

**STUDIES ON ANAEMIA IN GOATS WITH SPECIAL
REFERENCE TO MINERALŞ AND TRACE ELEMENTS
DEFICIENCIES IN RELATION TO SOIL AND PLANT**

**A Thesis
Submitted to the
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in
VETERINARY MEDICINE**

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1 9 8 9

*Dedicated to
my beloved parents and brother*

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C E R T I F I C A T E

This is to certify that the work recorded in the thesis entitled "STUDIES ON ANAEMIA IN GOATS WITH SPECIAL REFERENCE TO MINERALS AND TRACE ELEMENTS DEFICIENCIES IN RELATION TO SOIL AND PLANT" submitted by Shri Samar Sarkar for the award of the Degree of Doctor of Philosophy in Veterinary Medicine of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

Dated: Mohanpur

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LIST OF ABBREVIATION USED IN THE TEXT

Following abbreviations have been adopted for the purpose of convenience in the present text.

AT	=	After treatment
B	=	Basophil
BGL	=	Blood glucose level
BT	=	Blood transfusion
b.wt.	=	body weight
Ca	=	Calcium
CHA	=	Chronic haemorrhagic anaemia
Co	=	Cobalt
Cu	=	Copper
DLC	=	Differential leucocytic count
Fig.	=	Figure
g	=	gramm
Hb	=	Haemoglobin
I	=	Iron
I/M	=	Intra-muscular
I/V	=	Intra-venous
kg	=	kilogram
L	=	Lymphocyte
M	=	Monocyte
MCV	=	Mean corpuscular volume
MCH	=	Mean corpuscular haemoglobin
MCHC	=	Mean corpuscular haemoglobin concentration

mg	=	milligram
ml	=	millilitre
mm	=	millimetre
μ^3	=	Cubic micron
μ g	=	Microgram
μ/μ g	=	Micromicrograms
M : E	=	Myeloid : Erythroid ratio
N	=	Neutrophil
NA	=	Nutritional anaemia
P	=	Phosphorus
PCV	=	Packed cell volume
ppm	=	parts per million
SCA	=	Serum calcium
SP	=	Serum phosphorus
SI	=	Serum Iron
SCu	=	Serum copper
SCo	=	Serum cobalt
TEC	=	Total erythrocytic count
TLC	=	Total leucocytic count
TS	=	Treatment started
$\pm$	=	Standard error
%	=	percent

CHAPTER—I

INTRODUCTION

INTRODUCTION

The Goat occupies an unique position among domestic animals in India particularly in West Bengal as it contributes 35% of the total meat produced in India (Chawla et al., 1981) and its meat is acceptable to all the communities of the country. Moreover, goat keeping plays an important role in the agricultural economy of the small and marginal farmers and landless labourers of the country particularly in West Bengal and other Eastern states. But, due to poor management, under nutrition, lack of browsing/grazing facilities and parasitism the goats become unthrifty, anaemic having poor growth, muscular weakness, depression and low meat production.

Blood et al. (1983) defined anaemia as deficiency of erythrocytes or haemoglobin or both per unit volume of blood. Accordingly, goat anaemia may be classified as haemorrhagic anaemia, haemolytic anaemia and anaemia due to reduced or defective erythropoiesis.

Haemorrhagic anaemia is generally encountered in surgery, accidental injuries, intestinal parasitism,

particularly haemonchosis, strongyloidosis, coccidiosis (Jennings et al., 1956; Bremner, 1966; Bremner, 1970; Schalm et al., 1975; Blood et al., 1983), Enzootic haematuria (Singh et al., 1973; Blood et al., 1983), poisoning by sweetclover, warferin, brackenfern; heavy infestation with ticks and sucking lice (Peterson et al., 1953; Risk, 1957; Blood et al., 1983).

Haemolytic anaemia is a manifestation of many infectious and non-infectious disease. Haemolytic anaemia due to haemoprotozoan parasite infection was recorded in goats. It also occurs in leptospirosis, bacillary haemoglobinuria, poisoning of onions, rape and other curciferous plants and by chronic copper poisoning etc. (Blood et al., 1983).

The least but the commonest form of anaemia in ruminants is due to decreased erythropoiesis which occurs mainly due to deficiency of trace elements like iron, copper and cobalt giving rise to "Nutritional anaemia" in cattle, buffalo and goat (Filmer, 1933; Hibbs et al., 1963; Becker et al., 1965; Kaneko and Mills, 1970; Pal et al., 1970; Domanski et al., 1972; Mollenburg, 1974). Anaemia due to hypoproteinaemia has also been reported by some workers in the past (Bremner, 1966; Coles, 1967; Schalm et al., 1975).

Anaemia has also been seen to occur in association with chronic suppurative processes and trychostrongylosis

infection, which is believed to be due to selective depression of bone marrow activities but the detail of the pathogenesis still remains obscure (Vaughans and Saifi, 1939; Schalm, 1972; Schalm et al., 1975).

Minerals are dietary essential and probably the chief factor limiting the production of meat, milk and eggs. Deficiency diseases were recognised as important entities only after the discovery of vitamins. The disease may occur either due to the deficiency of one or more nutrients in the feed or a result of improper or defective utilization of the nutrients present in the feed. Deficient or imbalanced ration produces specific and non-specific symptoms.

Undernutrition is commonly accepted to be the most important limitation to herbivore livestock production in tropical countries (McDowell et al., 1985). Lack of sufficient energy and protein is often responsible for suboptimum herbivore production. Mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproduction problems among florida beef cattle (Cunha et al., 1964; Becker et al., 1965). Research from other warm climate regions has shown mineral supplementations to increase calving percentages by 20 to more than 100%, to increase growth rates from 10 to 25% and to reduce mortality significantly (McDowell and Conrad, 1977). The first world

not cited in ref

reports of Cu or Co deficiency in grazing cattle originated in Florida (Becker et al., 1965). Nutritional anaemia or "Saltsick" in cattle, later established as a deficiency of Fe, Cu and Co, was noted as early as 1972 (Becker et al., 1965). Cobalt and Copper deficiencies have been reported under natural grazing conditions in many countries of the world (Ammerman, 1970; McDowell, 1976; Fick et al., 1976). Therefore, studies of the minerals and trace elements in soil plant-animal relationship are important because of their implications for animal production, there are very little or no information on them in India.

The literature on the "trace" or micromineral nutrition of the monogastric is vast and readily available (Prasad and Uberleas, 1976a,b; Underwood, 1977). However specific nutritional guidelines for the ruminants are limited and often extrapolated from the results of research with monogastrics.

Specific differentiation between toxicity of one element and deficiency of another is confusing to the clinician, and makes the grey area of trace element deficiency a fertile field for inter relationship research. Grazing livestock usually do not receive mineral supplementation except for common salt and must depend almost exclusively upon forages for their requirements. Only rarely, however, can forages completely satisfy all mineral requirements. Border line or deficient

levels of certain elements were noted for many forages during 1974 in Latin American (McDowell et al., 1977).

Concentration of mineral elements in forages are dependent upon the interaction of a number of factors, including soil plant species, stage of maturity, yield, pasture management and climate on seasonal conditions. Most naturally occurring deficiencies in herbivores are associated with specific regions and are directly related to soil characteristics.

Since tropical forages contain less minerals during the dry season, it is logical to assume that cattle would most likely suffer mineral inadequacies during this time particularly in our country where the dry period is long. On the contrary, numerous reports including those from Kenya, Brazil and South Africa noted specific mineral deficiencies more prevalent during the wet season (McDowell et al., 1977). In tropical regions under conditions of heavy rainfall and high temperature there is a marked leaching and weathering of soils, making them deficient in plant minerals (Pfander, 1971). It is generally accepted that tropical forages are less digestible than are temperate species, and, therefore, daily consumption by grazing ruminants is lower (McDowell et al., 1986).

As the soil pH increases, the availability and uptake of Fe, Mn, Zn, Cu and Co decrease whereas Mo and

Se concentrations increase (Latteur, 1962; Miller et al., 1972; and Pfander, 1971).

Large variations in mineral content of different plant species growing on the same soil have been reported from Kenya (Dougall et al., (1958). It is generally an accepted view that herbs and legumes are richer in a number of mineral elements than are grasses (Felming et al., 1973).

As plants mature, mineral contents decline due to a natural dilution process (Felming et al., 1973) and translocation of nutrients to the root system.

Without question, forage analysis is a much better indicator of mineral status for ruminants than is soil analysis. Likewise, animal tissue mineral concentrations are better indicators of the availability of mineral than are forage mineral analysis (McDowell et al., 1986) because like soils and plants, animal tissue mineral concentrations are influenced by many factors (Ullrey et al., 1983). (Wilson) (1979) stated that blood profiles act as a guide to nutritional status in the field. When the evidence obtained from clinical, pathological and biochemical examinations of the animal and from chemical analysis of the diet and its components is combined and assessed, it is usually possible to detect and define any nutritional abnormality of mineral

origin, even when it is mild (Underwood, 1981). Mullenax (1979) attributes much of the abortion, secadera, fractures, calambre and Vaca inflada to mineral deficiencies or imbalances. The most reliable method to confirm mineral deficiencies is ^{the} response derived from specific mineral supplementation. However, supplementation studies are costly in time and resources if conducted with adequate control and assessment (McDowell et al., 1985). *not cited in ref.*

Blood et al. (1983) [✓] reported the clinical manifestation of anaemia as pallor of the mucosa as the outstanding clinical sign but appreciable degrees of anaemia can occur without clinically visible change in mucosal or skin colour. These degrees of anaemia are usually not sufficient to cause signs of illness but they may interfere with performance and production. There are other signs of anaemia like unthriftiness, muscular weakness, depression and anorexia. The heart rate is increased, the pulse has a large amplitude and the absolute intensity of the heart sound is markedly increased depending on the degree of anaemia. Terminally the moderate tachycardia of the compensatory phase is replaced by a severe tachycardia, a decrease in the intensity of the heart sounds and a weak pulse. The initial increase in intensity of heart sounds is caused by cardiac dilatation and an increase in blood pressure. If the dilatation is sufficiently severe the atrioventricular orifices become dilated causing relative insufficiency of the valves and

a haemic systolic murmur is audible at the peak of inspiration. Laboured breathing occurs only in the terminal stages. Additional signs which often accompany anaemia but are not essential parts of the syndrome are oedema, jaundice, and haemoglobinuria.

Diagnosis of anaemia is usually suggested by the obvious clinical signs but the clinical signs do not appear until the haemoglobin level of the blood falls below about 50% of normal. The erythrocyte count and the haematocrit are usually depressed and differentiation between haemorrhagic and haemolytic anaemias and those caused by deficient production of erythrocytes or haemoglobin depends upon the history of haemorrhage, haemoglobinuria, jaundice or diet and upon clinical evidence of these signs. A biopsy of bone marrow is the most satisfactory method available but there is very limited practices or work in the veterinary field.

It has been observed that in all such forms of anaemia discussed earlier mere chemotherapy of parasitic or infectious diseases and removal of specific deficiency or deficiencies do not in any way help the patient so long as anaemia persists. In cases of severe anaemia associated with the above conditions, recovery is mostly remote.

Goat anaemia is of now greatest economic importance because of direct losses due to death of animals and indirectly

by the reduced productive deficiency, reduced growth rate and body weight and reduced meat quality and production. The consequent losses due to those factors are inestimable and an accurate estimate of economic loss either in cattle or in goats due to anaemia has not yet been worked out. Further, no systematic and detailed studies have been undertaken on the pathogenesis of anaemia in goats to evolve suitable therapy.

In severe cases of anaemia in bovine when haemoglobin level falls below 5 gm% blood transfusion is the most satisfactory treatment (Metcalf and Stahl, 1942; Ferguson, 1947). Blood transfusion in goats have been undertaken by workers in the past by Jhonston (1946), Simpson et al. (1952); Archer and Franks (1960); Balu and Ganapathy (1965), Schalm (1970); and Pandey and Misra (1987) but detail informations are lacking.

Informations are scarce in the literature on the clinical use of blood transfusion under field conditions with respect to standarization of dose of blood required for alleviating anaemia alongwith its haemodynamic effects in the recipients goats.

Our knowledge for a proper diagnosis and appropriate treatment of different forms of anaemias in goats is also very meagre as no systemic and detailed study has been undertaken so far to uncover various aspects of pathogenesis, diagnosis and effective therapy of goat anaemias. Therefore, present

day treatment of anaemia in goat is almost based on the model of human therapy which has no relevance in goats.

In view of the above facts, the present study on goat anaemia envisages to undertake the following investigations.

1. Incidence of anaemia in goats through clinical examinations.
2. Haematological changes in anaemic goats.
3. Biochemical changes in anaemic goats.
4. Minerals and trace minerals status of soil in grazing field.
5. Minerals and trace minerals status of plants in grazing field.
6. Experimental production of anaemia in goats
 - (i) Nutritional anaemia
 - (ii) Chronic haemorrhagic anaemia
7. Bone marrow changes of experimentally produced anaemic goats of both the cases
8. Pathological changes in different organs.
9. Meat quality assessment.
10. Therapy
 - (i) For nutritional anaemia
 - (ii) For haemorrhagic anaemia.

CHAPTER—II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 Incidence of Anaemia in Goats

2.1.1 Clinical manifestations of anaemia

✓ Madsen and Nielsen (1939) ✓ studied the clinical symptoms in dairy cows suffering from parturient haemoglobinuria and observed accelerated pulse rate as the characteristic earliest symptom followed by forceful heart beat with the result that palpitation of the heart was clearly audible. Anaemia and icterus were evident with extreme weakness and staggering gait. The period required for complete recovery varied from one week to two months.

✓ Evans (1951) ✓ reported occurrence of haemoglobinuria in cattle following ingestion of frosted Kale and rape. The only characteristic symptom in cases of anaemia caused by Kale poisoning in cattle included red urine without any other apparent symptom.

✓ Parkinson and Sutherland (1954) ✓ observed 14 cases of post-parturient haemoglobinuria in dairy cows of 4-8 years of age and all within 11 - 29 days of parturition. Clinical

symptoms observed were rapid onset, weakness, inappetance, reduced milk yield, haemoglobinuria and rapid loss of condition. Some affected cows also showed depraved appetite.

Udall (1954) reported that anaemia due to increased blood destruction was mostly associated with faulty nutrition, chronic infectious diseases, ascariasis, strongyloidosis, stomach worm diseases, parasitism in general piroplasmosis and parturient haemoglobinuria. Haemolytic agent may either be bacterial toxins or a parasitic toxins as in ascariasis. Symptoms thus observed were depression, emaciation, paleness of mucus membrane and skin.

Koger (1956) observed anaemia accompanied with haemoglobinuria and jaundice as the constant sign in cases of onion poisoning in cattle. Severity of anaemia was such that many cattle succumbed to this condition.

Settlemyre et al. (1964) studied the physiological compensatory mechanism of newly born calves suffering from iron deficiency anaemia and observed that the animals were able to compensate physiologically for their reduced oxyhaemoglobin content by significant increase in the rate of respiration.

Nagpal et al. (1968) reported the occurrence of haemoglobinuria in buffaloes in India due to hypophosphatemia and observed to occur mostly during third week after parturition

particularly in third to fourth lactation. Clinical symptoms observed included coffee coloured urine in severe cases, marked anorexia, reduced milk yield, anaemia, icteric conjunctiva and constipation.

Boddie (1969) reported that animals suffering from anaemia showed general symptoms of debility, the coat or fleece was harsh and lacks lusture, the animal was easily fatigued and any strenous exertion caused dyspnoea. Frequently, the animal was thin and might even be emaciated. The visible mucous membranes were pale and watery in appearance. The pulse was fast and weak. The heart beat was loud.

Greenhalgh et al. (1969) reported that kale poisoning in cattle produced haemolytic anaemia accompanied by haemoglobinuria.

Hungerford (1970) experimentally produced babesiosis in calves (Babesia bigemina) and observed the characteristic clinical symptoms like anorexia, high body temperature (104 - 108°F) severe anaemia and haemoglobinuria.

Singh and Goutam (1971) investigated sixty cases of haemoglobinuria in bovine in its different stages of severity. Initially urine was observed pale to dark brown which was passed infrequently. With the advancement of the disease in-appetance, reduced milk yield and constipation developed. In

the affected animals symptoms like increased pulse rate with panting respiration and loud heart beat were observed. The body temperature remained within the normal range.

(Berry and Dargie (1978) experimentally produced fascioliasis in sheep and observed anaemia. This anaemia was due to combination of haemodilution intrahepatic and biliary haemorrhage.

(Pandey and Misra (1978) observed high fever 105 - 108°F with toxæmia in early stage followed by fall in body temperature, progressive jaundice, anaemia, weakness of hind quarters and haemoglobinuria as clinical symptoms in experimentally produced babesiosis in calves.

(Mallick et al. (1979) made observations on cases of anaplasmosis in goats. Clinical symptoms manifested by the goats were anorexia, depression, rise of temperature, paleness of conjunctival mucus membrane and debility.

(Saror (1980) studied anaemia in Red Sokoto goats caused by *Trypanosoma vivax* and observed clinical signs like emaciation, weakness, rough hair coat, profuse lacrimation and development of corneal opacity

Roberts (et al.) (1982) reported that three sheep were severely anaemic in the presence of less than 100 worms of Haemonchus contortus.

✓ Blood et al. (1983) described pallor of mucus membrane being outstanding clinical sign of anaemia but appreciable degrees of anaemia could occur without clinically visible changes in mucus membrane or skin and usually not sufficient to cause signs of illness but could interfere with production or performances. They described clinical cases of anaemia as pale mucus membrane, muscular weakness, depression and anorexia with increase in heart rate and sounds, tachycardia and murmurs in advanced cases. Respiratory distress, laboured breathing were seen in terminal stages. Sometimes oedema, jaundice and haemoglobinuria were seen.

✓ Borah et al. (1983) were of the opinion that a profound anaemia could develop in goats infected with Strongyloides papillosus.

✓ Yousuf et al. (1983) reported anaemia due to anaplasmosis in Iraqi goats.

✓ Pandey and Misra (1985) observed anaemia in cow-calves suffering from ascariasis with symptoms of weakness, pale conjunctiva, prominent ribs and unthriftiness. Constipation was observed in some ^{cases.} Heart pulse and respiration rates were slightly elevated.

✓ Singh and Misra (1986) recorded anaemia as one of the prominent clinical symptoms in experimental trypanosomiasis in cattle and buffaloes.

(Pandey and Misra (1987) conducted the study of 10 female buffaloes suffering from nutritional haemoglobinuria and observed red to coffee coloured urine, jaundice, mild to severe anaemia, weakness, dyspnoea and complete anorexia.

2.1.2 Incidence of anaemia in goats

(Sawhney et al. (1973) studied the haemoglobin status of animals in the hilly areas of Himachal Pradesh and observed more than half of the animals anaemic.

Sawhney et al. (1974) conducted a survey about the haemoglobin content of blood of 326 representative animals of various species, breed, age and sex belonging to various Government and private livestock farms in the hilly areas of Jammu and Kashmir and recorded more than 50% of the animals with low haemoglobin. In goat, the haemoglobin content was 6.0 ± 0.5 to 7.83 ± 0.3 g%.

(Chhillar et al. (1979) surveyed various livestock farms in the Tarai area of the districts of Nainital, Pilibhit and Lakhimpur in Uttar Pradesh for examining haemoglobin content in blood of 260 cattle and buffaloes of varying ages and observed that about 60% of livestock had low haemoglobin content in the area.

Bedi and Khan (1984) observed about 65% of the animals in Bijnore district of Uttar Pradesh had less than 10 g of haemoglobin per 100 ml of blood.

2.2 Haematological Changes in Anaemic Goats

Filmer (1933) reported the absence of macrocytosis and reticulocytic response in cobalt deficiency anaemia in cattle. In such cases erythrocyte count dropped to as low as 2.8 million/cmm of blood, but in none of these cases either polychromasia or basophilic stipplings were observed.

Taylor (1935) studied anaemia due to chronic blood loss as a result of chronic bleeding or from heavy infestations with blood sucking parasites in ruminants, which was reported to be initially macrocytic due to response of the bone marrow in the presence of adequate iron but latter when iron stores of the body were depleted due to continued blood loss, a macrocytic hypochromic anaemia was superimposed.

Hahn and Whipple (1939) stressed the importance of adequate supply of dietary protein for optimum erythrogenesis, since a low protein intake lowered the optimal production of haemoglobin resulting in anaemia.

Medsen and Nielsen (1939) studied the various aspects of parturient haemoglobinuria of dairy cows and reported marked

reduction in the erythrocytic count, the lowest being 1.45 million/cmm of blood. The anaemia was reported to be macrocytic hypochromic.

Peterson et al. (1953) observed that extremely heavy infestation of cattle by blood sucking louse Haemotopinus eurysternus produced severe anaemia with haematocrit value as low as 9% along with corresponding reduction in haemoglobin and erythrocytic count.

Udall (1954) reported that anaemia due to increased blood destruction mostly associated with faulty nutrition, chronic infectious diseases, ascariasis, strongyloidosis, stomach worm diseases, parasitism in general, piroplasmosis and parturient haemoglobinuria. He further observed that haemolytic agent may be a bacterial toxin as in ascariasis. The haematological changes included decrease in the total erythrocytic count upto 50 - 75% with a marked decrease in haemoglobin.

Jennings et al. (1956) reported that anaemia due to liver fluke infestations resulted from the blood sucking activities of adult flukes in the bile ducts and the blood loss in such cases ranged from 0.1 to 1.0 ml/day/fluke.

Settlemyre et al. (1964) while studying the physiological compensatory mechanism of a new born calves suffering from iron deficiency anaemia observed that they were able to

compensate physiologically for their reduced oxyhaemoglobin content (oxyhaemoglobin less than 9 g%) by significant increase in respiration rate.

Dimpoulios and Bedell (1965) reported that osmotic fragility of erythrocytes of calves suffering from anaemia of non-specific origin remained within normal range.

Wujanz and Rittenbach (1966) produced immune haemolytic anaemia in a cow and four steers by repeated transfusions of large volumes of serologically incompatible blood. Plasma haemoglobin concentration indicative of haemolysis reached high levels only for a short period after transfusion and there after it declined.

Schnappauf et al. (1967) made some interesting observations into the erythropoietic response in calves after withdrawing variable quantities of blood through ^evanipuncture. A loss of 60 to 70% of the original erythrocytic volume over a period of ten days caused only slight or no reticulocytosis, where as, a sudden loss of 30 to 40% of erythrocytic volume resulted in appearance of some reticulocytes in peripheral circulation with marked anisocytosis. It was further observed that withdrawal of third of the total volume of red blood cells in cattle within 12 hours evoked marked reticulocytosis which ranged from 9 to 14%. Lastly it was concluded that reticulocytes appeared in blood of calves only after severe and sudden

blood loss and disappear early during the recovery process, even though macrocytosis continued to persist.

(Nagpal et al. (1968) reported the occurrence of haemoglobinuria in buffaloes in India due to hypophosphatemia. Haematological changes observed by him included coffee coloured urine in severe cases, marked anorexia, reduced milk yield, anaemia to icteric conjunctive and constipation. There was distinct decrease in haemoglobin, erythrocytic count and packed cell volume, which were found to be 5.792 ± 0.21 g%, 2.922 ± 0.26 million/Cmm of blood and $16.909 \pm 1.017\%$ respectively. Total leukocytic count showed slight increase as it was found to be $13,330 \pm 0.834$ /Cmm against the normal of 11,320/Cmm of blood.

(Hungerford (1970) experimentally produced babesiosis in calves (Babesia bigamina) and observed severe anaemia and haemoglobinuria. Upto 75% of erythrocytes were reported to have been destroyed.

Mapes^{and Coop} (1970) experimentally produced haemonchosis (Haemonchus contortus) in lambs and observed severe anaemia and fall in haematocrit values.

(Rogers (1971) studied the haematological changes in Babesia argentina infection in cattle and observed that in fatal cases the lowest mean haemoglobin concentration and

haematocrit values were 3 g% and 11% respectively, whereas in non-fatal but severe cases, the corresponding values were 3.6 g% and 13%.

(Schalm (1972) conducted studies on different types of anaemia of cattle and the findings were much informative. A similarity between haemorrhagic and haemolytic anaemia was noticed. Erythropoietic response was observed in the circulating blood after 4 to 5 days of severe blood loss, which was evident by increased size and basophilic stippling of red blood cells. Anaemia due to depression of erythrocytogenesis was found to be normocytic normochromic. In severe cases of haemorrhagic or haemolytic anaemia, reticulocytosis was recorded. His findings revealed that normocytic normochromic anaemia were commonly secondary to chronic diseases in which erythrocytogenesis was depressed. It was concluded that anaemia in cattle was indicated by a haematocrit value less than 24%, an erythrocytic count below 5 million/Cmm of blood or haemoglobin concentration less than 6 g%.

(Smith et al. (1972) described chronic haemorrhagic anaemia of ruminants to be hypochromic and slightly microcytic or normochromic in which poikilocytosis was a prominent feature. They further reported that Neoascaris vitolorum infection in cattle was responsible for causing haemorrhage when the larvae crawled out of the pulmonary capillaries to enter the alveoli.

Weise et al. (1972) reported the severe symptoms of anaemia with haemonchosis infection in lambs.

Poeschel et al. (1973) conducted studies on experimentally inoculated with graded doses of Haemonchus contortus isolates in sheep. It was observed that more than 16% adult haemonchus were required to alter the haemoglobin concentration of infected lambs.

Thakur and Misra (1973) carried out haematological studies on 493 calves with helminthic infections and observed that there was a decrease in the percentage of haemoglobin, packed cell volume and total Red Blood Corpuscles (RBC) count. The results also showed an increase in the percentage of monocytes and eosinophils with slight decrease in the neutrophil counts in affected calves.

Gupta et al. (1974) studied the haematological changes in Anaplasmosis in sheep and observed that there was fall in haemoglobin and packed cell values. The maximum proportion of reticulocytes (25%) was recorded at the time of severe anaemia.

Schalm et al. (1975) observed that microcytic hypochromic anaemia was specific to iron deficiency or failure to utilize iron. They suggested that in such cases chronic blood loss or iron, copper deficiency must be considered as the cause.

They observed that parasitism in cattle particularly trychostrongylosis produced a severe normocytic normochromic anaemia with haematocrit values as low as 12% without any evidence of reticulocytosis to compensate anaemia.

Gardner et al. (1976) concluded after an investigation into some clinical cases of acute post-parturient haemoglobinuria in bovine that a high proportion of such cows had Heinz body anaemia without any evidence of haemoglobinuria.

Kolb et al. (1977) studied anaemia in cattle caused by immune antibody and observed development of severe haemolysis accompanied by either mild haemoglobinuria or no haemoglobinuria.

Pandey and Mishra (1977) reported significant fall in haemoglobin, packed cell volume, and total erythrocytic count in experimentally produced babesiosis in calves and the corresponding mean lowest values observed were 3.4 g%, 7% and 0.32 million/Cmm of blood. Leucocytosis (19,674/Cmm of blood) with neutrophilia (60%) and lymphopenia (34.5%) were also noticed.

Ansari et al. (1978) reported that experimental infection of hookworm Gaigeria pachyscelis in sheep and goat caused the reduction of Hb, PCV and TEC.

(Ogunsuri (1978) observed rapid decline in the value of PCV, Hb. and red blood cells. Fluctuations were also observed in the leucocyte count.

(Rama et al. (1978) conducted studies on sheep experimentally inoculated with 4500 sporulated oocysts of Eimeria sp. and the findings were fall in erythrocyte count and haemoglobin content. There was proportionate increase of lymphocytes and neutrophils.

(Mallick et al. (1979) made observations on cases of anaplasmosis in goats. Haematological changes observed in the goats were reduction in haemoglobin, packed cell volume and total erythrocytic count.

(Adams (1981) observed that Haemonchus contortus infection causes a blood loss anaemia in sheep and also stated leucopenia, mild lymphopenia, thymus atrophy, decreased size of spleen and enlargement of adrenal glands which suggested these were caused by the stress of infection.

(Bezubik et al. (1981) observed that there was decrease in the haemoglobin and haematocrit levels during first two weeks in sheep after experimentally infected with haemonchus infection.

(Blood et al. (1983) reported that clinical signs of anaemia do not appear until the haemoglobin level falls below

50% of normal. There has been depression of erythrocyte count and haematocrit values. In haemorrhagic and haemolytic anaemia increase in immature red cells in the blood has been observed. Discoloured plasma has been observed in haemolytic anaemia. In iron deficiency anaemia there has been hypochromasia caused by reduction in MCHC, low Hb level with normal erythrocytic count.

(Abbot et al. (1984) observed normochromic normocytic anaemia in lambs infected with Haemonchus contortus.

(Pandey and Misra (1985) recorded low PCV, Hb and TEC in calves suffering from ascariasis, varying from 20 - 24%, 6.8 to 7.4 g/dl and 4.01 to 4.52 millions/Cmm of blood respectively.

(Pandey and Misra (1986) experimentally induced chronic haemorrhagic anaemia in 10 cow calves by withdrawal of 100 ml of blood daily for 24 to 32 days and observed marked decrease in the values of haematocrit with mild decrease in the erythrocyte count and fall in MCV, MCH and MCHC. Anaemia, punctate basophilia, anisocytosis and poikilocytosis were evident in the peripheral circulation. The critical low values of haematocrit and haemoglobin in chronic haemorrhagic anaemia in calves 17.00 to 17.60% and 4.86 to 5.00 g% respectively warranting immediate therapy. A marked increase in the heart, pulse

and respiration rates along with thumping heart beat and dyspnea were observed.

Pandey and Misra (1987) observed marked decrease in PCV, HB, TEC, MCHC and leucocytosis with neutrophilia in buffalo cows suffering from anaemia secondary to nutritional haemoglobinuria. The anaemia was macrocytic hypochromic. There was increase in the osmotic fragility of erythrocytes.

2.3 Biochemical Changes in Anaemic Goats

2.3.1 Status of blood glucose

Madsen and Nielsen (1939) observed that blood glucose was commonly increased in cases of cow suffering from post-parturient haemoglobinuria. Based on the analysis of blood from six such cases blood glucose was observed to vary from 42.3 to 79.6 with a mean of 63.5 mg% of blood.

Pandey and Misra (1977) reported gradual and significant decrease in blood glucose level in babesiosis in calves. The average value at the time of death of infected calves was 12.5 mg% of blood as against 40.5 mg% of blood in the control animals.

Prasad et al. (1977) conducted experimental study on seven crossbred calves by feeding exclusively on a fern "Diplazium esculentum" for several days. These calves after

feeding the above fern developed progressive anaemia with decrease in blood glucose value (44mg% of blood).

✓ Pandey and Misra (1985) observed normal blood glucose level in calves suffering from ascariasis.

✓ Pandey and Misra (1987) observed decrease in the value of glucose in cases of haemolytic anaemia in cattle suffering from babesiosis.

✓ Pandey and Misra (1987) recorded increased blood glucose level in buffalo cows in anaemia due to nutritional haemoglobinuria.

2.3.2. Total serum protein

✓ Bremner(1966) observed a linear relationship between serum protein value and haemoglobin concentration in calves suffering from chronic anaemia. Anaemia in these calves was produced by infecting orally with one of the three gastrointestinal nematodes mentioned below, or by bleeding 200 to 500ml of blood daily for 8 to 14 weeks. It was noticed that for a given fall in haemoglobin concentration the relative severity of reduction in serum protein concentration was in decreasing order Oesophagostomum radiatum, Bunostomum phlebotomum, Haemonchus placei and jugular phlebotomy.

Coles (1967) discussed the importance of estimation of plasma protein for diagnostic and prognostic values for different diseases. He further recommended that the determinations of total plasma protein values following shock or haemorrhages were of much value as a guide for emergency fluid therapy. Reduction in total plasma protein value had been reported in cases of haemorrhages.

Suteu and Giurgea (1971) recorded hypoproteinaemia in 36% of acute cases of cattle suffering from babesiosis. A fall in albumin was noted in 71% of cases with an increase in globulin value.

Reveron et al. (1971) reported that lambs severely affected with Trichostrongylus colubriformis causes reduction in albumin in serum.

Buonaccorsi et al. (1972) carried out different haematological tests on ten calves with symptoms of anaemia. The animals were exclusively fed on milk substitutes. Out of ten calves, three were observed to be suffering from ferroprotein deficiency anaemia and the rest with either iron deficiency or haemolytic anaemia.

Schalm (1972) stressed the importance of determination of total plasma protein alongwith value and examination of blood smears in order to distinguish different types of anaemia

due to blood loss, lysis of erythrocytes and inadequate production of erythrocytes. A combination of anaemia, reticulocytosis and hypoproteinaemia signifies blood loss from haemorrhage. Anaemia, reticulocytosis and normal or increased total plasma protein were characteristic of haemolytic crisis. Normocytic normochromic anaemia and normal or increased plasma protein content were suggestive of depression of erythropoiesis.

Singh et al. (1973) observed no changes in total serum protein in twenty cases of bovine haematuria but reduction in serum albumin and increase in serum globulin resulting in decreased albumin (A/G) ratio was recorded in all twenty cases studied.

Schalm et al. (1975) reported that low dietary protein intake leads to nutritional deficiency anaemia.

Gardner et al. (1976) observed mean values of and seasonal variations in total plasma protein of a dairy herd with post parturient haemoglobinuria similar to those recorded over the same period in a healthy control herd.

Borah et al. (1983) reported no significant change in total serum protein in twenty cases of goat infected with Strongyloides papillosus, but reduction in serum albumin and increase in serum globulin resulting in decreased albumin globulin (A/G) ratio was recorded.

Abbot et al. (1984) recorded hypoproteinaemia in lambs suffering from haemonchosis.

Pandey and Misra (1985) observed low total serum protein (4.99 ± 0.05) in all the affected cow calves suffering from ascariasis as compared to the healthy control values (6.3 ± 0.15). The electrophoretic pattern of serum protein showed decrease in albumin ($34.13 \pm 0.30\%$) with relative increase in the three fractions of globulins (α 14.21 ± 0.22 ; β 12.82 ± 0.26 and γ $38.82 \pm 0.28\%$).

Pandey and Misra (1987) studied the biochemical responses to haemolytic anaemia in cattle babesiosis and observed no change in the protein profile of the serum.

2.3.3. Status of serum calcium

Madsen and Nielsen (1944) reported normal serum calcium level in cases of cows with post parturient haemoglobinuria. year
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Greenhalgh et al. (1967) analysed the plasma of twelve steers suffering from haemolytic anaemia which was produced by feeding exclusively on rape and observed plasma calcium level to be normal.

(Nagpal et al. (1968) did not observe any significant decrease in serum calcium value in cases of haemoglobinuria in twentyfive buffaloes. The serum calcium value in such animals varied between 8.00 to 14.50mg% with exception of one animal which had serum calcium level as 6mg%.

(Jerichow and Jungman (1969) determined the blood calcium in female cattle with clinical Babesia divergens infection and recorded it to be 8.16mg% (9.79mg% in control). The difference was significant. It was noticed that seven days after the treatment of the animal with Berenil, calcium value gradually increased to almost normal level which was evident from the findings of the experiment that calcium concentration on the day of diagnosis was 7.98mg%, 8.32mg% after four days of treatment and 8.56mg% after seven days of treatment.

(Barger (1973) observed that calcium absorption in the infected sheep with Trichostrongylus colubriformis was only one tenth that of the non-infected control.

(Singh et al. (1973) reported low serum calcium level in twenty cattle suffering from haematuria.

(Sharma et al. (1976) observed that buffalo suffering from haemoglobinuria, had normal calcium value in whole blood, plasma and also in serum. Similar observations were also recorded by Pandey and Misra (1987) in cattle suffering from haemolytic anaemia due to babesiosis.

Prasad et al. (1977) observed decrease in the calcium content of the serum of seven cross bred calves, kept on feeding a fern "Diplazium esculentum" for several days. These calves developed progressive anaemia with mean haemoglobin value dropping to 5.75 g% against the corresponding control value of 8.50 g%. The mean lowest serum calcium value was recorded as 3.50 ± 0.809 mg% on 90th day of experiment.

Samad et al. (1979) analysed the serum from twelve buffaloes suffering from haemoglobinuria and observed that calcium levels were normal in these buffaloes (10.68mg%).

Pandey and Misra (1985) observed normal serum calcium level in calves suffering from ascariasis.

2.3.4. Status of serum phosphorus

Madsen and Nielsen (1939) reported that inorganic phosphorus values of blood plasma of cattle suffering from post parturient haemoglobinuria was significantly very low. It was observed that the values were lowest at the start of the disease, in some cases being as low as 0.22mg%. In few cases, during the early stage of the disease the value was observed to be within 0.40mg%.

Parkinson and Sutherland (1954) analysed the blood of eight cows with post parturient haemoglobinuria for plasma inorganic phosphorus value which always remained lower than 4mg%.

Greenhalgh et al. (1967) did not observe reduction in blood phosphorus level from its normal values in cases of experimentally produced kale anaemia in twelve steers of one year age.

Nagpal et al. (1968) analysed the blood of buffaloes with haemoglobinuria and recorded blood phosphorus level as low as 1.7mg% against the normal value of 6.2mg%.

Reveron et al. (1971) reported that inorganic phosphorus value of blood plasma of lambs infected with Trichostrongylus colubriformis was low.

Singh and Gautam (1971) analysed blood of sixty buffaloes suffering from haemoglobinuria for blood phosphorus values. The reduction in blood phosphorus was found significant which was as low as 1.83mg% against the normal value of 6.19 mg%.

Dhillon et al. (1972) reported low inorganic phosphorus level in the sera of fifteen buffaloes suffering from haemoglobinuria which was 2.05 ± 0.69 mg% of blood.

Gardner et al. (1976) did not observe any reduction in plasma inorganic phosphorus value of cattle suffering from post parturient haemoglobinuria as compared with the values of a normal healthy control herd.

(Sharma et al. (1976) reported low serum inorganic phosphorus value in cases of buffaloes suffering from haemoglobinuria.

(Kolb et al. (1977) conducted experimental studies on anaemia in cattle caused by immune antibody and observed marked decline in inorganic serum phosphorus value immediately after the onset of iso immune serum transfusion, which resulted in severe haemolysis.

(Samad et al. (1979) reported low serum inorganic phosphorus ($1.97 \pm 0.53\text{mg\%}$) concentration in cases of haemoglobinuria in twelve buffaloes.

2.3.5. Status of serum iron

Iron deficiency seldom occurs in adult livestock, unless there is considerable blood loss from parasites or disease. Signs of a lack of iron, in addition to anaemia and related blood changes, include lower weight gains, listlessness, inability to withstand circulatory strain, laboured breathing after mild exercise, reduced appetite and decreased resistance to infection (Miller, ^{et al} 1972 and McDowell et al., 1982). Iron requirements of ruminants are not well established; however, it is known that young animals have higher requirements than adults. For adult ruminant species, the iron requirement is estimated to range from 20-50 ppm while the requirement for calves is thought to be 100 ppm (McDowell et al., 1982).

(Taylor (1935) was of the opinion that chronic blood loss in ruminants, which resulted due to chronic bleeding from heavy infestation with blood sucking parasites, deplete iron stores of the body.

(Hibbs et al. (1963) reported the occurrence of neonatal iron deficiency anaemia in dairy calves. On the basis of determination of oxyhaemoglobin, it was observed that nearly 30% of the calves undertaken for study had haemoglobin less than 9gm% at birth. It was interesting to note that no relation existed between average oxyhaemoglobin level of the calves at birth and their dams postpartum. On the other hand, dams of the affected calves were found to have oxyhaemoglobin values in high ranges. In addition to the low values of oxyhaemoglobin, the values of haematocrit, erythrocytic count, serum iron and liver iron content also indicated that the calves born anaemic were deficient in iron right at the time of birth. Lastly, it was concluded that low oxyhaemoglobin in the new born calves was due to iron deficiency of prenatal origin, the cause of which was obscure.

