GENETIC STUDIES ON POLYMORPHISM OF SOME BLOOD PROTEINS IN GOATS

By

A. K. SHAMSUDDIN

THESIS

submitted in partial fulfilment of the
requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Breeding and Genetics
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy - Trichur

1984

DECLARATION

I hereby declare that this thesis entitled "GENETIC STUDIES ON POLYMORPHISM OF SOME BLOOD PROTEINS IN GOATS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Mannuthy,
7--12--1984.

(A.K. SHAMSUDDIN)

CERTIFICATE

Certified that this thesis entitled "GENETIC STUDIES ON POLYMORPHISM OF SOME BLOOOD PROTEINS IN GOATS" is a record of research work done independently by Sri.A.K.Shamsuddin under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

DR. G.MUKUNDAN
(Chairman, Advisory Board)
Professor & Head,
Department of Animal Breeding and Genetics.

Mannuthy,
7--12--1984.

Dedicated to

my son Raja

ACKNOWLEDGEMENTS

With immense pleasure the author expresses his deep sense of gratitude to:

Dr.G.Mukundan, Professor and Head, Department of Animal Breeding and Genetics for his valuable guidance, helpful suggestions and constant encouragement throughout this work.

Dr.C.A. Rajagopala Raja, Associate Professor, Department of Animal Breeding and Genetics; Dr.B.R.Krishnan Nair, Geneticist, All India Coordinated Research Project on Goats for Milk, Mannuthy; and Mr.K.L. Sunny, Assistant Professor, Department of Statistics for their whole-hearted help and valuable suggestions during the present study as members of the Advisory Board.

Dr. (Mrs.) Sosamma Iype, Associate Professor, Department of Animal Breeding and Genetics for the help and encouragement in carrying out this work.

Dr.B. Nandakumaran, Assistant Professor, Department of Animal Breeding and Genetics for his constant help and valuable suggestions extended for the preparation of thesis.

Dr.K.C. Raghavan, Dr.K.V. Reghunandanan, Dr. (Mrs.) C.R.Girija and other staff members of the Department of Animal Breeding and Genetics for the encouragement rendered by them.

Dr.M.Krishnan Nair, Dean, College of Veterinary and Animal Sciences for providing the facilities for the study.

The Director, Animal Husbandry and Veterinary Department, Government of Assam for granting deputation to undergo this course.

The Director, Manpower Development, North Eastern Council, Shillong for providing financial assistance in the form of fellowship during the course of study.

Dr.A.G.Anil Kumar, Mr.B.P. Nair, Dr.S.Talukdar, Mr. Mathew Sebastian, Dr.T.Linyu and other friends and colleagues for their help and encouragement.

Mr.T.D.Jose for the elegant typing of the manuscript.

The author also expresses gratitude to his family members especially to his beloved wife for her constant inspiration and encouragement in spite of all the odds she had to face.

A.K. SHAMSUDDIN.

C O N T E N T S

---oOo---

INTRODUCTION

INTRODUCTION

The discovery in 1949 that patients with sickle cell anaemia carried a haemoglobin which was electrophoretically different from normal haemoglobin, has opened up a new area of research on biochemical genetics. The studies on biochemical genetics progressed rapidly with another breakthrough in evolving a new technique for separation of serum proteins by the starch-gel-electrophoresis. During recent years extensive work has been conducted in animals to have intimate acquaintance with the gene profile through electrophoretic studies of the proteins, enzymes and red cell antigens. The existence of a widespread genetic variation in these biochemicals provoked keen interest to explore the possibility of its utilisation for assessing the changes that may come about due to planned breeding in the process of evolution of new breeds/strains.

In any study of population dynamics, there is a need for gene markers, by which, changes in the genetic variation or the resemblance between different populations may be measured. The markers should show simple inheritance and be fairly neutral with regard to the production, viability and reproduction. The loci controlling the polymorphic proteins and enzymes serve the purpose in excellent manner for application in the parentage control and for the genetic investigations. The gene frequencies of alleles at different loci controlling proteins/enzymes in

livestock can be employed in studies of relationship among breeds and breed structure.

Kerala possesses 2.0 million goats, which produce 74 thousand tons of milk, forming about 8 per cent of the total milk produced in the State. Nearly 4 lakhs of goats are slaughtered every year in this State, which do not include animals slaughtered privately in clandestine manner. The goat husbandry is one of the most important livestock enterprise among the rural community in Kerala. Realising the importance of goats in the rural economy of Kerala, Indian Council of Agricultural Research sanctioned an All India Coordinated Research Project on Goats for Milk to Kerala Agricultural University. Two breeds of Switzerland viz. Saanen and Alpine were used to cross the goats of Malabari breed at this centre, for evolving a new breed of goat for increased milk production adapted to the agro-climatic conditions of Kerala.

