Scanning electron microscopic study of caprine intestine with special reference to gut-associated lymphoid tissues

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The intestine of adult indigenous goat of Assam (*Capra hircus*) was studied by scanning electron microscopy (SEM) for elucidating the morphology of intestinal mucosa as well as the morphology of gut-associated lymphoid tissue including Peyer's patches (PP) and solitary lymphoid nodule. SEM of intestines revealed the presence of villi in the small intestinal mucosa. Goblet cells were noticed as white pinheads on the villus surface between the enterocytes. The large intestinal mucosa of adult Assam local goat was devoid of villi. SEM of small intestinal mucosa revealed leaf or finger-like absorptive villi covering PP. Even the dome villi were completely covered by absorptive villi and were shorter than the absorptive villi. The absorptive villi in all segments of the small intestine had numerous microvilli. The interfollicular region had high endothelial venules. Propria nodules were lymphoid nodules predominantly in lamina propria and covered by distinct follicle-associated epithelium which lacked goblet cells and openings to deep invaginations into the mucosa.

Keywords: Goat, gut-associated lymphoid tissue, intestine, scanning electron microscopy, villi.

SCANNING electron microscopic studies on intestinal mucosa and gut-associated lymphoid tissue (GALT) have been conducted by several researchers like Mebus *et al.*[1] in gnotobiotic calf; Cormack[2] in human and mouse; Wile and Nakov[3] in horse; Wile[4] in ox, sheep and goat. However, such studies on the intestine and GALT of goat are meagre. In the present study, intestine of adult indigenous goat of Assam (*Capra hircus*) was studied by scanning electron microscopy (SEM) for elucidating the morphological characteristics of intestinal mucosa and GALT including the Peyer's patches (PP) and the solitary lymphoid nodule (SLN). The study, therefore, would contribute to further research on the GALT of herbivores.

The intestines were procured from local slaughter houses after careful observation of the slaughtered animals. Representative tissue samples were collected from all segments of small and large intestines. From each segment, samples were obtained from cranial, middle and caudal parts. The samples were preserved in 2% glutaraldehyde solution in 0.1 M cacodylate buffer and processed for SEM[5] and were examined in JMS-35(CF) Joel scanning electron microscope operated at 20 kV at the Sophisticated Analytical Instrument Facility, North Eastern Hill University (NEHU), Shillong, India.

The SEM of intestines of adult goat revealed the presence of villi in the small intestinal mucosal surface. The villi were mostly finger-like with variable size and shape depending upon area. The duodenal villi, especially in the proximal part were mostly leaf-like and broader, whereas the villi of distal duodenum, jejunum and ileum were finger-like, longer and slender (Figures 1 and 2). Microvilli were seen on the villus surface and the cores of villi were made up of lamina propria (Figure 3). Similar observations were reported by Cormack[2] in human small intestine where variations in villi size and shape due to climate and individual variations were noticed. In the present study, the villus surface was rough with transverse furrows and was lined by columnar epithelium (Figure 3). Goblet cells were noticed as white pinheads on the villus surface between the enterocytes. Crypts

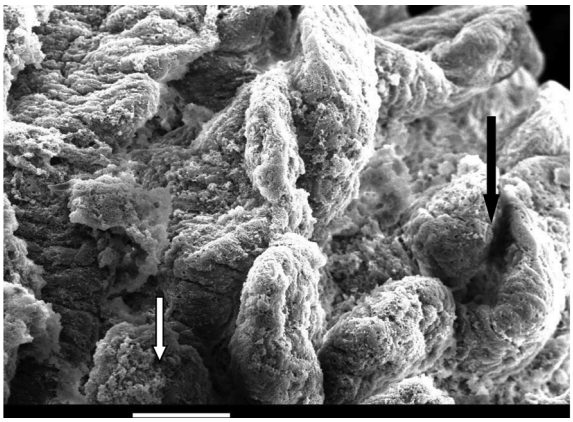

Figure 1. Scanning electron micrograph showing leaf shaped duodenal villi (black arrow) and goblet cells (white arrow). Bar = 100 μm.