(Beckner et al. (1965) reported occurrence of "Nutritional anaemia" in cattle due to mineral malnutrition, which was characterised by anaemia, poor growth and related production. The anaemia was caused by inadequate intake of iron, copper, and/or cobalt and was marked by intestinal parasitism.

Jerichow and Jungman (1969) reported that cattle naturally affected with Babesia divergens and manifesting clinical symptoms had blood iron concentration as 36.3mg% as against 147 mg% of the control.

Kaneko et al. (1970) reported close relationship between the extent of the morphological changes of blood cells in iron deficiency anaemia and the degree and severity of deficiency of iron in the body. He suggested that differential diagnosis of anaemia of varied causes could be made by finding decrease in serum iron, increase in unsaturated iron binding capacity (UIBC) and decrease in iron stores together with the microcytic hypochromic anaemia. The normal serum iron and unbound iron binding capacity of healthy calves were reported to be 148mg% corresponding values of healthy adult cows were 97 ± 29 g% (57-162) and 131 ± 36 g%(63-186).

Kaneko and Mills (1970) reported that anaemia in calves and cattle with porphyria erythropoietics was accompanied by hypoferraemia with macrocytic and hypochromic erythrocytes. The lowest serum iron value recorded in such anaemic calves on 21-24 days of life was as low as 17.7 to 52.2 with mean value as 30.3 g% against the control value of 118 to 230 with mean value of 175 g%. Serum iron binding capacity (SIBC) varied between 383 to 390 with mean value of 386 g% against the control value of 220 to 396 with mean value of 360 g%. The result showed

that there was significant decrease in serum iron concentration with corresponding increase in serum iron binding capacity.

(Mollenburg (1974) observed that 3 to 35% of calves purchased in Sweden had iron deficiency anaemia. In these calves which were kept on milk, hay and concentrates, the haemoglobin and the serum iron values dropped during first ten months of life and thereafter the values gradually increased..

(Underwood(1977) reported that high proportion of the total body iron was present as circulating haemoglobin. Therefore any condition influencing the level of haemoglobin in the blood such as anaemia, polycythemia etc. could greatly affect the iron content of the body.

(Dargie et al. (1979) reported on the basis of erythrokinetic study in experimental Trypanosoma brucei infection in cattle that the anaemia produced by this haemoprotozoan was of haemolytic origin and was due to impairment of iron reutilisation from the degraded erythrocytes.

(Pandey and Misra (1985) observed decrease of iron, unsaturated Iron Binding Capacity (UIBC) and Total Iron Binding Capacity (TIBC) (111.36 ± 3.26 , 155.75 ± 7.98 and 267.12 ± 8.37 respectively) in calves suffering from ascariasis.

(Pandey and Misra (1987) recorded increase in the value of iron and decrease in unsaturated and total iron, iron binding

capacities in cattle suffering from haemolytic anaemia due to babesiosis.

Pandey and Misra (1987) observed increased value of serum iron with decrease in Unsaturated Iron Binding Capacity (UIBC) in anaemic buffalo cows suffering from nutritional haemoglobinuria.

2.3.6 Status of serum copper

Clinical signs of Cu deficiency include scours, pale membranes of the eyes and mouth, rough and bleached hair, slow growth and loss of body weight (Blood et al., 1983).

Bennets and Beck (1942) reported that deficiency of copper in cattle and ewes resulted in hypochromic microcytic anaemia.

Becker et al. (1965) reported the occurrence of "Nutritional anaemia" in cattle running on certain fine sands and was due to inadequate intake of trace elements of which copper was one.

Pal et al. (1970) reported that copper was important for the process of erythrocytogenesis in cattle.

Klimov and Polyakov (1971) reported disturbance of copper metabolism in Theileria annulata infection in twenty two

young cattle. Abnormality in the utilization and excretion of copper was observed in cases of theileriasis in cattle. It was considered that low copper levels in the liver and bone marrow of the affected cattle resulted in anaemia contrary to the earlier belief that anaemia was secondary to hypocupraemia.

Binot et al. (1972) reported mean plasma copper in four young healthy cattle as 74.3 $\mu\text{g}\%$.

Domanski et al. (1972) described the occurrence of anaemia in cattle and sheep due to deficiency of copper.

Smith et al. (1972) discussed the importance of copper in prevention of anaemia in cattle as it was necessary for the utilization of iron in the production of haemoglobin.

Gardner et al. (1976) reported the association of post parturient haemoglobinuria of dairy herd with low level of copper in blood and liver and in the pasture grazed upon. It appeared that the severity of Heinz body anaemia in this disease was related with the degree of hypocupraemia. The low copper status seemed to be related to pasture molybdenum and lime application.

Givens et al. (1978) estimated copper (mean 10.4 mg/kg DM) in 225 samples of herbage from 2 areas in North Yorkshire with a history of bovine hypocupraemia. 2

Lamand (1985) did an experiment with diet deficient in copper in goat and observed that there was marked anaemia with other symptoms.

Pandey and Misra (1987) observed increase in the value of copper in cattle suffering from haemolytic anaemia due to babesiosis.

Pandey and Misra (1987) recorded marked decrease in serum copper (63.03 ± 6.324 to 70.908 ± 4.033 mcg%) in anaemic buffalo cows suffering from nutritional haemoglobinuria.

2.3.7 Status of serum cobalt

Visual manifestation of cobalt deficiency are not specific and are similarly be found in cases of malnutrition due to low intake of energy and protein. Animals on cobalt deficient pastures gradually loose appetite and failure of growth or loss of weight is followed by extreme loss of appetite, rapid muscular wasting, depraved appetite, severe anaemia and death. If the deficiency is mild or marginal, the above clinical signs may never occur and only the young, most susceptible animals may exhibit signs of unthriftiness which are indistinguishable from the effects of parasitism or low feed intake (McDowell et al., 1983).

Reid (1923) described the clinical symptoms of cobalt deficiency among affected cattle and sheep as progressive

anaemia, emaciation, loss of energy, exhaustion and death. It is reported that the clinical symptoms appear in about five months time after allowing the animals to live in deficient pastures.

Filmer (1933) reported cobalt deficiency in sheep and cattle grazing in the Denmark district near South coast of Australia properly known as "Enzootic Marrasmas". The young cattle and sheep were more severely affected than adults. Even sheep seemed to be more susceptible than cattle. The clinical symptoms observed by them were loss of appetite, pica, progressive emaciation, anaemia and death. Young calves showed diarrhoea more commonly than adult cattle. Similar condition in sheep known as nutritional anaemia was also noticed by them in areas of New South Wales but no reference was then made to cobalt deficiency.

A condition similar to "Enzootic Marramas" in South Australia was recorded by Marston & McDonald (1938) as "Coast Disease".

Bendixen and Pedersen (1945) described outbreak of cobalt deficiency in cattle grazing in sandy soil of Jutland, Denmark. They observed calves between 2-4 months of age showed progressive loss of appetite, pica, stunted growth, loss of weight and emaciation. They developed coarse dirty and starring coat with long hairs. The affected animals got exhausted,

dry pelleted to mucus coated faeces was seen. Diarrhoea was seen in exhausted animals before death.

(Lee(1950) reported that the young growing animals have been severely affected when reared on deficient pastures. Young growing sheep were sensitive to cobalt deficiency followed by mature sheep, calves and adult cattle in order. In severe cobalt deficiency there is extreme emaciation, listless, sleepy look, long hair, starved condition. The mucus membranes were blanched, skin pale and fragile, progressive anaemia, stunted growth, constipation, pelleted faeces with intermittent diarrhoea at late stages, impaired wool growth were also noticed.

(Russel and Duncan(1956) recorded that similar condition of cobalt deficiency in cattle and sheep and goats known as "Licking Disease" was reported by Brinkman and Sjollem in Netherland. The clinical symptoms used to appear in winter but disappear when animals were turned out to pasture. Similar condition under the name "Hinsch" was seen in cattle(9-15 months old) sheep and goats in Germany. According to their report cobalt deficiency was seen in ruminants where the pasture contains 0.02-0.05 ppm of cobalt on the dry matter basis.

(Marston(1970) studied cobalt deficiency in sheep causing anaemia.

Smith and Marston (1970) reported anaemia and fatty liver in sheep in cobalt deficient diet.

Pal et al. (1970) reported that cobalt was important for the process of erythropoiesis in cattle.

Domanski et al. (1972) was of the opinion that anaemia in cattle and sheep was due to deficiency of cobalt.

Mongo et al. (1981) observed that twenty female East African short horned goats, 1-2 years old when fed cobalt deficient hay from "Chloris gayana" for 15 weeks could develop macrocytic normochromic anaemia and lost weight.

Hansard (1983) reported anaemia due to deficiency of cobalt in ruminants.

Lamand (1985) conducted experiments with diets deficient in cobalt resulting in gradual reduction of appetite, progressive emaciation and anaemia in goats.

2.4 Minerals and Trace Minerals Status of Soil in Grazing Field

2.4.1 pH of the soil in grazing field

Halder (1977) in his study with different soils of West Bengal observed that the pH of the soil was ranged from 5.3 to 8.3.

(Halder (1977) reported that the pH of the soil of Nadia District was varied between 6.4 - 7.9.

(Halder (1977) further observed that the pH of the soils of Murshidabad, 24-Parganas, Burdwan, Hooghly and Howrah were 6.7 - 8.3, 6.4 - 7.8, 5.3 - 7.7, 5.7 - 7.4 and 6.4 - 7.5 respectively.

2.4.2 Status of calcium in soil

Very little work has been done in India on the soil test for calcium. Calcium became a limiting nutrient only in acid and alkali soils (Kanwar, 1978).

(Mukhopadhyay and Halder (1988) in their study on the important characteristics of acid soils of North Bengal observed that the exchangeable calcium ranged from 37.20 to 240.00 mg/100 gm.

* Pal (1984) estimated the phosphorus content in soil of Kalyani and Sriniketan in West Bengal and found 1920 ppm and 1040 ppm respectively.

2.4.3 Status of phosphorus in soil

(Saha (1976) studied the phosphorus content in soil of Birbhum and Bankura Districts of West Bengal and found that the content was 18.23 ppm and 17.96 ppm respectively.

2.4.4 Status of iron in soil

(Mitra (1975) in his study with different soils of rice growing tracts of West Bengal observed that under air dried condition the content of water soluble plus exchangeable ferrous iron was practically nil in almost all the soils.

(Saha (1982) reported a mean value of available iron content in the soils of West Bengal to be 75.7 ppm. *et al.*

(Report (1983-84) of the scheme on Micronutrients in soils of West Bengal indicated that the mean content of DTPA extractable iron in soils of Nadia and Hooghly are 62.6 and 94.1 ppm respectively. The same in the soils of Cooch-behar and Jalpaiguri District are 72.6 and 117.2 ppm respectively.

(Pal et al. (1985) studied about the distribution of Fe in soil collected from low land rice field of four Districts of acidic tracts of West Bengal and found that the contents of Fe and Cu varied between the range from 13.3 to 116.2 ppm.

2.4.5 Status of copper in soil

(Randhawa and Kanwar (1964) reported that the total content of Cu in the soil of Punjab varied from 6.6 to 36.4 ppm.

Kanwar (1978) reported the normal available range of Cu in soil in India varied from 1 - 40 ppm (average 9 ppm).

Halder and Mandal (1979) while studying the total and extractable content of copper in some soils of West Bengal reported that total copper content ranged from 18.75 to 52.78 ppm with mean value of 32.7 ppm.

Saha (1982) reported that the mean value of available copper content in the soils of West Bengal was 7.62 ppm. *et al*

Report (1983-84) of the scheme on Micronutrients in soils of West Bengal indicated that the mean content of DTPA extractable copper in soils of Nadia and Hooghly were 6.5 and 5.4 ppm respectively.

The same in the soils of Coochbehar and Jalpaiguri district were 8.7 and 9.0 ppm respectively.

Pal et al. (1985) studied about the distribution of copper in soil collected from low land rice field of four Districts of acidic tracts of West Bengal and found that the contents of Cu varied between the range from 3 to 37 ppm.

2.4.6 Status of cobalt in soil

According to Davison and Mitchell (1940) the nutritional disorders among livestock could be expected in areas

where total cobalt content in soils is less than 5 ppm. It seems that in many soil in Delhi, Punjab, Gujrat and Maharashtra cobalt is deficient for the livestock.

(Datta Biswas and Dakshinamurty (1958) was found to be cobalt content in the range of 3.8 - 7.1 ppm.

(Reddy and Mehta (1961) reported that the available cobalt content of Gujrat soil varied from 0.1 - 2.01 ppm with an average of 0.37 ppm.

(Badhe and Zende (1962) have reported in available cobalt extractable with neutral normal ammonium acetate in Konkon soils in Maharashtra ranges from 0.06 - 0.40 ppm.

(Randhawa and Kanwar (1964) observed that the available cobalt content in Indian soils varied from 4.4 - 32.5 ppm

2.5 Minerals and Trace Minerals Status of Plants in Grazing Field

2.5.1 Status of Ca content in plants

(Sen et al. (1978) reported that calcium content in barseem, barley, and in grasses (Aeluropus logopoides) were 1.44%, 0.51% and 0.47% respectively.

The calcium content in Bermuda grass (Cynodon dactylon) was estimated and was found to be 0.70% (Sen et al., 1978).

(Murugan (1987) observed that Ca level in the tree leaves of Tamil Nadu varied from 0.83 and 3.53 percent and was maximum in Albizia lebbeck (3.53%) followed by Ficus religiosa (2.83%), Azardirachta indica (2.05%), Millintonia hortensis (1.94%) and in Enterolobium saman (0.83%). Red

2.5.2 Status of phosphorus content in plants

Sen et al. (1978) reported that phosphorus content in barseem, barley, grasses (Aeluropus logopoides), and in bermuda grass (Cynodon dactylon) were 0.14%, 0.25%, 0.21% and 0.36% respectively.

(Murugan et al. (1987) was found the status of phosphorus in the range of 0.16 - 0.37% of certain tree leaves of Tamil Nadu.

(Saba (1987) was found to be the distribution of phosphorus in the plants in the range of 0.5 - 4.8 g/kg. et al

2.5.3 Status of iron content in plants

The iron content of rice straw was found to be 2044 ppm (Aiyer, 1948).

Brown et al. (1955) observed that iron content in corn and rice were 178 and 80 ppm respectively.

Wallace et al. (1960) was found to be that iron content of soyabean in the range of 40 - 60 ppm.

Karwar et al. (1963) reported that iron content in citrus plant was 144 ppm.

Arora and Smith (1969) reported that iron content of soyabean plant was 524 ppm.

Milap Chand (1969) observed that the content of iron in grain and straw of wheat, Var-Kalyansona was in the range of 50.3 - 50.7 ppm and 94.8 - 116.5 ppm respectively.

Chimania (1969) reported that the iron content in grain and straw of paddy was in the range from 26.6 to 35.4 ppm and 429 - 722 ppm of paddy, var-IR-8 respectively.

McDowell and Conrad (1977) stated natural feed-stuffs usually contained enough Fe to meet the requirements of farm livestock.

Sawhney et al. (1977) estimated the values of iron contents in $\mu\text{g/g}$ of dry matter ranged from 93.12 to 488.35 in cereal straws, in grasses 144.23 to 502.97 and 229.11 to 514.29 in legume fodders.

NRC (1978) made dietary recommendation of 50 ppm of Fe to prevent iron deficiency in ruminants cattle.

Murugan et al. (1987) reported that the available iron content in certain tree leaves of Tamil Nadu such as Ficus religiosa, Azadirachta indica, Enterolabium saman, Albizia lebbek and Millingtonia hortensia are 220.61 ± 0.90 , 239.59 ± 1.52 , 201.75 ± 4.99 , 126.66 ± 3.30 and 140.94 ± 2.81 respectively.

2.5.4 Status of copper content in plants

Subba Rao (1953) determined the optimum requirement of copper for barley, rice, maize and sugarcane and concluded that these crops required 1.9, 6.25, 26.0 and 2.11 ppm of copper respectively.

Pattanaik (1955) found that the optimum requirement of copper for rice was 0.001 ppm as determined by water cultures.

Agarwala and Sharma (1961) observed that the copper concentration in the barley, legumes, cereals, paddy straw and wheat grain were 0.55, 9.5 - 17.5, 12.5 - 29.6, 3.1 - 20.8 and 2.3 - 3.1 ppm respectively.

Sawhney et al. (1977) observed that wheat-bhusa and Jowar kadbhi were found to contain this important mineral in a range of 3.21 to 9.06 ppm on dry matter basis, however in

about 75% of these fodder roughages the copper content lay within a narrow range of 3.21 to 5.71 $\mu\text{g/g}$ which if fed alone will cause serious deficiency of copper. Similar was the case with grasses but the copper content in leguminous fodders was satisfactory being in the range 8.0 to 23.22 $\mu\text{g/g}$.

The copper contents of legumes, cereals, fodder crops (non-legumes) and vegetables were reported to be in the range of 9.5 to 17.5 ppm, 12.5 - 29.6 ppm, 6.0 - 29.2 ppm and 8.8 to 22.7 ppm respectively (Kanwar, 1978).

N.R.C. (1978) reported the dietary recommendations of Cu for cattle 10 ppm.

Murugan et al. (1987) in their study have observed that the copper content of certain tree leaves in Tamil Nadu varied from 6.22 ± 0.11 to 9.34 ± 0.29 ppm.

Saba (1987) reported that fodder of Poland contained copper 0.5 - 10.9 mg/kg D.M. (dry matter). *l et d*

2.5.5 Status of cobalt content in plants

Young (1948) concluded that 0.10 to 0.17 ppm of cobalt is the minimum amount of cobalt in plants for the normal health of cattle.

Dutta and Datta Biswas (1951) found that all grasses had high cobalt content in the young stage, but with the increasing age, they found a gradual decrease in the content of cobalt.

According to Iyer (1958) legumes show a marked concentration of cobalt than the grasses.

Reddy and Mehta (1961) after analysis of 24 grasses, cereals and legumes concluded that in them, the cobalt content varied from 0.36 to 0.64 ppm. The average cobalt content of 6 fodders were varied from 0.23 to 0.79 ppm.

Dube (1964) reported that the paddy straw from Orissa and Assam was deficient in cobalt. From this observation it appears that there is wide spread deficiency of cobalt in Indian soils and crops which may affect animal health. Thus the application of cobalt may be required not from the point of view of crop production but from that of animal production.

Dube (1964) reported that the cobalt content of paddy straw collected from Madhyapradesh, Orissa, West Bengal and Assam were 0.094, 0.043, 0.050 and 0.031 ppm respectively.

Murugan et al. (1987) estimated cobalt content in Ficus religiosa, Azardirachta indica, Enterolobium saman, Albizia, lebbeck and Millingtonia hortensis tree leaves of Tamil Nadu and he observed the total content was 5.67 ± 0.09 , 1.29 ± 0.06 ,

0.92 ± 0.19 , 1.95 ± 0.09 and 3.16 ± 0.10 respectively.

2.6 Experimental Production of Anaemia in Goats

2.6.1 Nutritional anaemia

2.6.1.1 Status of iron

Becker et al. (1965) reported occurrence of 'Nutritional anaemia' in cattle due to mineral malnutrition which was characterised by anaemia, poor growth and retarded production. The anaemia was caused by inadequate intake of iron, copper and/or cobalt and was marked by intestinal parasitism.

Mollenburg (1974) observed that 13 to 35% of calves purchased in Sweeden had iron deficiency anaemia. In these calves which were kept on milk, hay and concentrates, the haemoglobin and the serum iron values dropped during the first two months of life and thereafter the values gradually increased.

Pandey (1980) produced experimental nutritional anaemia in calves which was accomplished by keeping the animals exclusively on wheat straw and water. The serum iron level was dropped to $101.39 \mu\text{g}\%$ at 67 days.

2.6.1.2 Status of copper .

Becker et al. (1965) reported the occurrence of 'Nutritional anaemia' in cattle running on certain fine sands and was due to inadequate intake of trace elements of which copper was one.

Gardner et al. (1976) reported the association of post-parturient haemoglobinuria of dairy herd with low level of copper in blood and liver and in the pasture grazed upon. It appeared that the severity of Heinz body anaemia in this disease was related to the degree of hypocupremia. The low copper status seemed to be related to pasture molybdenum and lime application.

Givens et al. (1978) estimated copper (mean 10.4 mg/kg DM) in 225 samples of herbage from 2 areas in North Yorkshire with a history of bovine hypocupremia.

Pandey (1980) observed the serum copper level of calves by producing nutritional anaemia in calves by keeping the animals exclusively on wheat straw and water and was observed significant fall in the copper and cobalt levels in blood of anaemic calves.

Lamand (1985) did an experiment with diet deficient in copper in goat and observed that there was marked anaemia with other symptoms.

2.6.1.3 Status of cobalt

✓ Filmer (1933) reported cobalt deficiency in sheep and cattle grazing in the Denmark District near South coast of Australia properly known as "Enzootic Marrasmas".

✓ Bendixen and Pedersen (1945) described outbreak of cobalt deficiency in cattle grazing in sandy soil of Jutland, Denmark.

✓ Lee (1950) reported that the young growing animals were severely affected when reared on deficient pastures.

✓ Andrews (1956) opined that young growing sheep are the most sensitive of all animals to cobalt deficiency, next are mature sheep, calves between 6 and 18 months old and mature cattle in that order.

✓ Smith and Marston (1970) reported anaemia and fatty liver in sheep in cobalt deficient diet.

✓ NRC (1978) made dietary recommendation of 0.10 to 0.17 ppm of Co to prevent Co deficiency in ruminants.

✓ Hansard (1983) reported that the signs of cobalt deficiency may resemble those of starvation. They are usually seasonal and may include loss of appetite, lacrimation, pale skin, impaired growth, listlessness and normocytic, normochromic

anaemia. Plasma cobalt levels may be below 0.2 ppm. Lambs are most sensitive to cobalt deficiency followed by ewes, calves and cows (Underwood, 1977) in that order.

McDowell et al. (1984) stated that cobalt deficiency occurs in large areas of many countries and is largely, but not exclusively, restricted to grazing ruminants which have little or no access to concentrates. With the exception of P and Cu, Co deficiency is the most severe mineral limitation to grazing livestock in tropical countries. Cobalt deficiency signs are not specific and it is often difficult to distinguish between a deficiency of Co and malnutrition due to low intake of calories and protein. However, Co deficient cattle respond quickly to Co treatment, recovering appetite, vigour and weight. Cobalt sub-deficiencies or border line status are extremely common and are characterised by two production rates unaccompanied by clinical manifestations or visible signs. Subdeficiencies of Co often go unnoticed, thereby resulting in great economic losses to ruminant livestock industry. Incidence of Co deficiency can vary greatly from year to year from an undetectable mild deficiency to an acute stage.

Lamand (1985) conducted experiments with diets deficient in cobalt resulting in gradual reduction of appetite, progressive emaciation and anaemia in goats.

Movsium (1986) reported that the clinical signs of cobalt deficiency are preceded by decreased concentration of cobalt and other metabolites in blood. The disorder hypcobal-tosis develops in two stages : a subclinical when blood cobalt value is upto 1 μ g per 100 ml and a clinical when it is below 1 μ g/100 ml.

2.6.1.4 Bone marrow changes in experimentally produced nutritional anaemic goats

Pandey and Misra (1983) carried out study on the functional behaviour of bone marrow of cow calves suffering from nutritional anaemia due to malnutrition, induced by exclusively feeding wheat straw with adlibitum drinking water for a period of about two months. Bone marrow cytology remained unchanged upto first 32-48 days. Thereafter erythropoiesis and cellularity started decreasing and at the peak of anaemia, a significant decrease ($P < 0.05$) in cellularity and erythropoiesis (M.E. ratio varied 1.471 ± 0.345 to 1.761 ± 0.432) with prominent myelopoiesis and active thrombopoiesis was evident. It was concluded that a temporary suppression of erythropoietic activity of bone marrow occurs in nutritional anaemia due to malnutrition. Ref
misra

2.6.2.5 Histopathological changes in nutritional anaemic goats

2.6.1.5.1 Macroscopic changes

Davies (1962) described the post-mortem changes in cases of anaemia in general. Autopsy changes included haemorrhages on the mucus membrane, oedema of tissues.

(Smith et al. (1972) described the necropsy findings of anaemia in animals such as pale mucus membrane and tissues, grey dot on the liver and hyperplastic bone marrow. Cardiac hypertrophy and oedema were also observed.

(Schalm et al. (1975) reported that enlargement of heart occurred in cases of anaemia to make compensatory circulatory adjustment.

(Blood et al. (1979) discussed pallor of the tissues, thin watery blood and contraction of the spleen as autopsy findings in anaemic animal.

(Pandey (1980) conducted experimental studies of nutritional anaemia in calves and observed that five animals of the group died due to nutritional anaemia which included dilatation of the right side of the heart, gelatinous degeneration of the fat in the hilus of the kidneys, absence of subcutaneous fat and decreased intensity of the color of the sternal bone marrow. Ascitis of mild degree with quantity of fluid varying from 2-5 litres was in common. In one animal which died on day 67 was having hydropericardium with about 200 ml of fluid inside the pericardial sac.

2.6.1.5.2 Microscopic changes

(Pandey (1980) reported microscopical changes in liver and spleen of calves with nutritional anaemia. There

was mild fatty changes in the liver of the experimental nutritional anaemic calves with portal fibrosis in some. Haemosiderrosis in the reticuloendothelial cells of periportal areas was seen only in one calf out of five. Spleen showed moderate to severe degree of haemosiderrosis.

2.6.1.5.3. Estimation of iron content of liver of nutritional anaemic goats.

(Pandey (1980) while conducting experimental nutritional anaemia in calves observed fall in the iron content in the liver of anaemic calves.

2.6.1.5.4. Estimation of copper content of liver of nutritional anaemic goats.

(Pandey (1980) while studying experimental nutritional anaemia in calves observed fall in the iron content in the liver of anaemic calves.

2.6.1.5.5. Estimation of cobalt content of liver of nutritional anaemic goats.

Literatures on the cobalt content of liver of anaemic ruminants were not found.

2.6.1.6. Therapy for nutritional anaemia

(Underwood and Filmer(1935) reported the curative effect of cobalt in the treatment of cattle suffering from

anaemia due to the deficiency of cobalt at the daily dose rate of 0.3 to 1.0 mg in the form of cobaltous chloride.

(Killham(1941) treated cattle suffering from anaemia due to cobalt deficiency using a much larger dosage of cobaltous chloride. Thirty grams of cobaltous chloride were dissolved in 4000ml of water and 15ml of this solution was administered orally daily to each of such anaemic animals.

(Parkinson and Sutherland(1954) claimed to have treated four cows with post parturient haemoglobinuria by intramuscular injection of Procain Penicillin 1 to 2 million units per day for four days. On the other hand, other cows with the same disease also improved without receiving any treatment. Therefore, lastly no conclusion was drawn by them on the efficacy of such treatment.

(Hibbs et al., (1963) showed the efficacy of iron therapy on newly born calves suffering from anaemia. A single injection of 500mg of iron dextran during the first three days of life increased the oxyhaemoglobin content of blood and haematocrit value.

(Baustad and Tollerarud(1966) studied the effect of iron supplementation on dairy calves. It was shown that intramuscular injection of iron at the dose rate of 25mg/kg b.wt. in the first week of life increased all the erythropoietic indices.

(Tammemagi(1966) did not observe any therapeutic value of iron dextran therapy in alleviating anaemia of bovine babesiosis. Dose schedule followed was five intramuscular injections of iron dextran of 20ml each on alternate days.

(Ammerman et al., (1967) compared the biological availability of various forms of iron viz. ferric oxide, ferric chloride, ferrous sulphate and ferric carbonate to ruminants. Ferrous sulphate, ferrous carbonate and ferric chloride ranked in decreasing order of availability. This result revealed the supremacy of ferrous sulphate over other three iron compounds in the treatment of iron deficiency anaemia in ruminants.

(Getty et al., (1968) reported that ferrous sulphate given by mouth or iron dextran administered by intramuscular injections to calves produced significant increase in haemoglobin and haematocrit values as compared with the control. The therapy also raised and maintained serum iron concentration.

(Marston(1970) showed that application of fertilizer supplemented with cobalt improved the condition of anaemia due to the deficiency of cobalt in sheep.

(Klimov and Polyakov(1971) reported the abnormality with utilisation and excretion of copper in theileriasis in cattle and suggested that copper therapy had beneficial effect in alleviating the anaemia of this origin.

Domanski et al., (1972) observed that application of fertilizer supplemented with cobalt and copper to the grazing field checked the development of anaemia due to the deficiency of copper and cobalt.

Schalm et al., (1975) did not indicate the use of haematinics, B vitamins and liver extract injections in cases of normocytic anaemias due to selective depression of bone marrow.

Tait and Dubeski (1979) administered intramuscular injection of iron dextran of 5ml each on alternate days to lambs suffering from anaemia. It was observed that after first week of treatment there was increase in all the erythropoietic indices.

Blood et al., (1983) recommended haematinic preparations in ten severe cases. They recommended iron preparations both orally/parenterally with Vit. B₁₂ or cobalt salt orally.

Boila et al., (1984) observed that application of injectable copper complexes (copper glycinate and copper sulphate) as supplementary copper for grazing cattle improved the condition of anaemia due to copper deficiency.

Pandey and Misra (1985) treated ten cases of anaemia in calves suffering from ascariasis with piperazine adipate

@ 10-15g. orally on the first day and was repeated after 15 days. From I/M injections of Imferon B_{12} (4ml) were given on alternate day. In addition, a mixture of copper sulphate 0.25g. and cobalt sulphate 10mg was given orally daily for 10 days. On completion of the therapy there was significant improvement in general condition and disappearance of the symptoms of anaemia in those calves.

Movsium (1986) observed that for healing and preventing hypcobalosis it is essential to use not only cobalt but also iron, copper and a preparation of protein and vitamin.

Pandey and Misra (1987) treated 10 buffalo cows suffering from nutritional haemoglobinuria with anaemia with sodium acid phosphate 20% 300ml I/V and 300ml S/C for first two days followed by 60g. orally for 7 days. To combat anaemia copper sulphate 3.5g. and cobalt sulphate 100mg orally daily for 10 days along with iron dextran 500mg I/M on alternate days for five injections had complete recovery.

2.6.2 Chronic haemorrhagic anaemia in goats

2.6.2.1 Status of iron

Taylor (1935) studied anaemia due to chronic blood loss as a result of chronic bleeding or from heavy infestation with blood sucking parasites in ruminants, which was reported

to be initially macrocytic due to response of the bone marrow in the presence of adequate iron but later when iron stores of the body were depleted due to continued blood loss, a microcytic hypochromic anaemia was superimposed.

(Hibbs et al. (1963) reported neonatal iron deficiency anaemia in dairy calves due to iron deficiency of prenatal origin. Serum iron and liver iron content were found to be low.

(Kaneko and Mills (1970) reported lowest serum iron values in anaemic calves with suffering from porphyria erythropoietics.

(Pandey and Misra (1986) experimentally induced chronic haemorrhagic anaemia in 10 cow calves by withdraw of 100ml of blood daily for 24 to 32 days and observed that the serum iron was decreased to 89.028 ± 1.092 $\mu\text{g}\%$ from the 0-day value of 140.120 ± 4.010 $\mu\text{g}\%$.

2.6.2.2 Status of copper

(Pandey and Misra (1987) observed in experimentally produced chronic haemorrhagic anaemia that the copper level was decreased to 111.684 ± 4.393 $\mu\text{g}\%$ from the 0-day value of 139.926 ± 2.336 $\mu\text{g}\%$.

2.6.2.3 Status of cobalt .

Information on the status of cobalt in cases^{of} haemorrhagic anaemia are lacking in the literature.

2.6.2.4 Bone marrow changes of experimentally produced chronic haemorrhagic anaemia in goat

Begovic et al. (1967) studied sternal bone marrow picture of six cows suffering from chronic haematuria at six months interval for 1 to 3 years. They reported that such cows had increased erythroblast and decreased myeloid cell counts along with lower leucocytic counts and lymphocytosis in the peripheral blood with a tendency towards agranulocytosis. Erythropoietic index was markedly increased particularly at the end of March and beginning of April, indicating that chronic haematuria first developed or recurred during these months.

Loeb (1969) reported no morphological aberration in the bone marrow cells during the early stage of chronic haemorrhagic anaemia. Generalised hyperplasia of the haemopoietic elements, particularly of erythroid series occurred with the depletion of body iron store. At this stage, the precursors of erythrocytes^{series were microcytic especially in rubricyte} and the meta-rubricyte. In some cases of chronic blood loss anaemia in hyperplasia of bone marrow had abruptly ceased and was followed by aplasia of bone marrow.

Adams(1981) examined the bone marrow cytology in cases of Haemonchus contortus infection in sheep and observed that there was four fold increase in erythroid series of cells.

Pandey and Misra(1987) studied the bone marrow cytology in experimentally produced haemorrhagic anaemia in calves and observed that there was marked fall in M.E. ratio along with increased cellularity and prominent erythropoiesis.

2.6.2.5 Histopathological changes

2.6.2.5.1 Macroscopic changes

Hijarre(1930) observed haemorrhagic ulcers on the abomasum besides the presence of numerous pin head size grey yellow lesions on the capsular and incised surface of liver in cases of cattle suffering from post-parturient haemoglobinuria.

Madsen and Nielsen(1939) observed icterus as the most prominent change in body tissues with other changes like yellow liver, watery dark blood, swollen oedematous lymph glands and urinary bladder full with coffee black urine.

Smith et al.(1972) described anaemia with pale mucus membrane and tissues, grey dots on the liver and hyperplastic bone marrow changes. Oedema and hypertrophy of the heart, due to loss of plasmaprotein.

2.6.2.5.2 Microscopic changes

Ellood et al. (1979) described pallor of tissues, thin watery blood and contraction of the spleen in autopsy findings of anaemic animals.

Pandey (1980) observed that liver of 3 experimental calves had moderately fatty changes. Liver of one animal showed presence of haemosiderin pigment. Spleen of one out of 3 animals showed severe haemosiderosis.

2.6.2.6 Iron content of the liver of anaemic goats

Pandey (1980) reported decreased level of iron content in the liver of anaemic calves.

2.6.2.7 Copper content of the liver of anaemic goats

Pandey (1980) observed low level of copper in the liver of anaemic calves.

Blood et al. (1983) reported low level of copper in the liver of sheep having deficiency symptoms and low copper diet.

2.6.2.8 Cobalt content of the liver of anaemic goats

McDowell et al. (1983) reported low cobalt level in the liver of ruminants grazing on cobalt deficient pastures.

2.6.2.9 Therapy for haemorrhagic anaemia

Metcalf and Stahl (1942) was of the opinion that blood transfusion was the most satisfactory treatment in cases of severe haemorrhages. They recommended that in large animals blood could be transfused at a maximum speed of 43.3 ml/minute.

Jhonston (1946) recommended blood transfusion with good result in cases of post-parturient haemoglobinuria and haemorrhages. He was of the opinion that transfusion of 2 to 3 litres of citrated blood was sufficient to bring excellent effect in acute cases of post-parturient haemoglobinuria in cows. If found necessary, a second transfusion of another two litres of blood was recommended at the most to hasten the recovery.

Ferguson (1947) reported that the first blood transfusion in bovine was very safe provided no previous transfusion had ever been to the recipient. He further observed that second and subsequent transfusion caused severe haemolytic reactions, if repeated blood transfusion was practised. In the event of such reactions in cattle, intravenous use of 2 to 10ml of 1 : 10,000 solution of adrenaline was found to be effective to some extent.

Holmes (1949) described the method of gravity blood transfusions in cattle using a simplex apparatus. Dose used for transfusion of calves was 400 ml of whole blood.

Simpson et al. (1952) suggested that one gallon of blood could be collected from a 1000 lb cow and a minimum of 1 to 2 gallons of blood were found effective in an adult cow to combat anaemia, which could be administered intravenously at the rate of 500 ml/minute.

Koger (1956) was of the opinion that blood could be transfused to an adult as fast as 720 ml/minute with positive pressure. He reported that with the use of ten gauze needle, one gallon of blood could be collected from a cattle in 6 to 10 minutes.

Archer and Franks (1960) discussed the various aspects of blood transfusion in cattle. A detailed description of method of collection, preservation and transfusion of blood of cattle had been given. They were of the opinion that in large animals, like cattle, not more than one litre of blood could be given in ten minutes time.

Balu and Ganapathy (1965) treated a cow with idiopathic anaemia by transfusing 1.5 litres of citrated blood at the rate of 100 drops/minute. After twentyfour hours of transfusion erythrocytic count, leukocytic count, haemoglobin and haematocrit values increased from the pre-transfusion values of 2.5 million/Cmm of blood, 9,100/Cmm, 2.5 g% and 11% to 2.97 million/Cmm of blood, 13,400/Cmm of blood, 6.5 g% and 18% respectively.

Schnappauf et al. (1967) observed that the apparent half life time of Cr^{51} labelled homotransfused erythrocytes in cattle was 2.5 days. They concluded that taking into consideration of very short survival time of transfused erythrocytes, transfusion therapy would be of little value and dangerous, unless compatability of blood was done before hand.

Vander Walt and Osterhoff (1969) reported high incidence (41%) of transfusion reaction in pregnant cattle.

Schalm (1970) was of the opinion that blood transfusions were of little value in slowly developing anaemia that resulted due to depression of erythropogenesis associated with chronic infections.

Schalm et al. (1975) reported that transfusion of fresh compatible whole blood provided complete benefit of the treatment because administered erythrocytes remained in circulation of the recipient for almost their normal life span, whereas in case of incompatible blood transfusion, erythrocytes were quickly destroyed.

Kvart and Jones (1977) observed that about 3.5 to 4 litres of blood could be withdrawn from a cow in 8 to 10 minutes without any ill effect on the health of the donar animal.

O'Neill (1979) successfully treated anaemia in cattle due to babesiosis and few cases of acute haemorrhages with transfusion of eight litres of blood to each animal. It was recommended that transfusion of one litre of blood given during the early stage of bovine babesiosis resulted in higher recovery.

Flood et al. (1983) recommended blood transfusion in both acute haemorrhagic anaemia or even in chronic anaemia of severe degree. They recommended supportive treatment after transfusion.

Fandey and Misra (1987) treated 10 clinical cases of babesiosis (8 cows and 2 buffaloes) with parenteral Perenil, Imferon, Folic acid, dextrose 5% and oral dosing of copper and cobalt sulphate with good results.

2.7 Quality of Meat in Anaemic Goats

Skjevdal (1974) and Robstad (1976) reported that the percentage of protein, fat and ash were assessed on dry matter basis in goat and it was noted that with the advancement of age the protein percentage decreases, fat percentage increases and there was no change in ash percentage.

Thornton (1974) reported that the meat of the anaemic animals are discarded for human consumption due to paleness and increased water content of meat.

The cross striated muscles of meat animals contain about 75% of water (Hamm, 1975) but breed, sex and plane of nutrition affect the water content of the meat (Lawrie, 1975).

Paul (1975) observed that the influence on cooking/heating had been very widely investigated by many workers and cooking loss and its variation had been established as a reliable parameter for meat quality estimation/assessment.

The quality of meat was governed by its chemical composition, notably protein, fat, ash and water (Jenson, 1982).

Mahapatra (1986) reported that the cooking loss is inversely related to water holding capacity of meat.

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CHAPTER—III

MATERIALS AND METHODS

3.1 Incidence of Anaemia in Goats

3.1.1 Clinical manifestations of anaemia in goats

Goats showing clinical symptoms like paleness of the visible mucus membrane, weakness, depression, anorexia, increased rate and intensity of heart sounds, respiratory distress, laboured breathing, and oedema in terminal stages were identified during the course of study and were examined for the estimation of haemoglobin (Hbg%) and Packed Cell Volume (PCV%) of the blood. Details history of such cases including grazing and browsing practices and nutritional level were also recorded.