Although goats play an important role in the uplift of rural population in India, very little information on Indian goats is available, atleast with regard to biochemical polymorphism and no information is available on the native goats of Kerala. The present investigation was, therefore, undertaken with the following objectives:

i) To study the haemoglobin, transferrin, albumin and amylase types and their gene frequencies in Malabari goats and their exotic cross-breds.

ii) To study the inheritance of these biochemical variants in these groups.

iii) To study the association, if any, between these biochemical variants and traits of economic importance such as birth weight, body weights at 3 months, 6 months and 12 months, age at first kidding, first lactation milk yield, peak yield and interkidding interval.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Studies on the genetic polymorphism of blood proteins/ enzymes as a means for discovering genetically determined differences between various breeds of goats were carried out in several laboratories in India as well as abroad. Literature of the studies on polymorphism of haemoglobin, transferrin, albumin and amylase in goats are reviewed as hereunder:

Haemoglobin

Haemoglobin, the oxygen carrying component of blood, is composed of large spheroid molecules having a haemoprosthetic group combined with a protein moiety, globin. Each molecule consists of four polypeptide chains normally occurring in two pairs of identical chains.

Work done abroad

Pouling et al. (1949) studied haemoglobin in man by means of paper electrophoresis and found a fraction (Hb S) which was different from the normal haemoglobin (Hb A). This finding gave a further scope of electrophoretic study of haemoglobin and other proteins.

Bernhardt (1964) made some preliminary investigation to establish different haemoglobin types in 250 German goats. Three phenotypes HbAA, HbAB and HbBB were reported. Efremov and

Braend (1965) studied the haemoglobin polymorphism in the native Norwegian goats with starch-gel-electrophoresis. They observed only one type of haemoglobin which was indistinguishable from HbBB of sheep.

Boyer (1967) observed that Hb^A was replaced by Hb^C in the anaemic goats and sheep. He also observed that Hb^C differed from Hb^A and Hb^B only in the beta chain and that the beta chain was the product of a distinctive gene.

Braide and Enyenihi (1969) reported three haemoglobin types in Nigerian goats on the basis of electrophoretic mobility. These types included haemoglobin with relatively fast migration towards anode, another with relatively slower migration and a third type with intermediate electrophoretic mobility.

Osterhoff and Wardcox (1972) investigated some biochemical polymorphic systems of goats in South African breeds viz. Angora, indigenous and Boer goats. They found three Hb phenotypes HbAA, HbAB and HbBB which were controlled by two codominant alleles Hb^A and Hb^B.

Osterhoff et al. (1972) analysed 54 families of goats in South Africa and reported that there was no significant difference between aborting and non-aborting goats with respect to haemoglobin gene frequencies.

Odermatt (1973) reported two haemoglobins in Toggenburg and Grisons striped (GS) goats.

Enyenihi (1974) carried out electrophoretic analysis of 414 blood samples from adult Nigerian Red Sokoto, Kano Brown and Sahel (West African Long-legged) goats. In the first two breeds he found atleast three electrophoretically distinct haemoglobin types. These were similar to those described for Kano-Brown goats by Braide and Enyenihi (1969). Sahel blood samples revealed atleast four electrophoretically distinct types, three of which were identical with those of the first two goat breeds (Hb-N, Hb-S and Hb-F). The fourth type (Hb-S') was extremely slow in migration towards anode.

Kunz (1974) studied the blood samples from 105 Appenzell, 118 Verzasca and 122 Valais Black neck (V-B) goats of Switzerland. Except few Appenzells all the animals had only HbAA type. Few animals of Appenzell breed were of HbAB type.

Schmid and Kunz (1974) described that foetal haemoglobin could persist in kids upto the age of 34 days. The change over from foetal Hb to adult Hb took place in steps, and in individual kids it occurred at different times.

Garzon Garrido Espiga et al. (1976) demonstrated haemoglobin

polymorphism in 30 Granada goats by using electrophoresis. The gene frequencies of Hb^A and Hb^B were 0.88 and 0.12 respectively.

Antova and Mkrtchyan (1977) investigated 567 Russian Altai Mountain goats for haemoglobin polymorphism. The Hb system included the usual alleles Hb^A and Hb^B and also a new allele designated as Hb^H at a frequency of 0.0044. The frequency of Hb^A allele was found to be higher (0.82). The heterozygote animals were slightly heavier (by about 3 per cent) than the homozygotes and significantly exceeded the homozygotes in undercoat yield. Double heterozygote animals for both haemoglobin and transferrin were significantly heavier than single heterozygotes.

