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Defaunation and Its Effects on Rumen Ecology and Animal Performance

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ARTICLE ID: 20

Introduction

Rumen has diverse flora consisting of 10^9-10^{10} bacteria, 10^5-10^6 protozoa and 10^3-10^4 fungi per ml of rumen fluid. Over 200 species of bacteria, 10 species of protozoa and eight species of fungi have been described. Among rumen microbes, theprotozoa are the largest in size and contribute 40-50% of the total biomass and enzyme activities in the rumen. Many low levels of good quality protein or nitrogen, less fermentable carbohydrates and lipids, and low digestibility have some restriction in the way of efficient use of forages because of high fiber content resulting in poor animal performance due to decreased feed intake (VFI) and an imbalance in the absorbed nutrients (protein/energy ratio), causing slow growth, and low reproductive rate and milk production performance. Such limitations are aggravated by the presence of anti-nutritional factors such as tannins, lignins, saponins, mimosine, and others. Rumen manipulation by way of removing protozoa (defaunation) is an alternative way of increasing absorbed nutrients.

Defaunation defined and its methods

Defaunation is the process of making the rumen of animals free of rumen protozoa and the animal is called defaunated animal. There are several ways to defaunate the animals.

Separation of new born

One of the methods of defaunating the animal is by separation of newborn animals from their dams after birth and preventing any contact with the adult ruminant animals. The newborn animals should be separated 2 to 3 days after birth. During this time the newborn

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animals gets contaminated with the native bacterial population but do not get rumen ciliate protozoa.

Chemical method

Another method of defaunation is by use of chemicals.The chemicals which have been widely used to defaunate the animals are copper sulphate, manoxol and sodium lauryl sulphate. Chemicals which are used as defaunating agent are introduced in the rumen of animals either orally by a stomach tube or through rumen fistula. However, these chemicals are not only toxic to the rumen protozoa but also kill the other rumen microorganism like bacteria. Various chemicals are

- Drenching of starved adult goats with 2%copper sulphate for two successive days
- Use of 2% copper sulphate to defaunate the lambs
- Sodium lauryl sulphate (9g/100 kg b.w.) can be used as a defaunating agent
- Manoxal(10g/100 kg b.w.) also defaunated the buffalo calves

Dietary manipulations

The ciliate protozoa are very sensitive to the pH change in rumen, so activity of ciliate protozoa is stunted when the pH of the rumen falls below 5.8 and if the rumen pH falls below 5.0, the ciliate protozoa may be completely eliminated. Therefore, offering high energy feed (especially cereal grains like barley, maize etc.) to the starved (for 24 hours) animals creates acidic condition in the rumen and rumen pH fall below 5.0. This fall in rumen pH eliminates the ciliate protozoa completely and the animal becomes defaunated. The drenching of vegetable oils can also eliminate ciliate protozoa and hence can be used as a defaunating agent.

Use of plant extract

Plant extracts has potential to act as defaunating agent although, secondary metabolites such as tannin and saponine, may appear detrimental to animal feeding and nutrition, but they can also be used to manipulate rumen function and fermentation. Many studies have also validated the use of tannins and saponins being toxic to protozoa, and the use of some tree leaves or plant extracts reduced the number of rumen protozoa which in turn has led to improved intake, fiber digestion, and weight gain. Furthermore, forages of *Centrosema pubescens*, *Desmodium intortum*, Fern leaf, *Leucaena leucocephala*, *Vigna*

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parteri, *Desmodium uncinatum* as defaunating agents were tested in vitro but *Enterolobium cyclocarpum* was found to be effective in vitro and in vivo.

Effect of defaunation on the rumen ecosystem

Defaunation causes both qualitative and quantitative change in rumen bacterial population. A total of 4 to 45 g bacterial dry matter is engulfed by rumen protozoa per day per sheep. Defaunation increase the number of amylolytic bacteria due to elimination of nutritional competition between bacteria and protozoa for using starch whereas the cellulolytic bacterial population become decreased. Fungal population in the rumen also increase due to defaunaton.

Rumen pH

The rumen pH starts falling immediately after ingestion of feed, both in faunated and defaunated animals whereas, the drop in pH was much higher in defaunated than in faunated animals. Rumen protozoa engulf the readily fermentable carbohydrate (starch) which is stored in their body as amylopectin and thus decrease the rate of carbohydrate (starch degradation) fermentation, resulting in a lower pH in the rumen of defaunated compared to faunated animals.

Volatile fatty acid (VFA) production

The rate of VFA production and its composition are greatly influenced by experimental diet. High concentration of VFAin the rumen of faunated animals may be due to higher hydrolytic enzyme activity because about 40- 60% of hydrolytic enzyme activity is found in the rumen protozoa and also due to stimulatory effect of protozoa over bacteria. The ciliate protozoa engulfed the feed particle and degrade it to acetic acid and butyric acid during carbohydrate metabolism. Therefore, defaunation increases the molar proportion of propionic acid. It has been reported that in defaunated animal’s number of acetates producing species such as Ruminococcus spp. are not predominant while succinate producing bacteria such as Bacteroides spp. are predominant. These changes in ruminal bacterial population may stimulate more propionate production in the rumen of ciliate free animals.