3.1.2 Incidence of anaemia in goats

Black Bengal goats of different ages and sex presented at the University Veterinary Clinic from villages around Bidhan Chandra Krishi Viswavidyalaya (B.C.K.V.) at Mohanpur (District, Nadia, West Bengal) were examined during the period from January 1986 to December 1986. To find out the seasonal incidence of anaemia the year was divided broadly into four seasons

- i) Winter (December to February)
- ii) Summer (March to May)
- iii) Monsoon (June to August)
- iv) Autumn (September to November)

and the results were tabulated and statistically analysed.

3.1.2.1 Examination of faecal samples of anaemic goats

Faecal samples of all such goats clinically found anaemic were collected and examined for the detection of parasitic ova/oocyst as per the methods described by (Soulsby, 1982). The anaemic goats were grouped as gr I (anaemia with heavy parasitism), gr II (anaemia with low parasitism) and gr III (anaemia without parasitism).

3.1.2.2 Examination of blood smears of anaemic goats

Blood smears from each of the clinically anaemic goats were prepared on clean Blue star slides and stained with Giemsha's stain and examined under microscope as per the method of Schalm et al. (1975) for the detection of haemoprotozoan parasites if any. Wet films for the detection of blood protozoa were also examined for the presence of Trypanosomes/microfilaria.

3.2 Haematological Changes in Anaemic Goats

3.2.1 Collection of blood from anaemic goats for analysis

Blood samples in three separate screw capped containers previously cleaned with tripple distilled water and dried was collected from each anaemic goats.

In the first heparinized container 5 ml of blood was collected. Immediately after collection the content was mixed by gentle horizontal rotation. The whole blood mixed with heparin as anticoagulant was used for the determination of the following parameters :

Haemoglobin (Hb)

Packed Cell Volume (PCV)

Total Erythrocytic Count (TEC)

Total Leucocytic Count (TLC)

Differential Leucocytic Count (DLC)

Mean Corpuscular Volume (MCV)

Mean Corpuscular Haemoglobin (MCH)

Mean Corpuscular Haemoglobin Concentration (MCHC)

3.2.2 Haemoglobin (HB)

Hb was determined by Sahlis's method as described by Schalm et al. (1975) and the value was expressed as g%.

3.2.3 Packed cell volume (PCV)

PCV was measured in mm by micro-haematocrit method and was expressed as percentage of total volume (Schalm et al., 1975).

3.2.4 Total erythrocytic count (TEC)

TEC was estimated by haemocytometer as described by Schalm et al. (1975) and was expressed as millions per cubic millimeter ($10^6/\text{cmm}$).

3.2.5 Total leucocytic count (TLC)

TLC was estimated by haemocytometer as described by Schalm et al. (1975) and was expressed as thousands per cubic millimeter ($10^3/\text{cmm}$).

3.2.6 Differential leucocytic count (DLC)

DLC was determined as per the methods described by Schalm et al. (1975) and was expressed as percentage of the total leucocytes.

3.2.7 Mean corpuscular volume (MCV)

MCV was expressed by the ratio of percentage of PCV with TEC/cmm.

$$\text{MCV} = \frac{\text{PCV}}{\text{RBC in millions}} \times 10 \text{ cubic microns}$$

3.2.8 Mean corpuscular haemoglobin (MCH)

MCH was calculated by the formulae

$$\text{MCH} = \frac{\text{Hb in gms/100 ml}}{\text{RBC in millions}} \times 10^{\text{micro}} \text{ micrograms}$$

3.2.9 Mean corpuscular haemoglobin concentration (MCHC)

MCHC was estimated by the formulae

$$\text{MCHC} = \frac{\text{Hb in gms/100 ml}}{\text{PCV}} \times 100\%$$

3.3 Biochemical Changes of Anaemic goats

3.3.1 Estimation of blood glucose

In the second container 0.5 ml of blood was collected using sodium fluoride as anticoagulants for the estimation of blood glucose (BGL) as per the method of Nelson and Somogyi (1979) and expressed in terms of mg%.

In the third tube about 15 ml of blood from each of the anaemic goat was withdrawn and allowed to clot for separation of serum and the same was used for the estimations of Serum calcium (SCa), Serum phosphorus (SP), Serum Iron (SI), Serum Copper (SCu) and Serum Cobalt (SCo).

3.3.2 Estimation of serum protein

Serum protein was estimated as per the method described by Renhold et al. (1950) and was expressed as g%.

3.3.3 Estimation of serum calcium

Serum calcium was estimated colorimetrically as per the method described by Roe and Kalhon (1929) and the result was expressed in mg%.

3.3.4 Estimation of serum phosphorus

Serum phosphorus was estimated colorimetrically as per the method described by Fiske and Subbarow (1925) the result was expressed as mg%.

3.3.5 Estimation of serum iron (SI)

SI was determined as per the method described by Sandel (1950) and Arneza et al. (1977) utilizing atomic absorption spectrophotometer. Accordingly, a known volume of serum was digested with double the volume of triple acid (Nitric acid 10 parts, perchloric acid 3 parts and sulfuric acid 1 part) on hot plate and dilution to a known concentration was finally made with deionised water. There after the clear solution was processed in Atomic absorption spectrophotometer (Perkin Elmer) with standard solution of different concentrations of iron in order to estimate the final concentration of iron in the serum and the result was expressed as $\mu\text{g}\%$.

3.3.6 Estimation of serum copper (SCu)

SCu was estimated from the clear solution processed as per the method described in the estimation of serum iron

in the Atomic Absorption Spectrophotometer with the standard solution of different concentrations of copper. The result was expressed in terms of $\mu\text{g}\%$.

3.3.7 Estimation of serum cobalt (SCo)

For estimation of serum cobalt the same method was applied as in serum iron and serum copper and the value was expressed as $\mu\text{g}\%$.

3.4 Minerals and Trace Minerals Status of Soil in Grazing field

3.4.1 Collection of Soil sample for Analysis

The soil samples for analysis were collected from the grazing field of the anaemic goats in and around Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.

The profile pit was excavated deep enough (6" - 1') so that profile was uniformly lighted and to reveal the principle features and to extend down to the parent material. Each soil sample thus collected was placed in a double walled cloth or paper bag. The bag was labelled and a file card was dropped into it, bearing the area and date of collection. The bags were then transported to the laboratory.

The soil sample was then air dried at a temperature of about 25° to 35°C . The bulk soil samples for chemical

analysis were passed through a 2 mm (10 meshes per inch) sieve, usually by rubbing with the fingers or with the use of grinders or pestle and motor (Jackson, 1967).

3.4.1 pH of the soil sample

5 gm of soil kept in a 25 ml beaker was added 12.5 ml volume of distilled water (Soil : Water ratio of 1 : 2.5). The suspension was stirred at regular intervals for 20 to 30 minutes. Equilibrium could be attained in 5 minutes of continuous vigorous shaking with a reciprocating mechanical shaker. Then the pH was measured with the glass electrode (Jackson, 1967).

3.4.2 Status of calcium in soil

5 gm of the air dried soil sample was taken in a 500 ml erlenmeyer flask. 125 ml of neutral 1.0N NH_4OAC (ammonium acetate) was added to it and shaken thoroughly. Allow it to stand overnight. It was then filtered with Whatman No.1 filter paper.

10 ml of the filtrate was taken in a 250 ml beaker and 140 ml of distilled water was added to it to obtain a volume of about 150 ml. 10 drops each of KCN, $\text{NH}_2\text{OH}\cdot\text{HCL}$ (Hydroxylamine hydrochloride) and triethanol amine were mixed in it. It was then added with enough 10% NaOH to raise the pH to 12 or slightly higher. After adding 5 drops of Calcon indicator,

the filtrate was then put to titration with standardised EDTA. The colour was changed from red to blue (Black, 1965).

1 ml EDTA is equivalent to 0.2004 mg of Calcium.

Calculation : $Ca = X \times 3.98 = \text{mEq}/100 \text{ gm}$

$Ca = \text{mEq}/100 \text{ gm} \times 20 = \text{mg}/100 \text{ gm}$

3.4.3 Status of phosphorus in soil

In the procedure of Olsen et al. (1954) 5 gram sample of soil was suspended in 100 ml of the NaHCO_3 extraction solution of pH 8.5 along with 1 teaspoon of carbon black. The suspension was shaken for a period of 30 minutes. The solution was filtered through a Whatman No.42 filter paper. Ten ml aliquot of the phosphorus containing test solution was pipetted into a 50 ml volumetric flask and adjusted to pH 3 with 4N NH_4OH . 2,4 dinitrophenol was being used as an indicator. Then 10 ml of the chloromolybdic acid solution was added by means of a pipette. The solution was diluted to the 50 ml volume mark, mixed and poured into a 125 ml conical flask. Five drops (0.25 ml) of the chlorostannous acid reductant solution was added to the solution in the flask and mixed thoroughly. The colour intensity was nearly constant between 4 to 20 minutes and was read photometrically after 5 minutes with a 660 mu light.

Calculation : $Y = X \times 1.92 \times 50 \text{ (dilution factor) ppm}$

3.4.4 Status of iron in the soil

The soil samples were extracted with DTPA (diethylene triamine penta acetic acid).

The extractant used in this investigation was prepared according to the procedure developed by Lindsay and Norvell (1969). The extractant was prepared by mixing DTPA, CaCl_2 and triethanolamine (TEA) in such a proportion as to get a solution containing 0.005M DTPA, 0.01M CaCl_2 and 0.1M TEA in it. For this purpose 7.62 ml of the pentasodium salt of DTPA (33% solution) and 13.29 ml of triethanolamine (density 1.22 gm/ml) were taken in a 1 litre flask. 1.47 gm of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ was taken in the same volumetric flask and volume was made up to 1 litre with de-ionized water. The solution was mixed thoroughly and the pH was adjusted to 7.3 by adding HCl acid before the volume was made up.

Extraction procedure :

Ten gms of soil sample was taken in a test tube, 20 ml of DTPA extractant was added into it, corked tightly and shaken for 2 hours in a shaker. It was then filtered through Whatman No.42 filter paper. Appropriate aliquots were taken from this solution for the estimation of iron in the Atomic Absorption Spectrophotometer with standard solution of iron. The value was expressed in terms of $\mu\text{g/g}$ or ppm.

3.4.5 Status of copper in soil

The extracted soil samples with DTPA were used for the estimation of copper content in the soil. The value was expressed in terms of $\mu\text{g/g}$ or ppm.

3.4.6 Status of cobalt in soil

The same aliquot produced from the soil with DTPA extraction was used for determination of cobalt content in the soil in Atomic Absorption Spectrophotometer with the standard solution of cobalt. The value was expressed in terms of $\mu\text{g/g}$ or ppm.

3.5 Minerals and Tracemineral Status of Plants in Grazing Field

The grasses and leaves of the shrubs of the pasture land grown in the soil of the grazing area of the anaemic goats around B.C.K.V. Mohanpur, Nadia, West Bengal were collected in an envelop containing bearing number, date of collection and place of collection for each sample. The plants collected were got identified by Taxonomist, of the Deptt. of Botany, Kalyani University. Then the envelop was put in a hot air oven at 100°C for drying up of the samples and the samples were processed further as per the method described by A.O.A.C. (1970) for analysis of calcium & phosphorus, ...

3.5.1 Status of calcium in plants

The estimation of calcium content in the plants was done as per the method of Talapatra et al. (1940) and expressed as %.

3.5.2 Status of phosphorus in plants

The same method of Talapatra et al. (1940) was employed for the estimation of phosphorus content in the plants and expressed as percentage.

3.5.3 Status of iron in plants

Oxidation of the organic matter of the plant tissue and release of the mineral elements was effected through wet oxidation by means of oxidizing acid such as HNO_3 , H_2SO_4 , HClO_4 ternary acid mixture in the ratio of 10 : 1 : 4.

0.5 gm of the dried plant sample was taken in a 100 ml conical flask. Ten ml of tri-acid mixture was added. Digestion was carried out on hot plate at $180-200^\circ\text{C}$ until dense white fumes of H_2SO_4 and HClO_4 were evolved. The content in the flask after digestion was transferred to 50 ml volumetric flask by washing several times the contents in the conical flasks with tripple distilled water and made up the volume to 50 ml with tripple distilled water (Jackson, 1967).

The content of iron in the aliquot was estimated with the help of Atomic Absorption Spectrophotometer and was described as $\mu\text{g/g}$ or ppm.

3.5.4 Status of copper in plants

The same extractants was used for the estimation of copper in the plants in Atomic Absorption Spectrophotometer and the value was expressed in terms of $\mu\text{g/g}$ or ppm.

3.5.5 Status of cobalt in plants

The same method was applied as in iron and copper for determination of cobalt content of the plants and the result was described as $\mu\text{g/g}$ or ppm.

3.6 Experimental Production of Anaemia in Goats

3.6.1 Nutritional anaemia

3.6.1.1 Preparation of experimental animals

Fifteen healthy Black Bengal goats of either sex age 8 months were selected for this study. The experimental goats were divided into three groups of five goats in each (gr A, gr B, gr C) and kept separately in clean well ventilated sheds. Before the start of the experiment all the goats of each group were thoroughly examined clinically for the detection of any disease condition. Faecal and blood samples were also examined for any abnormality and presence of parasitic ova/oocyst,

haemoprotozoan parasites in blood. Since, the goats had varying degree of gastro-intestinal parasitic infection as evident from faecal sample examinations, they were treated with Ivermectin (1%) at the dose rate of 200 μ g/kg body weight injected subcutaneously once. Subsequent faecal examination at 7, 14 and 21 days post-treatment revealed negative results and the goats were 100% free of the gastro-intestinal parasites (Najanja, 1987). From the beginning, the experimental goats of gr A, B & C were maintained on grazing, browsing with concentrates, feed additives and vitamins to bring them to normal condition at the earliest before the start of the actual experiment. Fresh and clean drinking water was provided adlibitum to the goats. Goats which were anaemic due to worm infestations were given a course of haematinics and tonics orally and parenterally to bring their haemogram to normal. The body weights of all the goats were also taken regularly. Haemoglobin, Packed Cell Volume, total erythrocytic and leucocytic counts were also estimated by standard method (Schalm et al., 1975).

For the study of nutritional anaemia in goats the animals of gr A were kept as healthy control. They were allowed to feed the normal diet as before. The animals of gr B & C were subjected to experimental production of 'Nutritional anaemia' by maintaining the animals exclusively on grazing and browsing without concentrates and feed additives or vitamins with adlibitum drinking water for a period of 15 weeks

till the goats become anaemic. The anaemic goats of gr C were treated for anaemia whereas the anaemic goats of gr B were allowed to be anaemic throughout. Periodical stool examinations were done in both the groups for maintaining the animals free from parasitic infection throughout the period of experiment. The body weights were also taken regularly.

3.6.1.2 Observation of symptoms of anaemic goats

All the 10 goats of gr B & C were regularly examined and the observations of symptoms and clinical manifestations of anaemia were recorded in comparison to goats of gr A which were kept as healthy control.

3.6.1.3 Haematological and biochemical analysis

Blood samples from all the goats of gr A, B and C were collected before the start of the experiment and at weekly intervals and analysed for haematological (Hb, PCV, TEC, TLC, DLC, MCV, MCH and MCHC) and biochemical parameters (Total serum protein, serum calcium, serum phosphorus, serum iron, serum copper and serum cobalt) as per the standard methods described earlier. The results were tabulated and statistically analysed.

3.6.1.4 Estimation of Myeloid : Erythroid (M:E) ratio in the bone marrow of nutritional anaemic goats

Sternal bone marrow aspirations from each goats were done at two weeks intervals with a special needle and syringe and films were prepared on clean grease free blue star slides and stained with freshly prepared Leishman stain.

Equipments and chemicals required for the sterile bone marrow aspirations are as follows :

1. Enamel tray (8" x 12")
2. 5 ml glass syringes with metal tip locking arrangement,
3. Bone marrow needles No. 5D with stylet
4. Savlon 10% solution,
5. Safety razor with blade,
6. Cotton,
7. Sprit,
8. Gauze,
9. Clean glass slides,
10. Blotting papers.

previously sterilized (Autoclaved)

Syringes and bone marrow needles were sterilized before hand.

The technique of aspiration of bone marrow, as used in goats during the present study, has been given below :

The goats were restrained in lateral recumbancy with all four legs tied together with a rope. The site of puncture of sternum for collection of bone marrow aspiration was the centre of third sternebrae. The sternal area of the animal was thoroughly cleaned with water in order to remove dung and other gross contaminations. Thereafter, the site of puncture was shaved and disinfected with 10% savlon followed by spirit and was allowed to dry. The area is anesthetized with ether & 2% procaine or 2% xylocains. The centre of third sternebrae was located and the bone marrow needle alongwith stylet was carefully introduced through the skin to the periosteum. When the periosteum was reached, a quick hard blow with the posterior of the right hand palm over the back of the needle resulted in penetration of the needle into the marrow cavity. The stylet was then removed and a 5 ml glass syringe was attached with the needle. Marrow fluid (about 0.5 - 1 ml) was aspirated by creating a gentle negative pressure within the syringe and thereafter the needle was removed along with the syringe. As soon as fluid appears, the suction process should be stopped, otherwise, dilution of the marrow fluid with blood may occur. The site of puncture was then painted with tincture of iodine.

Immediately after collection of marrow aspirations, smears were prepared on the glass slides employing a special technique. Two to three drops of marrow aspirates were put on the upper portion of glass slides, which were kept at an

inclination of 30°C over the blotting paper in order to drain out the blood, leaving the marrow fragments at the top of the slides. Thereafter, the slides were tapped gently over the blotting paper 2-3 times to exclude the excess of blood from the slides. Marrow films were made by placing a second slide firmly down over the marrow particles and thereafter drawing the two slides very carefully apart. Slides were rapidly dried by waving them in the air. At least 3-4 marrow smears were made from each animal at one occasion. Bone marrow films thus prepared were stained with Leishman stain.

Stained bone marrow films were examined microscopically first under high power, then under oil immersion and evaluations of bone marrows were made as per the method described by Schalm et al. (1975). Myeloid : Erythroid (M:E) ratio was determined on the basis of differentiation of 500 cells which included both nucleated cells of the erythrocytic series and cells of granulocytic series. Microphotographs were taken from the films.

The average values of M:E ratios of both the occasions for individual animal was calculated which constituted the zero day value of M:E ratio of the particular animal.

3.6.1.5 Histopathological changes of nutritional anaemic goats

Five experimental anaemic goats of gr C having Hb% 6.5 - 7.0 were sacrificed during the present study and gross lesions noted. For histopathological studies small pieces of liver, spleen, lungs and heart were collected and kept in 10% formalin till the tissues were processed in the laboratory.

Tissue sections from liver, spleen, lungs and heart were dehydrated in ascending grades of alcohol and were cleared in psuederwood oil. After preparing paraffin blocks, sections of 3 - 5 μ thickness were cut and stained with routine haematoxylin and eosin staining procedure as adopted by Lillie (1976).

3.6.1.6 Estimation of iron content of the liver of nutritional anaemic goats

A pieces of liver was removed from the sacrificed animal for the determination of iron concentration in the organ. One gram of liver tissue was cut into several fine pieces, digested with tripple acid, processed and analysed (as discussed earlier) by the Atomic Absorption Spectro-photometer. The value was expressed as $\mu\text{g/g}$ or ppm.

3.6.1.7 Estimation of copper content of the liver of nutritional anaemic goats

SCu concentration of liver was estimated from the clear solution processed in the Atomic Absorption Spectrophotometer with the standard solution of copper for determination of this element in the organ. The value was expressed as $\mu\text{g/g}$ or ppm.

3.6.1.8 Estimation of cobalt content of the liver of nutritional anaemic goats

For estimation of cobalt content in the liver, the same method was applied as in serum iron and serum copper. The result was expressed as $\mu\text{g/g}$ or ppm.

3.6.1.9 Treatment of anaemic goats of nutritional anaemia

When the haemogram of experimental goats of gr C dropped around 7 g% the goats were declared anaemic. The following line of treatment was adopted for each anaemic goat of gr C. In order to study the response of treatment collection of the blood at the 3rd, 7th, 10th and 15th day of the treatment were done and the results from the examinations were compared with the healthy control gr A.

Line of treatment :

1. Imferon B-12 (2 ml ampoule) was given I/M on alternate day with a total of 5 such injections.

2. A mixture of Ferric ammon citrate - 2.5 gm

Copper sulphate - 200 mg

Cobalt sulphate - 10 mg

was given orally daily for 15 days.

3. Restoration of balanced feeding with concentrates along with grazing and browsing.

3.6.2 Chronic haemorrhagic anaemia in goats

3.6.2.1 Preparation of experimental animals

The study was undertaken in 10 eight month old healthy goats of either sex. The goats were divided into two groups of 5 goats each (gr D and gr E) and were subjected to detail examinations and treatments adopted as per the experimental goats used for the study of nutritional anaemia. All the goats were kept under optimum management with grazing browsing and concentrates. Chronic haemorrhagic anaemia was produced in both the groups by withdrawal of 20 ml of blood daily by jugular venipuncture for 72 to 76 days till the peak anaemia was achieved. The anaemic goats of gr E were subjected to emergency treatment for anaemia whereas the anaemic goats of gr D were further used for withdrawal of same quantity of blood daily till death due to anaemia when emergency slaughter was done to evaluate the quality of the meat of anaemic goats.

The five untreated, control goats of gr A of experimental nutritional anaemia were kept also as healthy control groups for this study.

3.6.2.2 Observation of clinical symptoms of anaemic goats

The clinical symptoms produced by the goats of both the groups were observed as described by Blood et al. (1983).

3.6.2.3 Haematological and biochemical analysis

Blood samples were collected at weekly intervals from both the experimental (gr D₁ and E₁) groups for haematological (Hb%, PCV, TEC, TLC, DLC, reticulocytes, morphology of erythrocytes, mean corpuscular values, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration) studies and were determined by the standard methods of Schalm et al. (1975).

Biochemical analysis of blood (BGL, TSP, SI, SCu, SCo) was done as per the standard methods described earlier.

The above haematological and biochemical profiles were tabulated and statistically analysed.

3.6.2.4 Estimation of Myeloid : Erythroid (M:E) ratio in the bone marrow of anaemic goats

Sternal bone marrow aspiration from each goat was done at weekly intervals. Then it was processed as per the method described earlier.

3.6.2.5 Histopathological changes of chronic haemorrhagic anaemic goats (Macroscopic & Microscopic changes)

Experimental goats which died during the present study were immediately placed for post-mortem examination and gross lesions were noted. Histopathological studies were made as per the method described earlier as in case of nutritional anaemia.

3.6.2.6 Estimation of iron content of the liver of chronic haemorrhagic anaemic goats

The sample was processed and was estimated for the iron content of the liver as per the method described earlier.

3.6.2.7 Estimation of copper content of the liver of chronic haemorrhagic anaemic goats

The same technique was adopted for the estimation of copper content in the organ as per the method described earlier.

3.6.2.8 Estimation of cobalt content of the liver of anaemic goats having chronic haemorrhagic anaemia

The method applied for determination of cobalt content of liver was already outlined earlier.

3.6.2.9 Treatment of anaemic goats of chronic haemorrhagic anaemia

All the five goats of group 'E' which were under severe anaemia were given blood transfusion to overcome the crisis as per the method described by Blood et al. (1983) followed by oral and parenteral haemetinics.

Blood was collected into an anticoagulant solutionss (anticoagulant citrate dextrose solution) through a venepuncture into the jugular vein using blood transfusion set.

So to avoid any possibility of producing an agglutination-haemolysin reaction a matching and crossmatching tests were carried out by mixing the serum of the recipient with the cells of the donar and viceversa (Blood et al., 1983).

After the confirmation of compatibility for blood transfusion, 20 ml/kg body weight of blood was transfused with the help of blood transfusion set. In order to study the response of the treatment with blood transfusion, blood was collected and examined at 24 hours, 48 hours and 72 hours after transfusion. Then the other treatments was started and examination of blood was done at 3rd, 5th, 7th, 10th and 15th day from the date of starting of the treatment to study the efficacy of the treatment.

3.6.2.10 Histopathological changes of chronic haemorrhagic anaemic goats

Experimental goats which died during the present study were immediately placed for post-mortem examination and gross lesions.

3.7 Quality of meat in anaemic goats

After the slaughter of goats, Longissimus dorsi muscles were collected and packed in polythene bag in thermocole containers and were transported to the laboratory. The samples were kept in a refrigerator at 2-4°C for 24 hours for subsequent analysis of the following parameters for quality assessment.

- (a) Moisture, (b) Protein,
- (c) Ether extract and (d) Total ash

The samples were processed in the laboratory and the estimation of the above parameters were done as per the method outlined by AOAC (1975).

Samples were cooked as per the procedure described by Biswas and Radhakrishnan (1988) and then cooled and cooking loss was calculated as follows :

$$\text{Cooking loss(\%)} = \frac{\text{Wt. of the meat before cooking} - \text{wt. of the meat after cooking}}{\text{Wt. of the meat before cooking}} \times 100$$

The results was expressed as - %

CHAPTER—IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

4.1 Incidence of Anaemia in Goats

4.1.1 Clinical manifestations of anaemia in goats

The goats presented at the University Veterinary Clinics from villages around Bidhan Chandra Krishi Viswavidyalaya at Mohanpur, Nadia, West Bengal were clinically examined for anaemia manifesting the varied symptoms like pallor of visible mucous membrane, muscular weakness, anorexia, increased heart rate and intensity of heart sounds, respiratory distress (dyspnoea), laboured breathing and oedema in terminal stages in some cases.

The clinical symptoms noticed in goats during the present study were of varied nature and the majority of the symptoms noticed supported the reports of Boddie (1969), Mallick et al. (1979), Saror (1980), Roberts et al. (1982), Blood et al. (1983), Borah et al. (1983), Yousuf et al. (1983), Pandey and Misra (1985) and Pandey and Misra (1987) in domestic animals. Similar anaemic symptoms due to postparturient haemoglobinuria in cattle and buffaloes were also described by Madsen and Nielsen (1939), Evans (1951), Parkinson and

Sutherland (1954), Nagpal et al. (1968), Singh and Goutam (1971), and Pandey & Misra (1987).

4.1.2 Incidence of anaemia in goats

The results of the incidence of anaemia in goats according to age and sex were presented in table 1. The results indicated that out of 1768 goats clinically examined 1087 (61.48%) were found to be clinically anaemic. Out of 621 goats of 3-6 months of age examined 371 goats (59.74%) were found to suffer from anaemia. From the aforesaid group 175 (55.20%) male and 196 (64.47%) females were affected with anaemia out of 317 males and 304 females respectively. 638 male and female goats were examined out of them 391 (61.28%) goats were positive clinically for anaemia of which 198 (66.22%) and 193 (56.93%) were male and female respectively. Amongst 329 goats above 1 year to 2 years of age examined 211 (64.13%) goats had the signs of anaemia. From this group 57 (55.33%) males and 154 (68.14%) females were positive clinically for anaemia out of 103 males and 226 females examined respectively. Of 180 goats of above 2 years of age (26 male and 180 female) examined, 114 goats (63.33%) of which 12 males (46.15%) and 102 (66.23%) females were having the characteristic symptoms of anaemia. Out of 745 male and 1023 female goats examined 442 (59.32%) males and 645 (63.04%) females were clinically positive for anaemia. Statistical analysis showed insignificant differences in the

Table 1. Showing distribution of anaemia in goats according to age and sex

Age	Sex	Number of goats examined	Number of goats clinically anaemic	Percentage (%)	Remarks
3-6 months	M	317	175	55.20	Total number of male goats examined = 745
	F	304	196	64.47	
	Total	621	371	59.74	Total number of male goats found clinically anaemic = 442 (59.32%)
7 months to 1 year	M	299	198	66.22	
	F	339	193	56.93	Total number of female goats examined = 1023
	Total	638	391	61.28	
above 1 year to 2 years	M	103	57	55.33	Total number of female goats found clinically anaemic = 645 (63.04%)
	F	226	154	68.14	
	Total	329	211	64.13	
above 2 years	M	26	12	46.15	
	F	154	102	66.23	
	Total	180	114	63.33	
Grand total		1768	1067	61.48	

incidence of anaemia according to age and sex. Detail systematic studies on the incidence of anaemia according to age and sex in goats were scarce in the literature. Sawhney et al. (1973) and Sawhney et al. (1974) studied the haemoglobin status of animals in the hilly areas of Himachal Pradesh and hilly areas of Jammu Kashmir and recorded that more than 50% of the animals were with low haemoglobin. Chhillar et al. (1979) while observing the haemoglobin status of the blood of 260 cattle and buffaloes of varying ages in Tarai area of U.P. recorded that 60% of the livestock had low haemoglobin in the area. Similar observations were recorded by Bedi and Khan (1984) with 65% of the animals having low haemoglobin in Bijnore District of U.P. It was observed that age and sex of animals had no influence on the incidence of anaemia.

According to the seasons, the incidence of clinical anaemia was presented in table 2. From the table it was evident that 300 (59.17%) out of 507, 287 (59.49%) out of 474, 319 (66.45%) out of 480 and 186 (60.58%) out of 307 goats were anaemic during the winter (December to February), summer (March to May), Monsoon (June to August) and autumn (September to November) respectively. Statistical analysis revealed that the incidence of clinical anaemia was significantly higher ($P/0.05$) in monsoon than that of winter and summer and there was insignificant difference with autumn. Work on the aspects of seasonal incidence of anaemia in goats and in other ruminants

Table 2. Showing the seasonal incidence of clinical anaemia in goats.

Seasons	Number of goats examined	Number of goats clinically anaemic	Percentage (%) of incidence
Winter (December - February)	507	300	59.17(a)
Summer (April - June)	474	282	59.49(a)
Monsoon (July - September)	480	319	66.45(b)*
Autumn (September - December)	307	186	60.58(ab)
Total	1768	1087	61.48

* P / 0.05

were not traceable in the literature. However, the high incidence of anaemia during the rainy season might be due to leaching and weathering of soils as a result of heavy rainfall and high temperature making the soil deficient in plant minerals (McDowell et al., 1984). This could also be possible due to high incidence of gastro-intestinal parasitism during rainy season with hot, humid climatic conditions along with a fall of plane of nutrition (Blood et al., 1983).

4.1.2.1 Examination of blood smears from the anaemic goats

The blood smears of 1087 anaemic goats revealed negative for the presence of any haemoprotozoan parasites. None of the anaemic goats showed any rise of temperature or any discoloration of urine.

4.1.2.2 Examination of faecal samples of anaemic goats

The faecal samples of 1087 clinically anaemic goats were examined and tabulated in table 3. From the table it was revealed that out of 1087 clinically anaemic goats 270 (24.83%) were suffering from heavy gastro-intestinal parasitic infestations, 438 (40.29%) goats were having low degree of parasitic infestations with or without nutritional deficiencies and 379 (34.86%) goats were having negative for parasitic infection and were supposed to be suffering from nutritional anaemia.

Table 3. Showing the seasonal incidence of different types of anaemia in goats

Seasons	Number of goats examined	Number of goats clinically anaemic	Number of anaemic goats with heavy parasitism	Number of anaemic goats with low degree of parasitism	Number of anaemic goats without parasitism (nutritional anaemia)
Winter (December - February)	507	300	60	133	107
Summer (April - June)	474	282	64	128	90
Monsoon (July - September)	480	319	75	120	124
Autumn (September-December)	307	186	71	57	58
Total	1768	1087	270 (24.83%)	438 (40.29%)	379 (34.86%)

Anaemia due to parasitism was described by Taylor(1935), Udall (1954), Peterson et al. (1954), Jennings et al. (1956), Smith et al. (1972), Weise et al. (1972), Thakur and Misra (1973), Schalm et al. (1975), Ansari et al. (1978), Adams(1981) Roberts et al. (1982), Borah et al. (1983) and Pandey and Misra (1985) in ruminants.

Literature on anaemia due to nutritional deficiency in goats were scarce. However, nutritional anaemia in other ruminants was reported by Filmer(1933) due to cobalt deficiency in cattle, Schalm et al. (1975) due to iron and copper deficiency in cattle, and Blood et al. (1983) due to iron, copper and cobalt deficiency in ruminants. Anaemia due to protein deficiency was reported by Hahn and Whipple (1939).

4.2 Haematological Changes in Anaemic Goats

4.2.1 Examination of blood

The results of the analysis of blood samples of anaemic goats (1087) having anaemia with heavy parasitism (++ or +++), anaemia with low degree of parasitism (+) and anaemia without parasitism (supposed to be nutritional) of different parameters like Hb, PCV, TEC, TLC, MCV, MCH, MCHC were estimated and tabulated in table 4. The informations on goat anaemia on these parameters were scarce in literature.

Table 4. Haematological changes in clinically anaemic goats

Profiles	Anaemia with heavy parasitism (Group I)	Anaemia with low degree parasitism (Group II)	Anaemia without parasitism (Group III)
Hb (g%)	4.96 ±1.16	6.24 ±1.04	7.69 ±1.20
PCV (%)	16.20 ±2.33	20.60 ±1.89	23.20 ±1.08
TEC ($10^6/\text{cmm}$)	4.84 ±2.11	6.11 ±1.66	6.96 ±0.90
TLC ($10^3/\text{cmm}$)	13,110.00 ±233.28	11,908.00 ±476.42	11,180.00 ±361.95
N (%)	36.60 ±0.96	31.20 ±1.21	31.40 ±2.81
L (%)	54.20 ±1.40	60.60 ±1.76	60.80 ±1.59
E (%)	3.40 ±1.47	4.60 ±1.78	4.20 ±1.56
B (%)	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
M (%)	5.20 ±0.98	4.40 ±0.50	3.20 ±1.80
MCV (μ^3)	33.47 ±2.15	34.73 ±1.19	32.17 ±2.11
MCH ($\mu/\mu\text{g}$)	10.21 ±2.23	10.06 ±3.21	10.09 ±2.33
MCHC (%)	28.61 ±1.17	31.33 ±2.41	31.37 ±2.29

4.2.2 Haemoglobin (Hb)

From table 4, it was seen that the mean values of haemoglobin percentage of 270 goats having anaemia due to heavy parasitism (group I), 438 goats having anaemia with low degree of parasitism (group II) and 379 goats having anaemia without parasitism (group III) were 4.96 ± 1.16 g%, 6.24 ± 1.04 g%, and 7.69 ± 1.20 g% respectively.

Low haemoglobin percentage in ruminants suffering from anaemia was reported by Filmer (1933), Taylor (1935), Hahn and Whipple (1939), Peterson et al. (1953), Udall (1954), Jennings et al. (1953), Settlemyre et al. (1964), Schalm (1972), Sawhney et al. (1974), Chhillar et al. (1979), Ansari et al. (1978), Bejúbik et al. (1981), Blood et al. (1983), Pandey and Misra (1985), Pandey and Misra (1986) and Pandey and Misra (1987).

4.2.3 Packed cell volume (PCV)

Packed cell volume of the anaemic, goats of gr I, gr II and gr III were $16.20 \pm 2.33\%$, $20.60 \pm 1.89\%$ and $23.20 \pm 1.08\%$ respectively.

Mallick et al. (1979) and Adams (1981) observed reduction in the PCV in anaemic goats and sheep respectively. Similarly, drop in the PCV in anaemic ruminants was reported by Peterson et al. (1953), Schnappauf et al. (1967), Rogers (1971), Schalm (1972), Thakur and Misra (1973), Gupta et al.

(1974), Schalm et al. (1975), Pandey and Misra (1977), Ogunsuri (1978), Ansari et al. (1978), Blood et al. (1983) and Pandey and Misra (1985). Drastic fall of the PCV to as low as 20% and even 12% was observed by Schalm (1972), Schalm et al. (1975) and Pandey and Misra (1985). Peterson et al. (1953) observed haematocrit value as low as 9% with corresponding reduction in haemoglobin and erythrocytic count in cases of anaemic cattle infested with heavy affection of the blood sucking louse.

4.2.4 Total erythrocytic count (TEC)

Total erythrocytic count of the anaemic goats of gr I, gr II and gr III were 4.84 ± 2.11 millions/cmm, 6.11 ± 1.66 millions/cmm and 6.96 ± 0.90 millions/cmm respectively.

Similar low erythrocytic count in cases of anaemia in goats and sheep were recorded by Ansari et al. (1978) and Bezubik et al. (1981). However, low erythrocytic counts were reported in other ruminants suffering from anaemia (Filmer, 1933; Madsen and Nielsen, 1939; Peterson et al., 1953; Udall, 1954; Schnappauf et al., 1967; Nagpal et al., 1968; Hungerford, 1970; Schalm, 1972; Thakur and Misra, 1973; Pandey and Misra, 1977; Pandey and Misra, 1985; and Pandey and Misra, 1987).

4.2.5 Total leucocytic count (TLC)

Total leucocytic counts of the anaemic goats of gr I, gr II and gr III were 13, 110.00 ± 233.28 /cmm, $11,900.00 \pm 476.42$ /cmm, and $11,180.00 \pm 361.95$ /cmm respectively.

Information regarding the changes in the leucocytic counts in anaemic goats were untracable in the literature. However, Pandey and Misra (1987) observed leucocytosis in buffaloe cows suffering from anaemia secondary to nutritional haemocylobinuria due to stress.

4.2.6 Differential leucocytic count (DLC)

The differential leucocytic counts of the anaemic goats of gr I, gr II and gr III were neutrophils ($30.60 \pm 0.96\%$, $31.20 \pm 1.21\%$ and $31.40 \pm 2.81\%$), lymphocytes ($54.20 \pm 1.40\%$, $60.60 \pm 1.76\%$, and $60.80 \pm 1.59\%$), Eosinophils ($3.40 \pm 1.47\%$, $4.60 \pm 1.78\%$ and $4.20 \pm 1.56\%$), basophils ($0.00 \pm 0.00\%$) and monocytes ($5.20 \pm 0.98\%$, $4.40 \pm 0.50\%$ and $3.20 \pm 1.80\%$) respectively.

Literature on the changes in differential counts in anaemic goats were not available. In case of anaemic calves due to helminthic infections Thakur and Misra (1973) noted increase in the percentage of monocytes and eosinophils with slight decrease in neutrophil counts. Pandey and Misra (1977) observed neutrophilia and lymphopenia in anaemic calves due to experimental babesiosis. Rama et al. (1978) recorded proportionate increase of the lymphocytes and neutrophils in anaemic sheep suffering from coccidiosis. In case of chronic haemorrhagic anaemic neutrophilia was observed by Schalm et al. (1975) and Pandey and Misra (1987).

4.2.7 Mean corpuscular volume (MCV)

The mean corpuscular volume of the anaemic goats of gr I, gr II and gr III were $33.47 \pm 2.15 \mu^3$, $34.73 \pm 1.19 \mu^3$ and $32.17 \pm 2.11 \mu^3$ respectively.

The present findings were in close similarity with the results of Pandey and Misra (1986) in cases of chronic haemorrhagic anaemia in calves.

4.2.8 Mean corpuscular haemoglobin (MCH)

Mean corpuscular haemoglobin of anaemic goats of gr I, gr II and gr III was $10.21 \pm 2.23 \mu\mu\text{g}$, $10.06 \pm 3.21 \mu\mu\text{g}$ and $10.09 \pm 2.33 \mu\mu\text{g}$ respectively. The values in all the three groups were decreased insignificantly in comparison with the healthy control groups of experimental goats. Information on MCH in anaemic goats were not traceable. Pandey and Misra (1986) observed low MCH value in cases of chronic haemorrhagic anaemia in calves.

4.2.9 Mean corpuscular haemoglobin concentration (MCHC)

Mean corpuscular haemoglobin concentration percentage in anaemic goats of gr I, II and III were recorded as $28.61 \pm 1.17\%$, $31.33 \pm 2.41\%$ and $31.37 \pm 2.29\%$ respectively. The MCHC value in all the three groups were reduced significantly ($P < 0.05$) in comparison with the values of the healthy control goats of the experimental groups.

This finding was in close similarity with the findings of Blood et al. (1983) in iron deficiency anaemia, Pandey and Misra (1986) in chronic haemorrhagic anaemia in calves and Pandey and Misra (1987) in buffaloe calves suffering from anaemia secondary to nutritional haemoglobinuria.