Bannister et al. (1979) typed 327 inbred goats of Malta in flocks of 10 - 30 animals for haemoglobin. 109 goats were found to be of type AD and 29 of type D. The frequency of Hb^D was found to be 0.255, compared with an expected value of 0.065. Analysis of Hb from goats homozygous for type D revealed that these animals also carried 1 to 5 per cent type C, which was controlled by Hb^C, a gene not allelic with Hb^A and Hb^D.

Mostaghni (1979) investigated haemoglobin polymorphism in 208 Iranian goats employing electrophoresis on cellulose acetate. Three types of haemoglobin (A, B and C) were identified with four phenotypes viz. B, AB, BC and ABC. The gene frequencies of Hb^A,

Hb^B and Hb^C were 0.194, 0.577 and 0.229 respectively. In sheep and goat Hb^A had been shown to switch to Hb^C when the animals were made anaemic.

Watanabe et al. (1979) studied 37 native Japanese, 25 Ogasawara, 5 Yakushima, 80 Phillipine, 122 Thailand and 3 Pakistan goats, and reported that all the animals were of HbAA type. In 2 population of Japanese Saanens (79 and 21 respectively) all were of HbAA type, except very few animals which were of HbAB type. The frequency of Hb^B gene was 0.013 and 0.074 in the two populations respectively.

Buvanendran et al. (1981) studied haemoglobin variants in 104 adult Red Sokoto goats and 49 kids and reported three haemoglobin variants viz. Hb^F, Hb^N and Hb^S with five phenotypes viz. HbNN, HbNS, HbFS, HbNF and HbSS. The gene frequencies for Hb^F, Hb^N and Hb^S were found to be 0.077, 0.591 and 0.327 respectively. The heterozygote animals (viz. HbNS) had significantly low helminth egg counts than homozygotes.

Using starch-gel-electrophoresis, Fesus et al. (1983) typed 224 Hungarian native female goats for haemoglobin. Two phenotypes viz. HbAA and HbAB were reported. The gene frequencies for Hb^A and Hb^B were found to be 0.954 and 0.046 respectively. There was no apparent relationship of Hb type with female reproductive performances.

Work done in India

Khanolker et al. (1963) reported the existence of three haemoglobin phenotypes HbAA, HbAB and HbBB in Indian goats controlled by two codominant alleles Hb^A and Hb^B.

Joshi et al. (1975) studied haemoglobin types of 76 Barbari and 70 Jamnapari goats using horizontal paper electrophoresis. They reported that the percentage of A, B and AB types in Barbari were 89.5, 2.6 and 7.9 and in Jamnapari goats were 90.0, 1.4 and 8.6 respectively.

Naik (1975) investigated haemoglobin polymorphism in 166 Indian goats along with some other species of animals. He could report only two haemoglobin variants which were determined by codominant allelic genes. He also indicated that the cattle Hb^A like variant was found in all ruminants except spotted deer and the last variant in cattle Hb^{kh} (Hb-D) was found in goat only.

Goel and Nair (1976) studied blood samples from 224 goats belonging to Alpine, Beetal, Alpine x Beetal and Anglo-Nubian breeds by using starch-gel-electrophoresis. In these 4 breeds the gene frequency of Hb^A was 0.88, 0.92, 0.94 and 0.92 respectively.

Gopinathan and Nair (1976) studied haemoglobin types in

129 goats belonging to Alpine, Beetal and cross-breds involving 8 sire groups. The data were recorded on birth weight, age at first kidding and lactation milk yield. Females of HbAA phenotype had a significantly lower age at first kidding (by 2.5 months) than females of other Hb phenotypes.

Singh et al. (1977) typed 275 non-descript, 38 Barbari, 16 Beetal and 63 Barbari x Beetal goats for haemoglobin polymorphism. They observed only one phenotype (HbAA) in Barbari, Beetal and its crosses. But HbAA and HbAB were found in non-descript goats with frequencies of 0.9382 and 0.0618 respectively.

Boruah and Bhat (1980) studied 230 goats belonging to Jamnapari, Black Bengal and Barbari breeds for haemoglobin polymorphism. In Jamnapari and Black Bengal only HbAA phenotype was observed, but in Barbari goats two phenotypes HbAA and HbAB controlled by two codominant alleles Hb^A and Hb^B were observed. The gene frequencies of Hb^A and Hb^B were 0.97 and 0.03 respectively.

Transferrin

The transferrin is a specific iron binding protein, whose major function is transportation of iron to bone marrow and tissue storage organs. The transferrin also participates directly in the regulation and control of iron absorption and protects from iron intoxication.

Work done abroad

Detection of genetically controlled transferrin heterogenity in human beings by Smithies (1957) initiated extensive investigation in various other species.

