Morphological Analysis of Rumen Mucus Membrane in Black Buck (*Antelopes cervicapra*), Nilgai (*Boselaphus tragocamelus*) and Spotted Deer (*Axis axis*)

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**Abstract**

The morphological variability of rumen mucus membrane, in Black bucks (*Antelopes cervicapra*), Nilgais (*Boselaphus tragocamelus*) and Spotted deer (*Axis axis*) were examined. The rumen specimens were collected immediately during postmortem at Zoological gardens [National park (Bannergutata) and Zoo (Mysore)] and were examined immediately for gross morphological parameters. The gross morphological features like size, shape, color and distribution of mucosal surface modifications of rumen of Black buck, Nilgai, and Spotted deer were observed. The interspecies variations were observed in the specimens collected during October (the vegetation) and December-January (winter) seasons. The most profound differences in rumen papillae are observed between animals studied. Furthermore, the shape of papillae in rumen was different, i.e. leaf/pointed shape papillae were observed in September-October period while blunt shape in December-January period. The length of ruminal papillae was highest in Spotted deer, least in Black buck and moderately tall in Nilgai. Differences in the width of papillae were detected between Spotted deer and others but not between Nilgai and Black buck. The Color of rumen is not related with season and sex. Based on morphological features, the animals under study may be grouped into three categories as Grazer (Black buck), Intermediate (Nilgai) and Browser (Spotted deer).

**Key words:** Morphology, Mucus membrane, Rumen, Papillae and wild ruminants.

1. **Introduction**

The digestive system of ruminants is adapted to process bulk plant material. In the forestomach the ingested food is subjected to microbial digestion and the products of the activity of microorganisms, volatile fatty acids (VFA), are absorbed directly by the rumen wall. The rumen mucosal membrane (MM) with its surface enlarged by papillae plays an important role in VFA absorption. Growth of rumen papillae is stimulated by VFA production, papillae respond to higher VFA production by increasing their size (Hofmann, 1989). Hence, the largest papillae can be found in the atrium ruminis where the most intensive fermentation occurs, while the smallest ones are in the dorsal sac.

Differences in forestomach anatomy between individual deer species originate from their ecophysiological adaptations. Using evidence from 65 ruminant species, Hofmann (1989) divided ruminants according to the differences in size of their digestive organs, density and size of forestomach papillae and dietary preferences. Three feeding types were identified i.e. *Browsers* (concentrate selectors - CS) are focused on the best digestible parts of plants and have the smallest stomach with the largest papillae of the highest density; *Intermediate feeders* (IM) without specific feeding requirements and *Grazers* (Grass and roughage eaters -GR) are capable of coping with the least digestible food with high fibre content. Therefore, their stomach has the largest capacity and is distinctively segmented internally. Grazers have the smallest rumen papillae which may be missing on rumen pillars and in the dorsal sac.

The quality of ingested food affects the forestomach capacity and the density and size of rumen papillae (Lentle et al., 1996) and often varies in free-living ruminants. In many species, mucosal differences were detected between seasons of the year (Merrill et al., 1995), localities (Homolka, 1996) and also between sexes (Thirgood, 1996). The most significant modifications of fore-stomach MM morphology are related to changes of forage and were observed between different seasons. For example, they appeared in Africa between the period with abundant vegetation...
and the dry season or in Europe in roe and red deer between the growing season and the winter (Hofmann, 1989). Earlier anatomical studies have not proven any quantitative differences in MM characteristics in response to animal's sex or age (Hofmann, 1973). Later Lentle et al. (1996) observed variations of papillary size between age categories, sexes and between game animals from different habitats.

In previous anatomical studies, the authors focused mostly on other compartments of digestive system, which is one of the seven attributes determining the food specialization according to Hofmann (1989). Hence, the data available on variability of rumen papillation are limited. The aim of the present study was to explore the variability of MM structures in rumen of Black buck, Nilgai and Spotted deer in relation to changes of feeding conditions in the studied habitats and to determine the similarity of their MM.

2. Material and Methods

Rumen samples were collected immediately during postmortem at Zoological gardens [National park (Bannerugattha) and Zoo (Mysore)] from three Black bucks (Antelope cervicapra), three Nilgais (Boselaphus tragocamelus), three Spotted deers (Axis axis). The cause of death in all animals was due to causes which were unrelated to the gastro-intestinal system.

Square samples of MM (50 mm x 50 mm) were taken from rumen washed gently in distilled water and pinned to cork support. Prepared samples were fixed in 10% neutral buffered formalin for later evaluation by the naked eye and stereozoom microscope. Samples were taken from the ventral sac of rumen.

The following MM characteristics of rumen were investigated: Size, shape, color, distribution of rumen papillae and the density of papillae per cm² was calculated and the height of the 10 longest papillae of each sample was measured.

