HISTOMORPHOLOGICAL STUDIES ON THE STOMACH OF INDIAN ELEPHANT (ELEPHAS MAXIMUS)

R.V Indu, K.M. Lucy, S. Maya and J.J. Chungath

Department of Veterinary Anatomy and Histology,
College of Veterinary and Animal Sciences, Mannuthy-680 651, India

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ABSTRACT
The present study was carried out on three elephant calves to elucidate the general histoarchitecture of stomach of Indian elephant. The stomach was simple and cylindrical with conical diverticulum ventriculi in the anterior border. Grossly the mucosa showed a pale smaller non-glandular region and a larger glandular part, which was folded in cardiac region, pitted in fundic region while smooth in the pyloric region. Cardiac gland area covered nearly half of the stomach and the fundic and pyloric regions formed one-fourth part each of the remaining area. Histologically, the tunica mucosa of the non-glandular region was lined with stratified squamous epithelium whereas that of glandular region was made of simple columnar epithelium. Lamina propria was densely packed with cardiac, fundic or pyloric glands depending on the regions. Diffuse lymphatic tissue was found in the lamina propria of cardiac and fundic regions of stomach. But in the pyloric region diffusely arranged and well organized aggregated lymphatic nodules could be located. Lamina muscularis was relatively thick in all regions and showed inner circular and outer longitudinal layers. The tunica muscularis was very thick and consisted of three distinct layers of smooth muscles. Externally tunica serosa was present. All these features were comparable to those of porcine stomach but the glands in lamina propria were more densely packed and lamina muscularis and tunica muscularis were relatively thicker.

Key words: Histomorphology, Indian elephant, Stomach.

INTRODUCTION
The elephants are the largest among the land mammals and are herbivorous with a simple stomach (Mariappa, 1985). The stomach which is an enlarged part of the digestive tube is engaged in both storage and digestion of food. References concerning the histology of the stomach of Indian elephant are very less. Since an understanding of the normal anatomy is critical to provide a basis for distinguishing normal anatomic variability from a pathologic change the present investigation was carried out.

MATERIALS AND METHODS
The study was conducted on the tissues collected after six hours of death, from three elephant calves aged three years, four years and seven years brought to Veterinary College, Mannuthy for post-mortem. After observing the gross features, small tissue pieces were collected from various regions of the stomach and were fixed using 10 per cent neutral buffered formalin. Standard procedures were adopted for histological examination.

RESULTS AND DISCUSSION
The stomach was simple and cylindrical with a length of 45cm, 68cm and 90 cm respectively and a maximum diameter of 18cm, 22cm and 30cm respectively in the calves aged three years, four years and seven years. The main axis was nearly vertical. There was a conical diverticulum ventriculi in the anterior border and thereafter body of the stomach narrowed towards the pylorus but there was no distinct pyloric valve. Grossly, the mucous membrane presented a pale small non-glandular region close to the cardia and a distinct glandular region. In the glandular part the mucous membrane was folded. It was pitted in the fundic region while the pyloric region was relatively smooth (Fig. 1). Similar reports were made earlier in the African elephants by Sikes (1971) and Mikota et al. (1994).
Histologically, mucosa of the non-glandular region was lined with stratified squamous epithelium with a lamina propria formed of loose connective tissue without any glands (Fig. 2). The lamina muscularis was relatively thick and contained smooth muscle bundles arranged in inner circular and outer longitudinal layers. Submucosa was made up of loose connective tissue with numerous blood vessels and submucosal nerve plexuses. The tunica muscularis consisted of three distinct very thick layers of smooth muscle each oriented in a different plane: an inner oblique, middle circular and an outer longitudinal layer (Fig. 3). Located between the circular and longitudinal smooth muscle layers were myenteric nerve plexuses. The tunica serosa was composed of mesothelium overlying a layer of loose connective tissue. All these features resembled more to the porcine stomach.