Ashton and McDougall (1958) reported transferrin variants in cattle, sheep and goat. They described it as β-globulin polymorphism resulting from 2 codominant alleles β^A and β^B.

Efremov and Braend (1965) showed that there was only one transferrin phenotype in Norwegian goats.

Watanabe et al. (1965) studied 1944 serum samples of goats from 7 different breeds. Three transferrin phenotypes were identified. There were marked breed differences in the frequency of types.

Watanabe and Suzuki (1966) reported three transferrin phenotypes viz. TfI-I, TfI-II and TfII-III controlled by two codominant autosomal alleles Tf^I and Tf^{II} in various breeds of goats from Japan and several other countries. The frequencies of TfI and TfII in the various breeds of goats were respectively as follows: Japanese Saanen 0.915 and 0.085; Tokara 0.966 and 0.034; Rhukyu native 0.979 and 0.021; German coloured (sic) 0.882 and 0.118; Italian Alpine 0.404 and 0.596; Hungarian

Saanen 0.462 and 0.538; Swiss Saanen 1.00 and zero. The frequency of TfI varied from 0.654 to 0.981 among the 7 populations of Japanese Saanen studied.

Salerno et al. (1968) studied the transferrin variants in South Italian goats. Two alleles Tf^A and Tf^B were reported with frequencies of 0.835 and 0.165 respectively.

Osterhoff and Wardcox (1972) reported four transferrin variants Tf^A, Tf^B, Tf^C and Tf^D in South African goats viz. Angora, indigenous and Boer goats.

Osterhoff et al. (1972) investigated transferrin polymorphism in 54 families of Angora goats. They observed no significant differences between aborting and non-aborting goats with respect to gene frequencies of transferrin types.

Tjankov (1972) observed that significant differences existed between Toggenburg, native Bulgarian and Toggenburg x Bulgarian goats in the frequencies of Tf^A and Tf^B genes. All Toggenburg goats had only TfA/TfA genotype. In the native Bulgarian goats and in the F_1 and F_2 crosses, the frequency of Tf^A was 0.78, 0.36 and 0.96 respectively. The increase in the frequency of Tf^A in the F_2 generation was attributed to the continuous use of TfA/TfA males for several years.

Odermatt (1973) could find only two transferrin types in 123 toggenburg and 127 Grisons-striped (GS) goats.

Watanabe and Suzuki (1973) observed a new allele Tf^C among serum transferrins of Korean, Phillipine and Thailand goats with frequency of 0.072, 0.019 and 0.006 respectively. It was concluded that the transferrin in goats classified into six phenotypes were genetically controlled by three codominant alleles Tf^A, Tf^B and Tf^C.

Kunz (1974) observed only TfAA genotype in the three breeds studied viz. Appenzell, Verzasca and Valais Black neck (V-B).

Garzon Garrido Espiga et al. (1976) typed 30 Granada female goats for transferrin polymorphism. Three transferrin alleles Tf^A, Tf^B and Tf^C with frequencies of 0.64, 0.34 and 0.02 respectively were reported.

Antova and Mkrtchyan (1977) studied 419 Russian Altai Mountain goats for transferrin variation. Three phenotypes TfAA, TfAB and TfBB controlled by two alleles Tf^A and Tf^B were observed. The frequencies of Tf^A and Tf^B were 0.74 and 0.26 respectively. Double heterozygote animals (HbAB; TfAB) were significantly heavier than AA/AB animals.

Fesus et al. (1983) analysed serum samples from 224 Hungarian native female goats for transferrin polymorphism. Two alleles Tf^A and Tf^B with frequencies of 0.588 and 0.412 respectively were reported. There was no apparent relationship of Tf type with female reproductive performance.

Work done in India

Goel and Nair (1976) observed transferrin polymorphism in 224 Alpine, Beetal, Alpine x Beetal and Anglo-Nubian goats. Two alleles Tf^A and Tf^B were reported. In the 4 breed groups respectively the gene frequency of Tf^A was found to be 0.89, 0.44, 0.47 and 0.30.

Gopinathan and Nair (1976) typed serum samples from 129 Alpine, Beetal and cross-bred goats involving 8 sire groups for transferrin polymorphism. Data were recorded on birth weight, age at first kidding and lactation milk yield. No significant difference was observed with respect to transferrin type.

Singh et al. (1977) studied transferrin polymorphism in 275 non-descript, 38 Barbari, 16 Beetal and 63 Barbari x Beetal goats. Two transferrin variants Tf^A and Tf^B with three phenotypes viz. TfAA, TfAB and TfBB were reported. The fast moving variant was designated as Tf^A while the slow moving one as Tf^B. The gene frequencies of Tf^A and Tf^B were 0.47 and 0.53, 0.12 and 0.88 and 0.40 and 0.60 in Barbari, Beetal and their crosses respectively.