4.3 Biochemical Changes in Anaemic Goats

The results of the biochemical changes in respect of blood glucose, serum protein, serum calcium, serum phosphorus, serum iron, serum copper and serum cobalt were presented in table 5.

4.3.1 Estimation of blood glucose (BGL)

The values of blood glucose in respect of anaemic goats of gr I, gr II and gr III were 42.66 ± 2.92 mg%, 54.83 ± 7.12 mg% and 52.72 ± 6.76 mg% respectively. The value of BGL in gr I anaemic goats due to severe parasitism was significantly decreased in comparison to the values of healthy control goats of experimental group. The values of BGL in gr II and gr III did not show any significant fall. Information on this aspect in cases of anaemic goats were scarce in the literature. Pandey and Misra (1977) and Pandey and Misra (1987) observed decreased in the value of glucose in cases of anaemia in calves due to babesiosis. In cases of nutritional haemoglobinuria the BGL value increased due to intravascular haemolysis (Pandey and

Table 5. Biochemical changes in clinically anaemic goats

Profiles	Anaemia with heavy parasitism (group I)	Anaemia with low degree parasitism (group II)	Anaemia without parasitism (group III)
BGL (mg%)	42.66 ± 2.92	54.83 ± 7.12	52.72 ± 6.76
TSP (g%)	5.07 ± 0.94	5.90 ± 0.81	6.71 ± 0.55
Ca (mg%)	9.56 ± 1.44	10.01 ± 1.71	10.20 ± 1.50
P (mg%)	3.96 ± 1.87	4.20 ± 0.84	5.00 ± 0.97
SI (μ g%)	102.28 ± 5.62	127.85 ± 9.84	141.76 ± 4.39
SCu, (μ g%)	83.57 ± 6.39	101.54 ± 4.07	113.08 ± 5.17
SCo (μ g%)	4.08 ± 1.94	7.90 ± 1.14	8.31 ± 2.22

Misra, 1987). There was no significant change in BGL value of gr II probably due to low degree of parasitism in comparison to healthy control.

4.3.2 Estimation of serum protein (TSP)

The values of TSP in cases of anaemic goats of gr I, gr II and gr III were 5.07 ± 0.94 g%, 5.90 ± 0.81 g% and 6.71 ± 0.55 g% respectively.

The TSP values in cases of gr I, gr II decreased significantly and in cases of gr III the values of TSP remained almost unchanged in comparison with TSP values of healthy control goats of the experimental group.

Borah et al. (1983) reported no significant change in TSP values of goats infected with *strongyloides papillosus* whereas Abbot et al. (1984) recorded hypoproteinaemia in lambs suffering from haemonchosis.

Fall in TSP values in cattle suffering from anaemia was observed by Bremner (1966), Coles (1967), Suteu and Giurgea (1971), Reveron et al. (1971), Schalm (1972), Singh et al. (1973), Schalm et al. (1975), Gardner et al. (1976) and Pandey and Misra (1985) in cases of haemorrhagic, haemolytic and nutritional anaemia. In the present study the fall in the value of TSP in gr I and gr II was due to intestinal

parasitism leading to diarrhoea, and malabsorption where as in case of gr III the decrease of TSP value was not significant probably due to marginal adequacy of protein available in the grazing pasture.

4.3.3 Estimation of serum calcium (SCa)

The serum Ca level in cases of anaemic goats of gr I, gr II and gr III was 9.56 ± 1.44 mg%, 10.01 ± 1.71 mg% and 10.20 ± 1.50 mg% respectively. The values were within the normal range in comparison with serum calcium level of the healthy control goats of the experimental group.

The results corroborated with the findings of Madsen and Nielsen (1944), Greenhalgh et al. (1967), Nagpal et al. (1968), Jerichow and Jungman (1969), Sharma et al. (1976), Samad et al. (1979) and Pandey and Misra (1985) in anaemic cattle and buffaloes.

4.3.4 Estimation of serum phosphorus

The phosphorus content of the serum of the anaemic goats of gr I, gr II and gr III was 3.96 ± 1.87 mg%, 4.20 ± 0.84 mg% and 5.00 ± 0.97 mg% respectively. The values in all the three groups of the anaemic goats were close to the normal range.

Literatures on the values of phosphorus in anaemic goats were not traceable. In cases of cattle suffering from

nutritional haemoglobinuria low serum phosphorus values were recorded (Madsen and Nielsen, 1939; Parkinson and Sutherland, 1954; Nagpal et al., 1972; Sharma et al., 1976; and Samad et al., 1979).

4.3.5 Estimation of serum iron (SI)

The serum iron content of the anaemic goats of gr I, gr II and gr III was found to be 102.28 ± 5.62 $\mu\text{g}\%$, 127.85 ± 9.84 $\mu\text{g}\%$ and 141.76 ± 4.39 $\mu\text{g}\%$ ^{respectively.} The SI values of all the groups were decreased significantly in comparison to the values of healthy control goats of experimental groups.

Informations on the status of serum iron in anaemic goats were not available in the literature. In case of other ruminants low serum iron values were recorded by Taylor (1935); Hibbs et al. (1963); Jerichow and Jungman (1969), Kaneko et al. (1970), Pandey and Misra (1985) and Pandey and Misra (1986).

Low serum iron values in gr I and gr II were due to parasitism whereas in cases of gr III low serum iron value in comparison to healthy control of experimental animals might be due to nutritional origin. McDowell et al. (1983) reported iron deficiency anaemia in livestock having blood loss due to parasites and disease.

4.3.6 Estimation of serum copper (SCu)

The analytical result of serum copper in respect of anaemic goats of gr I, gr II and gr III were 83.57 ± 6.39 $\mu\text{g}\%$, 101.54 ± 4.07 $\mu\text{g}\%$ and 113.08 ± 5.17 $\mu\text{g}\%$ respectively. The serum copper values of gr I decreased significantly and in cases of gr II and gr III the said values were marginally reduced in comparison to healthy control group of experimental animals.

Lamand (1985) observed anaemia due to diet deficient in copper in goats. Further informations on the status of serum copper in anaemic goats could not be traced in the literature. Low level of SCu was observed in anaemic ruminants by Becker et al. (1965), Klimov and Polyakov (1971), Domanski et al. (1972), Smith et al. (1972), Gardner et al. (1976), Givens et al. (1978) and Pandey and Misra (1987). However, Pandey and Misra (1987) observed increased in the value of copper in cattle suffering from haemolytic anaemia due to babesiosis. This increase in the SCu level was attributed to intra-vascular haemolysis.

Significant decrease of serum copper in gr I was due to parasitism, malabsorption or might be due to other factors which blocked the utilization of copper in the body (McDowell et al., 1983). The rest of the two groups recorded marginal deficiency of SCu due to low degree of parasitism and probably due to gradual loss of appetite.

4.3.7 Estimation of serum cobalt (SCo)

The serum cobalt content in cases of anaemic goats of gr I, gr II and gr III was found to be $4.08 \pm 1.94/\mu\text{g}\%$, $7.90 \pm 1.14/\mu\text{g}\%$ and $8.31 \pm 2.22/\mu\text{g}\%$ respectively. The fall of the value of cobalt in all the three groups of anaemic goats was significant in comparison to the value of healthy control goats of experimental group.

Russel and Duncan (1956) and Lamand (1985) observed cobalt deficiency in anaemic goats. Further reports in cases of goat anaemia due to cobalt deficiency were scarce in the literature. Cobalt deficiency was reported in sheep and cattle maintained on deficient pastures by Reid (1923), Filmer (1933), Bendexen and Pedersen (1945), Lee (1950), Russel and Duncan (1956), Smith and Marston (1970) and Domanaski et al. (1972). McDowell et al. (1983) observed that visual manifestation of cobalt deficiency were not specific and could similarly be found in cases of malnutrition due to low intake of energy and protein. They further observed that animals on cobalt deficient pastures gradually had reduced appetite, failure of growth, loss of weight followed by muscular wasting, depraved appetite, severe anaemia and death. In cases of mild or marginal deficiency above clinical symptoms could never occur and the most susceptible were the young animals which could exhibit signs of unthriftiness indistinguishable from parasitism or low feed intake. The anaemic goats of gr III

under study exhibited similar clinical symptoms which might be pointing towards mild cobalt deficiency among the grazing goats.

Low level of cobalt in cases of anaemic goats of gr I and gr II might be ascribed to the fact that could also make the goat highly susceptible to parasitism (Blood et al., 1983).

4.4 Minerals and Trace Minerals Status of Soil in Grazing Field

The details of the results of analysis of soil samples in relation to pH, Ca, P, Fe, Cu and Co from the grazing area of anaemic goats were presented in table 6.

4.4.1 pH of the soil samples

The pH of the soil samples of the grazing area of anaemic goats varied between 6.75 to 8.50. The majority of the soil samples analysed from different areas of the grazing field indicated alkaline pH (above pH 7).

Halder (1977) reported the pH of the soil of Nadia District varied between 6.4 to 7.9 which were close to the values of the present study. Reports on the different soil samples of West Bengal revealed that the pH of the soil ranged from 5.3 to 8.3 (Halder, 1977). McDowell et al. (1984) observed that with the increase of soil pH, the availability and

Table 6. Minerals and trace minerals status of soil samples in grazing field

Area of collection of soil samples	pH of the soil samples	Calcium mg/100gm	Phosphorus ppm= μ g/gm	Iron ppm= μ g/gm	Copper ppm= μ g/gm	Cobalt ppm= μ g/gm
1	2	3	4	5	6	7
Hatikanda (North)	7.35	354.22 $\pm$ 2.87	9.40 $\pm$ 2.32	55.60 $\pm$ 1.58	5.80 $\pm$ 0.19	1.20 $\pm$ 0.25
Hatikanda (South)	7.60	310.44 $\pm$ 2.84	16.51 $\pm$ 4.17	33.00 $\pm$ 0.07	2.23 $\pm$ 0.04	0.33 $\pm$ 0.04
Santoshpur (North)	7.20	366.60 $\pm$ 3.12	6.43 $\pm$ 1.94	82.60 $\pm$ 1.08	4.30 $\pm$ 0.62	1.46 $\pm$ 0.04
Santoshpur (South)	7.20	354.90 $\pm$ 2.57	4.89 $\pm$ 2.07	88.60 $\pm$ 1.64	3.84 $\pm$ 1.06	0.73 $\pm$ 0.27
Mohanpur (East)	8.50	250.74 $\pm$ 2.66	8.92 $\pm$ 2.34	84.60 $\pm$ 1.26	3.46 $\pm$ 0.08	1.03 $\pm$ 0.47
Mohanpur (West)	7.50	417.30 $\pm$ 4.10	6.81 $\pm$ 2.13	32.30 $\pm$ 0.88	1.83 $\pm$ 0.20	0.96 $\pm$ 0.29
Mohanpur (North)	8.50	433.82 $\pm$ 3.71	17.95 $\pm$ 1.47	62.00 $\pm$ 0.19	3.06 $\pm$ 0.08	1.50 $\pm$ 0.49
Mohanpur (South)	7.75	254.72 $\pm$ 3.45	3.82 $\pm$ 1.09	89.30 $\pm$ 0.15	3.63 $\pm$ 0.36	0.86 $\pm$ 0.04

Contd....

Table 6 (Contd.....

1	2	3	4	5	6	7	
Mohanpur	(Centre)	7.80	382.08 +2.15	14.49 +2.19	91.60 +0.29	5.10 +0.49	0.96 +0.04
Dharampur	(North)	7.45	250.74 +1.56	5.95 +2.11	93.60 +0.82	4.13 +0.04	1.23 +0.29
Dharampur	(South)	7.40	258.70 +1.31	8.54 +0.97	56.60 +0.20	2.60 +0.77	1.06 +0.43
Haringhata goat farm	(East)	6.95	643.50 +4.79	83.21 +3.19	286.70 +0.45	3.53 +0.85	2.13 +0.57
Haringhata goat farm	(Centre)	8.40	242.78 +2.06	5.37 +1.17	17.80 +0.78	3.10 +0.12	1.00 +0.49
Balindi	(North)	7.00	441.78 +1.55	6.52 +0.73	98.60 +1.49	5.80 +0.79	1.10 +0.11
Balindi	(South)	7.20	396.50 +2.43	7.16 +1.28	82.60 +2.04	4.84 +1.23	0.96 +0.08
Rajberia		7.20	241.80 +2.10	5.85 +0.94	97.00 +0.93	1.84 +1.07	0.90 +0.31
Anandapur		7.10	429.00 +4.18	9.88 +1.23	53.70 +0.84	3.40 +0.19	1.63 +0.15
Jaguli		7.60	262.80 +2.15	9.50 +0.99	53.30 +1.10	4.13 +0.33	0.53 +0.22
Santalpara		7.40	270.30 +2.61	6.44 +0.35	46.20 +1.17	4.27 +0.22	0.71 +0.20

uptake of iron (Fe), manganese (Mn), Zinc (Zn), Copper (Cu) and Cobalt (Co) decrease whereas molybdenum (Mo) and Selenium (Se) concentrations increase. This might be one of the reasons for low availability of the trace elements in the plants of the grazing field.

4.4.2 Status of calcium in soil

The calcium content of the soil samples of the grazing field of the anaemic goats was found to be in the range of 241.80 ± 2.10 to 666.90 ± 2.36 mg/100 gm. Very little work was done in India on the soil test for calcium. Kanwar (1978) reported that calcium became a limiting nutrient only in acid and alkaline soil. Mukhopadhyay and Halder (1988) while studying the soils of North Bengal observed that the exchangeable calcium ranged from 37.20 to 240.00 mg/100 gm. The calcium content of soil in Nadia District was within the normal range.

4.4.3 Status of phosphorus in soil

The phosphorus content of the soils of the grazing area of the anaemic goats was recorded in the range of 3.82 ± 1.09 to 83.21 ± 3.19 ppm ($\mu\text{g/gm}$) and remained within the normal range.

Informations on the status of phosphorus in soils of the grazing area in Nadia District were untraceable. However,

Saha (1976) studied the phosphorus content in soil of Birbhum and Bankura District and found to be 18.23 ppm and 17.96 ppm respectively.

4.4.4 Status of iron in soil

The iron content in the soil of the grazing area, of anaemic goats was found to be in the normal range of 17.80 ± 0.78 ppm to 328.30 ± 0.91 ppm.

The results of the present study were in close similarity with the findings of Saha (1982), Report (1983-84) and Pal et al. (1985). The upper range of iron level in soil in the present study was from 286.70 ± 0.45 to 328.30 ± 0.91 ppm because the samples collected from Haringhata Farm, Govt. of West Bengal in the District of Nadia were previously treated with the trace minerals. As regards the range of iron level of the soil samples collected from other public grazing areas of Nadia District which ranged between 17.80 ± 0.78 to 98.60 ± 1.49 which was in agreement with the previous workers cited above.

4.4.5 Status of copper in soil

The analytical result of copper status in soil of the grazing field of anaemic goats was 1.83 ± 0.20 ppm to 5.80 ± 0.79 ppm.

The result of the present study revealed low copper content of the soils of the grazing area around B.C.K.V., while compared to the normal status of copper in soils (average 9 ppm) reported by Kanwar (1964). Randhawa and Kanwar (1964) also reported that the total content of copper in the soil of Punjab varied from 6.6 to 36.4 ppm. While studying the copper content in soils of other parts of West Bengal, the results obtained by Halder and Mandal (1979), Saha (1982), Report (1983-84) and Pal et al. (1985) corroborated with the findings of Randhawa and Kanwar (1964) and Kanwar (1978).

4.4.6 Status of cobalt in soil

The cobalt status in soil samples of the grazing field of anaemic goats varied between 0.33 ± 0.04 ppm to 2.73 ± 0.47 ppm respectively. This result was similar to those of the findings of Reddy and Mehta (1961). Davison and Mitchell (1940) stated that the nutritional disorders among livestock could be expected in areas where total cobalt content in soils was less than 5 ppm. They further observed that in many soils of Delhi, Punjab, Gujrat and Maharashtra, cobalt was found deficient for the livestock. Heavy liming to soil also reduce the availability of cobalt (Flood et al., 1983).

Reports from Maharashtra also indicated low cobalt content of the soil (Badhe and Zende, 1962). In the present study the status of cobalt in the soil of the grazing area

was found to be low as per the observation made by Davison and Mitchell (1940). McDowell (1986) remarked that soil analysis is preferred to that of forage analysis to establish cobalt deficiency.

4.5 Minerals and Trace Minerals Status of Plants in Grazing Field

The list of the plants (with their botanical names) were listed and the results of the analysis of those plant samples of the grazing field of the anaemic goats were presented in table 7.

4.5.1 Status of calcium in plants

The calcium values of the plant samples collected from the grazing field of goats were 0.08 gm% to 2.01 gm%.

The present finding with respect to status of calcium in plants was in close similarity with those reported by Sen et al. (1978) and Murugan (1987). Further, the results of the calcium status of the blood of the anaemic goats were also found to be within the normal range.

4.5.2 Status of phosphorus content in plants

Phosphorus content in plants of the grazing field of anaemic goats varied between 0.12gm% to 1.5 gm%.

Table 7. Minerals and trace minerals status of pasture samples in grazing field

Area of collection of pasture samples	Scientific name of the pasture (plants and grasses) samples	Calcium %	Phosphorus %	Iron ppm= $\mu\text{g/gm}$	Copper ppm= $\mu\text{g/gm}$	Cobalt ppm= $\mu\text{g/gm}$
1	2	3	4	5	6	7
Hatikanda (North)	<u>Cyanodon dactylon</u>	0.67	0.22	2030.23 ± 1.07	49.28 ± 0.11	0.09 ± 0.05
	<u>Streblus asper</u>	1.91	0.24	420.59 ± 1.26	25.73 ± 0.43	0.11 ± 0.01
Hatikanda (South)	<u>Cyanodon dactylon</u>	0.61	0.17	1440.61 ± 5.40	42.34 ± 1.15	0.08 ± 0.02
Santoshpur (North)	<u>Cyanodon dactylon</u>	0.58	0.21	2580.39 ± 4.08	57.69 ± 0.96	0.10 ± 0.02
Santoshpur (South)	<u>Cyanodon dactylon</u>	0.63	0.22	2307.81 ± 6.14	64.06 ± 0.37	0.04 ± 0.02
	<u>Digitaria poscaee</u>	0.22	0.14	1510.59 ± 2.62	80.30 ± 3.18	0.24 ± 0.06
Mohanpur (East)	<u>Cyanodon dactylon</u>	0.25	0.20	610.66 ± 1.76	50.00 ± 2.59	0.02 ± 0.01
						Contd....

Table 7. (Contd.....)

1	2	3	4	5	6	7
Mohanpur (west)	<u>Cyanodon</u> <u>dactylon</u>	0.28	0.22	1280.75 +1.52	72.19 +0.97	0.04 +0.02
Mohanpur (North)	<u>Cyanodon</u> <u>dactylon</u>	0.16	0.18	1726.71 +2.19	63.46 +0.81	0.03 +0.01
Mohanpur (South)	<u>Cyanodon</u> <u>dactylon</u>	0.13	0.28	2130.64 +2.04	81.95 +1.23	0.09 +0.03
Mohanpur (Centre)	<u>Cyanodon</u> <u>dactylon</u>	0.83	0.30	950.37 +3.30	97.00 +0.46	0.05 +0.02
	<u>Cyanodon</u> <u>dactylon</u>	0.57	0.22	1139.51 +1.97	75.26 +1.26	0.07 +0.04
Dharampur (North)	<u>Scoparia</u> <u>quecis</u>	0.12	0.19	940.16 +0.56	30.97 +0.13	0.10 +0.06
	<u>Ficus</u> <u>religiosa</u>	0.50	0.19	360.44 +0.81	28.47 +0.29	0.30 +0.10
Dharampur (South)	<u>Cyanodon</u> <u>dactylon</u>	0.23	0.24	1379.42 +1.67	52.39 +0.77	0.08 +0.04
	<u>Parthenium</u> <u>hysterophorus</u>	2.01	0.30	377.25 +0.89	23.52 +0.17	0.14 +0.09
	<u>Bracharia</u> <u>poaceae</u>	1.40	0.09	2745.72 +2.78	59.62 +1.64	0.35 +0.11

Contd..

Table 7 (Contd.....

1	2	3	4	5	6	7
Haringhata goat farm (East)	<u>Cyanodon</u> <u>dactylon</u>	0.70	0.26	1827.30 +4.63	48.21 +1.51	0.24 +0.10
Haringhata goat farm (West)	<u>Cyanodon</u> <u>dactylon</u>	0.52	0.28	2710.00 +3.99	125.61 +0.35	0.33 +0.02
Haringhata (Centre)	<u>Cyanodon</u> <u>dactylon</u>	1.75	0.27	746.50 +1.32	39.41 +0.63	0.35
Balindi (North)	<u>Cyanodon</u> <u>dactylon</u>	0.53	0.33	3142.16	55.37	0.04 +0.01
Balindi (South)	<u>Cyanodon</u> <u>dactylon</u>	0.64	0.29	2740.97 +3.68	45.00 +0.87	0.06 +0.03
Rajberia	<u>Mikania</u> <u>scandens</u>	0.73	0.21	1500.00 +1.57	82.27 +0.29	0.20 +0.08
	<u>Cyperus</u> <u>rotendus</u>	0.80	0.30	1695.32 +3.44	35.82 +0.41	0.08 +0.02
	<u>Euphorbia</u> <u>hirta</u>	1.10	0.32	2405.30 +3.16	50.00 +0.47	0.09 +0.02

Contd....

Table 7 (Contd....)

1	2	3	4	5	6	7
Rajberia	<u>Heliodorpium</u> <u>indicum</u>	1.80	0.43	1170.36 +1.82	47.50 +0.98	1.20 +0.17
	<u>Hibiscus</u> <u>rosa-sinensis</u>	0.91	0.35	1422.61 +3.38	59.73 +0.23	0.12 +0.02
	<u>Cyanodon</u> <u>dactylon</u>	0.53	0.14	2782.31 +2.47	120.34 +0.77	0.09 +0.02
Anandapur	<u>Cyanodon</u> <u>dactylon</u>	0.66	0.24	2367.10 +2.11	75.62 +1.60	0.05 +0.02
Jaguli	<u>Cyanodon</u> <u>dactylon</u>	0.11	0.20	1212.36 +1.58	35.31 +0.92	0.04 +0.02
Santalpara	<u>Cyanodon</u> <u>dactylon</u>	0.94	1.50	3140.00 +3.15	67.42 +0.66	0.08 +0.04

The phosphorus content in plants was in agreement with those reported by Sen et al. (1978) and Murugan et al. (1987).

4.5.3 Status of iron in plants

The iron content in plants of the grazing field of anaemic goats was found to be in the range of 360.44 ± 0.81 ppm to 3142.16 ± 5.18 ppm.

The present findings with respect to status of iron in plants were in close similarity with those reported by Aiyer (1948) in rice straw. Sawhney et al. (1977) estimated the value of iron in grasses and found to be 144.23 to 502.97 ppm and in case of legume fodder it was 229.11 to 514.29 ppm. Natural feed stuffs usually contained enough iron to meet the requirements of farm livestock (McDowell, 1977). NRC (1978) also made dietary recommendation of 50 ppm of iron to prevent iron deficiency in cattle. The present work revealed the status of iron in plants of grazing area was adequate.

4.5.4 Status of copper in plants

The results of the analysis of plant samples of the grazing field of anaemic goats showed 23.52 ± 0.17 ppm to 125.61 ± 0.35 ppm of copper.

Literature on the status of copper status of the available plants in the grazing area was not available. NRC (1978)

reported the dietary recommendation of copper at 10 ppm for cattle. The copper content of legumes, cereals, fodder crops (non-legumes and vegetables) were reported to be 9.5 to 17.5 ppm, 12.5 to 29.6 ppm, 6.0 to 29.2 ppm and 8.8 to 22.7 ppm respectively (Kanwar, 1978). The results of the present study did not show any deficiency of copper in plants of the grazing area.

Though the copper content of soil was marginal to low it was found that the copper content of plants was within the normal range. This was due to the availability and mineral uptake of the plants from soils (McDowell, 1982).

4.5.5 Status of cobalt in plants

The analytical result of cobalt status in plants of the grazing field of anaemic goats were 0.02 ± 0.01 ppm to 1.20 ± 0.17 ppm.

Young (1948) and N.R.C. (1978) concluded that 0.10 to 0.17 ppm of cobalt was the normal range of cobalt in plants for the normal health of cattle. Dutta and Datta Biswas (1951) found that all grasses had high cobalt content in the young stage but with the increase in age they found gradual decrease in the cobalt content. According to Iyer (1958) legumes showed a marked concentration of cobalt than the grasses. Blood et al. (1983) reported that pastures containing less than 0.07

and 0.04 ppm of cobalt on dry matter basis lead to development of clinical signs of cobalt deficiency in sheep and cattle respectively.

From the table 7, it was observed that the Cobalt Content of the leaves of Streblus asper, Digitaria poaceae, Scoparia duecis, Ficus religiosa, Parthenium hysterophorus, Brackaria poaceae, Mikania scandens, Cyperus rotendus, Euphorbia birta, Helidorpium indicum, Hibiscus rosa-sinensis were 0.11 ± 0.01 ppm, 0.24 ± 0.06 ppm, 0.10 ± 0.06 ppm, 0.30 ± 0.10 ppm, 0.14 ± 0.09 ppm, 0.35 ± 0.11 ppm, 0.20 ± 0.08 ppm, 0.08 ± 0.02 ppm, 0.09 ± 0.02 ppm, 1.20 ± 0.17 ppm and 0.12 ± 0.02 ppm^{respectively}. The majority of the leaves of the above plants were having marginal or low level of Cobalt. The Cobalt status of grasses (Cyanodon dactylon) in the grazing field of anaemic goats around B.C.K.V. in the district of Nadia were having low level of Cobalt in comparison to the recommendation made by N.R.C. (1978). Since the bulk of the pasture land contained the grass (Cyanodon dactylon) having the Cobalt value ranging from 0.02 to 0.09 ppm) and the goats fully depended on such grasses for their maintenance it was likely to have low level of cobalt in their feed.

4.6 Experimental Production of Anaemia in Goats

4.6.1 Nutritional anaemia

4.6.1.1 Preperation of experimental animals

To bring all the experimental goats of groups of A,B,& C to the normal status they were treated with anthelmintic drugs after examination of fecal samples which were found positive for Haemonchus sp. strongyles sp. and were toned up with administration of systemic preparation of iron along with trace elements, (iron, copper and cobalt) supplementation in concentrate feed. Experimental goats of gr. A were kept as healthy control whereas gr. B and gr. C were kept exclusively on grazing and browsing in the grazing area around, B.C.K.V.

4.6.1.2 Observation of clinical symptoms of anaemic goats

The clinical symptoms noticed were inappetance, weakness, pale conjunctivae. Body temperature varied from 102.0°F. Heart rate and Pulse rate were higher than normal in the range of 95-110/minutes, Body weight decreased to 6.10 ± 0.18 kg from 9.60 ± 0.50 kg. Throughout the present study all five goats of gr. A remained in perfect health. Their average heart, pulse & respiration rates per minute were recorded to be 60-65/ minute, 60-65/minute and 20-25/minute respectively.

Informations on the clinical symptoms in nutritional anaemia in goat were not available. The clinical symptoms of

anaemia observed in the experimental groups B and C which were kept exclusively on grazing and browsings simulated with the clinical symptoms of anaemia observed by Boddie (1969), Hungerford (1970) and Blood et al. (1982). Becker et al. (1965) observed anaemia poor growth and retarded production with low intake of iron, copper and cobalt with parasitism in cattle due to mineral malnutrition.

4.6.1.3 Haematological and Biochemical analysis

The normal values of different parameters of blood and serum of all the five healthy control goats of group A was presented in table 8 and 9 and Fig 1-6. These values served as control for gr. B and gr. C for the study of nutritional anaemia in goats.

Haematological changes :-

During the entire period of study (total 120 days) Hb, PCV, TEC and TLC remained almost steady with marginal fluctuations varying between 10.24 ± 0.15 to 11.26 ± 0.25 g%, 27.30 ± 0.33 to $29.60 \pm 0.58\%$, 8.46 ± 0.26 to 9.22 ± 0.31 million/cmm, 9.650 ± 262.87 to $11,400 \pm 151.22$ /cm of blood of goats of gr. A respectively.

As evidenced from table 8 DLC, MCV, MCH, and MCHC remained within the normal range during the entire period of study.

Table 8. Haematological values in healthy control goats of group 'A'

Days	Hb g%	PCV %	TEC 10 ⁶ /cmm	TLC 10 ³ /cmm	N %	L %	E %	B %	M %	MCV μ ³		MCH μg		MCHC %
										11	12	11	12	
1	2	3	4	5	6	7	8	9	10	11	12	13		
0	10.80 +0.32	27.80 +0.14	8.64 +0.39	11,400 +151.22	33.40 +0.81	56.20 +1.46	4.40 +0.37	0	5.40 +0.17	32.17 +0.85	12.52 +0.19	38.92 +0.36		
8	10.80 +0.23	28.40 +0.67	9.22 +0.31	11,200 +241.66	34.60 +0.34	58.40 +0.31	3.20 +0.21		4.00 +0.08	30.80 +0.52	11.71 +0.38	38.02 +0.11		
16	11.20 +0.16	29.60 +0.58	8.66 +0.24	10,810 +331.44	31.20 +0.24	59.20 +0.13	4.60 +0.30	0	4.90 +0.38	34.18 +0.13	12.93 +0.23	37.83 +0.28		
24	10.66 +0.25	27.20 +0.33	8.45 +0.28	10,090 +202.33	31.60 +0.11	58.20 +0.74	5.40 +0.76	0	4.20 +0.18	32.18 +0.44	12.68 +0.29	39.41 +0.61		
32	11.26 +0.20	28.40 +0.15	8.92 +0.40	11,800 +415.88	32.60 +0.16	58.40 +0.74	3.40 +0.35	0	5.60 +1.05	31.83 +1.16	12.57 +0.69	39.50 +0.88		
40	10.92 +0.18	28.40 +0.55	8.64 +0.29	11,210 +331.33	33.40 +0.87	56.20 +0.51	5.20 +0.54	0	5.80 +0.90	32.87 +0.33	12.61 +0.17	38.38 +0.44		
48	10.24 +0.15	27.60 +0.76	8.48 +0.20	11,110 +191.41	31.60 +0.83	62.20 +0.39	3.20 +0.89	0	2.60 +0.17	32.54 +0.21	12.07 +0.34	37.10 +0.31		
56	10.80 +0.20	28.80 +0.22	8.46 +0.26	9,650 +262.87	34.20 +0.81	58.60 +0.13	4.40 +0.08	0	3.20 +0.15	34.04 +1.23	12.86 +0.88	37.71 +0.55		
64	10.60 +0.26	28.50 +0.19	8.80 +0.16	10,780 +236.82	36.40 +0.33	52.40 +0.74	6.20 +0.55	0	4.80 +0.61	32.38 +0.54	12.13 +0.39	37.47 +0.21		
72	10.80 +0.11	28.60 +0.17	8.74 +0.04	10,570 +141.70	31.80 +0.44	60.20 +0.33	4.20 +0.17	0	4.00 +0.40	32.72 +0.17	12.40 +0.23	37.90 +0.14		

Contd....

Table 8 (Contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13
80	11.20 +0.21	29.20 +0.74	8.90 +0.34	11.150 +284.10	31.20 +0.22	59.80 +0.55	5.20 +0.76	0	4.20 +0.70	32.80 +0.48	12.46 +0.76	37.97 +0.74
88	10.80 +0.17	29.20 +0.50	8.50 +0.17	10.060 +143.19	31.60 +0.26	60.20 +0.30	3.80 +0.15	0	5.20 +0.14	34.35 +0.33	12.80 +0.50	37.12 +0.38
96	10.58 +0.10	28.60 +0.19	8.40 +0.28	10.600 +231.11	32.20 +0.74	58.80 +0.18	4.20 +0.44	0	4.60 +0.31	34.04 +0.71	12.54 +0.76	36.48 +0.15
104	10.76 +1.16	28.40 +0.33	9.07 +1.42	10.583 +157.35	31.60 +0.35	59.40 +0.43	4.40 +0.11	0	5.20 +0.20	31.31 +0.93	11.86 +0.30	37.88 +0.26
112	11.06 +0.93	27.60 +0.21	9.03 +0.96	10.790 +263.08	29.20 +0.26	62.60 +0.31	4.40 +0.17	0	4.40 +0.27	30.56 +0.69	12.24 +0.41	40.07 +0.81
116	11.20 +0.45	29.20 +0.12	9.21 +0.83	10.650 +211.42	32.60 +0.16	58.80 +0.23	4.20 +0.08	0	4.60 +0.11	31.70 +0.54	12.16 +0.17	38.35 +0.79
120	10.94 +0.67	28.20 +0.18	9.06 +0.61	10.625 +227.54	33.20 +0.29	57.20 +0.34	3.20 +0.15	0	6.20 +0.16	31.12 +0.37	12.09 +0.29	38.86 +0.62

Table 9. Biochemical values in healthy control goats of group A

Days	BGL (mg%)	TSP (g%)	Ca (mg%)	P (mg%)	SI (ug%)	SCu (ug%)	SCO (ug%)
1	2	3	4	5	6	7	8
0	58.57 +1.66	6.50 +0.11	10.20 +0.29	5.04 +0.27	176.40 +3.36	143.00 +4.05	32.58 +2.01
8	59.74 +2.22	7.13 +0.17	10.44 +0.24	4.36 +0.22	179.80 +3.21	137.44 +2.86	31.80 +1.88
16	62.38 +2.38	7.54 +0.26	11.36 +0.27	4.80 +0.39	171.45 +6.39	139.28 +2.25	31.64 +1.60
24	54.36 +3.21	6.92 +0.19	11.17 +0.23	6.12 +0.11	174.82 +10.28	129.50 +6.57	29.03 +2.65
32	55.79 +2.43	7.00 +0.15	11.08 +0.97	5.22 +0.23	166.20 +3.72	137.62 +6.95	29.35 +4.12
40	58.20 +2.63	7.42 +0.16	11.00 +0.13	5.69 +0.20	168.26 +11.56	140.25 +6.38	23.80 +2.78
48	58.49 +3.26	7.28 +0.14	10.76 +0.71	5.65 +0.17	177.31 +8.08	142.69 +7.18	32.72 +2.16
56	58.12 +2.66	7.22 +0.18	11.44 +0.51	5.44 +0.13	169.08 +7.74	131.28 +4.20	30.60 +1.84
64	56.52 +3.43	6.86 +0.23	10.77 +0.27	6.16 +0.11	176.85 +4.56	137.44 +8.42	26.35 +2.74

Contd....

Table 9 (Contd.....)

1	2	3	4	5	6	7	8
72	55.86 +2.91	7.08 +0.07	9.96 +0.18	4.75 +0.22	167.02 +6.84	139.60 +4.50	29.85 +3.81
80	57.16 +3.20	6.58 +0.06	10.52 +0.26	5.21 +0.18	178.44 +9.50	138.42 +4.47	25.00 +2.14
88	59.29 +3.68	6.70 +0.21	9.80 +0.74	4.76 +0.18	182.12 +14.22	142.34 +6.23	27.29 +2.02
96	59.20 +1.88	7.25 +0.29	9.41 +0.95	4.12 +0.14	179.39 +10.58	148.89 +3.91	27.66 +1.72
104	58.13 +3.29	7.29 +0.35	9.87 +0.13	5.45 +0.16	171.48 +4.60	150.04 +7.33	24.44 +4.12
112	60.55 +4.21	7.20 +0.67	10.20 +0.21	4.96 +0.11	172.20 +7.60	140.88 +3.56	30.15 +4.62
116	56.24 +2.89	7.20 +0.58	10.42 +0.02	4.28 +0.17	166.26 +11.29	137.76 +4.21	28.60 +3.89
120	57.69 +2.67	7.00 +0.21	10.12 +0.26	4.50 +0.13	173.80 +5.56	139.18 +7.22	31.52 +2.67

Iron content in liver $213.66 \pm 0.47 \mu\text{g/gm}$ (ppm)

Copper content in liver $127.54 \pm 0.26 \mu\text{g/gm}$ (ppm)

Cobalt content in liver $0.28 \pm 0.09 \mu\text{g/gm}$ (ppm)

The values of different parameters of all the experimental nutritional anaemic goats of group B and C was presented in table 11, 12, 14 and 15 and Fig 1 to 6.

The Hb level gr. B and gr. C dropped significantly ($P/0.05$) to 9.60 ± 0.54 g% and 9.80 ± 0.18 g% at 40 days and 32 days after the onset of experiment from the 0 day value of 11.22 ± 0.35 g% and 11.00 ± 0.18 g% of goats of group B and C respectively (Fig 1).

It further dropped significantly ($P/0.05$ and $/0.01$ respectively) to 7.20 ± 0.51 g% and 6.80 ± 0.80 of group B and C respectively at 120 days of the experiment (Fig 1).

The PCV level dropped significantly ($P/0.01$) at 40 days to $26.40 \pm 0.08\%$ of goats of gr. B from the 0-day value of 28.60 ± 0.45 and in goats of gr. C, the same decreased significantly ($P/0.01$) to $26.40 \pm 0.23\%$ from $29.20 \pm 0.56\%$ at 32 days of the experiment. The value further reduced significantly ($P/0.01$) to $20.00 \pm 0.23\%$ and $19.40 \pm 0.29\%$ of gr. B and gr. C respectively (Fig 1).

The TEC of gr. B dropped significantly ($P/0.01$) to 7.73 ± 0.25 million/cmm at 48 days of the experiment from the 0-day value of 9.21 ± 0.37 million/cmm. It further dropped significantly ($P/0.01$) to 6.02 ± 0.19 millions/cmm. In case of gr. C the level dropped significantly ($P/0.05$) to 8.12 ± 0.16 million/

1

cmm at 32 days of experiment from the 0 day value at 9.03 millions/cmm. It further reduced significantly ($P < 0.01$) to 5.98 ± 0.31 millions/cmm of blood (Fig 2).

The TLC and DLC varied insignificantly during the entire period of study in both the groups of B and C (Fig 2).

The value of MCV remained unaltered till the end of the experiment (120 days). The value of MCH of group B and group C dropped significantly ($P < 0.05$) to 11.62 ± 0.62 μg and 11.50 ± 0.19 at 120 days of the experiment from the 0 day value of 12.16 ± 0.16 μg and 12.18 ± 0.27 μg respectively (Fig 3).

The MCHC dropped significantly ($P < 0.01$) to $35.00 \pm 0.38\%$ and $35.46 \pm 0.31\%$ at 120 days from the 0-day value of $38.16 \pm 0.94\%$ and $39.00 \pm 0.71\%$ of group B and C respectively (Fig 3).

Literatures on the haematological changes in case of nutritional anaemia in goats were scarce for comparison with the values of the present study. However, Pandey (1980) produced nutritional anaemia experimentally in cowcalves by feeding wheat-straw and water exclusively. He observed significant drop of the haematological parameters (Hb, PCV, TEC, MCV, MCH and MCHC) which corroborated with the present study in goats.

