CHAPTER V

SUMMARY AND CONCLUSION
Economics of ruminant feeding is based on taking best advantage of rumen function at an early age with particular emphasis on the utilization of roughage in best possible way. The conventional system of feeding milk up to 6 months of age involves high cost in rearing calves up to this age. The aim is to reduce the milk feeding to economise on calf rearing and also to divert the milk so saved for human consumption. The conventional methods were based on the assumption that the calves are less capable of utilizing the dry feeds in early age in the absence of a mature rumen. So far very little work has been carried out in this direction in India. Therefore, with the aim to achieve economic calf rearing and stimulate ruminal activity at an early age with the help of calf starters and roughages, the present investigation was undertaken. These studies were so oriented as to suit the conditions prevailing under tropical and subtropical climate.

1. Literature on the work carried out relating to present investigation has been reviewed. The methods employed for recording various observations have been described.

2. The investigation was taken up to 50 graded Murrah buffalo calves. The experiment was initiated in January 1970. Just after weaning, the calves were obtained from Military farm, Bangalore. Calves of both sexes were taken for the investigation. 48 calves were grouped into control, I, II, III, IV and V so as to contain 8 calves in each by randomization. Two calves of 3 weeks age were slaughtered for anatomical observations on stomach compartments in pre-ruminant stage.
3. Control group was fed according to conventional feeding schedule receiving milk up to 6 months of age along with calf starter beginning with small quantities. Group I calves received inoculation of rumen fluid from mature buffaloes in addition, from II to VII week of age, at weekly intervals with the aim to establish micropopulation at an early age so that its effect on performance of calves could be observed. The calves of II, III, IV and V groups received limited quantity of milk up to 7th week of age and hariyali hay to concentrate in the ratio of 1:1, 3:2, 2:1 and 3:1 respectively. Concentrate were offered from 15th day onward and hay from one month of age. Greens were offered from 15th day of age onwards.

4. Investigation carried out consisted of recording:
   (i) the daily feed intake, (ii) observations on growth rate once in a fortnight by measuring a) body weight, b) heart girth, (iii) observations on physiological activities of rumen once in a fortnight examining the a) pH, b) total VFA in rumen liquor, c) Individual VFA in rumen liquor, (iv) observations on blood constituents once in a fortnight by examining a) blood glucose, b) haemoglobin and packed cell volume, c) VFA in peripheral blood, (v) anatomical observations at 3, 13 and 26 weeks of age involving - volume displacement of recticulo-rumen, omasum and abomasum, weight of fresh tissue and contents of stomach compartments and papillary length and density and (vi) metabolism trial at 6 months and 1 year of age with the object of observing utilization of feed ingredients under different treatments.
and effect of different treatments on subsequent utilization of nutrients by calves.

5. The scheduled quantity of calf starter offered in gruel form in two lots from 3rd to 8th week of age was readily consumed by the calves without reluctance. However some calves, during first 2 months of life, without showing symptoms of any disease, showed total reluctance to the gruel. These calves were immediately treated with piperazine adepate for suspected ascaris infection and they responded well to it with the passage as observed by the ascaris in faeces next day. Five calves in II, III and IV groups were diarrhetic when given considerable amount of concentrates but were cured by dosing with astrigent drugs and withdrawal of meals.

6. Three calves died during the course of the investigation, one at 40 days of age due to bloat and two within 20 days of age due to exposure to cold and subsequent development of pneumonia. Replacements therefore were made.

Growth study

7. The growth rate assessed by body weight and heart girth measurement at 3 and 6 months of age was fastest in control and group I calves fed on milk upto 6 months of age compared with those of the calves of rest of the groups fed on limited quantity of milk upto 7th week and dry feeds from early age. The difference in the values between control and group I was
not significant. No significant difference between values recorded for calves of group II and III; III and IV; and IV and V was observed. The values recorded between calves of II and IV; II and V and, III and V groups were however found significant showing that growth in group II calves was significantly higher compared with those of IV and V group calves. Group III calves had significantly higher growth rate compared to those of group V calves. The average body weight gains were 418.8, 409.0, 372.2, 349.3, 322.9 and 311.1 g per day upto 3 months of age and 365.1, 385.1, 353.7, 335.2, 317.6 and 307.8 g per day upto 6 months of age in control, I, II, III, IV and V groups respectively. The heart girth increment per day upto 3 months of age were: 0.226, 0.222, 0.196, 0.192, 0.167 and 0.164 cm per day and upto 6 months of age 0.201, 0.199, 0.182, 0.174, 0.165 and 0.162 cm per day in control, I, II, III, IV and V groups respectively.