Baruah and Bhat (1980) conducted studies on transferrin polymorphism in 230 goats of Jamnapari, Black Bengal and Barbari Breeds. Three transferrin phenotypes TfAA, TfAB and TfBB controlled by two co-dominant alleles Tf^A and Tf^B were observed. The gene frequencies of Tf^A and Tf^B were 0.27 and 0.73, 0.37 and 0.63 and 0.44 and 0.56 in Jamnapari, Black Bengal and Barbari breeds respectively.

Trehan et al. (1981) analysed serum samples from 905 goats belonging to various breeds viz. Alpine, Beetal, Nubian, Saanen, Alpine x Beetal and Saanen x Beetal to study the transferrin polymorphism. The transferrin polymorphism was found to be controlled by atleast 3 co-dominant alleles. It was suggested that there might be more than 3 alleles at the transferrin locus. The 3 co-dominant alleles were Tf^A, Tf^B and Tf^C showing 5 phenotypes viz. TfAA, TfBB, TfAB, TfBC and TfAC. TfAA and TfBB were represented by 2 bands each on the starch gels. Faster band of TfBB corresponded with the slower band of TfAA. Phenotypes TfAB and TfBC were represented by 3 bands each and TfAC was represented by 4 bands.

Albumin

Albumin is one of the most important serum proteins in blood. This protein is of great importance because of its relative abundance, homogeneity, osmotic and transport functions.

Work done abroad

Albumin variants were first described by McIndoc (1962) in the domestic fowls.

Efremov and Braend (1965) could not find albumin polymorphism in 108 Norwegian goats studied.

Watanabe and Suzuki (1967) studied the serum albumin type of 1628 goats of various breeds from Japan and several other countries. Three albumin phenotypes AA, AB and BB controlled by two autosomal alleles Alb^A and Alb^B were reported. The frequency of Alb^A in the various breeds were as follows: Japanese Saanen 0.961, German coloured 0.289, Hungarian Saanen 0.801, Italian Alpine 0.171, Swiss Saanen Zero, Rhukyu native 0.745, native goats and their crosses in Formosa 0.304 and Angora and their cross-breds in Formosa 0.471. The frequency of Alb^A varied from 0.845 to 1.0 among 6 populations of Japanese Saanen.

By employing horizontal starch-gel-electrophoresis Salerno et al. (1968) reported albumin polymorphism in 100 goats, bred in Eucania (South Italy). Three phenotypes FF, FS and SS, controlled by two co-dominant alleles Alb^F and Alb^S were observed. FF phenotype was found only in three animals.

Osterhoff et al. (1972) did not find any significant difference of gene frequencies of albumin between aborting and non-aborting Angora goats in 54 families.

Osterhoff and Wardcox (1972) studied serum samples for albumin polymorphism in three African breeds of goats viz. Angora, indigenous and Boer goats. Two albumin variants Alb^A and Alb^B were observed.

Tjankov (1972) described two types of albumin alleles Alb^S and Alb^F in Toggenburg, native, Bulgarian and Toggenburg x Bulgarian goats. The frequency of Alb^S allele was found to be higher (0.83 in the Toggenburg and 0.77 in the native goats). In the F_1 and F_2 generations the frequency of Alb^S was 0.68 and 0.91 respectively. Only Alb^S males had been used for service for many years, thus the frequency of this allele was increasing.

Lee (1975) reported three albumin phenotypes AA, AB and BB in Korean goats controlled by two alleles Alb^A and Alb^B. The gene frequencies of Alb^A and Alb^B were 0.16 and 0.84 respectively.

In a study conducted by Fesus *et al.* (1983) in the Hungarian native female goats, all the animals had the same albumin type.

Work done in India

Singh *et al.* (1977) studied 275 non-descript, 38 Barbari, 16 Beetal and 63 Barbari x Beetal goats for albumin polymorphism. They did not find any albumin polymorphism in these Indian goats.

Bhat and Boruah (1980) could not observe albumin polymorphism in 230 goats belonging to Jamnapari, Black Bengal and Barbari breeds. Each albumin phenotype was represented by two bands on the starch gels.

Amylase

Mammalian amylases are mainly alpha-amylase which hydrolyses starch and glycogen by splitting central glucosidic linkages. Beta amylases which are found in plants, splits maltose units from the non-reducing end of carbohydrate chains. Gamma amylase which was observed in the small intestine of rat (Dahlqvist and Thomson, 1963) converts starch to D-glucose.

Work done abroad

Polymorphism in amylase in cattle was first observed by Ashton (1958). He named it as thread protein.

Meyer (1967) could not find amylase polymorphism in horses, sheep, goats, dogs and minks.