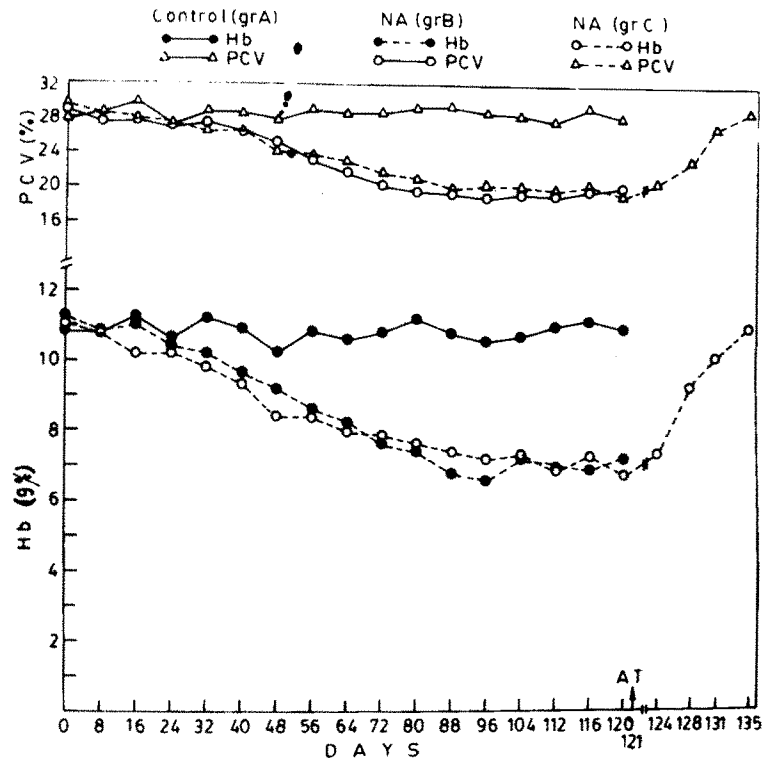


Fig 1 Haematological changes in respect of Hb and PCV of nutritional anaemic goats (NA). [AT=After treatment]

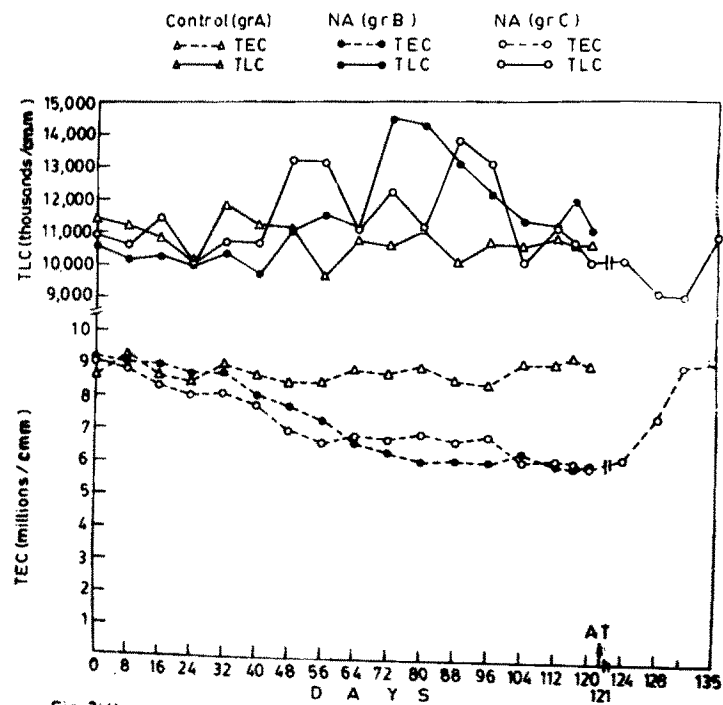


Fig 2: Haematological changes in respect to TEC and TLC of nutritional anaemic (NA) goats [AT=After treatment]

The drop of the values of the haematological parameters in the present study were in close similarity with the values of clinically anaemic goats of gr III (without parasitism)

Biochemical change :

During the entire period of study (120 days) BGL, TSP, SCA, Sp, SI, SCu and SCo remained almost steady with marginal fluctuations varying between 54.36 ± 3.21 mg% to 62.38 ± 2.38 mg%, 6.58 ± 0.06 g% to 7.54 ± 0.26 g%, 9.41 ± 0.95 mg% to 11.44 ± 0.51 mg%, 4.36 ± 0.22 mg% to 6.12 ± 0.11 mg%, 166.20 ± 3.72 μ g% to 182.12 ± 14.22 μ g%, 129.50 ± 6.57 μ g% to 148.89 ± 3.91 μ g% and 23.80 ± 2.78 μ g% to 32.72 ± 2.16 μ g%. respectively.

Blood glucose level of goats of gr B and gr C decreased significantly ($P \leq 0.05$) to 49.68 ± 3.29 mg% and 47.34 ± 0.89 mg% at 48 days and 72 days from the 0-day value of 62.20 ± 3.16 mg% and 55.09 ± 2.40 mg% respectively. It further dropped significantly ($P \leq 0.01$) to 46.61 ± 2.11 mg% in case of gr B whereas in gr C remained static till 120 days of the experiment. The TSP level decreased significantly ($P \leq 0.05$) to 5.88 ± 0.41 g% and 5.40 ± 0.70 g% at 120 days from the 0-day value of 6.92 ± 0.33 g% and 7.19 ± 0.27 g% of gr B and gr C respectively (Fig. 4).

There was no significant change in calcium and phosphorus level in serum throughout the period of experiment (Fig.5).

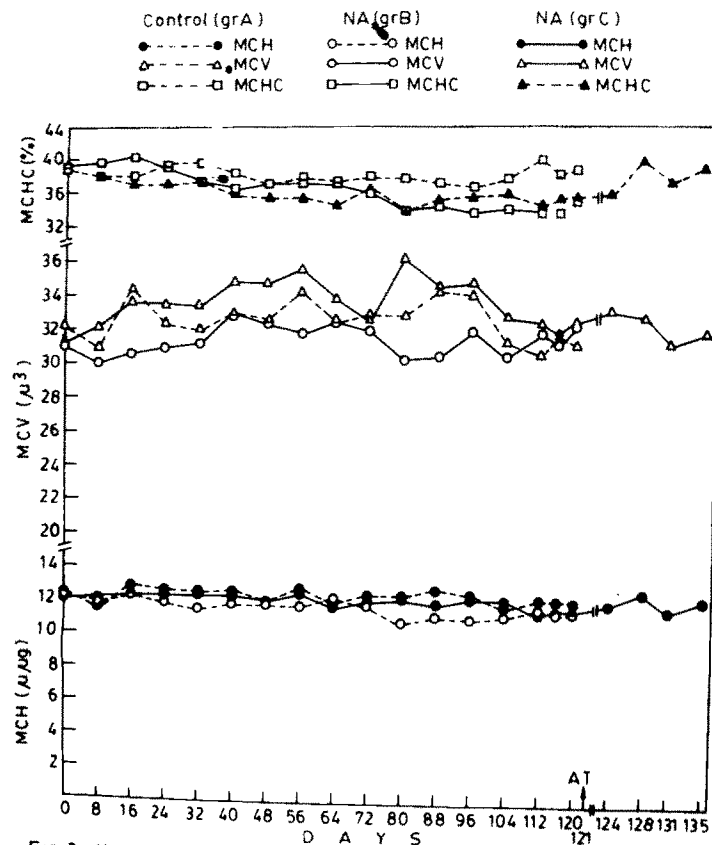


Fig 3 Haematological changes in respect to MCH, MCV and MCHC of nutritional anaemic goats (NA) [AT=After treatment]

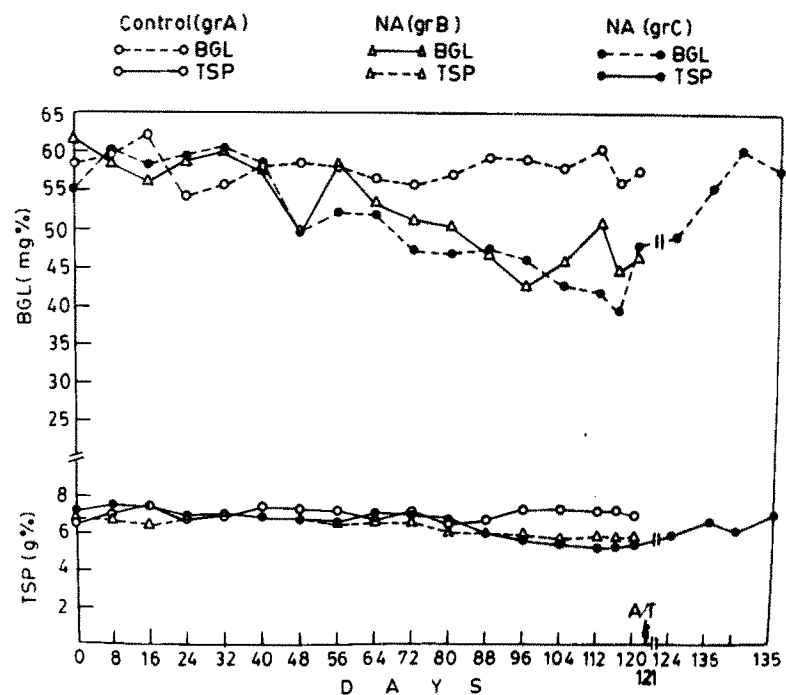


Fig 4: Biochemical changes in respect to BGL and TSP of nutritional anaemic (NA) goats of grB and grC [AT=After treatment]

The serum iron level dropped significantly ($P < 0.01$) to 147.62 ± 4.68 in gr. B at 56 days and further dropped significantly ($P < 0.01$) to 127.52 ± 2.87 at day 120 from the 0-day value of $178.71 \pm 7.38 \mu\text{g}\%$. In the case of gr. C the level decreased significantly ($P < 0.01$) to $105.25 \pm 3.92 \mu\text{g}\%$ at day 32 from the 0-day value of $182.38 \pm 4.12 \mu\text{g}\%$. It further dropped significantly ($P < 0.01$) to $107 \pm 5.68 \mu\text{g}\%$ at day 120 of the experiment. The analytical results showed significant decrease ($P < 0.01$) in copper content in serum (SCu) 125.41 ± 2.08 and 120.78 ± 4.11 at 56 days and then further significantly decrease ($P < 0.01$) at day 120 to $92.24 \pm 2.14 \mu\text{g}\%$ and $83.67 \pm 1.83 \mu\text{g}\%$ copper of goats of gr. B and gr. C from the 0-day value of $139.54 \pm 3.24 \mu\text{g}\%$ and $138.1 \pm 2.61 \mu\text{g}\%$ respectively (Fig 6).

The serum cobalt level shows from the 0-day value of $26.97 \pm 1.23 \mu\text{g}\%$ and $32.58 \pm 1.56 \mu\text{g}\%$ of gr. B and gr. C to $6.15 \pm 1.67 \mu\text{g}\%$ and $4.08 \pm 0.47 \mu\text{g}\%$ respectively at day 120 and it was found significant ($P < 0.1$) (Fig 6).

Literatures on the biochemical changes in BGL, TSP, Sca and Sp in nutritionally anaemic goats were not available for comparison with the results of the present study. Pandey (1980) experimentally produced nutritional anaemia in cow-calves by feeding exclusively with wheat straw and water and the values in cases of BGL, TSP and Sca dropped significantly

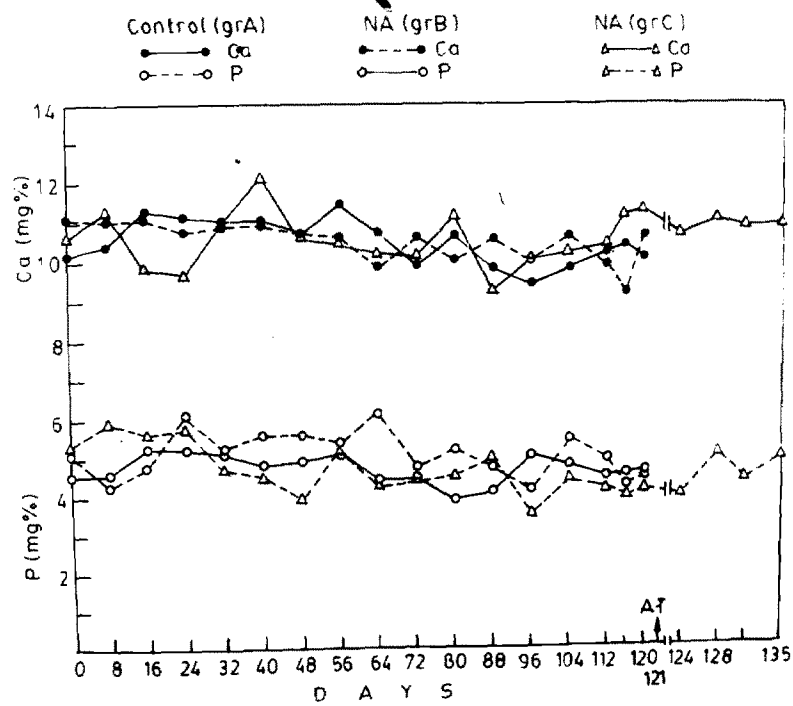


Fig. 5: Biochemical changes in respect to Ca and P of nutritional anaemic goats.(NA). [AT=After treatment]

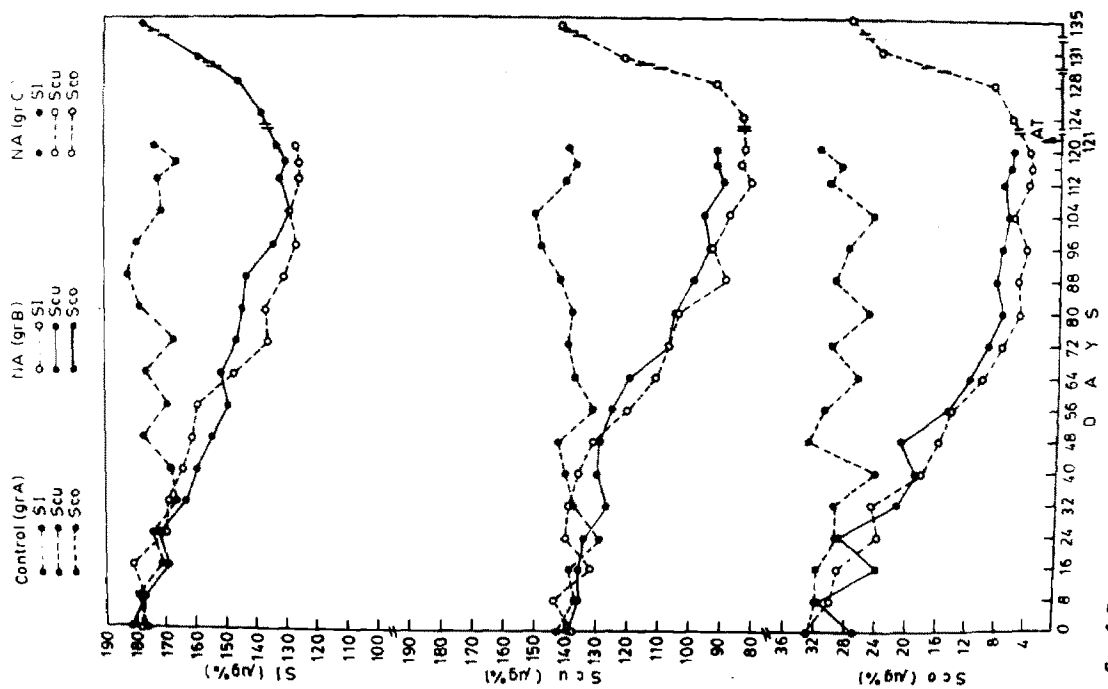


Fig. 6: Biochemical changes in respect to S.I., S.cu and S.co of nutritional anaemic (NA) goats [AT=After treatment]

which agreed with the results of the present study in nutritionally anaemic goats. However there was no fall in the values (BGL, TSP, Sca, SP) observed in clinically anaemic goats of gr.III of clinical cases in comparison with the values of the experimental cases of nutritional anaemic goats.

Fall in the value of iron and copper (compare to the healthy control gr.A) but not below the critical level was due to the maintenance of animals on restricted grazing and browsing. The present study in nutritional anaemic goats was similar to the value of copper obtained by Lemand (1985) in goats. Literatures on the status of iron and cobalt and further work on copper were scarce in the literature. Pandey (1980) while conducting experimental studies in nutritional anaemia in calves observed fall of iron and copper status of the serum of anaemic goats.

According to Andrews (1956), Underwood (1977) and Hansard (1983) young growing were the most sensitive of all animals to cobalt deficiency next were mature sheep, calves and cows in order. McDowell et al. (1983 and 1984) reported that cobalt deficiency occurs in large areas of many countries and is largely, but not exclusively, restricted to grazing ruminants which have little or no access to concentrates. With the exception of P, Cu, and Co deficiency is the most severe mineral limitation to grazing livestock in tropical countries.

Visual manifestation of cobalt deficiency were not specific and similar to those found in malnutrition due to low in-take of energy and protein. Animals on cobalt deficient pasture gradually showed loss of appetite, failure of growth or loss of weight followed by extreme loss of appetite, rapid muscular wasting, depraved appetite, severe anaemia and death. In cases of mild or marginal deficiency the above clinical signs might never occur and only the most susceptible animals could exhibit with signs of unthriftiness indistinguishable from the effects of parasitism or low feed in take. Mild forms of cobalt deficiency in grazing ruminants were difficult to diagnose on the basis of clinical and pathological signs because only the indications might be symptoms of unthriftiness without anaemia. Cobalt sub-deficiencies or borderline states are extremely common and are characterised by low production rates unaccompanied by clinical manifestations or visible signs. Sub-deficiencies of Co often go unnoticed, thereby resulting in great economic losses to the ruminant livestock industry. Co deficient animals respond quickly to Co treatment restoring appetite vigour and weight gain.

Cobalt is a dietary essential for ruminants and is needed in the bacterial synthesis of Vit B₁₂ in the rumen. The Vit B₁₂, a redish compound possessing a Co containing a tetrapyrrolic ring which is required for maturation of r.b.c. Cobalt deficiency interferes the synthesis of DNA and cell

replication through its precursor thymidylic acid (Schilling, 1953). In the present study cobalt deficiency in the diet might be the cause of low level of Fe & Cu in serum in experimental nutritional anaemic goats in comparison to healthy control goats albeit the natural feed stuffs contained the required amount of iron. Movsium (1986) concluded that for healing and preventing hypocobaltosis it is essential to use not only cobalt but also iron, copper and a preparation of protein and vitamin.

4.6.1.4 Estimation of Myeloid : Erythroid (M:E ratio) in the bone marrow of control and nutritional anaemic goats

The details of the results of evaluation of bone marrow with respect to cellularity, M:E ratio and haemopoiesis was presented in table 10, 13 and 16. The salient features of the study indicated that the marrow cytology of all the five goats of control gr. A remained almost unchanged. The M:E ratio was 2:1 with normal erythropoiesis and marrow cellularity (Fig. 7 and 8).

In experimental nutritional anaemic goats of gr.B and gr.C which were kept exclusively on grazing and browsing for a period of 120 days, bone marrow cytology remained unchanged upto first 48 to 64 days. Thereafter, erythropoiesis and

Table 10. Bone marrow cytology of healthy control goats of group A

Days	0	16	32	48	64	80	96	112	120
Cellularity	N	N	N	N	N	N	N	N	N
M:E ratio	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1	2:1
Erythropoe- sis	EN	EN	EN	EN	EN	EN	EN	EN	EN

Cellularity (Cellular marrow) - N = (Normal)

Erythropoiesis - EN = (Erythropoiesis normal)

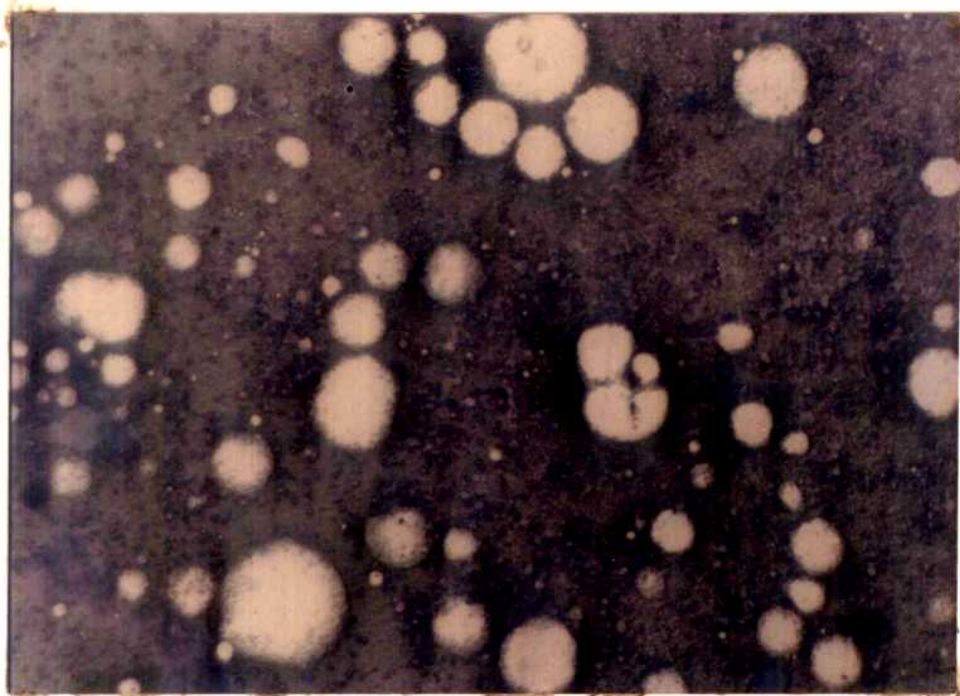


Fig. 7. Bone marrow smear of normal control goat showing M:E ratio 2:1. Leishman's Stain X 80.

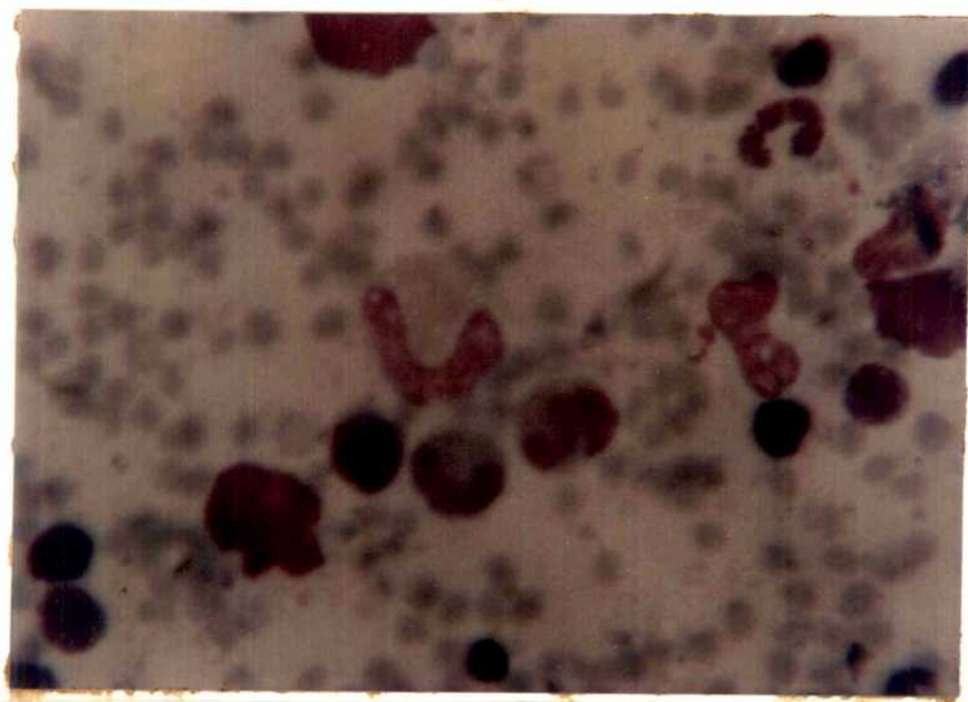


Fig. 8. Marrow smear of control normal goat (gr.A) showing distinct metamyelocyte and a few normoblast. Leishman's Stain X 800.

Table 11. Haematological changes in experimental nutritional anaemic goats of group B (untreated group)

Days	Hb g%	PCV %	TEC $10^6/\text{cmm}$	TLC $10^3/\text{cmm}$	N			L			E			B			M			MCV μ^3			MCH μg			MCHC %		
					6			7			8			9			10			11			12			13		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
0	11.22 ± 0.35	28.60 ± 0.45	9.21 ± 0.37	10,593 ± 331.26	30.80 ± 1.66	60.40 ± 0.47	4.40 ± 0.08	0	5.20 ± 0.11	31.05 ± 0.51	12.16 ± 0.16	38.16 ± 0.94																
8	10.88 ± 0.68	27.40 ± 0.92	9.09 ± 0.09	10,110 ± 592.77	29.40 ± 2.13	58.40 ± 0.32	6.20 ± 0.13	0	4.40 ± 0.17	30.14 ± 0.47	11.96 ± 0.08	39.70 ± 0.81																
16	11.00 ± 0.40	27.40 ± 0.88	8.93 ± 0.41	10,260 ± 122.59	30.40 ± 1.51	63.20 ± 0.15	5.40 ± 0.31	0	2.20 ± 0.32	30.68 ± 0.26	12.31 ± 0.13	40.14 ± 0.59																
24	10.42 ± 0.12	26.80 ± 0.14	8.67 ± 0.26	10,030 ± 209.21	30.60 ± 0.89	56.60 ± 0.81	6.60 ± 0.44	0	7.20 ± 0.41	30.91 ± 0.20	12.08 ± 0.79	39.10 ± 0.63																
32	10.20 ± 0.23	27.20 ± 0.71	8.73 ± 0.59	10,300 ± 157.42	31.20 ± 0.85	57.40 ± 0.27	3.20 ± 0.23	0	7.40 ± 0.57	31.15 ± 0.17	11.68 ± 0.27	37.50 ± 0.17																
40	9.60 ± 0.54	26.40 ± 0.08	8.03 ± 0.64	9,710 ± 283.39	31.40 ± 0.67	60.20 ± 0.30	3.20 ± 0.15	0	5.60 ± 0.27	32.87 ± 0.11	11.98 ± 0.42	36.43 ± 1.08																
48	9.24 ± 0.27	25.00 ± 0.21	7.73 ± 0.25	11,070 ± 281.27	31.80 ± 1.21	60.20 ± 0.43	3.80 ± 0.45	0	5.60 ± 0.21	32.34 ± 0.46	11.90 ± 0.47	36.80 ± 0.53																
56	8.60 ± 0.77	23.20 ± 0.41	7.31 ± 0.28	11,523 ± 510.58	34.80 ± 1.26	53.80 ± 0.17	4.20 ± 0.51	0	7.80 ± 0.13	31.73 ± 0.32	11.81 ± 0.31	37.24 ± 0.17																
64	8.22 ± 0.15	21.60 ± 0.77	6.67 ± 0.35	11,140 ± 237.64	28.60 ± 0.64	60.20 ± 0.32	5.20 ± 0.20	0	6.20 ± 0.22	32.38 ± 0.42	12.29 ± 0.19	36.96 ± 0.29																
72	7.60 ± 0.29	20.20 ± 0.15	6.32 ± 0.44	14,463 ± 211.44	38.00 ± 1.54	56.20 ± 0.83	4.00 ± 0.17		2.40 ± 0.17	31.96 ± 0.15	12.15 ± 0.23	36.01 ± 0.57																

Table 11 (Contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13
80	7.40 ±0.33	19.60 ±0.11	6.08 ±0.62	14,273 ±340.92	38.20 ±0.81	50.40 ±0.49	4.20 ±0.19	0	6.40 ±0.16	30.23 ±0.26	10.92 ±0.14	33.87 ±0.51
88	6.88 ±0.22	19.20 ±0.13	6.11 ±0.47	13,050 ±263.39	30.60 ±0.87	63.60 ±0.33	4.40 ±0.31	0	2.80 ±0.21	30.44 ±0.61	11.20 ±0.22	34.55 ±0.37
96	6.60 ±0.31	18.80 ±0.23	6.01 ±0.40	12,110 ±153.82	31.40 ±0.97	57.20 ±0.41	4.60 ±0.40	0	6.20 ±0.27	31.94 ±0.12	11.11 ±0.27	33.79 ±0.56
104	7.22 ±0.59	19.20 ±0.30	6.31 ±0.14	11,330 ±139.29	31.20 ±0.23	60.40 ±0.49	3.20 ±0.51	0	5.60 ±0.34	30.42 ±0.47	11.31 ±0.39	34.18 ±0.87
112	7.02 ±0.18	19.00 ±0.19	5.97 ±0.21	11,183 ±243.51	31.60 ±0.41	58.20 ±0.35	4.40 ±0.32	0	6.20 ±0.60	31.82 ±0.71	11.75 ±0.19	33.94 ±0.99
116	6.94 ±0.45	19.60 ±0.11	5.92 ±0.39	11,990 ±361.72	28.60 ±0.29	64.20 ±0.25	3.20 ±0.25	0	4.20 ±0.32	31.10 ±0.54	11.55 ±0.42	33.69 ±0.46
120	7.20 [†] ±0.51	20.00 ^{††} ±0.23	6.02 ^{††} ±0.19	11,110 ±418.22	32.20 ±0.22	58.40 ±0.16	3.40 ±0.43	0	6.40 ±0.16	32.22 ±0.66	11.62 [†] ±0.62	35.00 ^{††} ±0.38

* P / 0.05

** P / 0.01

Table 12. Biochemical changes in nutritional anaemic goats of group B
(untreated group)

Days	BGL mg%	TSP g%	Ca mg%	P mg%	SI μg%	SCu μg%	SCo μg%
1	2	3	4	5	6	7	8
0	62.20 ±3.16	6.92 ±0.33	11.10 ±0.45	4.63 ±0.36	178.71 ±7.38	139.54 ±3.24	26.97 ±1.23
8	58.79 ±2.94	6.81 ±0.56	11.08 ±0.67	4.59 ±0.28	177.25 ±5.59	136.35 ±3.61	31.40 ±2.45
16	56.26 ±2.86	6.52 ±0.17	11.12 ±0.81	5.29 ±0.33	181.34 ±4.21	136.58 ±2.11	23.85 ±2.41
24	59.37 ±2.55	6.96 ±0.37	10.80 ±0.35	5.27 ±0.41	170.17 ±9.40	134.95 ±4.17	28.62 ±3.62
32	60.17 ±2.44	7.11 ±0.59	10.92 ±0.43	5.13 ±0.16	169.28 ±6.66	127.36 ±4.29	21.05 ±1.22
40	57.32 ±1.87	6.97 ±0.39	10.94 ±0.21	4.84 ±0.15	164.72 ±5.41	130.53 ±2.68	18.72 ±1.95
48	49.68 ±3.29	6.86 ±0.27	10.76 ±0.23	4.92 ±0.31	161.39 ±3.83	129.47 ±5.36	20.56 ±1.67
56	58.33 ±1.85	6.57 ±0.15	10.59 ±0.51	5.10 ±0.19	159.08 ±5.17	125.41 ±2.08	14.38 ±2.51
64	53.40 ±2.08	6.63 ±0.19	9.88 ±0.74	4.40 ±0.36	147.82 ±4.68	119.73 ±3.11	11.63 ±2.32
72	51.25 ±2.61	6.67 ±2.06	10.60 ±0.46	4.47 ±0.23	136.64 ±6.12	107.88 ±2.77	9.37 ±1.61

Contd...

Table 12 (Contd.....)

1	2	3	4	5	6	7	8
80	50.64 +3.92	6.18 +0.14	10.05 +0.31	3.90 +0.21	137.72 +4.11	105.47 +1.21	7.69 +2.37
88	46.92 +1.63	6.08 +0.21	10.53 +0.17	4.14 +0.11	131.54 +5.66	99.47 +2.21	8.40 +2.68
96	42.71 +0.97	5.98 +0.12	10.00 +0.32	5.02 +0.17	127.30 +3.61	94.38 +3.15	7.60 +2.21
104	45.87 +2.04	5.76 +0.37	10.60 +0.61	4.87 +0.13	129.51 +4.20	96.38 +2.07	6.81 +1.85
112	51.08 +2.97	5.92 +0.29	9.90 +0.69	4.56 +0.17	126.75 +3.71	90.47 +1.96	7.45 +1.45
116	44.61 +3.68	5.83 +0.17	9.20 +0.35	4.50 +0.23	126.32 +3.98	92.35 +2.14	6.53 +2.08
120	46.61 [†]	5.88 [†]	10.67	4.63	127.52 [†]	92.24 [†]	6.15 [†]

* P /0.05; ** P/0.01

Iron content in liver : 148.60 ± 0.31 µg/gm (ppm)

Copper content in liver: 88.33 ± 0.17 µg/gm (ppm)

Cobalt content in liver: 0.11 ± 0.08 µg/gm (ppm)

Table 13. Bone marrow cytology of experimental nutritional anaemic goats of group B

Days	0	16	32	48	64	80	96	112	120
Cellularity	N	N	N	N	I	I	I	I	I
M:E ratio	2:1	2:1	2:1	2:1	1:2	1:2	1:2	1:2	1:2
Erythropoiesis	EN	EN	EN	EN	EI	EI	EI	EI	EI

N = Normal

I = Increased

EN = Erythropoiesis normal

EI = Erythropoiesis increased

Table 14. Haematological changes in experimental nutritional anaemic goats of group C (treated group)

Days	Hb (g%)	PCV (%)	TEC (10 ⁶ /cmm)	TLC (10 ³ /cmm)	N (%)	L (%)	E (%)	B (%)	M (%)	MCV u ³	MCH u/g	MCHC (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
0	11.00 +0.18 _	29.20 +0.56 _	9.03 +0.31 _	10,900 +261.34 _	31.90 +0.76 _	59.40 +0.55 _	5.20 +0.34 _	0	4.20 +0.11 _	31.22 +0.17 _	12.18 +0.27 _	39.00 +0.71 _
8	10.80 +0.34 _	28.40 +0.74 _	8.84 +0.39 _	10,590 +156.44 _	31.20 +0.51 _	62.00 +0.33 _	3.40 +0.17 _	0	3.60 +0.08 _	32.12 +0.22 _	12.21 +0.31 _	38.02 +0.63 _
16	10.26 +0.25 _	27.80 +0.31 _	8.29 +0.34 _	11,400 +231.54 _	34.60 +0.77 _	56.20 +0.89 _	3.80 +0.31 _	0	5.40 +1.20 _	33.53 +0.41 _	12.44 +0.41 _	37.12 +0.51 _
24	10.20 +0.33 _	27.40 +1.16 _	8.08 +0.28 _	10,090 +350.31 _	32.80 +0.45 _	58.40 +0.14 _	5.40 +0.76 _	0	3.60 +0.33 _	33.41 +0.14 _	12.37 +0.11 _	37.03 +0.40 _
32	9.80 +0.18 _	26.40 +0.23 _	8.12 +0.16 _	10,760 +242.50 _	31.20 +0.17 _	58.60 +0.54 _	4.60 +0.50 _	0	5.20 +0.44 _	33.33 +0.19 _	12.47 +0.42 _	37.42 +0.17 _
40	9.34 +0.30 _	26.40 +0.23 _	7.72 +0.11 _	10,650 +267.74 _	31.60 +0.28 _	60.20 +0.40 _	5.20 +0.17 _	0	3.80 +0.19 _	34.84 +0.33 _	12.47 +0.32 _	35.80 +0.44 _
48	8.40 +0.26 _	24.20 +0.11 _	6.97 +0.26 _	13,200 +359.76 _	36.20 +0.51 _	52.80 +0.44 _	6.40 +0.54 _	0	4.90 +0.26 _	34.72 +0.35 _	12.28 +0.15 _	35.37 +0.47 _
56	8.44 +0.31 _	23.60 +0.14 _	6.64 +0.15 _	13,120 +227.77 _	35.60 +0.20 _	58.20 +0.76 _	4.40 +0.55 _	0	2.70 +0.44 _	35.54 +0.23 _	12.65 +0.20 _	35.59 +0.13 _
64	8.00 +0.29 _	23.00 +0.08 _	6.80 +0.17 _	11,110 +265.54 _	33.20 +0.41 _	57.60 +0.22 _	3.80 +0.77 _	0	5.80 +0.11 _	33.82 +0.29 _	11.76 +0.22 _	34.78 +0.17 _
72	7.88 +0.23 _	21.60 +0.27 _	6.72 +0.25 _	12,270 +321.74 _	30.20 +0.94 _	62.40 +0.31 _	3.20 +0.26 _	0	4.20 +0.21 _	32.62 +0.26 _	12.02 +0.09 _	36.85 +0.36 _

Contd..

Table 14 (Contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13
80	7.66 ±0.22	21.20 ±0.51	6.89 ±0.21	11.150 ±346.21	28.60 ±0.88	62.20 ±0.66	3.40 ±0.28	0	6.00 ±0.53	36.12 ±0.14	12.21 ±0.21	33.81 ±0.23
88	7.42 ±0.31	19.80 ±0.23	6.73 ±0.09	13.800 ±224.50	37.20 ±0.32	50.60 ±0.22	6.20 ±0.10	0	6.20 ±0.15	34.55 ±0.18	11.93 ±0.04	35.54 ±0.21
96	7.20 ±0.25	20.20 ±0.45	6.82 ±0.24	13.090 ±209.08	28.20 ±0.74	64.20 ±0.43	5.40 ±0.27	0	2.80 ±0.64	34.70 ±0.34	12.37 ±0.12	35.64 ±0.29
104	7.30 ±0.44	20.00 ±0.77	6.09 ±0.43	10.110 ±153.21	33.20 ±0.33	56.20 ±0.53	4.20 ±0.11	0	6.20 ±0.27	32.84 ±0.41	12.01 ±0.19	35.60 ±0.61
112	6.96 ±0.23	19.80 ±0.61	6.11 ±0.26	11.163 ±273.46	29.60 ±0.29	63.20 ±0.39	3.60 ±0.19	0	4.60 ±0.33	32.40 ±0.47	11.39 ±0.24	35.15 ±0.57
116	7.28 ±0.64	20.20 ±0.83	6.03 ±0.50	10.755 ±306.15	30.20 ±0.41	62.40 ±0.23	3.20 ±0.27	0	4.70 ±0.11	31.84 ±0.16	11.64 ±0.15	35.76 ±0.26
120	6.80 ±0.80	19.40 ±0.29	5.88 ±0.31	10.147 ±193.24	32.40 ±0.16	60.20 ±0.17	2.40 ±0.35	0	5.20 ±0.17	32.44 ±0.81	11.50 ±0.19	35.46 ±0.31

* P / 0.05

** P / 0.01

Table 15. Biochemical changes in experimental nutritional anaemic goats of group C
(treated group)

Days	BGL (mg%)	TSP (g%)	Ca (mg%)	P (mg%)	SI (ug%)	SCu (ug%)	SCO (ug%)
1	2	3	4	5	6	7	8
0	55.09 +2.40	7.19 +0.27	10.70 +0.16	5.39 +0.12	182.38 +6.20	138.16 +2.61	32.58 +1.56
8	60.15 +4.27	7.54 +0.24	11.28 +0.23	5.90 +0.35	177.71 +10.51	144.68 +5.40	30.15 +1.17
16	58.38 +3.07	7.39 +0.36	9.87 +0.11	5.74 +0.33	169.50 +4.56	132.25 +1.99	29.16 +0.89
24	59.25 +3.61	7.07 +0.21	9.67 +0.18	5.79 +0.38	172.47 +4.27	140.23 +2.76	23.80 +1.27
32	60.30 +3.25	7.12 +0.26	11.02 +0.35	4.75 +0.17	163.25 +3.92	139.16 +3.51	24.55 +2.22
40	57.88 +4.12	6.95 +0.27	12.13 +0.31	4.56 +0.23	159.98 +4.08	136.13 +3.29	18.01 +1.23
48	49.82 +2.38	6.88 +0.15	10.60 +0.21	3.90 +0.30	154.56 +6.35	131.17 +2.97	15.72 +0.87
56	52.36 +4.52	6.59 +0.21	10.44 +0.22	5.20 +0.34	149.22 +6.16	120.78 +4.11	14.33 +0.55
64	51.80 +0.97	7.07 +0.27	10.22 +0.28	4.28 +0.47	151.57 +2.54	111.40 +5.08	10.05 +1.32
72	47.34 +0.89	7.02 +0.29	10.62 +0.19	4.47 +0.23	146.42 +2.11	107.11 +3.37	7.61 +1.52

Contd...