8. The analysis of variance carried out on regression values of body weight from birth to one year of age did not reveal any significant difference between groups indicating that the calves which exhibited slow growth during 6 months of life recouped during later phase of life. The heart girth values also showed the same pattern. The average weight gains from 7th month to 1 year of age were: 296.6, 300.7, 320.8, 341.0, 352.8 and 358.3 g per day in control, I, II, III, IV and V groups respectively indicating higher weight gains in experimental group of calves.

9. Cost of feeding upto 6 months of age in different groups was calculated on the prevailing market rates of milk and feeds
Physiological activities in rumen

10) The pH of rumen contents increased steadily from birth to 16 weeks of age in all groups. The pH in high roughage fed calves (IV and V groups) was significantly higher than those of control, I and II groups. The average values of pH ranged from 5.82 to 6.93 in control group; 5.75 to 7.01 in I group, 5.84 to 6.98 in II group, 5.57 to 7.08 in III group, 5.68 to 7.09 in IV group and 5.84 to 7.14 in V group during the 6 months period. The data revealed that with higher proportions of roughage in the ration, the pH was maintained at higher level and inoculation did not affect the pH of rumen contents.

11. Total volatile fatty acids in the rumen also increased with advancement of age in all groups. The VFA level reached to a maximum at the age of 12 weeks in control and group I calves while, in groups II, III, IV and V the maximum values were recorded at the age of 8 weeks. After reaching the maximum level, the values in all the groups declined slightly and attained more or less a constant level. Thus it is apparent that the functional development of rumen proceeds rapidly in calves fed on restricted milk and dry feeds at an early age and attains adult type activity also at an early age. While, in milk fed calves this stage is attained later depending upon
the availability of sufficient quantity of dry feeds to accelerate the same. The decline in VFA level observed in all groups indicated that the absorptive mechanism of the rumen became more effective than that of early age and the rate of absorption exceeds the rate of production similar to that noticed in mature type of rumen function. The total VFA concentration in rumen liquor ranged from 52.00 to 103.17; 50.50 to 101.00; 49.67 to 106.83; 50.17 to 101.83; 49.33 to 93.50 and 49.83 to 90.33 meq/litre in control, I, II, III, IV and V groups respectively. Analysis of variance showed significant difference in the contents of total VFA between the groups. The critical difference showed significant difference between the values recorded for II and IV and, II and V groups, but no significant difference between the values of II, III, control and I groups, between III, control, I and IV groups and between IV and V groups was noticeable. The average total VFA values in different groups revealed that highest concentration was in those of II group, lower in III, control and I groups, and least in IV and V groups. It was obvious that with high proportion of roughage in the diet the total VFA concentration goes down. No significant difference between the values recorded for control and I group was noticed which indicated that the cud inoculation did not influence total VFA in rumen contents.

12. The different diets reflected the production of individual VFA in the rumen in various proportions. The values of butyric acid ranged from 10.80 to 15.10; 9.40 to 15.33; 9.70 to 17.73; 9.20 to 14.40; 10.00 to 17.43 and 9.10 to 12.77 meq/litre in control, I, II, III, IV and V groups respectively.
The propionic acid concentration ranged from 16.37 to 28.60; 15.33 to 28.30; 14.33 to 31.13; 15.03 to 29.47; 11.77 to 23.03 and 12.07 to 22.17 meq/litre in control, I, II, III, IV and V groups respectively, while, the values of acetic acid ranged from 20.77 to 53.67 in control; 19.87 to 53.80 in I, 21.60 to 58.13 in II, 20.67 to 60.27 in III, 22.17 to 61.20 in IV and 22.07 to 60.67 meq/litre in V groups. The proportionate production of butyric and propionic acid was more with higher proportions of concentrate in diet and the increased proportion of roughage in diet resulted lowered production of these acids with compensated increase in the proportion of acetic acid. Lactic acid production was significantly higher in the calves of control and group I than those of the rest of the groups indicating higher production of lactic acid on milk diet.

**Blood constituents**

13. Blood glucose concentration fall with the advancement of age. The fall was quite marked upto 12 weeks of age in all groups and afterwards there was slight variation in the values. The blood glucose ranged 62.50 to 106.92; 64.32 to 108.80; 59.93 to 112.26; 60.26 to 111.63; 59.29 to 112.82 and 57.69 to 106.92 mg/100 ml of blood in control, I, II, III, IV and V groups respectively. The average values at 2 weeks ranged from 106.92 to 112.82 mg/100 ml which fell to 57.69 to 64.32 mg/100 ml of blood at 6 months of age. Glucose level was of significantly higher in the blood of calves/control and
group I, compared to those of group V. There was no significant
difference between the values of control, I, II, and III groups
and between II, III, IV and V groups. From the average values
in different groups it is seen that highest values were recorded
in blood of calves of control and group I and there was a gradual
fall with introduction of increased proportions of roughage in
the diet with lowest value recorded for calves of V group. It
is evident that type of diet fed to animals influences the
blood glucose concentration to considerable extent.

