Pig farming is popular among rural farmers, particularly among India's tribal population (Srikanth *et al.,* 2023) as a source of income (Manju *et al.,* 2023). Pig population in India was 9.06 million according to the 20th livestock census (Srikanth *et al.,* 2023).

The gastrointestinal (GI) tract of the neonatal pig encounters numerous challenges and severe stress, particularly at the time of birth and weaning. In response to these challenges, the GI tract in healthy animals undergoes marked changes in structure and function (Xu *et al.,* 2000). During the first three days after birth, the weight of the large intestine of piglets increased by 33% during the first day and doubled by the third day. This weight gain was due to both mucosal and non-mucosal tissue growth (Xu *et al.,* 1992). The large intestine in pigs has the gross appearance of a complex sacculated tube (Hedemann *et al*., 2002) and has four parts: the caecum, colon, rectum and anal canal. It acts as a site for microbial digestion, absorption of water, vitamins and secretion of mucous (Eurell and Frappier, 2006). Caecum plays an important role in absorption of water and electrolytes. The passage of ingesta depends mostly on normal functioning of colon (Katkar *et al.,* 2008).

[1]Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad- 500030, PV Narasimha Rao Telangana Veterinary University, India

[2]Department of Veterinary Anatomy, College of Veterinary Science, Mamnoor, Warangal-506166, PV Narasimha Rao Telangana Veterinary University, India

[3]Department of Veterinary Biochemistry, College of Veterinary Science, Korutla-505326, PV Narasimha Rao Telangana Veterinary University, India

Corresponding Author: Dr. Tejaswini Nagilla, Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad-500030, PVNRTVU, Telangana, India. e-mail: tejaswininagilla@gmail.com

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The caecum of pig is cylindrical blind sac and it lies against the dorsal and cranial part of the left flank (Getty, 1975). The caecum consists of the apex, body and base (Miller *et al*., 1993). The colon is divided into the ascending colon, transverse colon and descending colon (Getty, 1975; König and Liebich, 2007). The rectum is a continuation of the descending colon (Getty, 1975). It receives faecal material from the descending colon by regular peristaltic action of muscle and acts as a temporary storage for faeces

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(Siyag *et al*., 2024). The rectum becomes dilated to form an ampulla rectus and joining the anal canal (König and Liebich, 2007). Although the gross anatomy of the porcine large intestine has been described in standard anatomical texts, information regarding age-related morphometric changes under postnatal conditions is limited. This study was aimed to record gross morphometry of large intestine in postnatal age groups of Indian domestic pig (*Sus scrofa domesticus*).

Materials and Methods

The present study was carried out in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad. The large intestine of 18 apparently healthy pigs were collected from the slaughter houses in and around Hyderabad. The animals were categorized into three postnatal groups: Group I (piglets, 0-4 weeks), Group II (weaners, 4-10 weeks) and Group III (adults, above 10 weeks), with six animals in each group. The large intestine was dissected carefully and consisted of caecum, colon and rectum. Gross morphometrical measurements including total length of the large intestine, length and diameter of the caecum, ascending colon (centripetal and centrifugal turns), transverse colon, descending colon and rectum were recorded carefully by using a thread, tape and scale.

The data were analyzed statistically using one way ANOVA (Snedecor and Cochran, 1994) and the means were tested for significance ($p<0.05$) by Tukey's HSD test using Statistical Package for the Social Sciences (SPSS), version 27.

Results and Discussion

Gross Morphometry of the Large Intestine

The large intestine of the pig consisted of the caecum, colon and rectum and was attached to the dorsal abdominal wall by the mesentery (Fig. 1). The average total length of the large intestine increased significantly ($p<0.05$) from Group-I to Group-II and Group-III age, measuring 107.5±11.27 cm, 210.69±110.33 cm and 379.26±23.97 cm respectively. The increase in the intestinal length was according to their age advancement and change in diet. Similar observations had been reported by Reece (2005), who stated that the development of the large intestine varied among the animals according to diet. In the present study the average length of large intestine in adult age Group pigs (Group-III) almost coincided with the reports of Getty (1975) and Nickel *et al.* (1979) in pigs. Differences in total intestinal length among species reported in earlier studies may be related to species-specific anatomical characteristics and differences in age and body size.