Table 15 (Contd...)

1	2	3	4	5	6	7	8
80	47.14 ± 1.52	6.78 ± 0.31	11.15 ± 0.15	4.50 ± 0.11	144.29 ± 2.55	104.09 ± 2.59	5.38 ± 1.16
88	47.62 ± 3.08	6.12 ± 0.11	9.26 ± 0.31	4.90 ± 0.27	143.00 ± 6.87	89.31 ± 2.16	5.53 ± 0.77
96	46.11 ± 1.16	5.62 ± 0.18	10.08 ± 0.16	3.45 ± 0.37	134.21 ± 2.15	93.65 ± 5.11	4.49 ± 0.33
104	42.67 ± 2.88	5.46 ± 0.36	10.20 ± 0.09	4.46 ± 0.14	129.26 ± 5.29	88.00 ± 3.15	6.16 ± 0.88
112	41.90 ± 4.62	5.27 ± 0.68	10.40 ± 0.17	4.20 ± 0.13	132.25 ± 3.68	81.04 ± 2.68	4.31 ± 0.26
116	38.65 ± 2.10	5.28 ± 0.35	11.20 ± 0.15	3.96 ± 0.29	130.64 ± 2.61	84.12 ± 2.19	3.89 ± 0.29
120	48.15 ± 3.33	5.40 ± 0.70	11.28 ± 0.20	4.14 ± 0.17	133.57 ± 5.68	83.87 ± 1.83	4.88 ± 0.47

* P / 0.05

** P / 0.01

Table 16. Bone marrow cytology of experimental nutritional anaemic goat of group C

Days	0	16	32	48	64	80	96	112	120
Cellularity	N	N	N	N	I	I	I	I	I
M:E ratio	2:1	2:1	2:1	2:1	1:1	1:2	1:2	1:2	1:2
Erythropoiesis	EN	EN	EN	EN	EI	EI	EI	EI	EI

N = Normal,

I = Increased

EI = Erythropoiesis increased

EN = Erythropoiesis normal

cellularity started increasing and the M:E ratio was changed to 1:2 and 1:1 of gr. B and gr. C at 64 days from the 0-day ratio of 2:1 respectively (Fig 9-12).

Literatures on the changes in cellularity, erythropoiesis and M:E ratio in cases of nutritional anaemic goats were not available. However, Pandey and Misra (1983) observed decrease in the cellularity and erythropoiesis at the peak of anaemia in cow calves with nutritional anaemia. They further observed prominent myelopoiesis and active thrombopoiesis in their study. They concluded that a temporary suppression of erythropoietic activity of bone marrow occurred in nutritional anaemia due to malnutrition. In the present study in cases of nutritional anaemia in goats there was increase in the erythropoiesis, cellularity and change in the M:E ratio probably due to stress.

4.6.1.5 Histopathological changes in Nutritional Anaemic Goats

4.6.1.5.1 Macroscopic change :

Macroscopic changes noticed in all the sacrificed five goats of gr. B included mild degree of accumulation of fluid in serous cavities, pale liver, slightly enlarged heart, discoloration of the lungs and thin watery blood.

Schalm et al. (1972), Smith et al. (1972), Schalm et al. (1975) and Blood et al. (1983) observed similar changes in anaemic animals. Pandey (1980) while conducting experiments

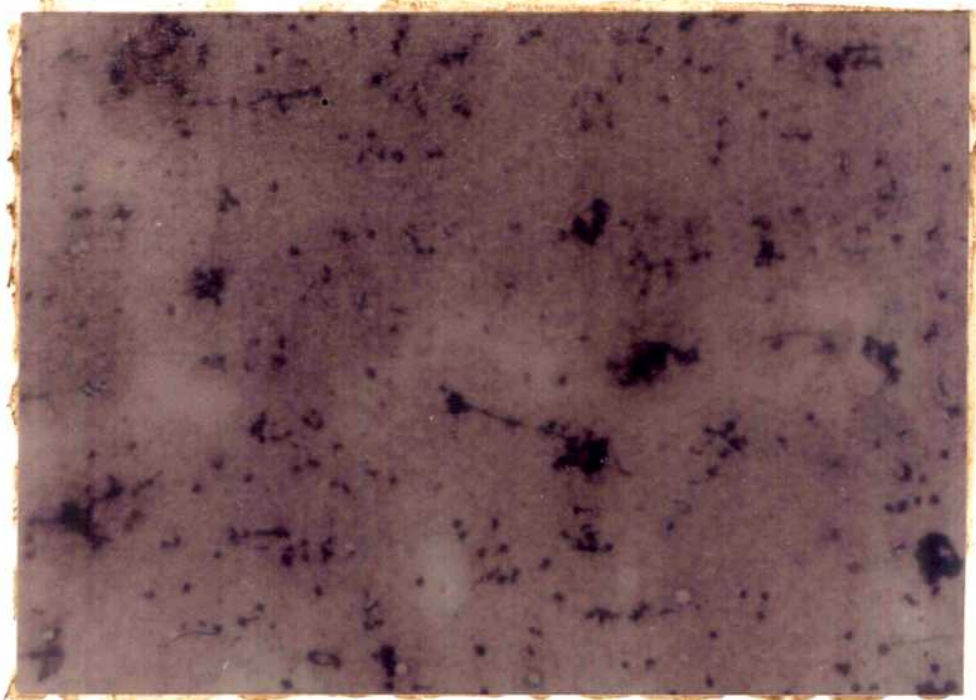


Fig. 9. Bone marrow smear of goat of nutritional anaemia showing hyperplastic marrow with sheets of normoblast. Leishman's Stain X 80.

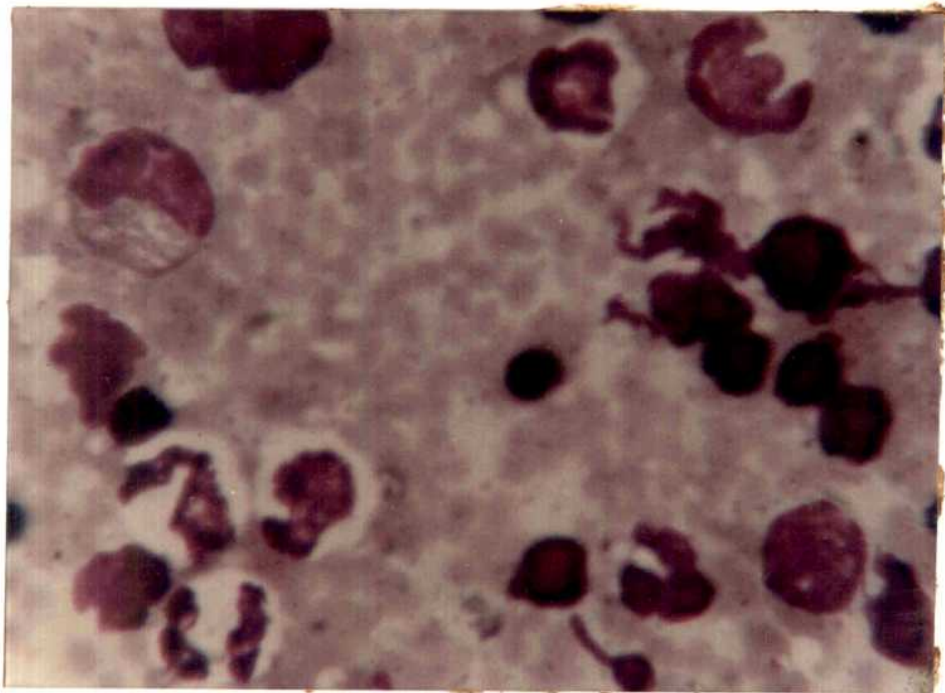


Fig. 10. Bone marrow smear of nutritional anaemic goat showing normoblastic reaction with a few myeloid series of cells. Leishman's Stain X 800.

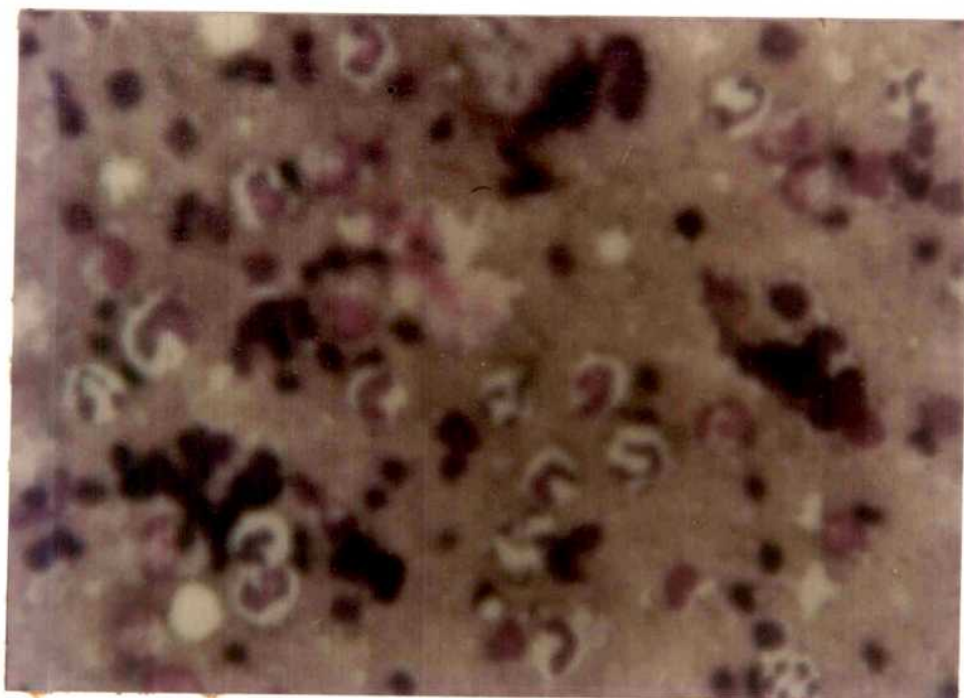


Fig. 11. Bone marrow smear of nutritional anaemic goat showing normoblastic reaction. Leishman's Stain X 360.

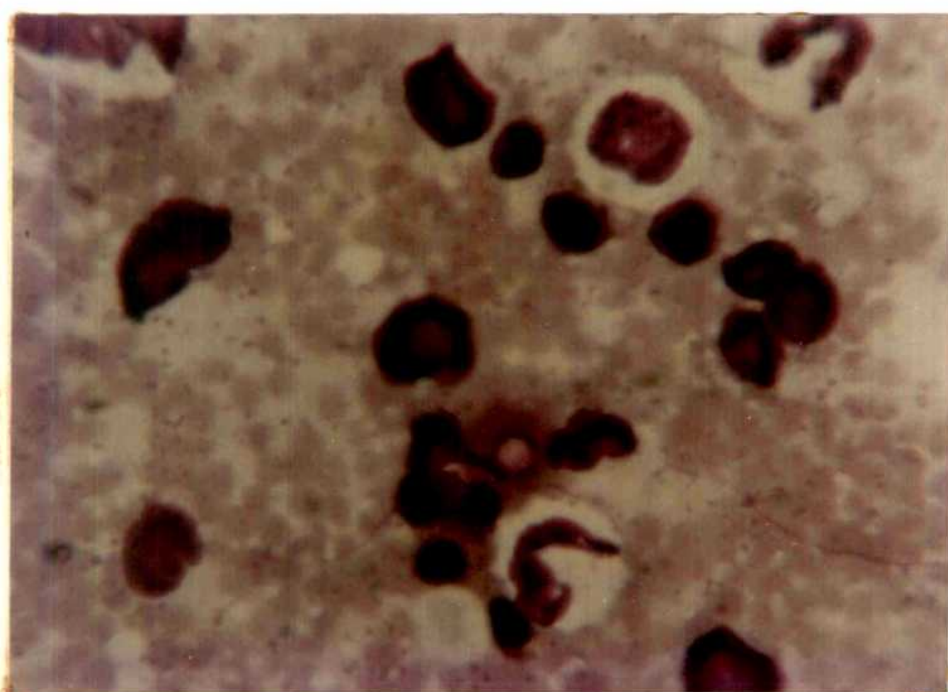


Fig. 12. Bone marrow smear of nutritional anaemic goat showing severe normoblastic reaction.
Leishman's Stain X 800.

on nutritional anaemia in calves observed similar changes with additional changes like gelatinous degeneration of the fat in the hilus of the kidneys, absence of subcutaneous fat and decreased intensity of the color of the sternal bone marrow because of severe anaemic condition in experimental animals which were fed exclusively with wheat straw and water. In the present study, since the experimental goats were kept exclusively on grazing on the local pasture land to study the effect of nutritional deficiency on grazing, the degree of anaemia observed in such goats was mild to severe.

4.6.1.5.2 Microscopic changes:

Microscopic changes of the internal organs like liver, spleen, heart and lungs were studied and the changes observed were as follows:

Liver: Vacuolar degeneration of hepatocytes with partial evidence of coagulation necrosis (Fig. 13).

Spleen: Necrosis of the lymphoid cells with ill-developed follicles and mild haemosiderosis (Fig. 14).

Heart: Oedematous change in the cardiac muscles with evidence of Zenker's degeneration (Fig. 15).

Lungs: There was no visible changes observed in the lungs.

There were two possibilities of degeneration leading to coagulation necrosis of parenchymatous organ was due to local ischaemia that was possibly initiated by inadequate Oxygen and

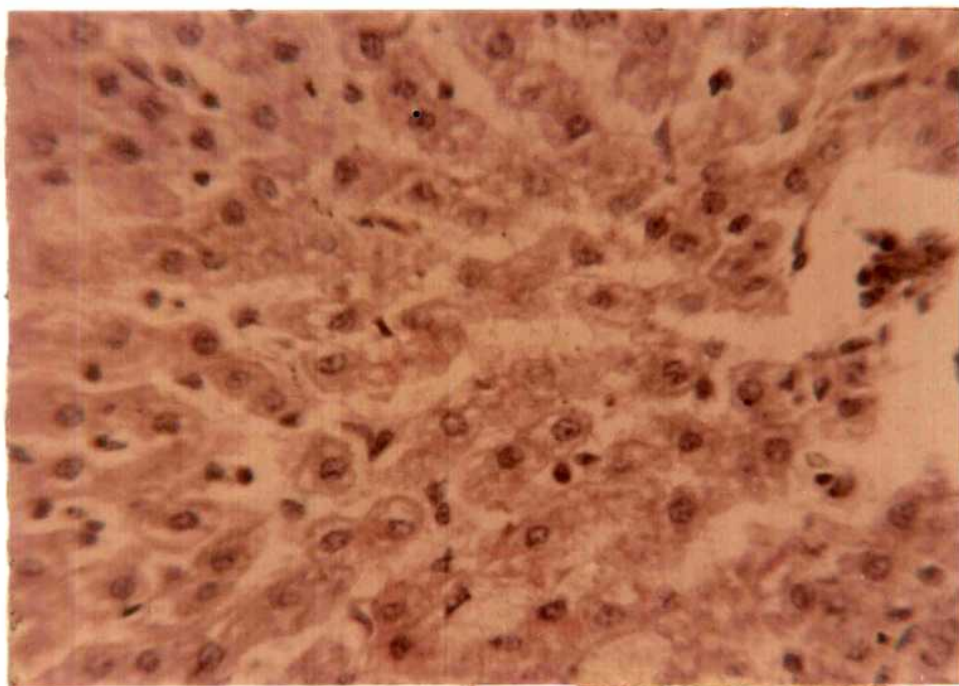


Fig. 13. Liver showing vacuolar degeneration of hepatocytes with partial evidence of coagulation H. & E. Stain X 400.

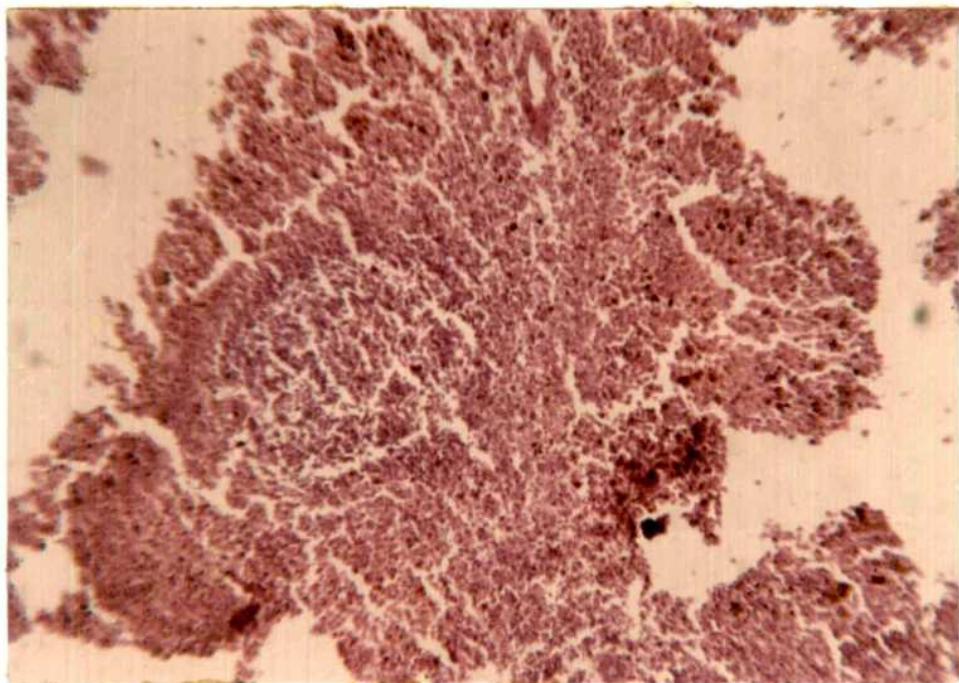


Fig. 14. Spleen depicting necrosis of lymphoid cells, ill developed follicles and mild haemosiderosis.
H. & E. Stain X 100.

nutrient of the tissues as a result of haemorrhages. The other factor was due to general anaemia in which supply of the essential nutrients were also inadequate. It is a fact that the haemosiderin pigment is accumulated in tissues of R.E. system of spleen when there is focal haemorrhage possibly resulting from anoxia. The Oedematous swelling observed in the cardiac muscle might be due to decreased of plasma colloid osmotic pressure resulting from protein deficiency as also confirmed in biochemical studies. The zenker's degeneration of cardiac muscle was possibly due to coagulation of protein of sarcoplasm as a result of anaemic anoxia.

Literatures on the microscopical changes in the internal organs of nutritional anaemic goats were untraceable. Pandey (1980) reported microscopical changes in the liver and spleen of calves in nutritional anaemia and the changes consisted of mild fatty degeneration of hepatocytes, portal fibrosis, haemosiderosis in the reticuloendothelial cells, and spleen showed moderate to severe degree of haemosiderosis. In the present study, moderate degree of haemosiderosis was also observed in the spleen.

4.6.1.6 Estimation of iron content of liver of nutritional anaemic goats

The results of the iron content of liver of the experimental nutritional anaemic groups of gr.A and gr.B were

tabulated in 9 and 12. The iron content of the liver of nutritional anaemic goats of gr.B dropped to 148.60 ± 0.31 $\mu\text{g/gm}$ from the normal value of 213.66 ± 0.47 $\mu\text{g/gm}$.

Literatures on the iron content of liver of nutritional anaemic goats were scarce. However, Pandey (1980) also observed decrease in iron content of liver of the nutritional anaemic calves.

4.6.1.7 Estimation of copper content of liver of nutritional anaemic goats

The result of the copper content of liver of the experimental nutritional anaemic goats of gr.A and gr.B were tabulated in table 9 and 12. The copper content of the liver of nutritional anaemic goats of gr.B dropped to 88.33 ± 0.17 $\mu\text{g/gm}$ from the normal value of 127.54 ± 0.26 $\mu\text{g/gm}$.

Literatures on the copper content of the liver of nutritional anaemic goats were scarce. Pandey (1980) observed decrease in copper content of liver of the nutritional anaemic calves.

4.6.1.8 Estimation of cobalt content of liver of nutritional anaemic goats

The results of cobalt content in liver of anaemic goats of gr.B dropped to 0.11 ± 0.08 $\mu\text{g/gm}$ from normal value of 0.28 ± 0.09 $\mu\text{g/gm}$ (Table 9 and 12).

Literature on the cobalt content of liver of nutritional anaemic goats were untraceable. McDowell et al. (1983) observed low level of cobalt in liver in ruminants grazing on cobalt deficient pastures.

Mild forms of cobalt deficiency in grazing ruminants are difficult to diagnose on the basis of clinical and pathological signs because the only indications may be a state of unthriftiness and without anaemia. Consequently, the only sure way of establishing that a cobalt deficiency is present is by observing and measuring the response following the administration of oral Co or Vitamin B₁₂ injections in terms of increased appetite and weight gain. Liver Co levels below 0.07 ppm on dry basis are indicative of low dietary Co levels. Pasture Co levels below 0.1 ppm on the dry basis will likely produce a deficiency in lambs and calves while prolonged access to pastures containing below 0.07 ppm of Co can be expected to produce a widespread disease (McDowell et al., 1983).

In the present study the cobalt content in liver of nutritional anaemic goats was low in comparison to healthy control goats ($0.28 \pm 0.09 \mu\text{g/gm}$).

4.6.1.9 Treatment of anaemic goats of nutritional anaemia

Treatment given to the nutritional anaemic goats of gr.C from day 121 for a period of 10 days proved very effective

in alleviating anaemia by day 135. The progress of the treatment at intervals after the start of the treatment was presented in table 17 and Fig. 1 to 6.

Haematological changes :

The Hb, PCV, TEC level increased significantly ($P < 0.05$, $P < 0.01$, $P < 0.05$ respectively) to 9.38 ± 0.15 g%, $20.60 \pm 0.17\%$ and 7.47 ± 0.33 millions/cmm at day 128, day 124 and day 128 from the starting day (day 121) value of 6.80 ± 0.80 g%, $19.40 \pm 0.29\%$ and 5.98 ± 0.31 millions/cmm of blood respectively. All the above values further increased significantly ($P < 0.01$) to 11.06 ± 0.21 g%, $29.00 \pm 0.13\%$ and 9.10 ± 0.24 millions/cmm at day 135 of the experiment (Fig. 1 and 2).

MCV and MCH values non-significantly increased and MCHC increased significantly ($P < 0.01$) to $38.93 \pm 0.31\%$ at day 135 of the experiment from the starting day (day 121) value of $35.46 \pm 0.31\%$.

TLC and DLC remained unaltered throughout the study.

Biochemical changes :

The results of the biochemical changes after treatment was presented in table 18.

Table 17. Haematological changes in experimental nutritional anaemic goats of group C
(post-treatment)

Days	HB g%	PCV %	TEC 10 ⁶ /cmm	TLC 10 ³ /cmm	N %	L %	E %	B %	M %	MCV μ ³	MCH μg	MCHC %
120	6.80 +0.80	19.40 +0.29	5.98 +0.31	10,147 +193.24	32.40 +0.16	60.20 +0.17	2.40 +0.35	0	5.20 +0.17	32.44 +0.81	11.50 +0.19	35.46 +0.31
121	T R E A T M E N T S T A R T E D											
124	7.40 +0.12	20.60 +0.17	6.21 +0.08	10,166 +250.34	30.20 +0.56	59.60 +0.37	3.20 +0.16	0	6.60 +0.21	33.02 +2.04	11.92 +0.53	35.97 +1.21
128	9.38 +0.15	23.20 +0.23	7.47 +0.33	9,170 +163.71	28.60 +0.18	61.20 +0.42	3.40 +0.20	0	7.20 +0.33	32.75 +0.97	12.55 +0.77	40.08 +0.39
131	10.24 +0.26	27.20 +0.16	8.97 +0.29	9,123 +208.42	31.20 +0.42	63.40 +0.31	2.60 +0.11	0	3.20 +0.15	31.29 +1.26	11.58 +1.17	37.50 +0.96
135	11.06 +0.21	29.00 +0.13	9.10 +0.24	10,963 +261.39	31.60 +0.19	57.20 +0.53	4.20 +0.14	0	7.40 +0.49	31.81 +0.85	12.15 +0.38	38.93 +0.31

* P / 0.05

** P / 0.01

Table 18. Biochemical changes of experimental nutritional anaemic goats of group C (post-treatment)

Days	BGL mg%	TSP g%	Ca mg%	P mg%	SI ug%	SCu ug%	SCo ug%
120	48.15 +3.33	5.40 +0.70	11.28 +0.20	4.14 +0.17	133.97 +5.68	83.67 +1.83	4.08 +0.47
121	T R E A T M E N T S T A R T E D - - - - -						
124	49.20 +3.14	5.92 +0.55	10.70 [*] +0.11	4.02 +0.31	138.90 +4.16	84.40 +2.26	6.35 +2.07
128	55.27 [*] +2.32	6.66 +0.24	11.02 +0.17	5.12 [*] +0.33	146.69 +5.39	92.51 [*] +2.71	9.04 +2.16
131	60.17 +2.11	6.13 +0.29	10.90 +0.14	4.40 +0.11	159.20 ^{**} +5.67	122.64 +4.18	23.61 ^{**} +2.19
135	57.24 ^{**} +2.60	6.90 +0.16	10.94 +0.23	4.90 [*] +0.15	177.69 ^{**} +7.28	142.11 [*] +3.56	27.42 ^{**} +2.13

* P < 0.05

** P < 0.01

Blood glucose increased significantly ($P < 0.01$) to 55.27 ± 2.32 mg% at day 128 from the starting day (day 121) value of 48.15 ± 3.33 mg%. It further increased nonsignificantly to 57.24 ± 2.60 at day 135 of the experiment. TSP level increased nonsignificantly to 6.90 ± 0.16 g% from the day 121 value of 5.40 ± 0.70 g%. The status of SI, SCu and SCo values increased significantly ($P < 0.01$, $P < 0.05$, $P < 0.01$ respectively) at day 131, 128 and 131 to 159.20 ± 5.67 μ g%, 92.51 ± 2.71 μ g% and 23.61 ± 2.19 μ g% from the starting day value of (day 121) 133.97 ± 5.68 μ g%, 83.67 ± 1.83 μ g% and 4.08 ± 0.47 μ g% respectively. All the above value increased significantly ($P < 0.01$) to 177.69 ± 7.28 μ g%, 142.11 ± 3.56 μ g% and 27.42 ± 2.13 μ g% at day 135 of the experiment (Fig. 4 and 6).

Bone marrow changes :

The results of the bone marrow cytology after treatment of anaemic goats of gr.C were presented in table 19 and Fig. 16. The M:E ratio of 1:2 changed to 2:1 at day 128 post-treatment. Erythropoiesis and cellularily became normal.

Literatures on the post-treatment effect of the treatment of nutritional anaemic goats were untraceable. However, Pandey (1980) conducted treatment of nutritional anaemic calves with blood transfusion along with parenteral and oral

Table 19. Bone marrow cytology of experimental nutritional anaemic goats of group C (post-treatment)

Days	120	124	128	131	135
Cellularity	I	I	N	N	N
M:E ratio	1:2	1:2	2:1	2:1	2:1
Erythropoiesis	EI	EI	EN	EN	EN

I = Increased

N = Normal

EI = Erythropoiesis increased

EN = Erythropoiesis normal



Fig. 15. Cardiac muscles showing oedema with Zenker's degeneration. H. & E. Stain X 100.



Fig. 16. Bone marrow smear of post-treatment effect of nutritional anaemic goat showing normal M:E ratio. Leishman's Stain X 360.

preparation of haematinics and observed similar improvement in haematological and biochemical profiles of blood as had been observed after the treatment of nutritional anaemic goats. Underwood and Filmer (1935), Kilham (1941), Marston (1970), Domanski (1972) and Pandey and Misra (1985) treated anaemia with cobalt salts with other haematinics with good results. Hibbs et al. (1963), Baustad and Tollerarud (1966), Tammemagie (1966), Ammerman et al. (1967), Getty et al. (1968), Schalm et al. (1975), Blood et al. (1983) and Pandey and Misra (1985) recorded the useful role of iron preparation in treating the cases of anaemia in ruminants. Klimov and Polyakov (1971) reported the usefulness of post-treatment of theileriosis cases in cattle with copper salts and obtained beneficial effect in alleviating anaemia, Movsium (1986) observed that for healing and preventing hypocobaltosis it was essential to use not only cobalt but also iron, copper and preparation of vitamins.

4.6.2 Chronic haemorrhagic anaemia

4.6.2.1 Preparation of experimental animals

Preparation of the experimental animals before the onset of the experiment was done as per the method described earlier as in case of nutritional anaemia.

4.6.2.2 Observation of clinical symptoms of anaemic goats

Body weight was decreased from 11.30 ± 0.43 to 5.70 ± 0.12 . There was marked increase in heart, pulse and respiration rates/minute in both the groups by the time attained peak of anaemia with their values as high as 120 - 130/minute, 120 - 130/minute, 32 - 35/minute respectively. Respiratory distress (inspiratory disпноic symptoms) and laboured breathing were observed. The anaemic goats became anorectic and weak. High rise of temperature was recorded at the peak of anaemia. The clinical manifestation observed in the present study corroborated with the observation of Blood et al. (1983) and Pandey and Misra (1986).

4.6.2.3 Haematological and biochemical analysis

Haematological changes :

The details of the results of analysis of experimental chronic haemorrhagic anaemia of gr.D and gr.E were given in table 20 and 23 and Fig. 17 to 22.

The values of Hb, PCV, TEC of gr.D dropped significantly ($P < 0.01$) to 9.22 ± 0.25 g%, $25.20 \pm 0.55\%$ and 7.92 ± 0.29 millions/cmm at day 16 after the onset of daily withdrawal of blood from the 0-day value of 11.44 ± 0.32 g%, $29.80 \pm 1.14\%$ and 9.21 ± 0.81 millions/cmm respectively (Fig. 17 and 18).

All the aforesaid values in order further dropped significantly ($P < 0.01$) to 3.96 ± 0.11 g%, $15.40 \pm 0.17\%$ and 4.40 ± 0.23 millions/cmm at day 74 of the experiment. Two animals out of five experimental animals died on day 73 and later one died on day 74 and the other two died on day 75 and 76 (Fig. 17 and 18).

TLC increased nonsignificantly to $13,263 \pm 344.27$ /cmm from the 0-day value of $11,162 \pm 239.33$. Neutrophils increased significantly ($P < 0.01$) to $53.80 \pm 0.31\%$ from $30.60 \pm 1.53\%$. Lymphocyte decreased significantly ($P < 0.01$) to $41.40 \pm 0.23\%$ from $59.30 \pm 1.77\%$. MCH and MCHC dropped significantly ($P < 0.01$) to 10.00 ± 0.21 μ g and $24.52 \pm 0.31\%$ from the 0-day value of 12.42 ± 0.52 μ g and $39.28 \pm 0.94\%$ respectively (Fig. 19). Reticulocytes increased significantly ($P < 0.01$) to $24.40 \pm 0.23\%$.

The values of Hb, PCV of gr.E reduced significantly ($P < 0.01$) to 8.88 ± 0.76 g% and $23.60 \pm 0.29\%$ at day 16 after the onset of the experiment from the 0-day value of 11.60 ± 0.31 g% and $29.20 \pm 0.50\%$ respectively. All the above values further dropped significantly ($P < 0.01$) to 4.02 ± 0.07 g% and $16.20 \pm 0.13\%$ at day 72 of the experiment. The TEC dropped significantly ($P < 0.01$) to 6.12 ± 0.21 at 49 days of the experiment from the 0-day value of 9.64 ± 1.15 millions/cmm. The value further dropped significantly ($P < 0.01$) to $4.56 \pm$

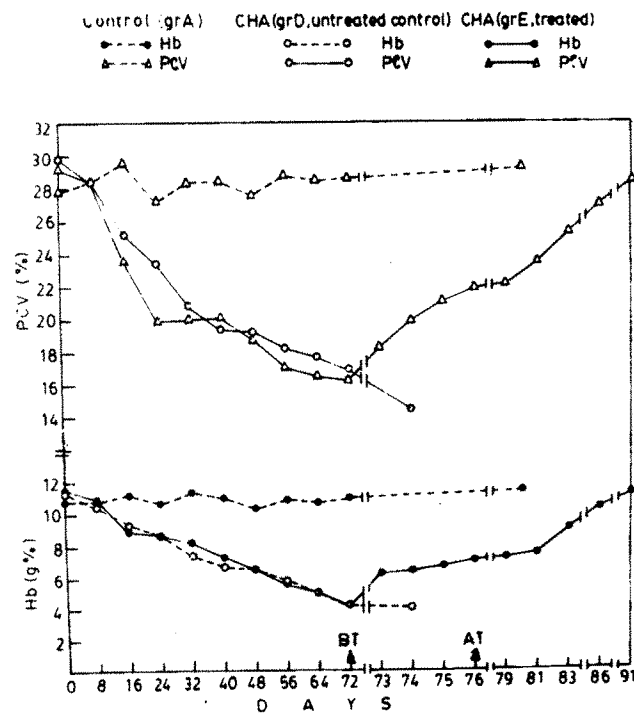


Fig 17: Haematological changes with respect to Hb and PCV in chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect (BT=Blood transfusion, AT=After treatment)

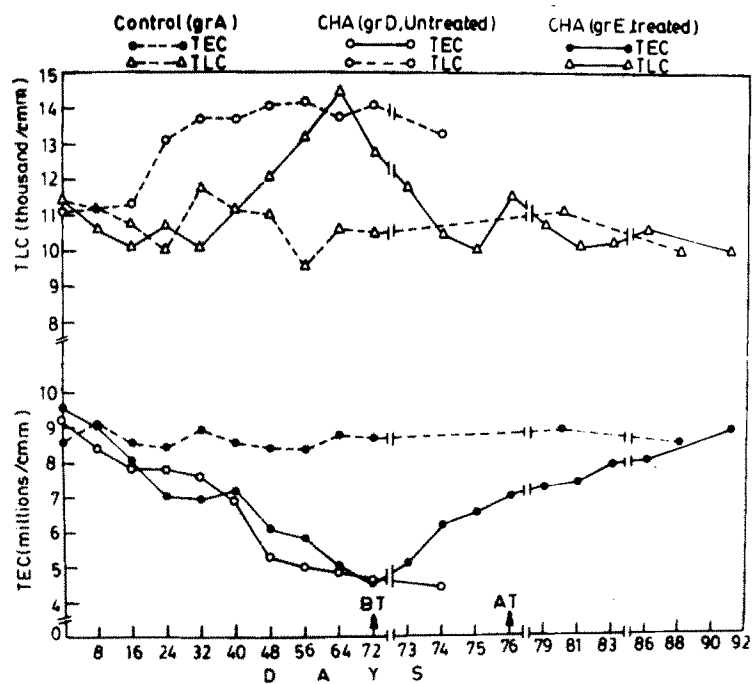


Fig 18: Haematological changes with respect to TEC and TLC in chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect. [BT=Blood transfusion; AT=After treatment]

0.37 millions/cmm at day 72 of the experiment. The TLC increased significantly ($P < 0.01$) to $12,790 \pm 369.72/\text{cmm}$ from the 0-day value of $11,382 \pm 133.47/\text{cmm}$. Neutrophils increased significantly ($P < 0.01$) to $49.20 \pm 0.15\%$ from the 0-day value of $30.60 \pm 0.41\%$. Lymphocytes decreased significantly ($P < 0.05$) to $46.20 \pm 0.22\%$ from the 0-day value of 58.50 ± 0.29 . MCV increased significantly ($P < 0.01$) to $36.12 \pm 0.67/\mu^3$ from $30.29 \pm 0.43/\mu^3$, MCH and MCHC dropped significantly ($P < 0.01$) to $9.19 \pm 0.21/\mu\text{ug}$ and $25.94 \pm 0.21\%$ at day 72 of the experiment from the 0-day value of $12.03 \pm 0.87/\mu\text{ug}$ and $39.72 \pm 0.84\%$ respectively. Reticulocytes increased significantly ($P < 0.01$) to $20.40 \pm 2.51\%$.

Literatures available on the haematological changes in chronic haemorrhagic anaemia in goats were scarce. However, Pandey and Misra (1986) studied the haematological changes in chronic haemorrhagic anaemia in calves and observed marked decrease in PCV, Hb with comparatively less fall in TEC and marked decrease in MCV, MCH and MCHC. The present findings were in close similarity with the results of Schalm et al. (1972), Smith et al. (1972) and Pandey and Misra (1986). The notable findings of the presents investigations were marked decrease in PCV and Hb and TEC at the peak of anaemia leading to development of microcytic hypochromic anaemia. The present observations supported the findings of earlier workers (Taylor, 1935; Schalm et al., 1975; Blood et al., 1983; and Pandey and

Misra (1986). Leucocytosis with neutrophilia observed during the study could be due to stress which agreed with the findings of Schalm et al. (1975) and Pandey and Misra (1986). The present investigation revealed absence of reticulocytosis till day 8 and by day 16 the reticulocytes appeared in the blood. This corroborated with the findings of Pandey and Misra (1986).

The peripheral blood picture of the anaemic goats of gr. D and gr. E revealed anisocytosis and poikilocytosis (Fig. 23) which could be explained by the fact that the release of new line of cells of erythrocytic series in the general circulation from the bone marrow in response to pronounced degree of anaemia caused anisocytosis, whereas the poorly structured red blood cells break apart in circulation producing poikilocytosis. Schalm et al. (1975) and Pandey (1980) also observed similar blood pictures in anaemic calves.

Biochemical changes :

The values of BGL and TSP of gr.D reduced significantly ($P \angle 0.05$) to 54.13 ± 2.11 mg% and 6.52 ± 0.14 g% at day 16 from the 0-day value of 60.86 ± 1.13 mg% and 7.12 ± 0.17 % respectively and the above values again dropped significantly ($P \angle 0.01$) to 36.08 ± 1.30 mg% and 5.10 ± 0.12 % at day 74 of the experiment. Ca and P level reduced significantly ($P \angle 0.01$) to 8.78 ± 0.16 mg% and 2.60 ± 0.21 mg% at day 74 of the experiment.

SI decreased significantly ($P \leq 0.05$) to $153.12 \pm 4.26 \mu\text{g}\%$ at day 24 after onset of the experiment from the 0-day value of $171.22 \pm 5.56 \mu\text{g}\%$ and the value of SI again dropped significantly to $67.83 \pm 2.08 \mu\text{g}\%$ at day 74 of the experiment. SCu level dropped significantly ($P \leq 0.01$) to $123.21 \pm 2.02 \mu\text{g}\%$ at 32 day of the experiment from $137.29 \pm 3.41 \mu\text{g}\%$ and it further decreased significantly ($P \leq 0.01$) to $76.14 \pm 1.55 \mu\text{g}\%$ at day 74 of the experiment. SCo decreased significantly ($P \leq 0.05$) to $19.81 \pm 2.15 \mu\text{g}\%$ at day 24 from the 0-day value of $29.32 \pm 2.28 \mu\text{g}\%$ and it again dropped significantly ($P \leq 0.01$) to $3.56 \pm 1.11 \mu\text{g}\%$ (Fig. 20 to 22).

The values of BGL and TSP of gr.E reduced significantly ($P \leq 0.05$) to $44.29 \pm 2.03 \text{ mg}\%$ and $6.20 \pm 0.21 \text{ g}\%$ at day 64 and day 40 respectively from the 0-day value of $55.14 \pm 3.14 \text{ mg}\%$ and $6.88 \pm 0.15 \text{ g}\%$ and it again dropped to $43.70 \pm 1.11 \text{ mg}\%$ and $5.22 \pm 0.19 \text{ g}\%$ at day 72 of the experiment. Ca and P level decreased significantly ($P \leq 0.01$) to $8.90 \pm 0.31 \text{ mg}\%$ and $3.08 \pm 0.20 \text{ mg}\%$ at day 72 (Fig. 20 and 21).