14. The haemoglobin and packed cell volume values recorded
the blood of calves of control and experimental groups did not
exhibit any difference between different groups indicating that
the rearing diets of restricted milk and dry feeds from early
age were adequate nutritionally as those of high milk diets and
calves in these groups were in good health. The Hb values ranged
from 7.82 to 10.25 g % and PCV values from 34.52 to 42.33% in
all groups during 6 months of age. A fall in Hb and PCV values
during first two months of life was observed in all groups which
has been discussed.

15. The VFA concentration in peripheral blood increased
with age in all groups till 14 weeks of age. The values re-
corded were 3.20 to 8.30; 3.30 to 8.50; 3.30 to 7.90, 2.90 to
7.80 and 3.10 to 7.50 mg % in control I, II, III, IV and V groups
respectively. Analysis of variance reflected significant differ-
ence/groups. The blood VFA in calves of group II were significantly
liquor
/than those of V group calves. Difference between the values of control, I, II, III, IV and between control, I, III, IV and V was not significant.

Anatomical Development

15. The weight of fresh tissue of reticulo-rumen expressed in g/100 kg I.F.E.W. recorded at 3, 13 and 26 weeks of age reflected that with the advancement of age, the tissue weight of reticulo-rumen increased. The weight of tissue was 1468.2 g/100 kg I.F.E.W. which increased to 2040.2, 2590.5, 2526.8, 2436.9 and 2236.6 g/100 kg I.F.E.W. at 13 weeks of age and 3281.8, 3388.5, 3396.0, 3269.2 and 3153.3 g/100 kg I.F.E.W. in the calves of control, I, II, III, IV and V groups respectively. At 13 weeks of age the weight of tissue was more in calves of II, III, IV and V groups compared with those of control and group I indicating that dry feed stimulated muscular development of this organ. While, on comparing the tissue weights of II, III, IV and V groups, it was observed that although total dry matter consumption per 100 kg body weight increased from II to V group, the tissue weight decreased from II to V group and also the proportion of concentrate in the diet. This indicated that higher proportion of concentrates in the diet induced more muscular development. This was further confirmed by the weight of fresh tissue of reticulo-rumen at 26 weeks of age in different groups, wherein more tissue weight was observed with higher concentrate intake in the diet.
17. The weight of fresh tissue of omasum increased with age. At 3 weeks age, weight was 216.7 g/100 kg I.F.B.W. At 13 weeks the values were 477.5; 487.1; 577.5; 596.7; 638.2 and 704.4 g/100 kg I.F.B.W. and at 26 weeks of age 1008.8; 1003.0; 1135.0; 1232.9; 1319.2 and 1429.2 g/100 kg I.F.B.W. in control, I, II, III, IV and V groups respectively. The weight of omasal tissue unlike that of reticulo-rumen increased with increased intake of dry matter in the diet being lowest in calves of control and group I and highest in group V. This trend was seen both at 13 and 26 weeks of age.

18. The tissue weight of abomasum at 3 week of age was 557.0 g/100 kg I.F.B.W. which increased at 13 weeks of age to 896.8, 894.4, 885.7, 878.1, 898.3 and 899.7 g/100 kg I.F.B.W. and at 26 weeks of age to 960.0, 949.6, 948.1, 958.5, 975.2 and 972.0 g/100 kg I.F.B.W. in calves of control, I, II, III, IV and V groups respectively. The observations revealed that abomasal tissue grow independent of the nature of diet and in proportion to body growth.

19. The weight of the contents of reticulo-rumen increased with age. At 13 as well as 26 weeks of age, the weight of contents was lowest in calves of control and group I and increased gradually with proportionate increase of roughage in the diet showing that with more bulk in the diet, the contents of reticulo-rumen increased. Same trend was observed with the weight of contents of omasum at both ages. The weight of
contents of abomasum both at 13 and 26 weeks of age did not show any definite pattern to indicate that weight of abomasal contents was not influenced by diet.

