INTRODUCTION

Human population is increasing at a rate of about 2% annually, 180,000 per day, 65 million per year for the world as a whole. The total food supplies needed by the year 2000 would require an increase in various commodities in the order of 100% in cereals, 200% in pulses and 190% in animal products in order to achieve minimum targets over the supplies at present.

The average deficit in the per capita food intake in India is presently estimated to be 528 for calories and 20 g for protein per day. Thus it is short of 20% energy requirement and about 30% short of protein requirement. Of 10 oz of milk 10 oz of meat and 1 egg recommended by the Nutritional Advisory Committee (1944) in the balanced diet of humans, the present availability of these is just about one half in respect of milk, one tenth in respect of meat and one thirtieth in respect of eggs. The immediate improvement of nutritional standards is possible in our country through increasing the supply of milk, meat, eggs and other animals products.

Therefore, it is the duty of the research workers in the concerned discipline to formulate the means for enhancing the availability of these food articles for human consumption.

The table No.1 reflects the efficiency of various domesticated-animals enterprises in the production of protein and energy for human consumption. Production levels under conditions found in good practice and feed requirements assessed on the basis of the recommendations of ARC taken as basis of these computations reveals the following pattern:
Table 1.

<table>
<thead>
<tr>
<th>Food product</th>
<th>Production of protein (g/meal of D.E.(^a)) as % of D.E.(^a)</th>
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<tbody>
<tr>
<td>Pork</td>
<td>6.1 18</td>
</tr>
<tr>
<td>Eggs</td>
<td>10.1 12</td>
</tr>
<tr>
<td>Broiler</td>
<td>11.9 12</td>
</tr>
<tr>
<td>Milk (3600 kg/yr)</td>
<td>10.5 22</td>
</tr>
<tr>
<td>Milk (54000 kg/year)</td>
<td>12.8 27</td>
</tr>
<tr>
<td>Beef</td>
<td>2.9 6</td>
</tr>
</tbody>
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\(D.E.\(^a\) = \) digestible energy ingested.

Also Preston (1968) has estimated that percentage of feed protein converted to animal protein edible by man for various animal products are as follows: milk - 28; broilers - 26; eggs - 23; pork - 17; and beef - 8. These observations in addition to those derived in the table given above suggest that the feed available would be more effectively utilised in the following order of efficiency - Milking ruminants, broilers, egg-laying hens, meat producing pigs, and meat producing ruminants. Although these conclusions hold good in the developed countries of the temperate part of the world, in tropics where the major problem of insufficiency of man's food exists and is expected to be more critical in the future, the role of ruminants as converter of course roughage to energy rich foods is of outstanding importance.
Role of Ruminants in India.

Ruminants, and bovines in particular, play an important role in the economic make-up of the country. It is interesting to note that cattle contribute to the national economy by way of milk and milk products to the value of 759.60 crores which form 64.5% of total income from animal husbandry (Chaudhari and Giri 1964).

Although India possesses 228.9 million heads of cattle (Livestock census of 1966) including 52.9 million buffaloes, the performance of milch animals is deplorably low. Of the total milk producing animals 94.3% cows and 19.2% of buffaloes yield less than one kg milk and only 0.4% of cows and 18.8% of the buffaloes yield over 2 kg of milk per day (Harbans Singh 1963). Sikka (1965) estimated that 45.5 million cows and only 21.9 million milch buffaloes contribute 42.2% and 57.8% respectively of total milk supply in India and thus average annual milk yield of cows and buffaloes were 173.0 and 431.0 kg respectively.

The present status of cow level productivity in Indian cattle may be attributed to a number of factors which need a thorough assessment for bringing about an improvement in their performance. Besides the poor genetic make up of our livestock for high milk yield and adverse climatic conditions of the tropical zone, the chronic under-nutrition conditions are the causes for low level of production. Whyte and Mathur (1965) have stated that by balance feeding alone the milk yield of cattle can be increased by 50% or more. The acute shortage of land to produce food for human consumption and feed for animals has resulted in sustaining cattle on bye products of human food and scant grazing.
Nevertheless, it is well recognised that through improved practices in agriculture and animal husbandry, the productivity of plants and animals can be increased manifold. However, for the improvement of animal husbandry practices extensive knowledge of physiology of domestic animals and ruminants in particular under Indian conditions of management and feeding is required.

**Importance of Human Studies**

Ruminants have been associated with the affairs of man since the earliest developments of human society. The transition of man from primitive hunter to agriculturist which began in early Neolithic period some 6000-7000 years ago, was largely dependent on two closely associated developments. These were, the cultivation of crops and domestication of the fore-runners of our present day ruminants.

Knowledge of ruminant anatomy and physiology dates back to 18th century. Considerable advances in the rearing and maintenance of cattle, sheep and goat have been achieved during the last century and by largely empirical methods of selection, which persist today, great improvements in individual breeds of livestock have been achieved. Detailed knowledge of rumen function, however, has only accumulated during past 60 years, a period in which rapid advances in physiology, anatomy and biochemistry have been made.