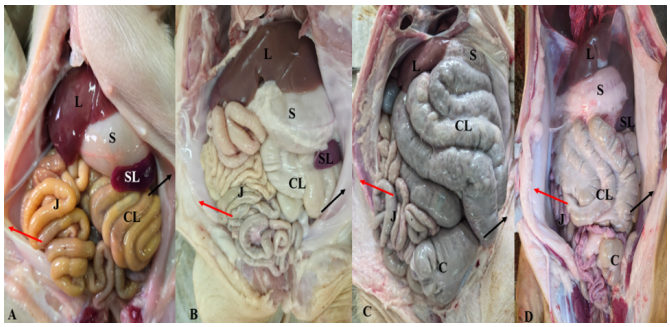


Fig. 1: : Ventral view in-situ photograph of abdomen of pig (A) G-I (0–day old) piglet, (B) G-II (37–day old) pig, (C) G-II (55–day old) pig and (D) G-III (11-months-old) adult pig showing position of large intestine. Stomach (S), spleen (SL), liver(L), jejunum(J), caecum(C) and colon (CL). Cut left lateral (black arrow) and right lateral (red arrow) abdomen wall.

Caecum

The caecum was a cylindrical blind sac comprising an ventral apex, body and dorsal end that continued with the ascending colon. It was located in the dorsocranial part of the left flank with its ventral apex (blind sac) lying on the floor of the abdomen. The caecum contained three longitudinal muscular bands- taeniae and three rows of sacculations- haustra haustra (Fig.5,6,7). The ventral muscular band attached to the ileocecal fold while the lateral and medial muscular bands were free and fused at the tip of the caecum haustra (Fig.5,6,7). These findings were in accordance with the description of caecum in pig (Getty, 1975; Nickel *et al.,* 1979; König and Liebich, 2007; Dyce *et al*., 2010; Frandson *et al*., 2018). The mean length of the caecum increased significantly ($p<0.05$) from Group I to Group III (Table 1). Similarly, the diameter at the apex, body and dorsal end increased significantly with age. The greatest diameter was recorded at the middle/body of the caecum in all three groups. The values indicate marked postnatal enlargement of the caecum in both length and diameter. These findings were closely associated with the reports in pigs (Getty, 1975; Nickel *et al.,* 1979; Paul, 2014) and in cattle and buffaloes (Shukla *et al.,* 2022). However, the dimensions differed from those reported sheep, goats, cattle, dogs and Bali cattle by Habel (1975), Rajput (2006), Abd-El-Hady *et al.* (2013) and Heryani *et al.* (2020), because of interspecies anatomical variation.

Colon

Like in most domestic animals, the colon of the pig was divided into three parts, *viz.,* ascending, transverse and descending colon (Fig.4,5,6). The ascending colon formed a cone- shaped organ (Fig.2,3). The base of the cone was attached to the abdominal roof and the apex points ventrally in the left half of the abdomen. The position of the cone depends on the degree of distension of the caecum. Further, the ascending colon formed a wider centripetal turns passing

Table 1: The mean values of large intestinal parameters studied in domestic pigs of different age groups