The values of SI, SCu and SCo dropped significantly ($P \leq 0.01$, $P \leq 0.05$ and $P \leq 0.01$ respectively) to $154.79 \pm 3.28 \mu\text{g}\%$, $129.21 \pm 2.73 \mu\text{g}\%$ and $18.67 \pm 2.19 \mu\text{g}\%$ at day 32, 24 and 24 respectively from the 0 day value of $187.40 \pm 7.20 \mu\text{g}\%$, $144.23 \pm 5.20 \mu\text{g}\%$ and $32.44 \pm 2.56 \mu\text{g}\%$ and the above values

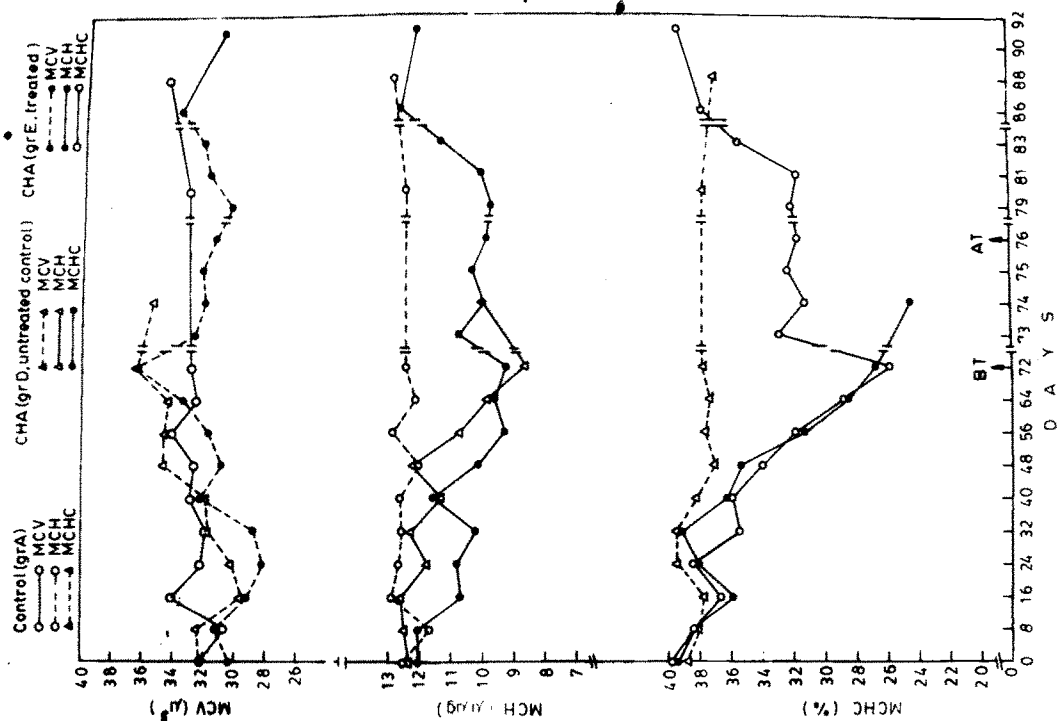


Fig. 19 Haematological changes with respect to MCV, MCH and MCHC in chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect [BT=Blood transfusion, AT=After treatment]

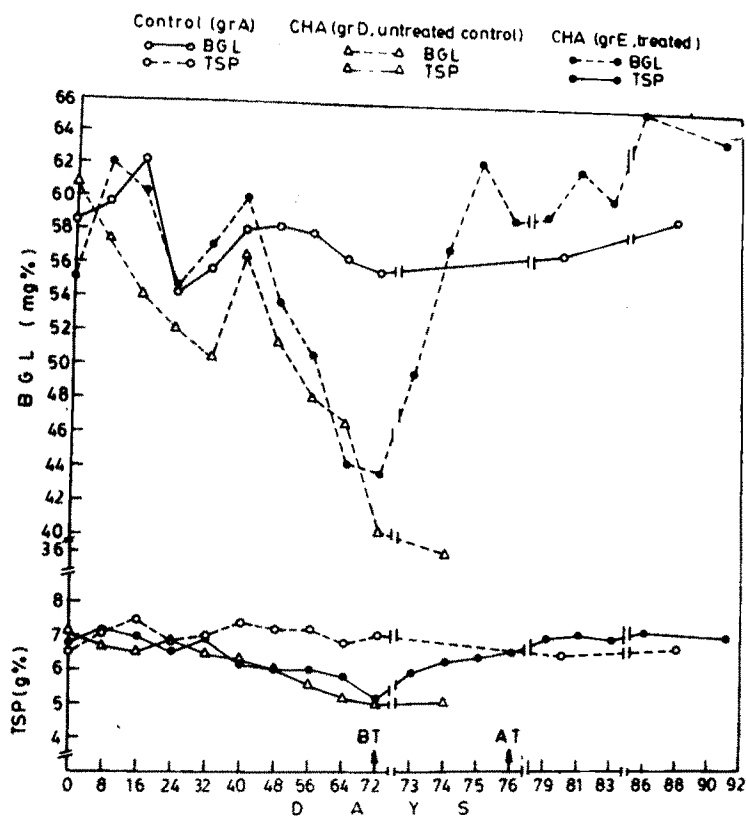


Fig. 20 Biochemical changes with respect to BGL and TSP in experimental chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect. [BT=Blood transfusion; AT=After treatment]

again decreased significantly ($P \leq 0.01$) to $79.88 \pm 2.15 \mu\text{g}\%$, $84.95 \pm 2.94 \mu\text{g}\%$ and $2.16 \pm 0.13 \mu\text{g}\%$ respectively (Fig. 22).

Literatures available on the biochemical changes in chronic haemorrhagic anaemia in goats were scarce. It was evident from the table 21 and 24 that serum iron started decreasing significantly ($P \leq 0.01$) from day 24 and 32 respectively. The initial normal serum iron did not estimate the low marrow to increase its erythropoietic activity which appeared to be the reason of nonappearance of reticulocytes initially in the peripheral blood. Later, the reticulocytic response recorded as high as $24.40 \pm 0.23\%$ and $20.40 \pm 2.51\%$ for gr.D and E respectively at the peak of anaemia. Schnappauf et al. (1967) recorded reticulocytosis ranging from 9 to 14% after severe and sudden blood loss in calves in contrast to a very high reticulocytic response upto 50% recorded by Schalm (1972) in similar condition. The present findings were in disagreement with the views of Schnappauf et al. (1967) that only severe and sudden blood loss causes reticulocytes to appear in the peripheral blood of calves. Pandey and Misra (1986) observed that withdrawal of even smaller quantity of blood (100 ml) over a long period (more than 8 days) from a cow calf (60 to 79 kg body weight) evoked appreciable degree of reticulocytic response. The present observation in goats were in close similarity with the findings of Pandey and Misra (1986).

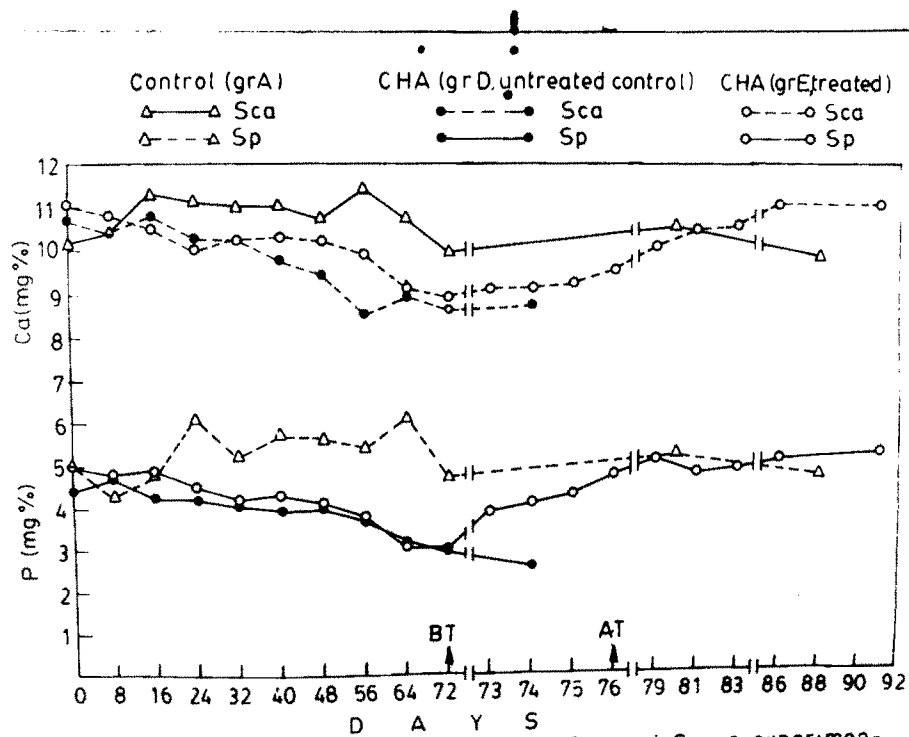


Fig. 21: Biochemical changes with respect to Sca and Sp in experimental chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect. [BT=Blood transfusion; AT=After treatment]

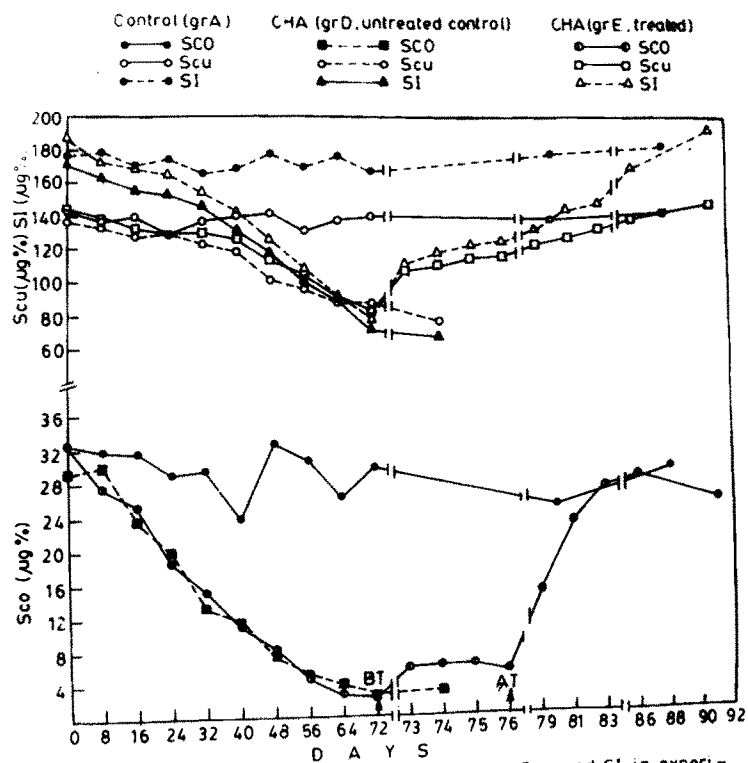


Fig. 22: Biochemical changes with respect to Sca, Scu and SI in experimental chronic haemorrhagic anaemia (CHA) in goats and its post therapeutic effect [BT=Blood transfusion; AT=After treatment]

Serum iron remained almost unchanged insignificantly in both the groups during first 24 (gr.D) and 32 (gr.E) days of study. Thereafter it started decreasing finally dropping markedly at the peak of anaemia. The initial maintenance of normal serum iron could have been due to the mobilization of iron from the ferritin in storage site in response to the increased erythropoiesis despite the continuous loss of iron in the blood being withdrawn. The subsequent hypoferrimia probably developed as available tissue iron reserve became exhausted. The present finding of decrease in serum iron corroborated with the reports of Kaneko (1970) and Pandey and Misra (1986).

The decrease of serum copper noticed during the present study of anaemic goats of gr.D and gr.E did not seem to have any significant value as far as pathogenesis of anaemia was concerned since the lower value of serum copper in both the groups were still within the normal ranges.

Serum cobalt level of both gr.D and gr.E started decreasing till day 24 when it was found to be significantly low ($P < 0.01$). Thereafter the SCo value dropped drastically. This fall might be due to the fact that the experimental goats were maintained only on grazing and browsing in the pasture land where the soil and plant were deficient in cobalt.

Serum calcium level in both gr. D and gr. E declined but not to that level of evincing hypocalcaemic symptoms in experimental goats which closely agreed with the findings of Pandey and Misra (1980).

Serum phosphorus dropped significantly in both the groups but the marked symptoms of hypophosphataemia could not be observed due to overlapping symptoms of anaemia. Informations in this regard were scarce.

BGL in both the groups D and E dropped significantly which could be due to the loss of glucose as a result of withdrawal of blood (Pandey 1980).

TSP values dropped significantly in both the groups D and E which supported similar observations made by Schalm et al. (1975) and Pandey (1980).

4.6.2.4 Estimation of Myeloid: Erythroid (M:E) ratio in the bone marrow of anaemic goats

The details of the results of evaluation of bone marrow with respect to cellularity, M:E ratio and haemopoiesis was presented in table 10, 22 and 25, ^{respectively}. The salient features of the study indicated that the marrow cytology of all the five goats of control gr. A (table 10) remained almost unchanged. The M:E ratio was 2:1 with normal erythropoiesis and marrow cellularity.

In experimental chronic haemorrhagic anaemic goats of gr. D and gr. E, bone marrow cytology remained unchanged up to day 8 of the experiment. Thereafter erythropoiesis and cellularity started increasing and the M:E ratio was changed to 1 : 1 and 2 : 1 of gr. D and gr. E at day 16 from the 0 day ratio of 2 : 1 respectively. The ratio further changed to 1 : 5 or 1 : 6 in both the groups, cellularity and erythropoiesis increased simultaneously (Fig 24 and 25).

Literatures on the bone marrow changes in chronic haemorrhagic anaemic goats were scarce. However Pandey and Misra (1987) observed marked fall in M:E ratio along with increased cellularity and prominent erythropoiesis in experimental calves. Adams (1981) also observed increased erythropoiesis while examining the bone marrow of sheep suffering from Haemonchus contortus. The present investigation which revealed prominent erythropoiesis, increased cellularity and marked decrease in M:E ratio were an evidence of marked erythropoietic activity of bone marrow.

4.6.2.5 Histopathological changes of chronic haemorrhagic anaemic goats (Macro and microscopic changes)

4.6.2.5.1 Macroscopic changes :-

Macroscopic changes noticed in all the five goats of gr. D died due to anaemia included accumulation of fluid in

serous cavities, gelatinous degeneration of fat in the hilus of kidneys. Besides, mild degree of hydropericardium was also noticed in three of the five goats.

Schalm et al. (1972), Smith et al. (1972) and Schalm et al. (1975) Blood et al. (1983) observed similar changes in anaemic animals.

4.6.2.5.2 Microscopic changes :-

Microscopic changes in the internal organs like liver, spleen, heart, lungs, kidneys, intestine and lymphnodes were studied and the changes observed were as follows:

Liver :-

Liver of all the five animals showed mid-zonal coagulation necrosis of hepatic cells characterised by pyknosis and karrorrhaxis (Fig. 2b), proliferation or thickening of the bile duct, infiltration of mononuclear cells in the sinusoidal space and accumulation of shiny, golden-yellow haemosiderin pigments (Fig. 27).

Spleen :

Spleen of all the animals showed haemorrhages, and deposition of haemosiderin pigment engulfed by macrophages (Fig.28).

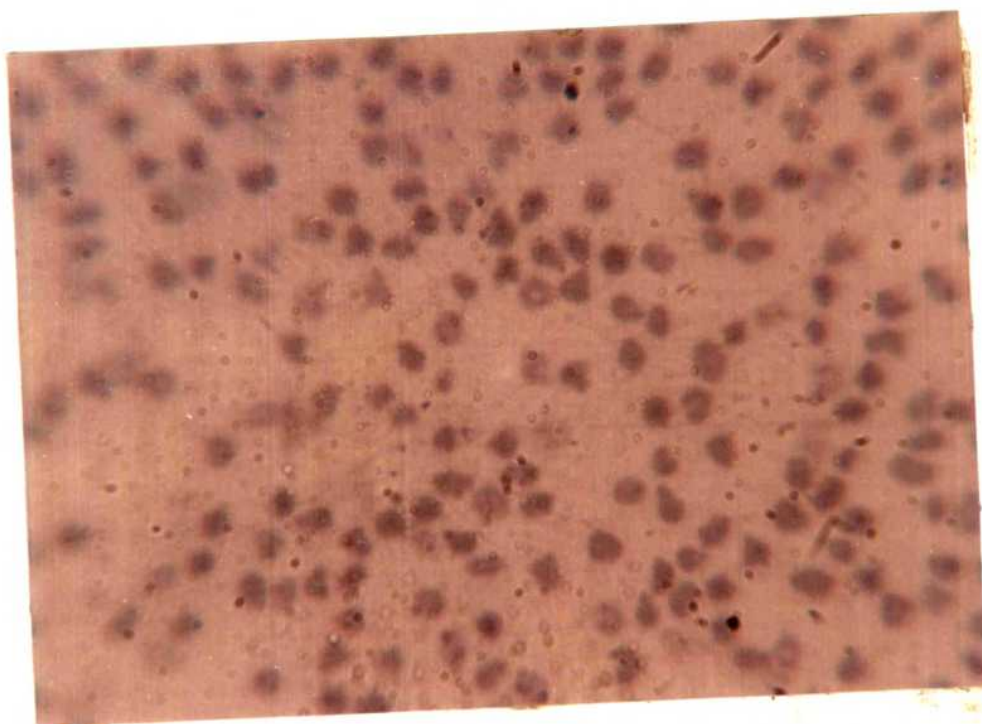


Fig. 23. Blood picture of the anaemic goats showing anisocytosis and poikilocytosis. Leishman's Stain X 1000.

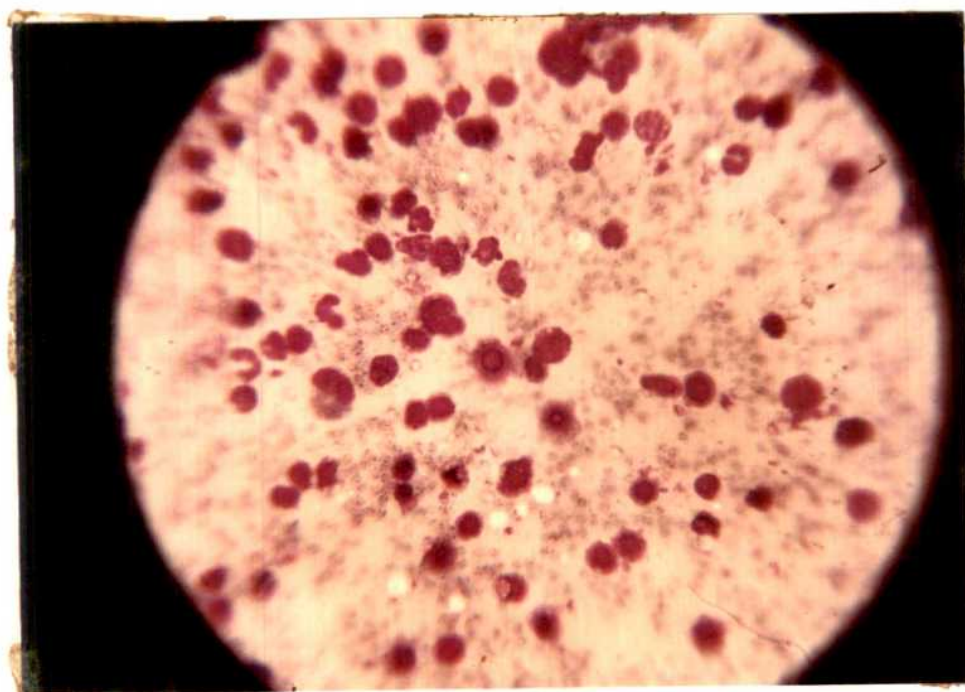


Fig. 24. Bone marrow smear of chronic haemorrhagic anaemic goats showing severe normoblastic reaction (M:E ratio 1:5) Leishman's Stain X 500.

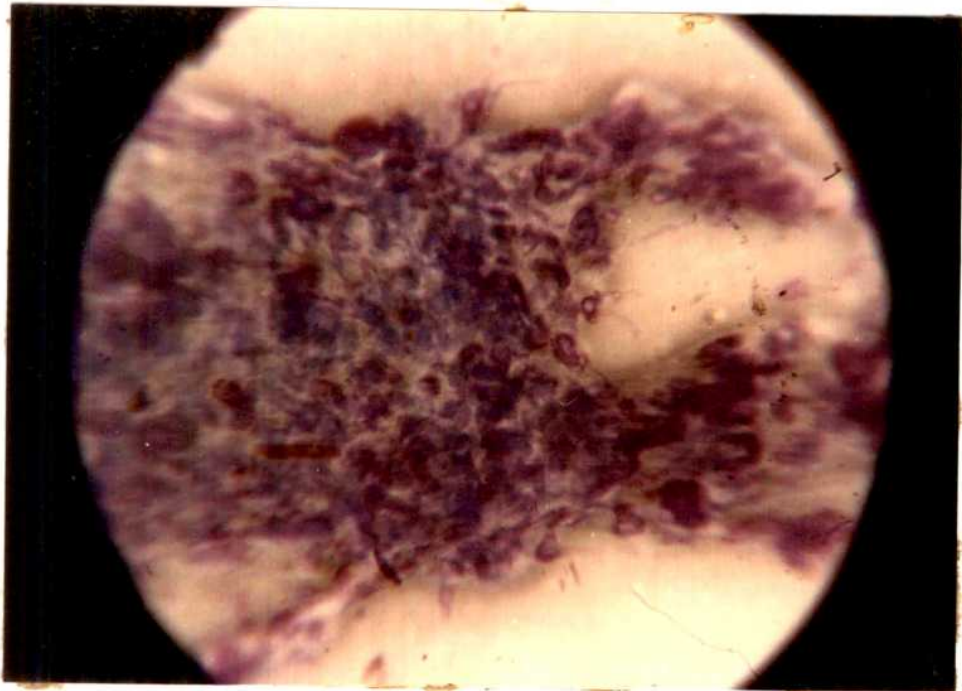


Fig. 25. Bone marrow smear of chronic haemorrhagic anaemic goats showing severe normoblastic reaction (M:E ratio 1:6) Leishman's Stain X 500.

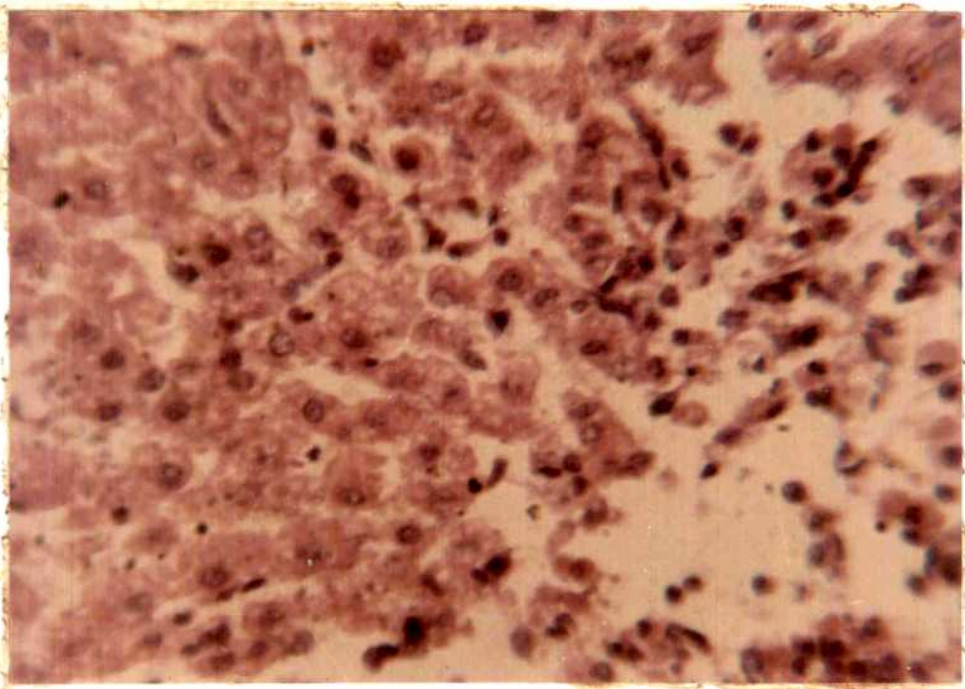


Fig. 26. Liver showing mid-zonal coagulation necrosis of hepatic cells characterised by pyknosis and karyorrhexis. H. & E. Stain X 400.

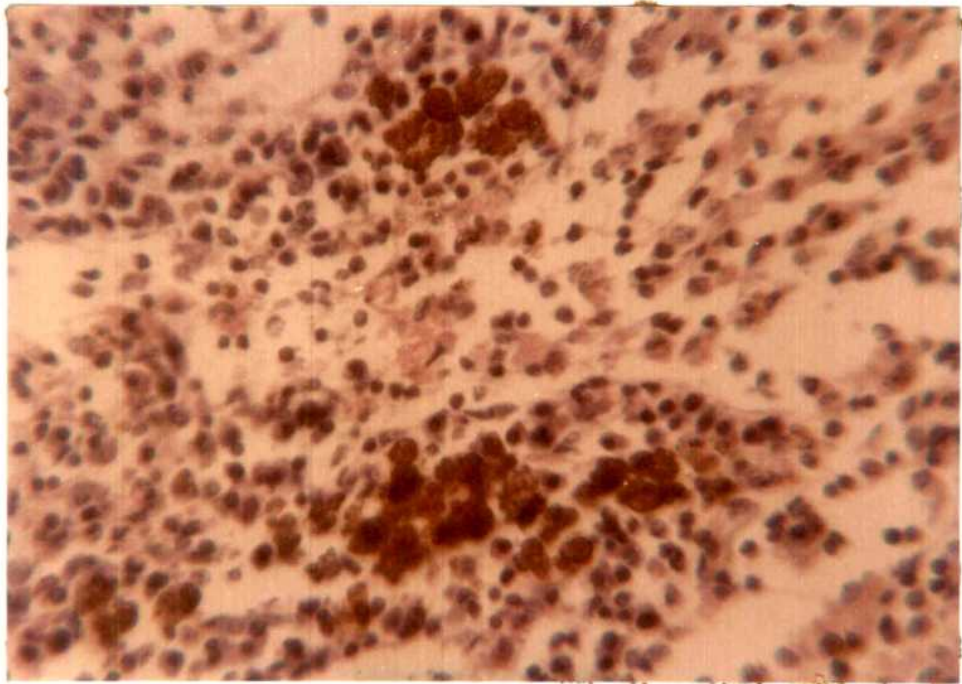


Fig. 27. Liver depicting accumulation of haemosiderin pigment engulfed by macrophages. H. & E. Stain X 400.

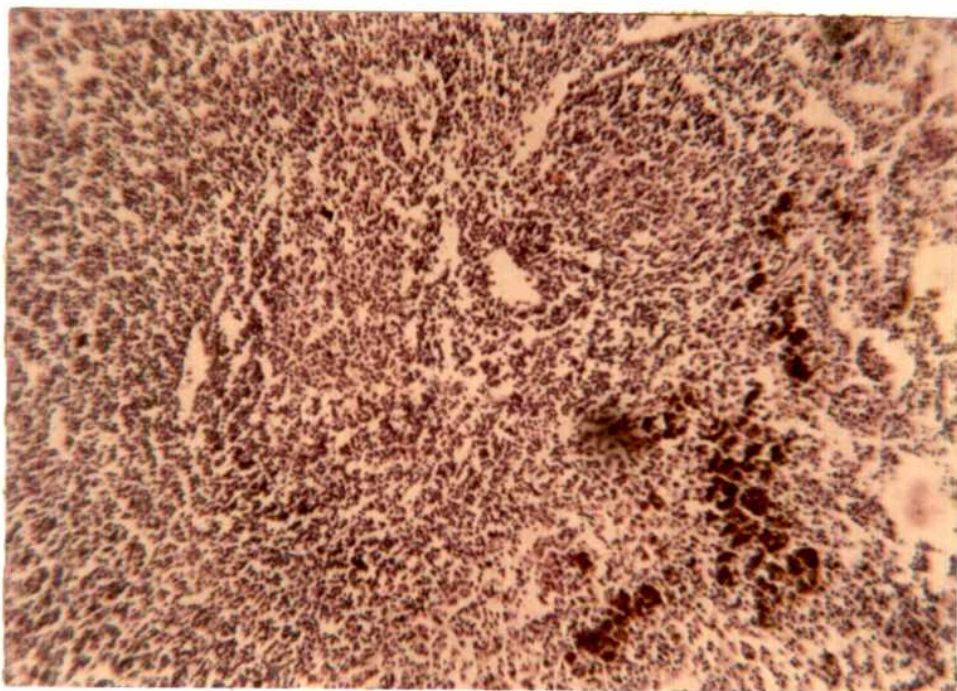


Fig. 28. Spleen showing haemorrhages and accumulation of haemosiderin pigment engulfed by macrophages. H. & E. Stain X 100.

Heart :

Microscopical changes in the heart revealed Oedematous swelling, Zenkers' degeneration and hypertrophy (Fig. 29).

Lungs :

Nothing abnormal was noticed in the lungs

Kidneys :

The changes in the kidneys revealed tubular nephrosis characterised by desquamation or proliferation and occasional sloughing of tubular epithelium with infiltration of neutrophils, desquamated cells occupied within their lumina (Fig.30).

Intestine :

Intestine showed increased cellularity in the lamina propria, excess activity of the goblet cells and muscular hypertrophy (Fig. 31).

Lymphnodes :

Microscopical examination of lymphnodes revealed congestion and necrosis of the lymphoidal cells (Fig. 32).

Literatures on the microscopical changes in the internal organs of chronic haemorrhagic anaemic goats were untraceable. Pandey (1980) reported microscopical changes in the

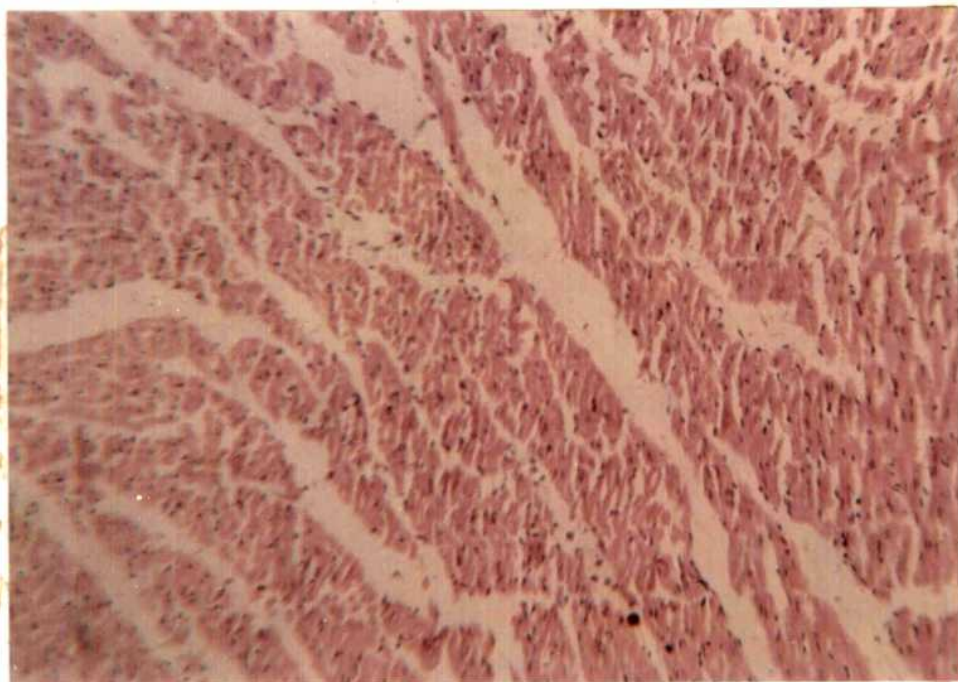


Fig. 29. Cardiac muscle showing oedematous swelling, Zenker's degeneration and hypertrophy. H. & E. Stain X 100.

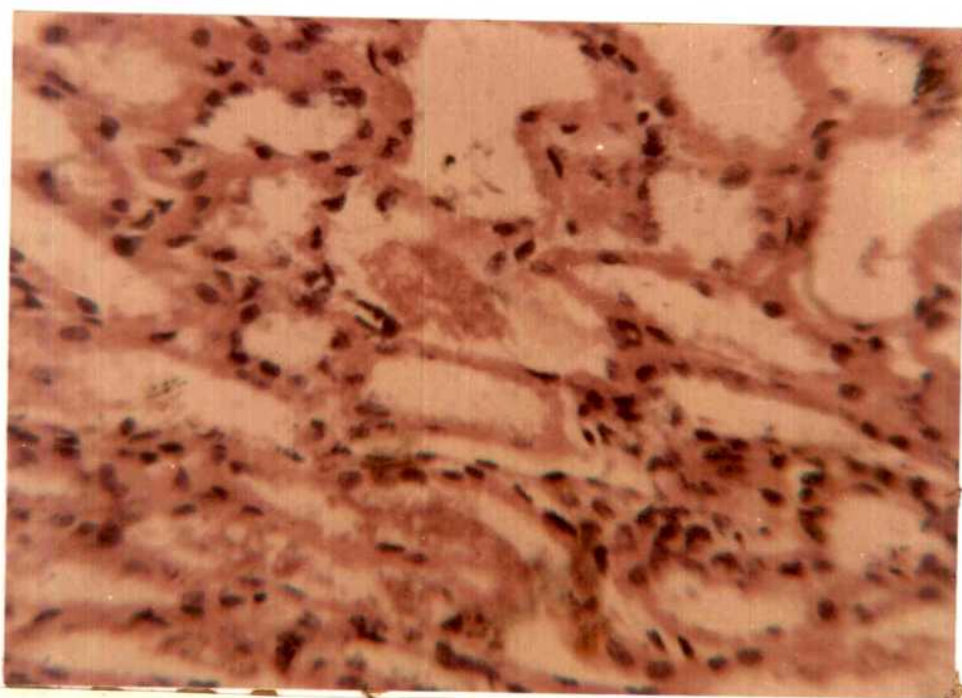


Fig. 30. Tubular nephritis characterised by desquamation or proliferation and occasional sloughing of tubular epithelium with infiltration of neutrophil, desquamated cells occupied within their lumina.
H. & E. Stain X 400.

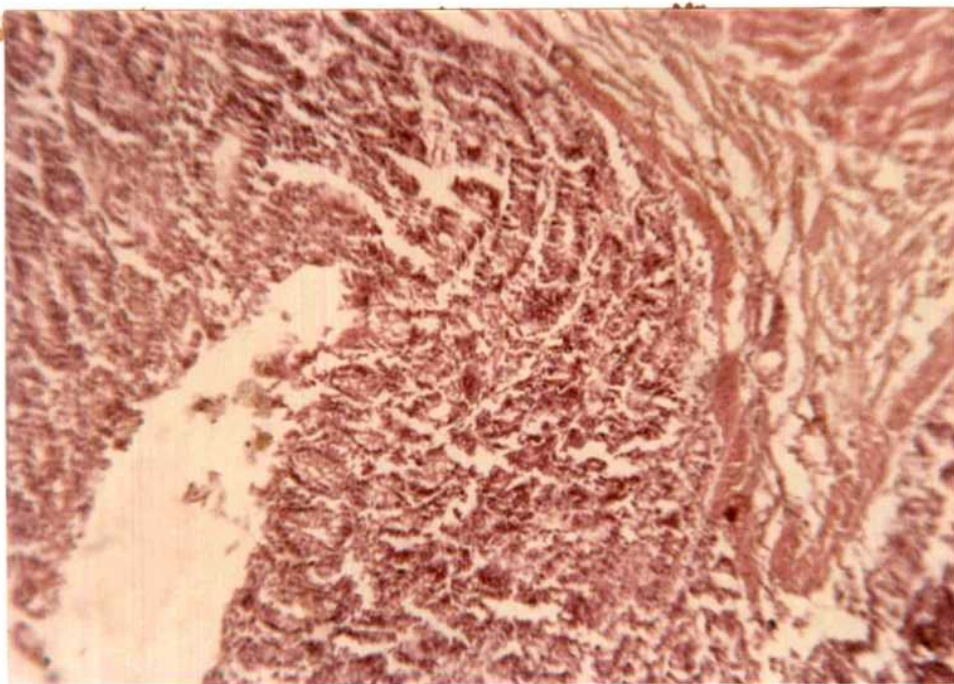


Fig. 31. Intestine showed increased cellularity in the lamina propria. H. & E. Stain X 100.

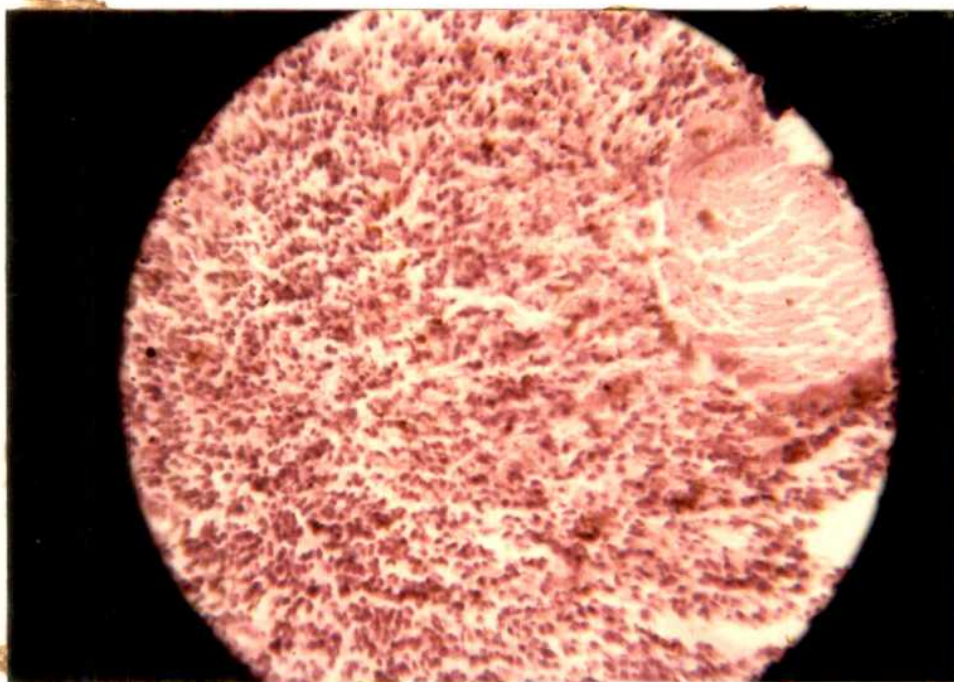


Fig. 32. Lymphnode showing congestion and necrosis of the lymphoid cells. H. & E. Stain X 200.

liver of one animal with presence of haemosiderin pigment. Spleen of one out of three animals showed severe haemosiderosis. The deposition of haemosiderin pigments in the reticulo-endothelial cells of liver and spleen indicated an augmented rate of erythrocyte destruction or disintegration. It is also fact that this pigment is accumulated in tissues of R-E system when there is focal haemorrhage as also observed in the histopathological studies. The observation of Zenker's degeneration of cardiac muscle was possible indication of coagulation of protein of sarcoplasm as a result anaemic anoxia. There were two possibilities of degeneration leading to coagulative necrosis of parenchymatous organ - one was due to local ischaemia that was possibly initiated by inadequate oxygen and nutrient of the tissues as a result of haemorrhages. The other factor was due to general anaemia in which supply of the essential nutrients were also inadequate. The enhanced metabolic and functional activity of both cardiac and smooth musculature in the intestine resulted the adaptive hypertrophy. The inflammatory changes observed in the tubules of the kidneys was possibly caused by hypovolemia.

4.6.2.6 Estimation of iron content of liver of chronic haemorrhagic anaemic goats

The results of the iron content of liver of the experimental chronic haemorrhagic anaemic goats of group D was

tabulated in table 21. The iron content of the liver of goats dropped significantly to $103.60 \pm 0.14 \mu\text{g/gm}$ as compared to that of control healthy animals ($213.66 \pm 0.47 \mu\text{g/gm}$).

