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Review

Rumen transfaunation

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ABSTRACT

The aim of this invited mini-review is to summarize the rumen transfaunation literature. Rumen transfaunation using the cud from a healthy donor animal to treat a sick recipient animal was practiced long before our understanding of rumen microorganisms. Around the mid-1900s, scientists began to explore the benefits of rumen transfaunation and the associated microbial populations. Rumen transfaunation has been used clinically to treat indigestion and to enhance the return of normal rumen function following surgical correction of a left-displaced abomasum. Rumen transfaunation was also used to introduce unique rumen microorganisms into animals that were exposed to toxic compounds in plants. Rumen liquor contains chemical constituents that likely contribute to the beneficial effects of re-establishing a normal reticulo-rumen anaerobic fermentation. Recommendations for collecting rumen fluid, storage and volumes transferred are discussed. Rumen transfaunation is a common practice to treat indigestion on dairy and livestock operations. The support of a healthy microbial community in the digestive tract is also used for humans. Fecal microbiota transplantation has been used to treat digestive disorders in humans. Rumen transfaunation, although not widely studied with respect to mode of action, is an effective, practical, and easy method to treat simple indigestion of ruminants.

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1. Introduction

The aim of this invited mini-review is to summarize the information available related to rumen transfaunation. Even though the method has been practice for decades [1] and is a common medical practice in food animal medicine to treat simple indigestion of ruminants [2–8], there is a paucity of scientific information to describe its benefits.

The ruminant can be considered to be a superorganism because it has a symbiotic relationship of life between the cells of the animal's body and the rumen microbes. Factors affecting the viability of microorganisms in the reticulo-rumen as well as anywhere along the gastro-intestinal tract of the ruminant impact the host animal.

Ruminants are mammals (Class – Mammalia) in the Order Arteriodactyla (even toed, hooved mammals) Suborder Ruminantia. Ruminant, from the Latin word ruminare, means to chew over gain hence the designation of cud chewing. Ruminants have a stomach with four compartments or chambers – reticulum, rumen, omasum, and abomasum (Fig. 1). The reticulum, rumen, and omasum are lined with non-glandular mucous membranes while the abomasum, the gastric compartment, is lined with glandular mucosa. The abomasum is similar in function to the human stomach. The largest compartment is the rumen, which along with the reticulum, serve as sites of anaerobic fermentation. There are coronary grooves in the rumen creating sacs. There is a cranial groove that separates the reticulum and rumen, and in cattle, sheep, and goats the two compartments are easily distinguished with the reticulum having a honey combed appearance. These compartments are lined with finger like projections called papillae that absorb nutrients (e.g. volatile fatty acids produced by the rumen microbiota). These finger-like projects are nature's way of increasing the absorptive surface area of the reticulum and rumen. Often ruminant nutritionists refer to these compartments as the reticulo-rumen because together they function in the rumen cycle (coordinated contractions) to support the acts of eructation and rumination. The contractions of the rumen cycle inoculate new food with microorganisms, distribute the end products of digestion for absorption by the mucosa papillae, and pass digesta to the omasum. Eructation is the process by which ruminants release gases from the reticulo-rumen that are produced during anaerobic fermentation. Eructation is a quiet process that involves eructated gas passing up the esophagus and into the trachea and the lungs to be respired. Rumination involves bringing a bolus of digesta up the esophagus (regurgitate) into the mouth where the bolus of digesta (cud) is

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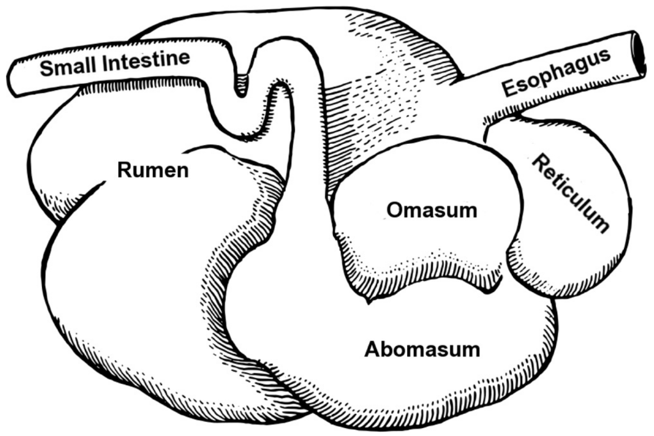

Fig. 1. Ruminant stomach. http://biobook.nerinxhs.org/bb/systems/digestion/1000px-Abomasum-ia-omaso.svg.png.

chewed. The cud is eventually re-swallowed and the process continues with another bolus regurgitated for cud chewing (crushing and grinding of particles by the molars). Cud chewing increases surface area of the feed particles, in particular fibrous material, to enhance microbial digestion. The act of cud chewing also stimulates salvia production, and the buffers present in the saliva help to maintain rumen pH when the bolus is re-swallowed. Digesta leaves the reticulum via the reticulo-omasal orifice. The omasum, with its many leaves or laminae, controls flow of digesta to the abomasum. The abomasum is the gastric, glandular compartment similar to the stomach of nonruminants (human, pig, mouse) with secretion of acid (HCl) and pepsinogen and a pyloric sphincter that regulates flow of digesta from the abomasum to the duodenum.

