The surface of the tonsils and their extensive crypts are important colonization sites for many pathogenic and commensal micro-organisms, including both bacteria and viruses (Beth et al., 2012). The nasopharyngeal tonsil has been studied extensively in horse, sheep and goat (Kumar and Timoney, 2001; Kumar et al., 2001, 2006, 2009). The present study has been conducted to elucidate histological and surface architecture of nasopharyngeal tonsil in pigs.

MATERIALS AND METHODS

The present study was conducted on 10 young male pigs of 8-10 months age, of local mixed breed. The nasopharyngeal tonsil was lined by pseudostratified ciliated epithelium with goblet cells. The respiratory epithelium was modified into follicle associated epithelium (FAE) where a few superficially placed dome shaped cells were considered as the M-cells. This FAE was further modified into a single cell layer having simple cuboidal epithelium. This type of epithelia has been reported first time in the tonsils. The lymphoid tissue mainly concentrated into lymphoid follicles was separated by interfollicular areas. The goblet cells of respiratory cells and mucus glandular acini showed preance of different mucopolysaccharides. Scanning electron microscopy confirmed pseance of different types of microvillus cells, brush cells and M-cells. Cluster of microvillus cells stacked one upon another like mulberry fruit or bunch of grapes pattern has never been documented earlier in any species and reported first time during the present study.

RESULTS AND DISCUSSION

The surface of the tonsils and their extensive crypts are important colonization sites for many pathogenic and commensal micro-organisms, including both bacteria and viruses (Beth et al., 2012). The nasopharyngeal tonsil has been studied extensively in horse, sheep and goat (Kumar and Timoney, 2001; Kumar et al., 2001, 2006, 2009). The present study has been conducted to elucidate histological and surface architecture of nasopharyngeal tonsil in pigs.
lymphoepithelium (LE) because of its relationship to lymphoid tissue in the propria submucosa as reported in horse (Kumar and Timoney 2001) and in sheep (Kumar and Nagpal, 2007). However, the epithelium without goblet cells was irregularly modified into follicle associated epithelium (FAE) having stratified features with a characteristic reduction in cell height, loss of cilia and infiltration of lymphocytes (Fig. 2). Most superficially placed epithelial cells presented dome shaped structure however in horse it was cuboidal and had flat surface (Kumar and Timoney, 2001). These cells having oval nuclei, and closely associated with the lymphocytes were identified as membranous/microvillus cells (M) as reported earlier (Kumar and Timoney 2001, Kumar et al., 2001; Kumar et al., 2006). FAE shared histological features with BALT and other MALTS in different species of animals (Mair et al., 1987; Giannasca et al., 1997). The flattened apical surface of M cells allowed close contact with particulate antigens which were trapped in the mucus blanket and not cleared by the mucociliary system of the respiratory epithelium (Giannasca et al., 1997). The topographical, structural and biochemical features of the apical membrane of M cells may enhance adherence and sampling of
microorganisms as part of an immune surveillance mechanism (Giannasca et al., 1997). The FAE was further modified into a simple cuboidal epithelium (Fig. 3), a feature which has not been reported earlier in tonsils of any domestic or laboratory animals. The occurrence of intraepithelial lymphocytes was a regular feature of the nasopharyngeal tonsil. They may originate from the underlying lamina propria as reported in GALT of swine (Chu et al., 1979). In addition, free lymphocytes were observed towards the free surface of the epithelium, particularly in large clusters in the crypt areas of the FAE.

The propria submucosa had loose irregular connective tissue comprising of collagen, reticular and elastic fibres (Fig. 4), dense aggregates of lymphoid tissue, fine blood capillaries and few nerve fibres as reported in the horse (Kumar and Timoney, 2001, Kumar et al., 2001) goat (Kumar et al., 2006) and in the sheep (Kumar and Nagpal, 2007). The lymphoid tissue was distributed in the form of isolated lymphocytes, lymphoid aggregates and lymphoid follicles of varying shapes and dimensions as reported earlier (Kumar and Timoney, 2001; Kumar et al., 2001; Kumar and Nagpal, 2007; Kumar et al., 2006). The majority of the follicles had darkly stained corona toward epithelial surface whereas, germinal center was observed in few follicles. The lymphoid nodules might help to guard against infections spreading from pharynx towards the inner ear (Mair et al., 1987). The high endothelial venules were mainly localized to parafollicular areas along with a few blood capillaries and venules as reported in goat (Kumar et al., 2006) and sheep (Kumar and Nagpal, 2007).