Segment	Parameter	Age group		
		Group I (0-4 wk)	Group II (4-10 wk)	Group III (>10 wk)
Total length of large intestine (cm)		107.58 ± 11.27[a]	210.69 ± 10.33[b]	379.26 ± 23.97[c]
Caecum	Length (cm)	5.53 ± 0.79[a]	10.83 ± 0.78[b]	23.30 ± 0.90[c]
	Diameter at apex (cm)	3.73 ± 0.65[a]	8.61 ± 1.17[b]	13.51 ± 0.74[c]
	Diameter at body (cm)	5.21 ± 0.99[a]	11.01 ± 1.07[b]	16.58 ± 0.81[c]
	Diameter at dorsal end (cm)	4.21 ± 0.93[a]	8.23 ± 0.78[b]	13.21 ± 0.62[c]
Ascending colon	**Total length of ascending colon (cm)**	80.53 ± 10.28[a]	164.97 ± 8.48[b]	287.83 ± 20.67[c]
	Centripetal turn length (cm)	45.26 ± 5.23[a]	87.58 ± 3.99[b]	152.66± 10.50[c]
	Centrifugal turn length (cm)	35.26 ± 5.05[a]	77.38 ± 4.62[b]	135.16 ± 10.24[c]
	Centripetal turn diameter (cm)	3.65 ± 0.82[a]	7.83 ± 0.40[b]	9.88 ± 0.26[c]
	Centrifugal turn diameter (cm)	2.52 ± 0.45[a]	5.41 ± 0.35[b]	7.30 ± 0.10[c]
Transverse colon	Length (cm)	9.03 ± 0.42[a]	13.83 ± 1.12[b]	25.55 ± 1.68[c]
	Diameter (cm)	2.28 ± 0.35[a]	4.48 ± 0.29[b]	6.62 ± 0.13[c]
Descending colon	Length (cm)	7.03 ± 0.52[a]	12.05 ± 0.71[b]	25.50 ± 1.76[c]
	Diameter (cm)	2.48 ± 0.48[a]	4.73 ± 0.17[b]	7.01 ± 0.27[c]
	Total average length of colon (cm)	96.60±11.23[a]	190.85±10.29[b]	338.88±23.94[c]
Rectum	Length (cm)	5.45 ± 0.56[a]	9.01 ± 0.52[b]	17.08 ± 0.66[c]
	Diameter (cm)	3.58 ± 0.41[a]	6.31 ± 0.30[b]	10.90 ± 0.62[c]

Mean values with different superscripts (a,b,c) in a row differ significantly ($p<0.05$).

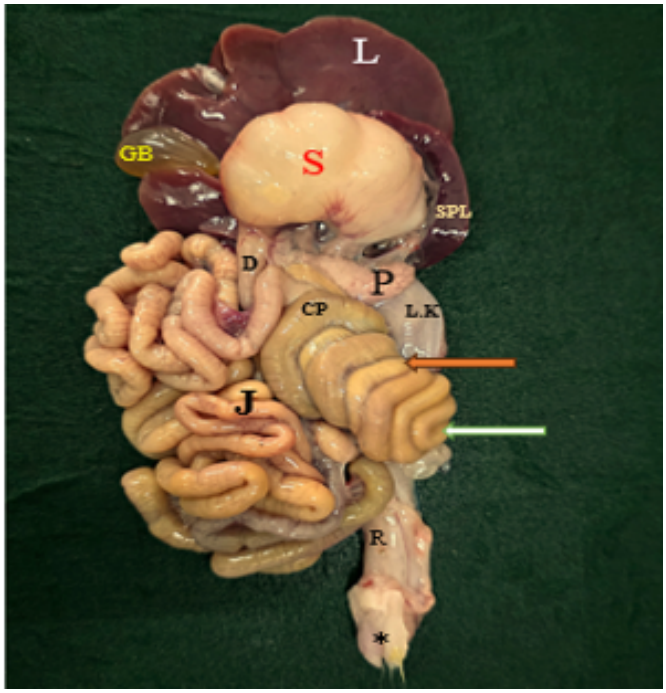


Fig. 2: Ventral view of abdominal viscera of zero -day old (Group-I) piglet showing Liver (L), Gallbladder (GB), Stomach(S), Spleen (SPL), Duodenum(D), Jejunum (J), Pancrease (P), Left kidney (L.K), Centripetal loop of ascending colon (CP), Centrifugal loop (orange arrow), central flexure (white arrow), Rectum (R), Anus(asterisk