Ammonia Nitrogen Concentration

Bacteria utilize ammonia to meet their nitrogen requirement for body protein synthesis while ciliate protozoa do not use it. In defaunated animals, the number as well as activity of rumen bacteria increases resulting in more uptake/utilization of ammonia by

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bacteria and as a result, ruminal ammonia concentration is reduced. The recycling of bacterial nitrogen in the rumen is higher in presence of ciliate protozoa and the number of ruminal bacteria capable to utilize ammonia decrease with increased ruminal break down of dietary protein.

Microbial protein synthesis

Microbial protein synthesis in the rumen of defaunated animals was higher than faunated animals. It is now generally accepted that in absence of rumen ciliate protozoa, the efficiency of rumen bacterial growth is enhanced and more microbial protein flows from reticulo-rumen to duodenum. About half of the microbial protein in the rumen can be of protozoal origin while as a proportion of the microbial protein leaving the rumen, protozoal protein is usually under 10% because of higher rate of bacterial was out from reticulo-rumen.

Enzyme profile

The ciliate protozoa and fungi are most important microbial groups of the rumen organisms required for the ruminal digestion of plant fibre. Carboxymethyl cellulase enzyme activity was lower in the rumen of defaunated than faunated animals. About 62% of the total rumen cellulase enzyme activity is associated with rumen protozoal population. Protease enzyme activity was lower in the rumen of faunated than defaunated animals. The specific activity of protease enzyme from bacterial fraction is 6-10 times higher than that from protozoal fraction. Defaunation, increases the number of ruminal bacterial population, resulting in higher ruminal protease enzyme activity. Bacteria are the only source of ruminal urease enzyme while ciliate protozoa have no urease enzyme activity and hence ciliates cannot utilize urea for their body protein synthesis.

Methane production

Defaunation decreases the methane production compared with the normal faunated animals. Rumen protozoa contribute hydrogen moiety for the production of methane by the methanogenic bacteria. Further, ectosymbiotic attachment methanogens have with ciliate protozoa and elimination of their symbiotic partner on defaunation results in reduced methane production.

Effect of defaunation on nutrient digestibility and animal performance

- **Nutrient digestibility:** The digestibility of fibre, NDF and ADF and hemicellulose and cellulose decreased by defaunation. Similarly, inoculation of protozoa into a

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defaunated rumen improved pentosan hydrolysis by 30-230%. However, effect of defaunation on the digestibility of starch and sugars is either negligible or there is a reduction in ruminal starch digestion in the presence of protozoa. Bacteria and free amino acids may provide nitrogen to satisfy the requirements of protozoa. Bacteria play a dominant role in degradation of most soluble proteins while rumen protozoa help in ruminal degradation of relatively insoluble protein. Defaunation had no effect on apparent protein digestibility. Rumen protozoa play an important role in the hydrogenation of unsaturated fatty acids.

- **Toxic substance in feeds**: Ochratoxin A produced more toxicity in the defaunated animals than in faunated animals. The activity of rumen ciliate protozoa to transform ochratoxin A is 6 times higher than that of bacteria. Defaunated animals are more sensitive to copper toxicity. The rumen protozoa induced the complex formulation of the Cu^{2+} in sulphide form. So, the toxic copper is not available for absorption from the intestine.
- **Animal performance:** The protozoa play a role in the production of energy utilizable by the host. They are involved not only in orienting the ruminal fermentation, but also in controlling their intensity. The amount of carbohydrate stored by ciliates during the four hours following feed intake could represent between 30 and 40% of their dry matter intake. In these conditions, the passage of even a small portion of the protozoal population from the rumen would contribute significant amounts of amylopectin in the intestine (e.g. 15-30g/day in sheep), considering the low amount of dietary starch which flows in the intestine. That's why, blood glucose levels decrease in defaunated animal. On high roughage fed animals, the protozoa do not seem to have any specific function to perform. The reduction in methanogenesis results in better feed conversion efficiency on such feeds. But when the animals are fed on high grain diet, the ciliate protozoa have a specific function to perform i.e. the pH stabilization by controlling the degradation of easily fermentable sugars. Thus, in the absence of ciliate protozoa, the pH drops below the optimum level required for various enzymes in the rumen. This results in poor feed utilization and decreased feed conversion efficiency on such feeds.

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Conclusion

Rumen is a natural fermentative anaerobic system which should be manipulated essentially by altering the composition of rumen microflora. There is ample scope to manipulate the rumen by feeding local plants or tree leaves or agro-industrial by products to defaunate the animals for improving its productivity. Different strategies are involved in defaunation like separation of newborn animals from their dams after birth, use of chemicals (copper sulphate, manoxol and sodium lauryl sulphate) for obtaining animals free from rumen ciliate protozoa and use of plant extracts such as secondary metabolites. It may be concluded that defaunation causes an increase in the rumen bacterial and fungal population, bacterial nitrogen yield, volume of rumen contents, change in rumen liquid or particle outflow. In the absence of rumen protozoa, methanogenesis also decreases. However, protozoa being the major source of cellulase activity in the rumen, their elimination decreases fibre digestion in rumen. In most of the tropical countries, crop residue (rich in lignocelluloses) are the major source of feed to ruminants and so the presence of protozoa in rumen seems to be desirable.