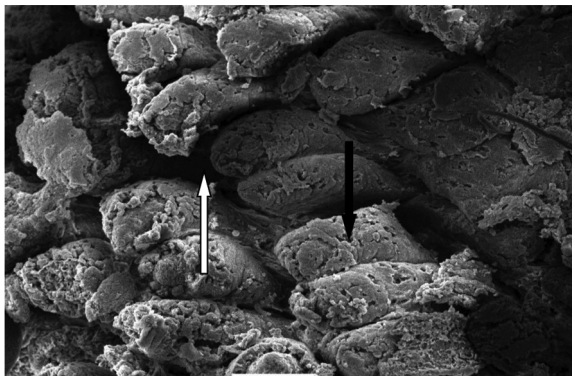

Figure 2. Scanning electron micrograph showing finger-like ileal villi (black arrow) and crypts (white arrow). Bar = 100 μm.

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were seen as gaps (depressions) between the villi (Figure 2). These observations agreed with those of Skrzypek *et al.*[6] in piglets. The large intestinal mucosa was devoid of villi. Enterocytes were embedded in thick mucus and the goblet cells were more numerous caudally (Figure 4). The crypt openings were lined by simple columnar epithelium (Figure 5). Similar findings were reported by Mebus *et al.*[1] in gnotobiotic calf; Cormack[2] in human and mouse; Wile and Nakov[3] in horse and Wile[4] in ox, sheep and goat.

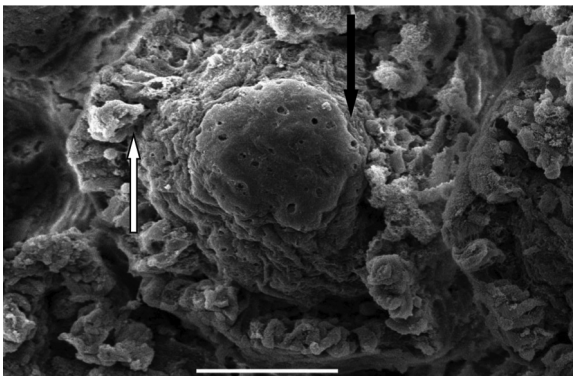

Figure 3. Scanning electron micrograph showing lamina propria core of ileal villi (black arrow) and enterocytes (white arrow). Bar = 10 µm.

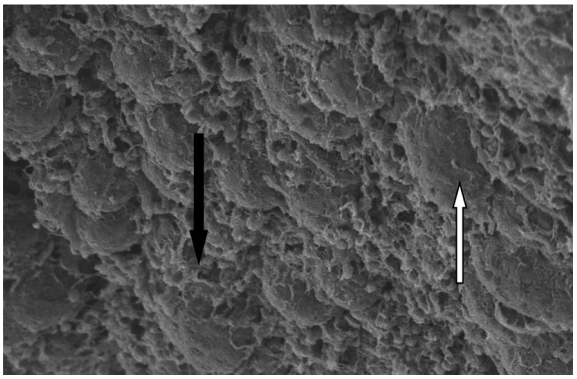

Figure 4. Scanning electron micrograph showing enterocytes of colon mucosa (white arrow) and thick mucus (black arrow). Bar = 50 µm.

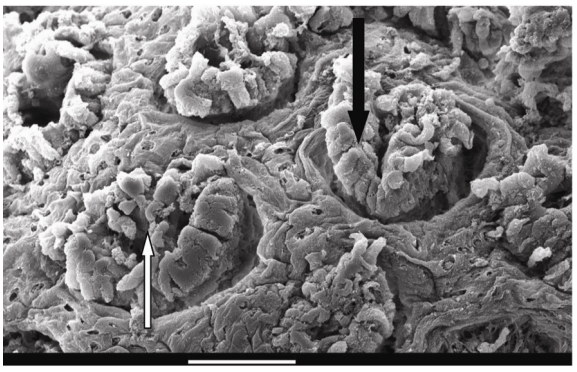

Figure 5. Scanning electron micrograph showing crypt openings of cecal mucosa (white arrow) and enterocytes (black arrow). Bar = 50 µm.

GALT was of two types: PP in the small intestine and SLN in the large intestine. SEM of GALT of small intestine of adult goat revealed leaf or finger-like absorptive villi covering PP (Figure 6). Sometimes the dome villi were completely covered by absorptive villi and were usually shorter than the absorptive villi. The length and size of both types of villi varied. Follicle associated epithelium (FAE) of PP lacked goblet cells and specialized M-cells were found interspersed between the enterocytes. The M-cells had irregular sparse microvilli and sometimes microfolds on their luminal surface and their visibility depended on the size of the surrounding enterocytes (Figure 7). These findings agreed with the observations of Parsons *et al.*[5] in cattle and Gebert *et al.*[7] in human. In the present study, the ileal PP revealed distinct compartmentalization in lamina propria formed by the collagen fibre bundles (Figure 6). The tunica mucosa showed a porous structure and its frequent gaps were likely the sites through which lymphocytes and other cells would freely migrate, thus, participating in the immunological activities of these structures. Prado *et al.*[8] reported similar observations in PP of swine. In adult Assam local goat,