Transfaunation in its current use includes a broad spectrum of microorganisms including bacteria, protozoa, fungi, and archaea that are transferred from rumen of a donor to the rumen of a recipient. In his seminal book on rumen microbiology, Hungate [9] stated that transfaunation of protozoa occurred when protozoa that were left on food by one animal were consumed by another animal. Young animals were faunated by their mothers when she licked them. It is not clear based on our reading of the literature where the term 'transfaunation' originated or how it was derived.

One dictionary definition of transfaunation is "*transfer of symbiotic fauna (usually mutualistic protozoa) from one host to another*". Originally protozoa were defined as unicellular protists. Some ciliated protozoa have the ability to move similar to animals. Protozoa are also eukaryotic while bacteria are prokaryotic. Defaunation of the rumen referred to elimination of protozoa [9]. One dictionary definition of defaunate is "*elimination of microscopic fauna, especially protozoa, in the rumen and cecum, with depressing effects on digestion*". Although the meaning of transfaunation is not clearly defined in the literature, in this review we will use the term transfaunation broadly. The discussion of rumen transfaunation will include both microflora and to a limited extent chemical constituents in the rumen contents.

2. Background

Brag and Hansen [1] stated rumen transfaunation was used long before research demonstrated the importance of the rumen microorganisms to animal metabolism. These authors reported that the earliest printed reference about transfaunation in Sweden that they found was from 1776 (Hjortberg) that stated "*It is common practice, even in the country side, to take the fodder out of the mouth of a sheep or a goat to give it to an animal which does not ruminate.*" Subsequent research related to the discovery of the importance of rumen microbial population occurred much later in the 1900s.

Research that was conducted at The Ohio Agricultural Experiment Station determined that the cud inoculated rumens of preweaned calves contained bacteria and protozoa as early as 3 weeks of age [10]. Rumens of non-inoculated control calves that were fed milk and alfalfa hay had only bacteria. A similar response in calves was observed when the cud material was obtained from cows grazing pasture [11]. Cud inoculated calves also digested a higher proportion of cellulose and dry matter compared with non-inoculated controls [12]. This advantage disappeared later once calves were fed an all forage diet. Presumably this loss of digestion advantage with inoculation was associated with normal rumen development of microflora at weaning. Rumen inoculation was subsequently used as a treatment method to impact calf health. In a field study with a herd experiencing bloody diarrhea and death of preweaned calves, rumen transfaunation improved calf health and survival [13].

Rumen fluid [14] from an alfalfa hay fed steer was transferred into protozoa free sheep that were fed either alfalfa ($n = 3$) or a high concentrate diet ($n = 3$). All 24 species of protozoa were established in the rumen of sheep fed alfalfa but only 9 species were established in rumen of sheep fed concentrate. Rumen protozoa play an important role in transfaunation. Rumen protozoa are predominately ciliates of two types: Entodiniomorphid protozoa and Holotrichs [15]. Garry [16] noted that rumen protozoa were sensitive to pH, which supports the lower number of protozoa when sheep were fed a concentrate diet [14]. Most rumen ciliates utilize starch and their numbers increased [15]. Feeding starch that caused a decrease in rumen pH reduced or eliminated rumen protozoa with the larger Holotrichs more sensitive to low pH. However, it is not simply the starch content of the diet that impacts rumen pH and protozoa numbers, but also the type of starch and its rumen availability, the fiber content of the diet, and the physical form of the fiber source, as well as other factors [15,17]. These dietary factors should be considered with respect to the rumen environment of both the donor and recipient animals when rumen transfaunation is performed.

3. Rumen transfaunation for digestive disorders

3.1. Simple indigestion

A clinical sign of simple indigestion in dairy cattle is anorexia (reduction in appetite) [18] with ruminal hypomotility to atony (stasis) [6]. Sudden changes in dietary ingredients may initiate anorexia in ruminants [4] that are reflected in changes in rumen pH [6]. For example, changes in dietary ingredients that contribute to rapid lactic acid production impact rumen pH and populations of rumen microorganisms, in particular a decrease in rumen protozoa with increase acidity. Steen [19] provided diagnostic criteria for indigestion that included (1) ketotest (test for ketones) of 0 or 1 and (2) one of the following rumen fluid parameters including (a) a methylene blue reduction time > 3 min, (b) few large or small protozoa, or (c) reduced protozoal activity.

Even though transfaunation of rumen fluid from a healthy door animal to an animal with simple indigestion is a common recommended practice for dairy cattle and other ruminants, there is little information on the practice in the scientific literature. Jasmin et al. [20] reported the beneficial effects of rumen transfaunation for sheep used in biomedical research that developed simple indigestion. In their biomedical research sheep were fed pelleted diets, which contributed to the development of subclinical rumen acidosis. Exacerbating the effects of the small particle size as well as grain content associated with the pelleted diet, there were also stresses