The mucosa of the glandular region was divided into cardiac, fundic and pyloric regions. The cardiac gland region covered nearly half of the stomach including most of the diverticulum ventriculi. The fundic and pyloric regions formed one-fourth part each of the rest of the gastric mucosa similar to that reported in monkey (Kararli, 1995) and in pigs (Dellman and Eurell, 2006). The lamina muscularis, submucosa, tunica muscularis and serosa were similar to that seen in non-glandular region.

In the cardiac gland region of the mucosa of stomach the epithelium abruptly changed to tall simple columnar type. Numerous gastric pits were present in the mucosa which were continuous with the gastric glands that densely packed the lamina propria. The loose connective tissue in lamina propria separated the cardiac glands from lamina epithelialis and extended towards the deeper levels forming lobules of cardiac glands (Fig. 4). Cuboidal cells with basal nuclei lined the short, simple, branched, coiled, tubular mucous cardiac glands. Each lobule showed excretory duct system with large ducts which emptied into lamina epithelialis at gastric pits (Fig. 5). The ducts were lined by stratified cuboidal epithelium. Sub-epithelial stream of diffuse lymphatic tissue could be seen similar to that seen in the cardiac stomach of pigs (Lugton, 1999). Thin strands of smooth muscle extended from lamina muscularis into the lamina propria between the glands towards the surface epithelium as reported in African elephants earlier by Van Aswegen (1994).

In the fundic gland region, the gastric pits were shallow but very close to each other. The simple columnar epithelium that lined the mucosa extended into the lamina propria forming fundic glands. Lamina propria was very thick and densely packed with simple, straight, branched, tubular glands that consisted of a neck, a long body and a slightly dilated blind end, called the fundus (Fig. 6.). These glands extended to the lamina muscularis. Four distinct cell types could be identified in the secretory epithelium of the fundic gland: the mucous neck cells, chief cells, parietal cells and endocrine cells (Fig.7). The mucous neck cells were similar to the surface epithelium. The chief cells were the most numerous of the gastric gland cells and were located in the basal regions of the glands. They were large pyramidal cells with a round nucleus and stained deeply with eosin. They occurred singly peripheral to the chief cells. The proximal portions of the fundic stomach showed more chief cells than the distal portions as reported in the monkeys, dogs and cats. The gastrointestinal endocrine cells were wedged between the basement membrane and chief cells. The lamina muscularis was composed of inner circular and outer longitudinal muscle layers. Thin strands of smooth muscle extending into lamina propria as seen in cardic gland region could not be identified. These observations were in agreement with the description given by Banks (1993) in porcine stomach except that the number of glands and parietal cells were comparatively more in elephants to digest the large amount of coarse vegetation eaten.

In the pyloric region, the glands were simple branched, coiled, tubular and relatively short compared to the cardiac and fundic gastric glands. The gastric pits were considerably deeper. The glandular cells were filled with mucous and the nucleus was flat located at the base of the cells. The lamina propria showed thick bundles of coarse collagen fibers which separated the epithelium from the underlying glandular region. Lamina muscularis
was thin and extended into the lamina propria in between the glands. In the pyloric region, lymphoid tissue was present in three different forms namely intraepithelial lymphocytes, diffusely arranged sub epithelial lymphocytes and organized aggregated lymphatic nodules as seen in the stomach of monkey (Vidal et al., 2008). Similar reports in elephants are not available for comparison. However, according to Tenorioa and Pabst (2006), lymphatic nodules were absent in ruminants and horse. In the lymphatic aggregations, six to seven lymphatic nodules were seen in the periphery and the centre was occupied by erythrocytic clusters and lymphatic and venous sinuses (Fig. 8). These nodules were oval to round in shape and varied in size.

In the present investigation extensive distribution of densely packed glands throughout the length of the glandular stomach in elephants could be explained on the basis of its food habits, there being need for more mucous glandular secretion for chemical digestion of food in the stomach. The thickened lamina muscularis and tunica muscularis may provide additional strength to the wall during the mechanical digestion of the large amount of food ingested. The presence of diffuse and aggregated lymphatic tissue was perhaps necessitated by the fact that the stomach was subjected to constant microbial and antigenic stimulation.

REFERENCES