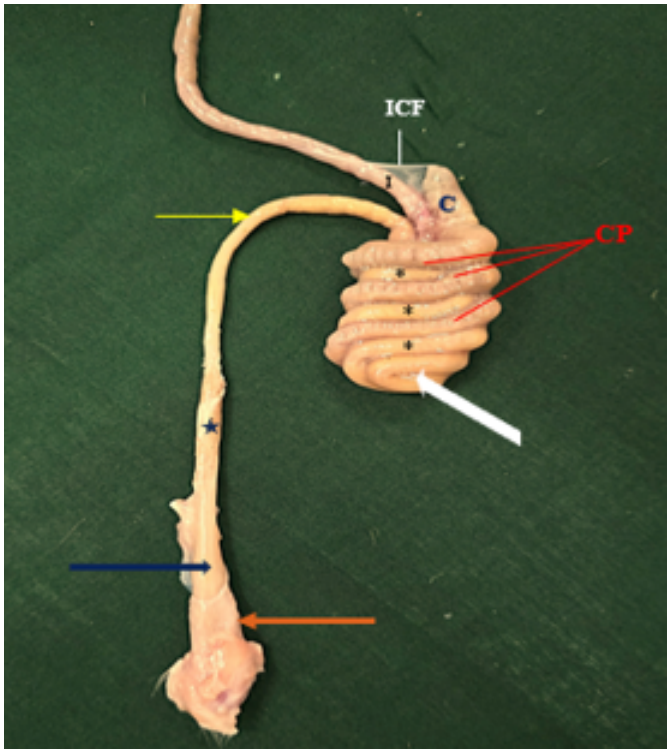


Fig. 3: : Large intestine of zero–day (Group-I) piglet showing Caecum (C), Centripetal loop of ascending colon (CP), centrifugal loop of ascending colon (asterisk), central flexure (white arrow), Transverse colon (yellow arrow), Descending colon (blue star), rectum (blue arrow), ampulla recti (orange arrow), Ileocaecal fold (ICF)

clockwise to the apex of the cone. It then reverses forming the central flexure and narrower tight counter clockwise centrifugal returns to the base of the cone (Fig. 2,3). The

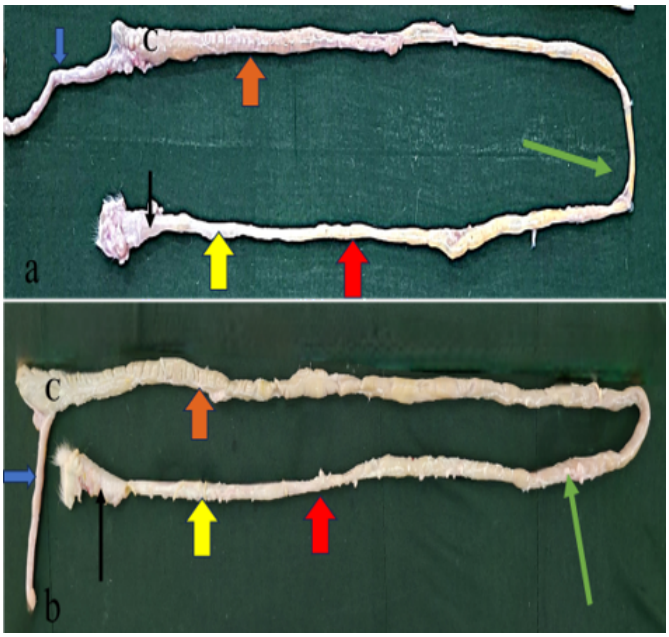


Fig. 4: Large intestine of Group- I piglets a) 0th -day, b) 7th -day showing Caecum(C), Centripetal loop of ascending colon (orange arrow), centrifugal loop of ascending colon (green arrow), Transverse colon (red arrow), Descending colon (yellow arrow), rectum (black arrow), Ileum (blue arrow).