Fetchter and Pretorius (1970) carried out investigation to study amylase polymorphism in 85 Angora goats. Three amylase phenotypes viz. A which was designated as fast moving type, S as slow moving type and AS as intermediate type were observed. Out of 85 goats, 81 were A type, 2 AS type and 2 S type found to be inherited in a co-dominant fashion.

Osterhoff and Wardcox (1972) studied amylase polymorphism in three South African goat breeds viz. Angora, indigenous and Boer goats. They observed that amylase phenotypes were determined by two co-dominant alleles Am^A and Am^B in all the three breeds.

Kunz (1974) studied serum samples from 105 Appenzell, 118 Verzasca and 122 Valais Black neck (V-B) goats. No polymorphism was observed in the amylase system.

Fesus et al. (1983) investigated 224 Hungarian native goats to study amylase polymorphism. Two alleles Am^A and Am^B with three phenotypes viz. AmAA, AmAB and AmBB were reported. Only one animal was of AmBB type. The gene frequencies for Am^A and Am^B were 0.996 and 0.004 respectively.

Work done in India

Singh et al. (1977) did not observe any polymorphism in the amylase system in 275 non-descript, 38 Barbari, 16 Beetal and 63 Barbari x Beetal goats.

Bhat and Boruah (1980) studied 230 goats belonging to Jamnapari, Black Bengal and Barbari breeds for amylase polymorphism using starch-gel-electrophoresis. Two amylase phenotypes Am-1 and Am-1-2 were observed. Animals with Am-2 type were not observed. The gene frequencies of Am-1 and Am-2 were found to be 0.995 and 0.005 respectively.

MATERIALS AND METHODS

MATERIALS AND METHODS

Blood samples collected from 188 goats belonging to Malabari breed and its Saanen halfbreds and Alpine halfbreds, maintained in the farm under All India Coordinated Research Project on Goats for Milk, Kerala Agricultural University, Mannuthy, formed the materials for the study. Out of these 188 goats, 40 belonged to Malabari, 72 Saanen x Malabari (halfbreds) and 76 Alpine x Malabari (halfbreds). The age of the animals varied from 3 months to 6 years.

The flock was managed under semi-intensive system of management. Suitable shelters were provided with necessary arrangements for optimum feeding and watering. A regular health calendar involving periodic vaccination and parasitic control were regularly followed as suggested by the experts. All animals that entered the experimental flock were identified by tatooing, with respect to its sire, dam etc.

Collection of blood samples

About 10 ml of fresh blood was collected aseptically by jugular vein puncture in two sterilised test tubes. For haemoglobin studies, the blood was collected in a tube which contained 0.5 ml of anticoagulant. The composition of the anticoagulant used was as follows:

Sodium citrate	20 g
Sodium chloride	5 g
Distilled water	1000 ml

For other proteins/enzyme the blood samples were collected in the test tubes without anticoagulant.

For haemoglobin, the samples were centrifuged first for 10 minutes at 2500 rpm and supernatant plasma was discarded. The red cells were then washed 3 times in normal saline solution (0.9 per cent solution of sodium chloride) in order to free the cells from plasma proteins. The washed cells were kept in the refrigerator until they were used.

For other proteins/enzyme, the blood samples were kept at room temperature for 3 - 4 hours. The separated serum was centrifuged at 2000 rpm for 10 minutes to free the serum from red cells. The supernatant serum was collected in small penicillin vials. The samples were stored in the deep freezer at $-10^{\circ}C$ until they were used.

Starch Gel Electrophoresis

Preparation of gel

The gels were prepared using 11 per cent hydrolysed potato starch (Sigma Chemical Co) in 250 ml of gel buffer in a 1000 ml filtering flask. To a required amount of hydrolysed starch,

the gel buffer was added and the mixture was heated over a naked flame with constant and vigorous swirling. The heating was continued until the temperature of the gel reached 90°C, when the consistency of the gel was fluid and the gel fluid became transparent. The next step consisted of applying a vacum for about 30 - 40 seconds to remove air bubbles from the gel. The hot gel was poured quickly into a glass plate (25 cm x 20 cm x 0.5 cm) which was edged by two pairs of removable glass bards (20 cm x 2 cm x 0.5 cm and 21 cm x 2 cm x 0.5 cm). The plate was filled until the gel came just above the top, then a glass plate of 25 cm x 20 cm x 0.5 cm size was gently placed over the surface of the gel. Care was taken to avoid trapping of air bubbles. The gel was kept for 1 hour at room temperature and then 1½ - 2 hours in the refrigerator.