The unique qualities of the ruminants are that the mechanism to hydrolyse cellulose, hemicellulose and other substances resistant to digestion by tissue elaborated enzyme,
an advantageously located gastro-intestinal system harbouring micro-population capable of synthesizing protein from ammonia and carbon chains, and of synthesizing vitamin K and B-Complex in the fore stomach. It is axiomatic that ruminant represents the most developed form of herbivore equipped to function under extensive managerial conditions.

Impressed upon by the qualities noted above, the research workers in this discipline were attracted to unfold the mysteries of physiology of ruminant. Amongst the earlier workers on ruminant digestion, particular reference may be made to Schalk and Amedon (1928) at North Dakota, whose pioneering studies provided firm foundation for further work. Later, an impetus to research was provided by the brilliant studies of Barcroft, Phillipson and Elsdon at A.R.C. unit of animal physiology during second world war. It was during this period that importance of short chain fatty acids in nutrition of ruminant was advocated. The work of McDonald (1952) on protein degradation and synthesis gave a better understanding of the role of rumen in nitrogen metabolism. Considerable advances have been achieved during recent years in the isolation and evaluation of individual microorganisms.

The reticulo-rumen comprise the fermentation vat where the bulky fibrous food forming major part of the diet is delayed to undergo extensive fermentation. The end products of fermentation and microflora of the vat are eventually utilised by the host for nutrient needs of growth, maintenance and production. The importance of microbial digestion in rumen can be assessed
in view of the fact that 70 to 85% of the total digestible dry
matter of usual diet is digested in the rumen (Gray 1947).

The cellulose and other complex carbohydrates are fermented
with the help of microbial enzymes with the production of VFA
which are absorbed and form the major source of energy to the
animal (Blaxter 1961). A large proportion of proteins of diet
are hydrolysed to amino acids and peptides by rumen microbes and
these intermediates are either incorporated into microbial pro-
tein or rapidly catabolised otherwise (Annison and Lewis 1959).

The rumen offers a unique example of symbiosis between
host animal and micropopulation harboured by it. The anaerobic
and reducing conditions in the rumen are most conducive to the
growth of the anaerobic microorganisms with the result under such
conditions enormous turnover of food takes place with small amount
of heat production.

Importance of present investigation

The chain of events taking place in rumen described in
brief above relates to the well developed rumen as found in
mature animals. The functional status is, however, not the
same in the early life of calf. In early life, the course of
digestion simulates with those of monogastric animals. If the
calves are kept for prolonged period on milk and milk sub-
stitutes, the rumen development is delayed in absence of proper
trigger (Herman 1936, Warner et al 1953). The development of
rumen is not a simple enlargement of organ, but involves
functional, anatomical, bio-chemical and microbiological
hierarchy.
Replacement of whole milk and milk substitutes with dry feeds viz., concentrates does not only reduce the cost of rearing the calf but also provides suitable stimulus for rumen development. Apart from these two advantages a fair amount of milk is saved for the purposes of human consumption.

With the formulation of suitable early weaning mixtures, attention was paid to increase the intake of the dry feeds by incorporation of sweetening agent like molasses and growth promoting agents with encouraging results, in advanced countries.

However, little work has been carried out in India on the different aspects of economic rearing of the calves. The method in vogue at present is to feed milk to the calves upto 6 months is very expensive with the result the estimated cost of rearing a calf comes to Rs.800/- to Rs.1200/- while in countries advanced in dairying such as Newzealand a well bred dairy cow can be purchased at an equivalent cost of Rs.300/- (Sikka 1962). This low cost is attributable to low cost of rearing by restricted milk feeding and making use of cheap gruels, butter milk powder and superior quality roughages in early calfhood.

Based on the reports from abroad on success of early weaning of calves, Razdan et al (1965) took up the studies at N.D.R.I., and reported better growth rate of calves reared on calf starters in the form of concentrates. However, they did not report the pattern of rumen development with the feeding methods although better growth is sufficient indication of efficient utilization of calf starters by young calf. Nangia (1966) in another series of such studies reported that within physic—anatomical limits,
the development of adult type rumen function is governed more by the rate at which calf eats solid food than by its age. However, before recommending the replacement of whole milk by cheap dry feeds it is imperative to accumulate detailed knowledge on the relationship between various diets and certain variable, reflecting physiological and anatomical events in the rumen.

Buffalo (Bubalus bubalis) holds a commanding position in the milk production of country with high fat content. Besides it possesses better capacity of utilization of coarse fibre of straws than Zebu cattle (Saini and Ray, 1964; Singh and Mudgal, 1967) which constitute the basis of roughages for livestock in this country throughout the year and for many years to come there is nothing to replace the straws. In view of the fact that buffaloe heifers attain the stage of maturity late and the feeding cost therefore is considerably higher the achievement of economy of rearing the calves is a must. Investigations were therefore undertaken to study this aspect. The pattern of study formulated was to replace part of whole milk by calf starters and further to replace a part of calf starters by good quality roughage and to study the anatomical and physiological events that follow in the compound stomach. Through the investigations reported in this thesis, an attempt has been made to have better understanding of the factors stimulating the chain of events in the development of rudimentary insignificant organ of the new born calf to highly capacious organ of the mature animal harbouring specialised population of microorganisms responsible for complex biochemical events which ultimately provides the source of energy to the host for its growth, maintenance and production.