3. Results

The gross morphological features like size, shape, color and distribution of mucosal surface modifications of rumen of Black bucks (Antelope cervicapra), Nilgais (Boselaphus tragocamelus), Spotted deers (Axis axis) are observed and presented in Table 1. The interspecies variations are observed in the specimens collected during October (the vegetation) and December-January (winter) seasons. The most profound differences in rumen papillation were observed between animals studied. Furthermore, the shape of papillae in rumen was different, i.e. Leaf/pointed shape papillae were observed in September-October period while blunt shape in December-January period. The length of ruminal papillae was highest in Spotted deer, least in Black buck and moderately tall in Nilgai. Differences in the width of papillae were detected between Spotted deer and others but not between Nilgai and Black buck. The Color of rumen is not related with season and sex (Table 1).

4. Discussion

The variations in size and density of rumen papillae observed between species, seasons and habitats correspond with the presumption that the development of rumen papillation depends on quality of the ingested food on production of VFA which stimulate papillary growth (Tamate et al., 1962; Hofmann, 1989) and at the same time, it is one of the seven attributes determining the food specialization of a ruminant (Hofmann, 1989). The highest density and size of papillae were found in roe deer, while mouflon showed the least papillation. The differences between red and fallow deer papillae were not significant. These data correspond with the classification of food specialization of the studied species according to Hofmann (1989).

The observed seasonal changes of rumen papillation conformed Hofmann's data (Hofmann, 1989). In the present studies, reduction of papillary size in atrium ruminis and in the ventral sac occurred during the winter season. The original tongue-like shape of papillae changed in the winter season to conical shaped. These seasonal variations correspond with the changes of food supply of free-living ruminants from our geographical latitude, where the botanical composition of forage profoundly changes in the winter period (Homolka, 1996) and its nutritional value decreases (Texier et al., 1997).

The differences in density and size of rumen papillae in animals indigenous to different habitats were evident only in the winter season although the botanical composition of the forage in mountains and in areas of lower altitude greatly varies during the growing season (Homolka, 1996). Analysis of rumen papillation revealed that during the growing season animals are able to find equally valuable forage even under climatically inferior conditions, and possible slight differences in its nutritional value have no considerable effect on rumen MM development.

In the present study, no variations in size and density of papillae between young and older animals. However, an increase in papillary size with age has been previously described in cattle by Tamate et al. (1962). Size and density of papillae in the specimens of present study were not dependent on sex of the animal although some differences in diet composition have -
Table 1: Characteristics of Ruminal mucosal surface of Black bucks (BB), Nilgais (NG), Spotted deers (SD)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Black buck (Antelope cervicapra)</th>
<th>(Antelope cervicapra)</th>
<th>Nilgai (Boselaphus tragocamelus)</th>
<th>Nilgai (Boselaphus tragocamelus)</th>
<th>Spotted deer (Axis axis)</th>
<th>Spotted deer (Axis axis)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BB1</td>
<td>BB2</td>
<td>BBm3</td>
<td>NG1</td>
<td>NG2</td>
<td>NG3</td>
</tr>
<tr>
<td>Category of Animal (Age wise)</td>
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<td>Adult</td>
<td>Calf</td>
<td>Adult</td>
<td>Adult</td>
<td>Calf</td>
</tr>
<tr>
<td>Sex</td>
<td>F</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Rumen papillae Average Length(cm)</td>
<td>0.55</td>
<td>0.60</td>
<td>0.4</td>
<td>0.5</td>
<td>0.45</td>
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<tr>
<td>Average Width(cm)</td>
<td>0.12</td>
<td>0.1</td>
<td>&lt;0.1</td>
<td>0.1</td>
<td>0.12</td>
<td>0.1</td>
</tr>
<tr>
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<td>Blunt</td>
<td>Blunt</td>
<td>Pointed</td>
<td>Blunt</td>
<td>Blunt</td>
</tr>
<tr>
<td>Distribution</td>
<td>Thin</td>
<td>Thick</td>
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<td>Thick</td>
</tr>
</tbody>
</table>

been reported. Thirgood (1996) and Lentle et al. (1996) observed higher papillation in males. In the present study, we found no papillary response to sex. The analysis of MM morphology in the sample of present studies conformed their classification into morphophysiological feeding types. Also we have shown the seasonal changes on rumen papillation and the dominant influence of forage quality on development of the papillae.

4. Conclusion

The variations of rumen papillae between groups of animals from different seasons, of different sex and age, and indigenous to different altitudes were analyzed. In all of the three studied species, significant differences in density and size of papillae between the growing season and the winter season were observed. Density of rumen papillae in ventral sac was higher in the growing season than in the winter in all cases. Based on morphological features of ruminal papillae the wild animals under study may be grouped into three categories as Grazer (Black buck), Intermediate (Nilgai) and Browser (Spotted deer).

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References