After removing the cover plate gently the gel was cut and the samples were inserted in the gel linearly after soaking on appropriate whatman chromatography paper cut into small bits of 1 x 0.5 cm size. The excess solution of the small paper bits was removed by placing it over a thick filter paper. The samples were inserted in the gel at a distance of 3 cm from the cathode bridge. The interspace between the samples were 5 mm. The gel was placed on an electrolyte vessel having platinum electrodes. Connections between the gel and the vessel buffer were made by wicks, made of Whatman filter paper No.I.

The gel was covered with plastic sheet to prevent evaporation. The voltage applied and the duration of electrophoresis, varied with different protein/enzyme systems. After the electrophoresis, the gel was bisected horizontally using a thin nylon thread and the upper half was thrown away. The lower half was stained for characterisation of different phenotypes.

Staining, destaining and fixing of the gels

The gels were stained employing appropriate staining techniques, which varied with different proteins. After staining the gels were destained and fixed in a destaining fluid.

The details of buffers and staining techniques employed for different proteins/enzyme systems were as follows:

Haemoglobin

A continuous buffer system described by Gahne et al. (1960) was employed for the haemoglobin typing. The gels were prepared by adding 27.5 g of hydrolysed starch (Sigma) in a filtering flask with 25 ml of tris buffer and 225 ml of distilled water. The tris buffer consisted of:

Tris (hydroxymethyl) aminomethane	40.4 g
Ethylenediamine tetra acetic acid (EDTA)	4.0 g
Boric acid	3.0 g
Distilled water ad	2 litres

Buffer was adjusted to pH 8.9.

The same buffer was used as the vessel buffer also. The haemoglobin solution was made by haemolysing 0.25 ml of washed cells in 2.5 ml of distilled water. Whatman chromatography paper No.I cut into small bits of 1 x 0.5 cm size, soaked with haemoglobin solution was used for charging the gel.

Electrophoresis was done at 15 mA. After 2 minutes the paper pieces were removed. Care was taken to avoid air bubbles in the place of insertion of the samples. Then the electrophoresis was continued for one and half hours at 15 mA. After completion of the electrophoresis, the gels were sliced horizontally using a thin nylon thread. The lower half was stained with Benzidine stain containing:

Benzidine	250 mg
Hydrogen peroxide 30%.. ..	0.4 ml
Glacial acetic acid	1.5 ml
Distilled water ad	100 ml

The stain was allowed to act on the gel for 3 minutes and then the excess stain was removed by washing with tap water. The destaining and fixation of the gel was done in methanol - water - acetic acid (5 : 5 : 1) (Smithies, 1955).

Transferrin

The transferrins were separated employing horizontal

electrophoresis in starch gels, using the discontinuous buffer system. The gels were prepared by taking 27.5 g of hydrolysed starch (Sigma) in a filtering flask with 14 ml of stock soln (A), 18 ml of stock soln (B) and 218 ml of distilled water. The pH of the gel buffer was adjusted to 7.6.

Gel Buffer

Stock Solution A

Citric acid	10.5 g
Distilled water ad	1 litre

Stock Solution B

Tris (hydroxymethyl) aminomethane	23 g
Distilled water	1 litre

Vessel Buffer

Boric acid	37.5 g
Sodium hydroxide	8.0 g
Distilled water ad	2 litres

Buffer was adjusted to pH 8.6.

Whatman chromatography paper No.3 was used for charging the gels.

At the beginning, the electrophoresis was run at 25 mA

for 30 minutes. After 30 minutes, the paper bits were removed and the electrophoresis was continued at 25 mA till the borate line moved 10 cm from the point of insertion of the samples.

After completion of the electrophoresis; the gels were sliced horizontally using thin nylon thread. The upper half was thrown away and the lower half was stained with a mixture of a saturated solution of 1 per cent amido black and 0.5 per cent solution of nigrosin (1:1). The gels were kept immersed in the staining solution for 3 minutes and then the excess stain was removed by washing the gel under running tap water. The gels were fixed in methanol-water-gracial acetic acid (5 : 5 : 1).

Albumin

The separation of albumin was employed on a discontinuous buffer system in horizontal starch-gel-electrophoresis (Poulik, 1957).

Gel Buffer

Stock solution A (15 ml) + Stock Solution B (10 ml) adjusted to pH 5.8 was used as gel buffer.

Stock solution A

Citric acid	..	..	10.5 g
Distilled water ad	..	..	1 litre

Stock solution B

Tris (hydroxymethyl) aminomethane	..	23 g
Distilled water ad	.. ..	1 litre

Bridge Buffer

Boric acid	.. ..	37.5 g
Sodium hydroxide	.. ..	8.0 g
Distilled water ad	.. ..	2 litres

Buffer was adjusted to pH 8.6.

For charging the gels, Whatman chromatography paper No.3 was used.