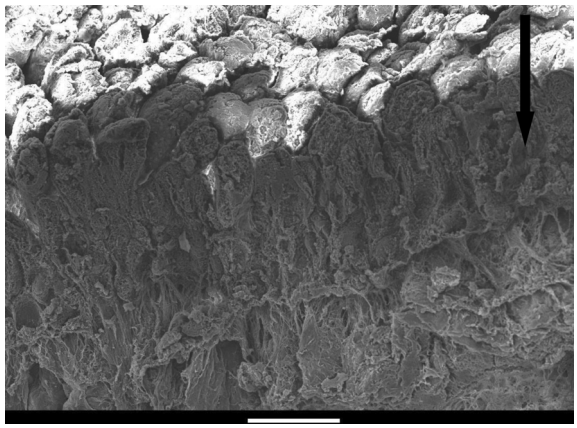

Figure 6. Scanning electron micrograph showing ileal Peyer's patches (arrow). Bar = 200 µm.

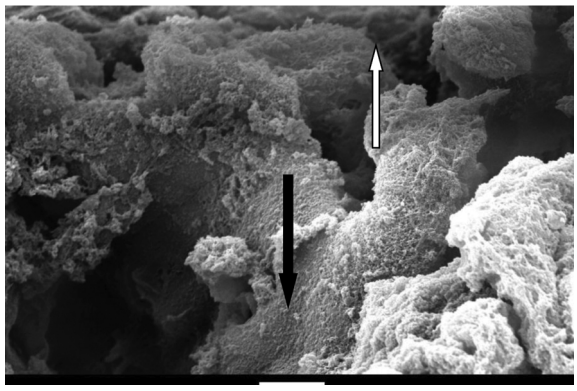

Figure 7. Scanning electron micrograph showing a part of M-cell with an invagination (black arrow) and part of one enterocytes (white arrow), Bar = 5 µm.

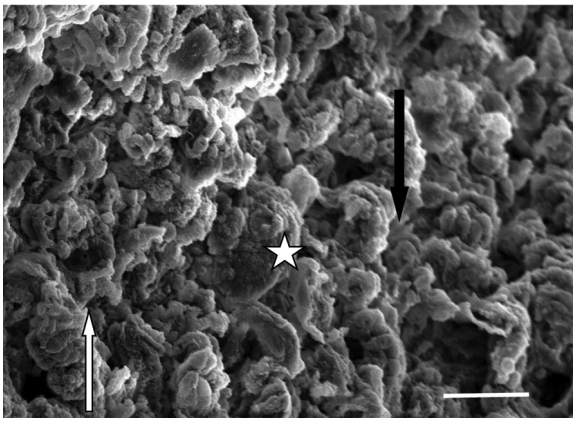

Figure 8. Scanning electron micrograph showing domes of propria nodules (star) interspersed among the enterocytes (black arrow) and goblet cells (white arrow), Bar = 20 µm.

the interfollicular region had high endothelial venules. Gebert *et al.*[7] opined that the interfollicular regions of PP in human are characterized by high endothelial venules, which are surrounded mostly by T cells.

The SLN of colon and rectum revealed two different units: propria nodules and lympho-glandular complexes (LGC) (Figure 8). Propria nodules had lymphoid nodules predominantly in lamina propria and were covered by distinct FAE which lacked goblet cells and openings to deep invaginations into the mucosa. Nodules were surrounded by wide crypts, which were also lined by FAE towards the luminal side. LGCs had lymphoid follicles in the tunica submucosa. At the centres of LGCs, protrusion of the lymphoid tissues was covered with distinct FAE. FAE had numerous membranous cells known as M-cells which were characterized by numerous microfolds. Similar findings were recorded by Liebler *et al.*[9] and Parsons *et al.*[5] in calf.

SEM of small intestinal mucosa revealed the presence of villi of variable size and shape, whereas the large intestinal mucosa was devoid of villi. GALT was in the form of PP and SLN in the small and large intestines respectively. The dome epithelium was covered by specialized FAE which had typical M-cells. For further characterization of the cellular population of GALT of goat, transmission electron microscopy and immunohistochemical techniques are must.

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