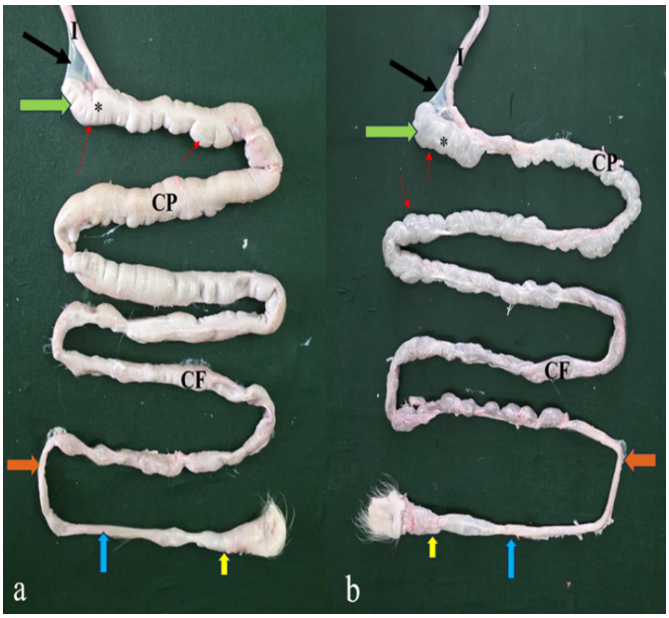


Fig. 5: Large intestine of Group-II pigs a) 32 -days, b) 50 -days showing Caecum (green arrow), muscular band (asterisk), sacculations (red arrow) in caecum and centripetal loop of ascending colon (CP), Centrifugal loop of ascending colon (CF), transverse colon (orange arrow), descending colon (blue arrow), rectum (yellow arrow), Ileum(I), Ileocecal fold (black arrow).

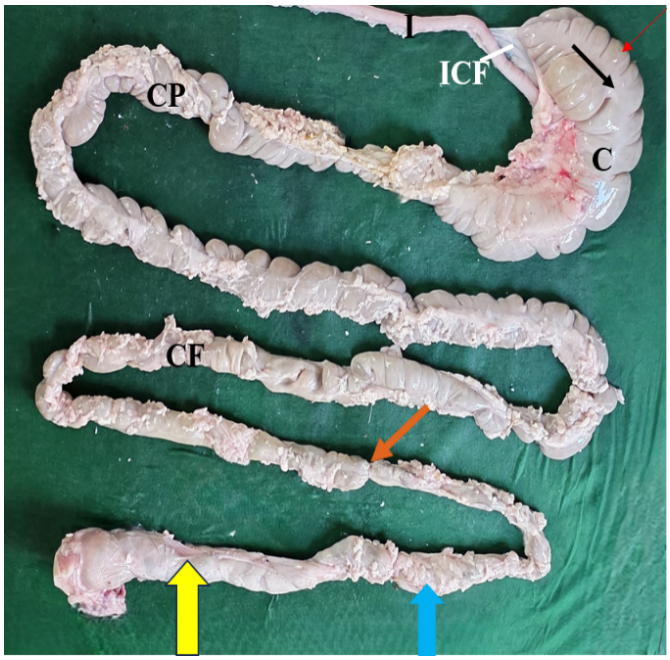


Fig. 6: Large intestine of Group-III pig of 5 months old showing Ileum(I), Ileocecal fold (ICF), Muscular band (black arrow), Caecum(C), sacculations (red arrow) in caecum and centripetal loop of ascending colon (CP), Centrifugal loop of ascending colon (CF), transverse colon (orange arrow), descending colon (blue arrow), rectum (yellow arrow).

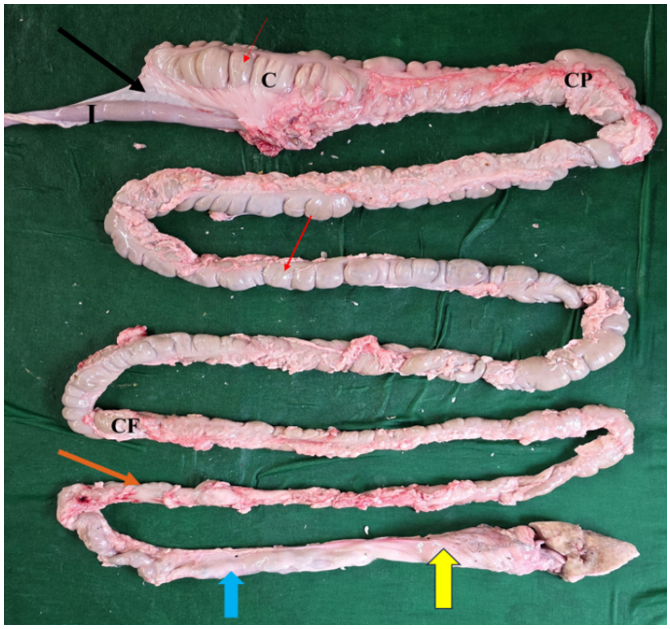


Fig. 7: Large intestine of Group-III pig of 7 months old showing Caecum(C), sacculations (red arrow) in caecum and centripetal loop of ascending colon (CP), Centrifugal loop of ascending colon (CF), transverse colon (orange arrow), descending colon (blue arrow), rectum (yellow arrow), Ileum(I), Ileocecal fold (black arrow).