20. The volume of reticulo-rumen at 3 weeks of age was 4.2 lit/100 kg I.F.B.W. which increased to 36.5, 36.6; 43.0; 48.3; 55.1 and 64.3 lit/100 kg I.F.B.W. at 13 weeks of age and 61.2, 60.9, 69.3, 71.3, 81.7 and 87.0 lit/100 kg I.F.B.W. at 26 weeks of age in control, I, II, III, IV and V groups respectively. The volume was lowest in calves of control and group I and increased with proportionate increase of roughage in the diet. Thus maximum volume was recorded was in calves of V group. There was clear linearity between volume of the reticulo-rumen and intake of roughage in the diet. This trend was obvious at 13 as well as 26 weeks of age. The volume of reticulo-rumen increased considerably from 3 to 13 weeks and then to 26 weeks of age showing that the same increased markedly with advance in the age of the calf. On comparing the volumes of reticulo-rumen with tissue weights, it is evident that dry feeds are required for proper stimulation of tissue growth and proportionately more concentrate in the diet increased the tissue weight while high proportion of roughage in the diet resulted in stretchability of the organ.

21. The volume of omasum increased markedly with age as revealed by the values at 3, 13 and 26 weeks of age. But the volume of abomasum increased from 3 to 13 weeks of age and afterwards there was practically no difference showing that
volume of abomasum did not exhibit change after 13 weeks of age. The volume of omasum increased successively from control and I group with proportionate increase of roughage in the diet. This was seen at 13 as well as 26 weeks of age. On the other hand, volume of abomasum did not reflect any such trend showing its independance over the nature of the diet.

22. The length of papillae increased with age, with concurrent decrease in the number of papillae. The average length at 3 weeks of age was 0.60 mm. and recorded a count of 455 per cm². The length at 13 weeks of age was 3.28, 3.26, 3.55 3.28, 3.10 and 2.36 mm while at 26 weeks of age 5.38, 5.71, 5.70, 4.38, 4.37 and 4.35 mm in control, I, II, III, IV and V groups respectively. The count at 13 weeks of age was 230, 228, 216, 204, 188 and 176/cm² and at 26 weeks of age 146, 148, 144, 135, 129 and 120/cm² in control, I, II, III, IV and V groups respectively. From the values, it is obvious that maximum length at 13 weeks of age was in II group which may be attributed to more concentrate intake upto this age by the calves of this group. The length of papillae in control, I and III groups was almost equal but less than that of II group and more than those of IV and V groups. It was opined that with decreased proportions of concentrate in the diet, the length of papillae also decreased. It was interesting to note that the consumption of concentrate by calves of control and group I was less than those of III group upto 13 weeks of age but the length of papillae was equal. It was felt that milk which is
known to enter the rumen under open pail feeding without nipple must have stimulated papillary development. At 26 weeks of age, papillary length was more in control, I, and II groups and decreased gradually in III, IV and V groups, with a corresponding decreased intake of concentrate in the diet. These observations further confirm the opinion recorded earlier that concentrates in the diet influence papillary development. Production of butyric and propionic acid was more on high concentrate diets. These acids, are said to be stimulatory for papillary development as reported by earlier workers and might be the probable cause of more papillary length recorded on high concentrate diets.

Metabolism Trials

23. Metabolism trials with 7 days collection were conducted when calves were 6 months and 1 year of age. The feeds and fodder offered were analysed. Balance of N, Ca, P and digestibility coefficients of the feed ingredients under different treatments were determined.

24. Dry matter consumption by calves at 6 months of age increased with increased proportion of roughage in the diet. The intake was 2.13, 2.06, 2.35, 2.40, 2.67 and 2.77 kg/100 kg body weight per day in control, I, II, III, IV and V groups respectively. The calves in high roughage groups (IV and V) consumed the proportionate roughage in the diet indicating
better adaptability of ruminant to consume large amounts of bulky diet to meet the nutrient needs of the body.

25. The digestibility coefficients at 6 months of age for D.M. were: 61.02 ± 1.78; 61.34 ± 0.78; 59.79 ± 0.51; 58.36 ± 1.43; 57.43 ± 1.46 and 55.74 ± 0.96 and for C.P. were: 65.08 ± 2.30; 65.55 ± 1.46; 64.09 ± 1.59; 62.70 ± 1.36; 61.22 ± 2.11 and 59.34 ± 1.10 in control, I, II, III, IV and V groups respectively. As seen from the figures, the digestibility coefficients of D.M. and C.P. decreased from control and I group to V group. Likewise, the coefficients of E.E. and N.F.E. digestibility also decreased. This shows that with increased proportions of roughage in the diet, these ingredients are less efficiently utilized by the calves. The digestibility coefficients of C.F. on the other hand increased with increased proportions of roughage in the diet. The values were 62.78 ± 0.95 in control group, 62.78 ± 1.28 in I group; 64.46 ± 2.46 II group; 66.36 ± 0.84 in III group; 69.34 ± 1.50 in IV group; 73.41 ± 1.99 in V group. It is obvious that animal tries to utilize to the maximum out of the diet provided in the best possible way to obtain the nutrient needs of the body. There was no difference in the digestibility coefficients in the nutrients between control and group I showing that inoculation with cud did not influence the efficiency of food utilization at 6 months of age.