The deeper part of the propria submucosa had very loose irregular connective tissue, mucus glandular acini, fatty tissue, nerve fibres and blood vessels as reported in horse (Kumar and Timoney, 2001) and goat (Kumar et al., 2006). The goblet cells of the pseudostratified columnar ciliated epithelium and mucus glandular acini along with their ducts were strongly PAS positive for glycogen, acidic and neutral mucopolysaccharides (Figs. 5, 6, 7, 8, 9). The areas of FAE did not exhibit any PAS positive reaction as reported in goat (Kumar et al., 2006). The PAS reaction was mild in fine blood capillaries and around the lymphoid follicles. Negligible amount of proteins could be localized only toward the free surface of the epithelium as reported in goat (Kumar et al., 2006). However, a very weak reaction was observed in the blood capillaries.

The SEM of nasopharyngeal tonsil of the pig revealed respiratory ciliated epithelium separated by islands of microvillus cells (Figs. 10, 11, 12) as reported in sheep (Stanley et al., 2001; Kumar et al., 2009), horse (Kumar et al., 2001, Kumar and Timoney, 2001) and goat (Kumar et al., 2006). The respiratory areas had ciliated, microvillus and goblet cells (Figs. 11, 12). Islands of microvillus cells were interspersed in between the ciliated areas which were...
comparable with FAE (Fig. 13) as reported in horse (Kumar et al., 2001, Kumar and Timoney, 2001). The microvillus cells (Fig. 14) were of varying shapes, and were categorized into three types on the basis of distribution of microvilli as reported in horse (Kumar et al., 2001, Kumar and Timoney, 2001), sheep (Stanley et al., 2001; Kumar et al., 2009) and goat (Kumar et al., 2006). The large sized type-I microvillus cells were most numerous and had uniform distribution of small sized microvilli. The round to oval type-II microvillus cells were smaller and had mixed distribution of small and large sized microvilli. The type III microvillus cells were distributed singly with their least number and drastically reduced size of microvilli. These cells actually represented membranous/microfold (M) cells (Fig. 15) as reported in the horse (Kumar et al., 2001) goat (Kumar et al., 2006) and in sheep (Kumar et al., 2009). Intermediate cells with microvilli and cilia were also observed.

At places, microvillus cells were stacked one upon another to make an arrangement similar to mulberry fruit or bunch of grapes. This pattern has never been reported earlier in tonsils of domestic or laboratory animals (Fig. 16). A few squamous cells showing microplicae were also observed (Fig. 17). Energy dispersing spectroscopy presented different elements (Table 1).

### REFERENCES


Kumar, Parveen, Kumar, Pawan and Kumar Suraj. 2006. Light and scanning electron microscopic studies on the nasopharyngeal tonsil of the goat. *Indian Journal of Animal Sciences*** **76**: 452-55.

Kumar, Pawan. and Nagpal, S.K. 2007. Histology and histochemistry of the nasopharyngeal tonsil of the sheep. *Haryana Veterinarian*** **46**: 75-78.


### Table 1. Energy dispersing spectroscopy showing different elements in the nasopharyngeal tonsil of pig

<table>
<thead>
<tr>
<th>Element</th>
<th>Series</th>
<th>unn. wt-%</th>
<th>C norm. wt-%</th>
<th>C Atom. at-%</th>
<th>Error %</th>
</tr>
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<tbody>
<tr>
<td>Carbon</td>
<td>K-series 2</td>
<td>9.71</td>
<td>29.71</td>
<td>35.38</td>
<td>9.0</td>
</tr>
<tr>
<td>Sodium</td>
<td>K-series 0.57</td>
<td>0.57</td>
<td>0.35</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>K-series 1.24</td>
<td>1.24</td>
<td>0.27</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>L-series 0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Silicon</td>
<td>K-series 0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>K-series 21.82</td>
<td>21.82</td>
<td>22.28</td>
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<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>K-series 46.66</td>
<td>46.66</td>
<td>41.71</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td></td>
</tr>
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</table>

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