centripetal turns formed the outside of the cone and the centrifugal turns were present inside the cone covered by centripetal turns (Fig. 3). The centripetal turns marked by two muscular bands and two rows of sacculations. The centrifugal turn lacked the muscular bands except near the

immediate vicinity of the central flexure. The centrifugal turns of the ascending colon winds around the root of the mesentery and turns to the left of the median plan as transverse colon. The transverse colon (Fig. 4,5,6) continues caudally as descending colon along the ventral surface of the pancreas and in close relation to medial surface of the left kidney. It lies close to the median plane and passes in a straight line to the pelvic inlet. These findings were in accordance with the description of colon in pig (Getty, 1975; Nickel *et al.,* 1979; Dyce *et al*., 2010; Frandson *et al.,* 2018). Significant ($p<0.05$) increases in the lengths and diameters of the centripetal and centrifugal turns of the ascending colon, transverse colon and descending colon from Group-I to Group-II and Group-III pigs (Table 1). Among the colonic segments the ascending colon showed greatest length and increased significantly from Group-I to Group-II and Group-III pigs (Table 1). The average measurements of different parts of the colon in adult age Group (Group-III) were almost similar to the reports of Habel (1975), Nickel *et al*. (1979) in adult ox, Rajput (2006) in Gaddi sheep and Heryani *et al.* (2020) in Bali cattle. Differences from goats, sheep, dogs and donkeys reported by Badawi *et al.* (1999) and Prakash (1998) in goat, may be attributed to species-specific anatomical adaptations and feeding behaviour.

The average total colon length increased significantly ($p<0.05$) with advancing age in pigs. Rajput (2006) recorded the average length of colon as 418.47 cm in Gaddi sheep. Casteleyn and Bakker (2021) reported the total length of colon as 46 cm in rhesus monkey. The reported length of colon measured is 4 to 5 meters in sheep and goat (Habel, 1975), whereas the length of colon and rectum together measured as 6 to 13 meters in ox (Nickel *et al.*, 1979), 3.5 to 7.5 meters in sheep and 3.88 meters in goat (Prakash, 1998).

Rectum

The rectum was continuation of descending colon (Fig. 4,5,6,7) and surrounded by a large amount of fat. The rectum becomes dilated to form an ampulla rectus and joining the anal canal (Fig. 2,3), and concurred with the earlier reports in pigs (Getty, 1975; Nickel *et al.,* 1979; Dyce *et al*., 2010; Frandson *et al*., 2018) and in the dog (Badawi *et al.,* 1999). A significant increase ($p<0.05$) was observed in the length and diameter of rectum from Group-I to Group-II and Group-III age pigs (Table 1). These findings were in close association with the reports of Getty (1975), Nickel *et al*. (1979). The average length and diameter of the rectum in adult age Group (Group-III) pigs were almost equal to those in rhesus monkey (Casteleyn and Bakker, 2021), goat and donkey (Badawi *et al.,* 1999), Bali cattle (Heryani *et al.,* 2020), Gaddi sheep (Rajput, 2006), Bali cattle (Heryani *et al.,* 2020), Vietnamese pot-bellied pig and human (Plakhotnyi *et al*., 2021) and in goat (Siyag *et al*., 2022). Among all the large intestine segments, rectum showed greatest diameter in adult animals.

Conclusion

The present study, in general, provides information on the gross morphometric development of the large intestine in postnatal pigs, which comprised of caecum, colon and rectum, with each segment showing the characteristic anatomical features of the species. A significant ($p<0.05$) increase in the total length of the large intestine and in the length and diameter of all its segments was observed from neonatal to adult age groups, indicating progressive postnatal growth and maturation. These findings demonstrate that the large intestine undergoes substantial structural development during postnatal life, likely reflecting increasing functional demands associated with growth and dietary transition.

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