Literatures on the iron content of liver of chronic haemorrhagic anaemic goats were scarce. However, Pandey (1980) observed decrease in the iron content of liver of the chronic haemorrhagic anaemic calves.

4.6.2.7 Estimation of copper content of liver of chronic haemorrhagic anaemic goats

The results of the copper content of liver of the experimental chronic haemorrhagic anaemic goats of group was tabulated in table 21. The copper content of the liver of goats dropped significantly to $67.20 \pm 1.23 \mu\text{g/gm}$ as compared to that of control healthy animals ($127.54 \pm 0.26 \mu\text{g/gm}$).

The result of the present study was in similarity with the findings of Pandey (1980) in case of anaemic calves and Blood et al. (1983) in case of sheep.

4.6.2.8 Estimation of cobalt content of liver of chronic haemorrhagic anaemic goats

The results of the cobalt content of liver of the experimental chronic haemorrhagic anaemic goats was presented in

Table 20. Haematological changes in chronic haemorrhagic anaemic goat of group D
(untreated group)

Days	Hb g%	PCV %	TEC $10^6/\text{cmm}$	TLC $10^3/\text{cmm}$	N %	L %	E %	E %	M %	MCV μ^3	MCH μug	MCHC %	Reticules cytes %
1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	11.44 ± 0.32	29.80 ± 1.14	9.21 ± 0.81	11,162 ± 239.33	30.60 ± 1.53	59.30 ± 1.77	3.20 ± 0.89	0	7.60 ± 1.24	32.35 ± 1.69	12.42 ± 0.52	39.28 ± 0.94	0
8	10.56 ± 0.40	29.40 ± 0.87	8.45 ± 0.62	11,239 ± 304.11	32.80 ± 1.14	58.20 ± 0.59	3.40 ± 0.73	0	6.20 ± 1.53	32.42 ± 1.33	12.49 ± 0.79	38.40 ± 0.67	0
16	9.22 ± 0.25	25.20 ± 0.55	7.92 ± 0.29	11,306 ± 191.57	35.20 ± 0.26	56.40 ± 0.83	3.20 ± 0.66	0	5.40 ± 1.29	29.58 ± 1.47	12.61 ± 0.33	35.89 ± 0.45	0
24	8.62 ± 0.24	23.40 ± 0.16	7.88 ± 0.22	13,141 ± 358.54	39.20 ± 0.31	48.20 ± 0.74	5.40 ± 0.80	0	6.80 ± 0.91	30.07 ± 1.15	11.78 ± 0.39	38.17 ± 0.53	2.20 ± 0.17
32	7.36 ± 0.19	20.80 ± 0.41	7.65 ± 0.14	13,718 ± 277.30	42.40 ± 0.25	47.20 ± 0.66	4.80 ± 0.42	0	7.20 ± 0.67	31.66 ± 0.43	12.34 ± 0.51	39.05 ± 0.37	5.60 ± 0.54
40	6.68 ± 0.61	19.40 ± 0.47	6.94 ± 0.27	13,690 ± 340.37	44.20 ± 1.23	47.80 ± 0.85	2.60 ± 0.82	0	7.00 ± 0.76	31.82 ± 0.55	11.82 ± 0.48	36.30 ± 0.18	7.40 ± 0.26
48	6.46 ± 0.43	19.20 ± 0.53	5.37 ± 0.32	14,150 ± 321.43	47.80 ± 0.26	43.60 ± 0.33	3.20 ± 0.16	0	6.20 ± 0.11	34.46 ± 0.57	12.23 ± 0.71	35.49 ± 0.22	11.60 ± 0.21

Contd..

Table 20 (Contd...)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
56	5.60 +0.31	18.20 +0.39	5.03 +0.23	14,218 +299.84	58.20 +0.31	39.20 +0.50	1.40 +0.16	0	1.60 +0.08	34.39 +0.63	10.73 +0.41	31.30 +0.74	16.20 +0.15	
64	4.82 +0.26	17.60 +0.44	4.92 +0.20	13,753 +361.22	53.40 +0.26	42.60 +0.47	2.20 +0.15	0	2.40 +0.21	34.14 +0.41	9.79 +0.51	28.69 +0.30	18.80 +0.11	
72	4.08 +0.17	16.80 +0.37	4.64 +0.23	14,158 +226.77	55.20 +0.45	40.20 +0.17	2.60 +0.35	0	1.80 +0.14	36.20 +0.29	8.64 +0.13	26.84 +0.24	21.20 +0.19	
74	3.96 +0.11	15.40 +0.17	4.40 +0.23	13,263 +344.27	53.80 +0.31	41.40 +0.23	2.20 +0.30	0	2.40 +0.16	35.13 +0.19	10.00 +0.21	24.52 +0.31	24.40 +0.23	

* P / 0.05

** P / 0.01

oo Only three animals studied (two animals died only day 73)
three animals died at day 74, 75 and 76.

Table 21. Biochemical change in chronic haemorrhagic anaemic goats of group D (untreated group)

Days	BGL mg%	TSP g%	Ca mg%	P mg%	SI ug%	SCu ug%	SCO ug%
1	2	3	4	5	6	7	8
0	60.86 +1.13 ±	7.12 +0.17 ±	10.76 +0.21 ±	4.46 +0.11 ±	171.22 +5.56 ±	137.29 +3.41 ±	29.32 +2.28 ±
8	57.45 +2.47 ±	6.76 +0.17 ±	10.40 +0.18 ±	4.70 +0.21 ±	163.71 +6.20 ±	133.75 +2.86 ±	30.18 +3.15 ±
16	54.13 +2.11 ±	6.52 +0.14 ±	10.80 +0.23 ±	4.21 +0.30 ±	156.89 +5.18 ±	127.31 +2.57 ±	23.74 +2.19 ±
24	52.28 +2.08 ±	6.90 +0.26 ±	10.28 +0.16 ±	4.20 +0.19 ±	153.12 +4.26 ±	129.45 +1.87 ±	19.81 +2.15 ±
32	50.41 +1.76 ±	6.50 +0.21 ±	10.20 +0.21 ±	4.08 +0.23 ±	146.50 +4.11 ±	123.21 +2.02 ±	13.36 +2.17 ±
40	56.73 +2.89 ±	6.37 +0.14 ±	9.88 +0.20 ±	3.90 +0.34 ±	132.47 +2.80 ±	119.27 +1.54 ±	11.79 +1.10 ±

Contd....

Table 21 (Contd.....)

1	2	3	4	5	6	7	8
48	51.39 +2.35 ±	6.06 +0.14 ±	9.40 +0.16 ±	3.96 +0.39 ±	118.19 +1.99 ±	102.46 +1.17 ±	7.28 +2.15 ±
56	48.21 +2.10 ±	5.62 +0.11 ±	8.55 +0.19 ±	3.70 +0.17 ±	101.04 +2.12 ±	96.29 +1.27 ±	4.67 +1.89 ±
64	46.74 +2.07 ±	5.20 +0.08 ±	8.90 +0.11 ±	3.26 +0.13 ±	88.72 +1.85 ±	89.71 +1.15 ±	3.96 +0.71 ±
72	40.38 +1.57 ±	5.07 +0.10 ±	8.62 +0.17 ±	2.94 +0.14 ±	71.40 +1.33 ±	87.86 +2.09 ±	2.37 +0.19 ±
74	36.08 +1.30 ±	5.10 +0.12 ±	8.78 +0.16 ±	2.60 +0.21 ±	67.83 +2.08 ±	76.14 +1.55 ±	3.56 +1.11 ±

* P /0.05; ** P /0.01

Iron content in liver: 103.60 ± 0.14 µg/gm (ppm)

Copper content in liver: 67.20 ± 1.23 µg/gm (ppm)

Cobalt content in liver: 0.09 ± 0.03 µg/gm (ppm)

Table 22. Bone marrow cytology of chronic haemorrhagic anaemic goats of group D
(untreated group)

Days	0	8	16	32	40	48	56	64	72	80
Cellularity	N	N	I	I	I	I	I	I	I	I
M:E ratio	2:1	2:1	1:1	1:4	1:4	1:4	1:5	1:5	1:6	1:6
Erythropoiesis	EN	EN	EI	EI	EI	EI	EI	EI	EI	EI

N = Normal

I = Increased

EN = Erythropoiesis normal

EI & Erythropoiesis increased

Table 23. Haematological changes in chronic haemorrhagic anaemic coats of group E (treated group)

Days	Hb g%	PCV %	TEC $10^6/\text{cmm}$	TLC $10^3/\text{cmm}$	N %	L %	E %	B %	M %	MCV μ^3	MCH μg	MCHC %	Reti- culocytes (%)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	11.60 ± 0.31	29.20 ± 0.50	9.64 ± 1.15	11,382 ± 133.47	30.60 ± 0.41	58.50 ± 0.29	4.40 ± 0.15	0	7.40 ± 0.28	30.29 ± 0.43	12.03 ± 0.87	39.72 ± 0.84	0
8	10.92 ± 0.27	28.40 ± 0.21	9.09 ± 1.08	10,670 [†] ± 251.65	35.20 ± 0.65	55.40 ± 0.32	3.20 ± 0.26	0	6.20 ± 0.11	31.24 ± 0.27	12.01 ± 0.54	38.45 ± 0.56	0
16	8.88 [†] ± 0.76	23.60 ^{††} ± 0.29	8.11 ± 0.57	10,120 ± 214.21	40.60 ± 0.23	51.20 ± 0.17	3.20 ± 0.42	0	5.60 ± 0.25	29.09 ± 0.49	10.70 ± 0.47	36.77 [†] ± 0.41	2.60 ± 0.04
24	8.60 ± 0.47	19.80 ± 0.17	7.03 ± 0.46	10,722 ± 343.17	33.40 ± 0.18	58.60 ± 0.13	4.20 ± 0.31	0	4.00 ± 0.13	28.16 ^{††} ± 0.21	10.81 ± 0.21	38.38 ± 0.49	5.20 ± 1.17
32	8.10 ± 0.39	20.00 ± 0.19	6.95 ± 0.33	10,177 ± 320.08	38.20 ± 0.35	49.20 ± 0.61	4.40 ± 0.33	0	7.80 ± 0.23	28.77 ± 0.57	10.21 ± 0.27	35.50 ± 0.73	7.20 ± 2.24

Contd...

Table 23 (Contd.....

1	2	3	4	5	6	7	8	9	10	11	12	13	14
40	7.20 +0.55 _	20.00 +0.33 _	7.23 +0.15 _	11,143 +163.37 _	40.20 +0.44 _	52.60 +0.17 _	3.20 +0.35 _	0	4.20 +0.11 _	32.10 +0.32 _	11.55 +0.65 _	36.00 +0.19 _	11.40 +1.56 _
48	6.40 +0.87 _	18.80 +0.14 _	6.12 [*] +0.21 _	12,149 +274.30 _	34.60 +0.31 _	54.20 +0.23 _	5.80 +0.26 _	0	6.20 +0.31 _	30.73 +0.17 _	10.13 +0.24 _	34.06 +0.77 _	13.40 +1.16 _
56	5.44 +8.11 _	17.00 +0.23 _	5.85 +0.12 _	13,242 +187.52 _	32.40 +0.39 _	59.60 +0.47 _	4.20 +0.17 _	0	4.40 +0.19 _	31.57 +1.08 _	9.29 [*] +0.33 _	32.00 +0.26 _	15.20 +0.96 _
64	4.86 +0.08 _	16.40 +0.20 _	5.06 +0.16 _	14,513 +373.51 _	35.60 +0.53 _	60.20 +0.27 _	2.60 +0.32 _	0	1.80 +0.94 _	33.21 +0.92 _	9.60 +0.19 _	28.92 +0.35 _	17.00 +1.04 _
72	4.02 ^{††} +0.07 _	16.20 ^{††} +0.13 _	4.36 ^{††} +0.37 _	12,790 ^{††} +369.72 _	49.20 +0.15 _	46.20 +0.22 _	1.80 +0.41 _	0	3.20 +0.24 _	36.12 ^{††} +0.67 _	9.19 +0.21 _	25.94 ^{††} +0.21 _	20.40 +2.51 _

* P /0.05

** P /0.01

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Table 24. Biochemical changes in chronic haemorrhagic anaemic goats of group E (treated group)

Days	BGL mg%	TSP g%	Ca mg%	P mg%	SI μg%	SCu μg%	SCo μg%
1	2	3	4	5	6	7	8
0	55.14 +3.14 ±	6.88 +0.15 ±	11.10 +0.53 ±	5.02 +0.16 ±	187.40 +7.20 ±	144.23 +5.20 ±	32.44 +2.56 ±
8	62.08 +2.06 ±	7.26 +0.17 ±	10.80 +0.47 ±	4.87 +0.47 ±	173.26 +5.65 ±	139.25 +3.26 ±	27.40 +2.14 ±
16	60.31 +2.17 ±	7.00 +0.19 ±	10.57 +0.15 ±	4.92 +0.14 ±	169.57 +5.42 ±	132.65 +2.94 ±	25.18 +1.96 ±
24	54.70 +1.94 ±	6.56 +0.11 ±	10.04 +0.18 ±	4.56 +0.33 ±	166.71 +6.16 ±	129.21 [†] +2.73 ±	18.67 ^{†*} +2.19 ±
32	57.24 +2.26 ±	6.90 +0.08 ±	10.24 +0.11 ±	4.20 [*] +0.27 ±	154.79 ^{†*} +3.28 ±	130.49 +2.54 ±	15.15 +1.13 ±

Contd....

Table 24 (Contd....)

1	2	3	4	5	6	7	8
40	60.18 +2.13 +2.13	6.20 [*] +0.21 +0.21	10.35 +0.13 +0.13	4.34 +0.20 +0.20	143.23 +3.59 +3.59	127.20 +2.21 +2.21	11.16 +2.08 +2.08
48	53.82 +2.19 +2.19	6.02 +0.21 +0.21	10.21 +0.26 +0.26	4.10 +0.13 +0.13	127.56 +2.08 +2.08	114.79 +2.39 +2.39	8.07 +2.67 +2.67
56	50.74 +2.77 +2.77	6.01 +0.30 +0.30	9.90 +0.23 +0.23	3.81 +0.28 +0.28	109.32 +3.52 +3.52	105.83 +1.17 +1.17	4.58 +1.69 +1.69
64	44.29 [*] +2.03 +2.03	5.87 +0.23 +0.23	9.10 [*] +0.19 +0.19	3.17 +0.12 +0.12	92.46 +2.46 +2.46	92.42 +2.02 +2.02	2.76 +0.55 +0.55
72	43.70 ^{**} +1.11 +1.11	5.22 ^{**} +0.19 +0.19	8.90 ^{**} +0.31 +0.31	3.08 ^{**} +0.20 +0.20	79.88 ^{**} +2.15 +2.15	84.95 ^{**} +2.94 +2.94	2.16 ^{**} +0.13 +0.13

* P / 0.05

** P / 0.01

Table 25. Bone marrow cytology of chronic haemorrhagic anaemic goats of group E.
(treated group)

Days	0	8	16	32	40	48	56	64	72
Cellularity	N	N	I	I	I	I	I	I	I
M:E ratio	2:1	2:1	1:2	1:3	1:4	1:4	1:4	1:5	1:6
Erythropoiesis	EN	EN	EI	EI	EI	EI	EI	EI	EI

N = Normal

I = Increased

EN = Erythropoiesis normal

EI = Erythropoiesis increased

table 21. The cobalt content of the liver of goats declined significantly to $0.09 \pm 0.03 \mu\text{g/gm}$ as compared to that of control healthy animals ($0.28 \pm 0.09 \mu\text{g/gm}$).

Literatures on the cobalt content of the liver of chronic haemorrhagic anaemic goats were scarce. McDowell et al. (1983) reported low cobalt level in the liver of ruminants grazing on cobalt deficient pasture.

4.6.2.9 Treatment of anaemic goats of chronic haemorrhagic anaemia

Blood transfusion given to the chronic haemorrhagic anaemic goats of gr.E from day 72 revealed gradual improvement in the haematological and biochemical profiles and thereafter treatment with systemic and oral haematinics was started from day 76 for a period of 10 days and it proved very effective in alleviating anaemia by day 91. The progress of the treatment related with haematological and biochemical status at intervals after the start of the treatment was presented in table 26 and 27 and Fig. 17 to 22.

Haematological changes :

By day 73, after blood transfusion Hb, PCV and TEC (Fig. 17 and 18) increased significantly ($P < 0.01$) to $6.02 \pm 0.11 \%$ $18.20 \pm 0.15\%$ and 5.14 ± 0.21 millions/cmm respectively from

the corresponding pre-treatment value of 4.02 ± 0.07 g%, 16.20 ± 0.13 % and 4.56 ± 0.37 millions/cmm of blood. The values of above parameters continued to increase when on day 76 parenteral and oral therapy of haematinics was started. The values of the above parameters (11.08 ± 0.11 g%, 28.20 ± 0.27 % and 8.94 ± 0.35 millions/cmm) were in increasing trend till the last day of the experiment (day 91).

Biochemical changes :

BGL and TSP were raised significantly ($P < 0.01$) to 64.26 ± 1.66 mg% and 7.08 ± 0.17 g% from the pre-treatment value of 43.70 ± 1.11 mg% and 5.42 ± 0.19 g% respectively (Fig. 20).

SCA and SP was increased significantly ($P < 0.01$) to 10.94 ± 0.21 mg% and 5.22 ± 0.08 mg% respectively from the pre-treatment value of 8.90 ± 0.31 mg% and 3.08 ± 0.20 mg% (Fig. 21).

There was significant rise of the SI, SCu and SCo to 192.20 ± 12.11 μ g%, 147.89 ± 1.59 μ g% and 25.75 ± 3.01 μ g% respectively from the pre-treatment value of 79.88 ± 2.15 μ g%, 84.95 ± 2.94 μ g% and 2.16 ± 0.13 μ g% respectively (Fig. 22).

Bone marrow changes :

The details of the improvement of bone marrow cytology was presented in table 28. It was evident from the table that

Table 26. Haematological changes in chronic haemorrhagic anaemic goats of group E
(post-treatment)

Days	Hb g%	PCV %	TEC $10^6/\text{cmm}$	TLC $10^3/\text{cmm}$	N %	L %	E %	B %	M %	MCV μ^3	MCH μug	MCHC %	Reticu- locytes %
1	2	3	4	5	6	7	8	9	10	11	12	13	14
BT 72	4.02 ± 0.07	16.20 ± 0.13	4.56 ± 0.37	12,790 ± 369.72	49.20 ± 0.15	46.20 ± 0.22	1.80 ± 0.41	0	3.20 ± 0.24	36.12 ± 0.67	9.19 ± 0.21	25.44 ± 0.21	20.40 ± 2.51
AT 73	6.02 ± 0.11	18.20 ± 0.15	5.14 ± 0.21	11,810 ± 266.75	52.40 ± 1.13	42.60 ± 1.31	2.40 ± 0.73	0	2.20 ± 0.45	32.44 ± 1.41	10.71 ± 0.88	33.02 ± 0.59	18.60 ± 2.10
74	6.22 ± 0.08	19.80 ± 0.11	6.23 ± 0.39	10,543 ± 202.56	46.20 ± 0.89	45.20 ± 1.08	2.20 ± 0.57	0	5.40 ± 0.67	31.78 ± 1.26	9.98 ± 0.94	31.41 ± 0.26	16.20 ± 1.40
75	6.56 ± 0.10	21.00 ± 0.17	6.58 ± 0.14	10,120 ± 353.42	40.20 ± 0.85	50.20 ± 1.53	3.20 ± 0.66	0	5.40 ± 0.54	31.91 ± 0.96	10.33 ± 1.23	32.38 ± 1.05	14.20 ± 0.89
TS 76	6.96 ± 0.17	21.80 ± 0.23	7.02 ± 0.33	11,670 ± 318.06	36.00 ± 0.55	52.00 ± 1.26	4.20 ± 0.44	0	6.20 ± 0.87	31.05 ± 0.59	9.88 ± 1.34	31.83 ± 0.84	9.20 ± 1.56

Contd..

Table 26 (Contd...)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
79		7.08 +0.23 _	22.00 +0.51 _	7.31 +0.40 _	10,790 +288.92 _	32.00 +0.67 _	56.00 +0.33 _	3.20 +0.66 _	0	7.20 +0.55 _	30.09 +1.04 _	9.68 +0.98 _	32.18 +0.47 _	6.40 +0.77 _
81		7.44 +0.11 _	23.40 +0.37 _	7.42 +0.86 _	10,120 +353.45 _	32.40 +0.89 _	58.20 +0.51 _	3.40 +0.44 _	0	6.40 +0.66 _	31.53 +0.88 _	10.02 +0.43 _	31.79 +0.94 _	3.20 +2.02 _
83		8.96 +0.41 _	25.20 +0.33 _	7.90 +0.29 _	10,280 +312.65 _	32.20 +1.12 _	60.20 +0.92 _	3.20 +0.40 _	0	4.20 +0.46 _	31.89 +0.73 _	11.34 +1.21 _	35.55 +1.06 _	2.40 +1.22 _
86		10.22 +0.21 _	27.00 +0.29 _	8.06 +0.24 _	10,650 +359.79 _	28.60 +1.04 _	62.20 +0.69 _	3.60 +0.53 _	0	6.20 +0.61 _	33.49 +0.55 _	12.67 +0.83 _	37.85 +1.23 _	0
91		11.08 +0.11 _	28.20 +0.27 _	8.94 +0.35 _	10,060 +287.89 _	30.20 +0.96 _	58.20 +0.54 _	4.20 +0.46 _	0	6.60 +0.53 _	30.75 +0.95 _	12.13 +0.76 _	39.44 +0.77 _	0

BT = Blood transfusion

AT = After transfusion

TS = Treatment started

*p/0.05; ** p /0.01

Table 27. Biochemical changes in chronic haemorrhagic anaemic goats of group E.
(post-treatment)

Days	BCL mg%	TSP g%	Ca mg%	P mg%	SI μg%	SCu μg%	SCo μg%
1	2	3	4	5	6	7	8
BT 72	43.70 +1.11 ±	5.42 +0.19 ±	8.90 +0.31 ±	3.08 +0.20 ±	79.88 +2.15 ±	84.95 +2.94 ±	2.16 +0.13 ±
AT 73	49.76 +2.56 ±	5.98 +0.34 ±	9.19 +0.76 ±	3.90 +0.63 ±	111.20 ^{††} +4.13 ±	107.63 ^{††} +2.63 ±	5.85 [†] +1.11 ±
74	57.28 ^{††} +2.18 ±	6.32 [†] +0.32 ±	9.10 +0.28 ±	4.14 +0.51 ±	117.68 +3.61 ±	109.22 +3.59 ±	6.07 +1.52 ±
75	62.59 +3.08 ±	6.41 +0.29 ±	9.24 +0.67 ±	4.36 ^{††} +0.16 ±	121.29 +2.22 ±	114.71 +3.05 ±	6.13 +2.05 ±
TS 76	59.14 +2.57 ±	6.66 +0.32 ±	9.56 +0.39 ±	4.87 +0.19 ±	124.20 +2.52 ±	115.56 +2.86 ±	5.33 +1.96 ±

Contd.....

Table 27 (Contd....)

1	2	3	4	5	6	7	8
79	59.29 +2.11 +2.17	7.00 +0.21 +0.21	10.08 +0.19 +0.19	5.11 +0.11 +0.11	132.63 +4.08 +4.08	123.40 +1.56 +1.56	15.08 +2.17 +2.17
81	62.24 +1.21 +1.21	7.11 +0.08 +0.08	10.44 +0.31 +0.31	4.80 +0.13 +0.13	143.08 +4.23 +4.23	127.67 +2.37 +2.37	23.25 +3.04 +3.04
83	60.51 +2.67 +2.67	6.96 +0.17 +0.17	10.57 +0.42 +0.42	4.94 +0.08 +0.08	147.26 +4.27 +4.27	132.54 +2.56 +2.56	27.29 +1.98 +1.98
86	66.30 +2.08 +2.08	7.22 +0.25 +0.25	11.02 +0.34 +0.34	5.14 +0.15 +0.15	169.71 +7.81 +7.81	139.56 +2.56 +2.56	28.65 +2.65 +2.65
91	64.26 +1.66 +1.66	7.08 +0.17 +0.17	10.94 +0.21 +0.21	5.22 +0.08 +0.08	192.20 +12.11 +12.11	147.89 +1.59 +1.59	25.75 +3.01 +3.01

* P / 0.05 ; ** P / 0.01

BT = Before transfusion

AT. = After transfusion

TS. = Treatment started

Table 28. Bone marrow cytology of chronic haemorrhagic anaemic goats of group E
(post-treatment)

Days	72	73	74	75	76	79	81	83	86	91
Cellularity	I	I	I	I	I	I	I	I	N	N
M:E ratio	1:6	1:4	1:3	1:3	1:3	1:2	1:2	1:1.5	2:1	2:1
Erythropoiesis	EI	EI	EI	EI	EI	EI	EI	EI	EN	EN

I = Increased

N = Normal

EI = Erythropoiesis increased

EN = Erythropoiesis normal

the M:E ratio changed to its original position i.e. 2:1 from the pre-treatment ratio of 1:5 or 1:6. Cellularity and erythropoiesis became normal.

The treatment which included single blood transfusion along with drug therapy proved to be effective, as all the animals of the anaemic gr.E recovered completely from anaemia. All the haematological biochemical and bone marrow changes restored to the normal. Metcalf and Stahl (1942), Schalm et al. (1975), and Blood et al. (1983) also advocated that in severe iron deficiency anaemia (haemorrhagic type) blood transfusion has been indicated as an emergency measure and as means of direct administration of whole blood. The organic iron preparation and salts of iron, copper and cobalt included in the treatment schedule as values of all these elements were significantly decreased. Cobalt sulphate was given orally since it was reported to be very powerful stimulator of erythropoiesis (Jackovson et al., 1959 cited by Pandey, 1980).

The present schedule of treatment proved to be of high therapeutic value as all the anaemic animals of the group made full clinical recovery from anaemia.

4.7 Quality of Meat of Anaemic Goats

The results of the assesment of meat quality was tabulated in table 29. It was evident from the table that the moisture content of meat increased significantly ($P < 0.01$) to $77.75 \pm 0.70\%$ from the normal value of $72.88 \pm 0.20\%$. Protein percent of meat was decreased significantly ($P < 0.01$) to $17.52 \pm 0.06\%$ from the normal value of $22.14 \pm 0.16\%$. There was no significant change between experimental group ($2.06 \pm 0.03\%$) and control group ($2.10 \pm 0.08\%$) in respect of ether-extract (fat %) of meat. Statistical analysis showed insignificant result of the ash content of the meat between experimental group ($1.04 \pm 0.07\%$) and control group ($1.00 \pm 0.09\%$). Cooking loss of the meat increased significantly to $25.57 \pm 1.83\%$ from the normal value of $17.78 \pm 0.52\%$.

Informations on the quality of meat in respect of moisture %, protein %, ether-extract (fat %), total ash % and cooking loss % in anaemic goats were scarce in the literature. Jenson (1982) stressed that the quality of meat was governed by its chemical composition notably protein, fat, ash and water. In the present study meat of anaemic goats revealed loss of protein and increase in the water content. However, no change in fat and ash % was observed in the present study. Cooking loss has been an important parameter for assessing the quality

Table 29. Changes in quality of meat in anaemic goats of group D

	Moisture (%)	Protein (%)	Ether extract fat (%)	Total ash (%)	Cooking loss (%)
Experimental goats	77.75 [±] ±0.70	17.52 [±] ±0.06	2.06 [±] ±0.03	1.04 [±] ±0.07	25.57 [±] ±1.83
Control goats	72.88 [±] ±0.20	22.14 [±] ±0.16	2.10 [±] ±0.08	1.00 [±] ±0.09	17.78 [±] ±0.52

* P < 0.05

** P < 0.01

of meat (Pal, 1975). Mahapatra (1986) also reported that cooking loss was inversely related to water holding capacity of meat. In the present study cooking loss % was increased in the meat of anaemic goats. The above study clearly indicated that the quality of meat in anaemic goats was inferior for human consumption as per the opinion of Thronton (1974).

CHAPTER—V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A detailed study was undertaken on the type of goat anaemia prevalent in and around Bidhan Chandra Krishi Viswavidyalaya (B.C.K.V.) Mohanpur, Nadia (W.B.) in relation to soil and plant. A survey was made in the area to ascertain the incidence of anaemia in goats. The analysis of soils and plants in relation to macro- and micro-elements of the grazing area of goats were undertaken. Experimental study was also conducted in reproducing both nutritional and haemorrhagic anaemia in goats and therapeutic measures were taken to alleviate anaemia.

Incidence of anaemia in goats :

The goats presented at the University Veterinary Clinics from villages around Bidhan Chandra Krishi Viswavidyalaya at Mohanpur, Nadia (W.B.) were clinically examined for anaemia. Out of 1768 goats clinically examined 1087 (61.48%), were found to be clinically positive for anaemia. According to season, the incidence of clinical anaemia was significantly higher ($P < 0.05$) during monsoon (June-August) than that of winter

(December-February) and summer (March-May). The incidence was insignificantly higher in monsoon than that of autumn (September-November). It was observed that age and sex of animals had no influence over the incidence of the disease. The clinically positive anaemic goats were classified as gr.I (anaemia with heavy infestation of parasitism) gr.II (anaemia with low degree of parasitism) and gr III (anaemia without parasitism, supposed to be nutritional). The haematological and biochemical changes included significant decrease in values Hb, PCV, TEC, TLC, MCH, MCHC, BGL, TSP, SI, SCu and SCo. The incidence of anaemia in goats was higher due to various factors as the animals maintained on restricted grazing and browsing in cobalt deficient soil and plants of the grazing area. Cobalt deficient animals might have shown increased susceptibility to parasitism in the area under study.

Mineral and trace minerals status of soil of grazing area :

The pH of the soil samples were alkaline. The Ca, P and Fe content of soils were adequate whereas the Cu and Co content of the soil was inadequate (marginal to low).

The results indicated that alkaline pH of the soil interfered with the availability and uptake of cobalt by the plants.

Minerals and trace minerals status of the plants of the grazing area :

The Ca, P and Fe content of the plants were found within the normal range. The Co content of the plants was marginal to low. Though the Cu content of soil was inadequate (marginal to low) it was found that the level of the said, element in the plants was within the dietary requirements of grazing ruminants. This was due to the availability and mineral uptake of the plants from soils.

Experimental production of anaemia in goats :

Nutritional anaemia :

Nutritional anaemia was produced in experimental goats of gr.B and gr.C by keeping the animals exclusively in grazing and browsing for a period of 120 days when the animals developed anaemia. The goats of gr.A which were supplied with concentrates feed additives and mineral mixture served as control group for gr.B and gr.C. The haematological and biochemical parameters (Hb, PCV, TEC, MCH, MCHC, BGL, TSP, SI, SCu and SCo) of goats of gr.B and gr.C dropped significantly in comparison with the values of experimental healthy control goats (gr.A) under normal feeding regimens. The bone marrow studies revealed that the change of M:E ratio from 2:1 to 1:2. Cellularity and erythropoiesis increased. The goats of gr.B were

sacrificed and macroscopic changes included mild degree of accumulation of fluid in serous cavities, pale liver, slightly enlarged heart, discoloration of the lungs and thin watery blood. Pathological changes in liver showed vacuolar degeneration of hepatocytes with partial evidence of coagulation necrosis, in spleen revealed necrosis of the lymphoid cells with yield developed follicles and mild haemosiderosis, the cardiac muscle examination showed oedematous swelling and Zenker's degeneration and there was no visible change observed in the lungs.

The iron, copper and cobalt contents of liver of anaemic goats of gr.E were dropped significantly in comparison to the normal value of control healthy goats.

Treatment of nutritional anaemic goats :

The nutritional anaemic goats of gr.C at day 121 were subjected to treatment with a course of systemic and oral haematinics along with the balanced diet and proved very effective in raising the dropped haematological and biochemical parameters to normal at day 135 of the experiment. The bone marrow changes returned to normal at the end of the treatment.

Natural feed stuffs of the grazing field usually contained enough iron to meet the requirements of farm livestock.

Copper content of the plants of the grazing area was also adequate whereas the cobalt content was marginal to low. Cobalt deficiency occurs in large areas of many countries and is largely, but not exclusively restricted to grazing ruminants which have little or no access to concentrates. With the exception of P and Cu, Co deficiency is the most severe mineral limitation to grazing livestock in tropical countries. Cobalt deficiency signs are not specific and it is often difficult to distinguish between a deficiency of Co and malnutrition due to low intake of calories and protein.

Cobalt is a dietary essential for ruminants and is needed in the bacterial synthesis of Vit.B₁₂. Cobalt, through the formation of B₁₂ exerts its effect on DNA synthesis and cell replication with the formation of DNA precursor thymidilic acid. Cobalt deficiency in the diet might be the cause of low level of iron and copper in serum in nutritional anaemic goats in comparison to healthy control goats though the natural feed stuffs contained required amounts of the above two elements.

Chronic haemorrhagic anaemia :

Chronic haemorrhagic anaemia was induced in experimental goats (of Gr.D and E) by daily withdrawal of 20 ml of blood arbitrarily from the jugular vein for a period of 72 days in

case of gr.E when the animals developed severe anaemia whereas in gr.D the daily withdrawal of same amount of blood was continued till death of the animals. Two out of five goats of gr.D died at 0-day 73 and the rest died at day 74,75 and 76 respectively. The haematological and biochemical parameters (Hb, PCV, TEC, MCH, MCHC, Reticulocytes, BGL, TSP, Ca, P, SI, SCu and SCo) dropped significantly in comparison with the values of experimental healthy control goats (gr.A) under normal feeding. The peripheral blood picture of the anaemic goats revealed anisocytosis and poikilocytosis. The bone marrow studies indicated that the change of M:E ratio was from 2:1 to 1:5 to 1:6. Cellularity and erythropoiesis increased. During post-mortem examination, macroscopic changes noticed in all the five goats of gr.D died due to anaemia revealed accumulation of fluid in serious cavities, gelatinous degeneration of fat in the hilus of kidneys, mild degree of hydropericardium was also noticed in three of the five goats. Microscopic changes of the liver showed midzonal coagulative necrosis of hepatic cells characterised by pyknosis and karryorrhexis, proliferation and thickening of the bile duct, infiltration of mononuclear cells in the sinusoidal space and haemosiderosis. Examination of spleen revealed haemorrhages, depletion of the lymphoid cells and haemosiderosis. There was oedematous swelling and hypertrophy of the heart. In lungs nothing abnormality was detected. The changes in the kidneys

revealed tabular nephrosis characterised by desquamation, proliferation and occasional sloughing of tubular epithelium with infiltration of neutrophils. Desquamated cells occupying the tubular lumina was also observed in kidney. Examination of intestine showed cellularity in the lamina propia, excess activity of the goblet cells and muscular hypertrophy. Congestion of the blood vessel and necrosis of the lymphoidal cells were observed in lymphnodes.

The results of the iron, copper and cobalt content of the liver of anaemic goats revealed that there were significant fall in the value of the above elements in comparison to the normal value of healthy control goats of gr.A.

Treatment of chronic haemorrhagic anaemic goats :

The chronic haemorrhagic anaemic goats of gr.E at the height of anaemia on day 72, emergency treatment with blood transfusion was carried out. After overcoming the crisis period, they were subjected to a course of oral and parenteral therapy of haematinics from the day 76. The treatment was extremely effective in alleviating anaemia. All the haematological and biochemical parameters of blood returned to normal by day 91 of the experiment. The bone marrow changes in respect to M:E ratio returned to normal i.e. 2:1 from 1:6. Cellularity and erythropoiesis also came to normal.

The anaemic animals of gr.D before death were subjected to emergency slaughter for evaluating the quality of meat. The results revealed that moisture % and cooking loss % increased significantly from the normal value of healthy control goats of gr.A. Protein % of meat decreased significantly in comparison to the normal value of healthy control goats. There was no significant change in respect to ether extract (Fat %) and total ash % of meat between the experimental group and control group. On the basis of the evaluation report, the quality of the meat of anaemic goats was found poor and as such unfit for human consumption.

Conclusion :

(1) While studying the incidence of anaemia in goats, around B.C.K.V., Nadia District, West Bengal, It was established that 61.48% of goats examined were suffering from anaemia either due to parasitism and/or malnutrition. According to season the incidence was found to be higher in monsoon (June-August) than that of winter (December to February) and summer (March to May). The incidence of anaemia in autumn (September to November) was insignificantly lowered in comparison to the incidence of monsoon. Age and sex had no influence over the incidence of anaemia.

(2) Results of the analysis of soils of the grazing area of goats revealed marginal to low level of copper and cobalt

content of soil. The other macro- and micro-nutrients like calcium, phosphorus and iron were within the normal range.

(3) The plants of the grazing area contained enough iron. Though the copper content of the soil was deficient, it was observed that in plants the same remained within the normal range whereas the cobalt content of the plants was found to be marginal to low.

(4) Normal healthy goats which were kept exclusively on grazing/browsing in the same grazing area, nutritional anaemia could be successfully reproduced in the experimental goats having low haematological and biochemical levels as in natural cases of anaemic goats. The bone marrow study revealed changes in the M:E ratio (from 2:1 to 1:2) with increased cellularity and erythropoiesis. The iron, copper and cobalt content of the liver decreased in comparison to normal value of healthy control goats. Characteristics pathological changes of nutritional anaemic goats in liver showed coagulation necrosis and in spleen haemosiderosis along with other changes were observed. The cardiac muscle examination revealed oedematous swelling and Zenker's degeneration.

(5) The treatment of the nutritional anaemic goats with oral and systemic haematinics along with the balanced diet proved very effective in alleviating anaemia.

. (6) Chronic haemorrhagic anaemia was successfully produced in normal healthy goats by daily withdrawal of 20 ml blood arbitrarily from the jugular vein. The haematological and biochemical profiles of the blood were reduced than the normal and the bone marrow examination indicated changes in the bone marrow (M:E) ratio to 1:5 to 1:6 from 2:1 with increased cellularity and erythropoiesis. The iron, copper and cobalt content of the liver reduced in comparison to the normal value of healthy control goats. Histopathological examination of different organs (liver, spleen kidney, heart, lungs, lymphnode and intestine) revealed varied anaemic changes. Showing to coagulation necrosis, haemosiderosis in liver and spleen, oedematous swelling and Zenker's degeneration and hypertrophy of the heart and tubular nephrosis. No characteristics changes were observed in lungs.

(6) The chronic haemorrhagic anaemic goats were subjected to blood transfusion as an emergency to over come the crisis period. After the crisis period was over the anaemic goats were given with oral and parenteral haematinics along with balanced diet. The above treatment was very effective in treating anaemia.

(7) Analysis of meat of anaemic goats revealed increase moisture content and cooking loss. Protein percentage was reduced and the anaemic meat was found unfit for human consumption.

In the present study, the goats in the villages around B.C.K.V. of Nadia District are being devoid of getting optimum level of cobalt from their diet as there is marginal to low level of this element in both soil and plants of the grazing area. Therefore, basing on this points it is concluded that mineral mixtures of iron, copper and cobalt with proteins and vitamins must be supplemented to the goats of the area for the maintenance of normal health with a view to upgrade their performance and to control the economic loss.

CHAPTER—VI

FUTURE SCOPE OF RESEARCH

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FUTURE SCOPE OF RESEARCH

1. To assess the optimum dietary requirements of Fe, Cu and Co in considering their interactions with other micronutrients in goats with reference to soil and plant analysis of micronutrients in grazing area of West Bengal.
2. To study the status of iron, total iron binding capacity and unsaturated iron binding capacity and serum enzymatic activity in anaemic goats secondary to malnutrition.
3. Further work on the seasonal variation in bone marrow cytology in anaemic goats of the area.
4. Experimental production of Co deficiency in goats to study the symptomatology and other pathological changes in marginal and severe Co deficiency.

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* Original not seen