26. Balance of nitrogen at 6 months of age showed that retention was more in control and group I and decreased in
II, III, IV and V groups gradually. The values were 21.52 ± 1.32; 21.47 ± 0.72; 19.61 ± 0.19; 19.24 ± 0.50; 17.14 ± 0.58 and 17.35 ± 1.15 g/day in control, I, II, III, IV and V respectively. Better utilization of proteins on high concentrate diets is no doubt apparent but when retention of nitrogen per 100 gm body weight gain was calculated there was no difference in the values obtained in different groups. This showed that the animal reserves the required amount of nitrogen to meet its requirements for growth etc. and excess is excreted out.

27. Ca and P were in positive balance in the calves of all groups at 6 months of age. The balance of Ca was: + 2.98; + 3.01; + 3.14; + 2.99; + 3.06 and + 3.20 g/day and that of P; + 3.24; + 3.45; + 3.02; + 3.32; + 3.07 and + 2.98 g/day in control, I, II, III, IV and V groups respectively. It is evident that type of diet in the study did not affect Ca and P metabolism.

28. Efficiency of feed utilization was calculated till 6 months of age in terms of T.D.M. per kg weight gain from the intake of milk, concentrate and roughage by the calves in different groups. The values were 2.36, 2.36, 2.46, 2.58, 2.63 and 2.66 kg T.D.N/kg weight gain in control, I, II, III IV and V groups respectively. The efficiency of feed utilization decreased with increased intake of roughage in the diet which accounted for lower weight gains in calves fed on proportionately more roughage in the diet.
29. At one year of age, the digestibility coefficients of D.M., C.P., E.E., C.F. and N.F.E. did not reflect differences between the groups showing that with intake of similar diets, the digestibility of feed component did not differ irrespective of the type of diet fed earlier. Thus it may be concluded that type of diet fed in early age did not affect the utilization of feed at later stage in the life.

30. There was no difference in nitrogen retention by calves of different groups at 1 year of age except for a slight variation. The percent retention of nitrogen was less (25.49 to 29.07 %) at 1 year of age than that at 6 months of age (32.80 to 39.52 %). It indicated that with decreased growth rate at later stage in life, the retention of nitrogen also decreased.

31. Ca and P balance were positive in calves of all the groups at 1 year of age. The values were, +5.85, +5.28, +6.24, +5.98, +6.20 and +5.78 g/Ca per day and +5.56, +5.04, +5.49, +5.10 and +4.94 g/P per day in control, I, II, III, IV and V group respectively. Higher balance of both elements at 1 year of age as compared to 6 months showed that with increase in body weight the requirements of Ca and P increase.

CONCLUSION

From the results obtained during the investigation on different aspects (Physiological, haematological and anatomical) it is concluded that young buffalo calf adapted itself
during earlier age and carried out characteristic ruminal function under different dietary environment. Full advantage of rumen function at an early age could be taken by reducing the quantity of milk fed and development of rumen with the help of calf starters and good quality hay and greens be established. Slight setback in growth in earlier stage was observed but this is understandable that it takes some time for rumen to adapt itself in early age to the dry feeds for efficient utilization of nutrients of the diet. However, this aspect is well looked after subsequently when calves attained an age of 6 months and continued to be fed on uniform ration. At one year of age, calves of all groups attained the same body weight and utilized the feed equally efficiently. The economy achieved in rearing calves on 1:1 ratio of roughage to concentrate appears to be the optimum.

This system proves to be the best under the acute shortage of milk existing at present in this country. Under this system reliance on abomasal digestion at an early age may be reduced by stimulation of rumen development and thereby taking best advantage of it. From the results obtained, it may be said that major changes from non-ruminant to ruminant type of metabolism occurs at 8 to 10 weeks of age and by 3 months of age, adult type of rumen function is achieved by restricted milk feeding and access to dry feeds. Apart from this, much of milk used for calf rearing from birth to 6 months of age could be saved and diverted for human consumption.
Thus within physico-anatomical limits, the adult type of rumen function may be achieved with the help of dry feeds in early age of ruminant, giving best benefits to dairyman by way of reducing the cost of rearing the calves and saving milk for human consumption at the same time.