The starting current was 10 mA. After 5 minutes the paper pieces were removed and the electrophoresis was continued at the same current until the borate line had moved 10 cm from the point of insertion of the samples.

The staining of the lower half of the gel was done in amido black (1 per cent) for 2 - 3 minutes and excess stain was washed in running tap water. The gels were then destained and fixed in the methanol-water-acetic acid (5:5:1) solution.

Amylase

The technique employed for the separation of amylase was essentially the same as described by Hesselholt et al. (1966).

A discontinuous buffer system in the horizontal starch-gel-electrophoresis was employed. The buffers used were as follows:

Gel Buffer

Stock solution A (10 ml) and stock solution B (10 ml) adjusted to pH 7.0 was used as gel buffer.

Stock solution A

Citric acid	..	..	10.5 g
Distilled water ad	..	..	1 litre

Stock solution B

Tris (hydroxymethyl) aminomethane	..	..	23 g
Distilled water ad	..	..	1 litre

Vessel Buffer

Boric acid	..	..	37.5 g
Sodium hydroxide	..	..	8.0 g
Distilled water ad	..	..	2 litre

Buffer was adjusted to pH 8.6.

The gels were charged with serum samples, soaked in 1 x 0.5 cm rectangular pieces of Whatman chromatography paper No.3.

The electrophoresis was run at 20 mA. After 15 minutes, the paper bits were removed. The electrophoresis was continued at the same current till the borate line had moved 8 cm from the point of insertion of the samples.

After bisecting the gels horizontally the lower halves were incubated in 0.1 M sodium acetate buffer (pH 5.5) at 37°C, with 2 ml of calcium chloride (0.005 M) in the incubator overnight. After incubation the gels were transferred to chilled 20 per cent alcohol and kept at 4°C in refrigerator for 3 - 4 hours. The amylase bands became very distinct when the gels were kept on a glass plate for 1 hour at 37°C. The gels were preserved in glycerine.

Collection of data

For studying the association, if any, between the blood protein polymorphism systems and traits of economic importance, data were collected on the following traits:

1. Body weight at birth
2. Body weight at 3 months
3. Body weight at 6 months
4. Body weight at 12 months
5. Age at 1st kidding
6. First lactation yield (120 days)
7. Peak yield
8. Inter kidding interval.

Analysis of data

The gene frequencies at different loci and phenotype frequencies were calculated by direct counting method, eg. the gene frequency of Hb^A in a population N was calculated as:

$$q\ Hb^A = \frac{2AA + AB}{2N}$$

χ^2 test was applied to find out whether the populations were in equilibrium or not, with respect to the particular proteins/enzyme polymorphism systems.

Statistical methods as described by Snedecor and Cochran (1967) were used to compare the gene frequencies at different loci in different genetic groups and to determine association between transferrin types and economic traits.

Analysis was carried out to determine the heterozygosity in different populations. The genetic variability of the population was measured as per the method described by Nei and Roychoudhury (1974). The heterozygosity of k^{th} locus (hk) could be defined as:

$$hk = 1 - jk$$

where $jk = \sum x_i^2$ is the homozygous at k^{th} locus

and $X_i = \frac{n_i}{n}$, denotes the gene frequency of i^{th} allele at k^{th} locus.

The average heterozygosity (H) of a population was calculated as the average of hk over all loci.

$$H = \sum_{k=1}^{r} \frac{hk}{r}$$

where r is the number of loci examined.

RESULTS

RESULTS

Haemoglobin

One hundred and eighty eight goats belonging to three genetic groups viz. 40 Malabari, 72 Saanen halfbreds and 76 Alpine halfbreds were typed for haemoglobin polymorphism.

Two haemoglobin phenotypes HbAA and HbAB (controlled by two alleles, the faster Hb^A and the slower Hb^B) were observed in the present study (Fig.1). HbAA was faster in mobility towards anode. HbAB had one component of Hb^A and other of Hb^B. Phenotype HbBB was not observed in the present study. The phenotype frequencies and gene frequencies of haemoglobin types in different genetic groups are presented in table 1. Phenotypes HbAA and HbAB were found in all the genetic groups. The frequency of phenotype HbAA was highest in Saanen halfbreds (0.9583) and lowest in Alpine halfbreds (0.9342). Comparatively higher frequency of HbAB was observed in Alpine halfbreds.

The gene frequency of Hb^A in Malabari, Saanen halfbred and Alpine halfbred goats was 0.9750, 0.9792 and 0.9671 respectively, and that of Hb^B in these genetic groups was 0.0250, 0.0208 and 0.0329 respectively. The diagramatic representation of gene frequencies in different genetic groups are shown in Fig.2.

Assuming Hardy-Weinburg equilibrium, the expected number

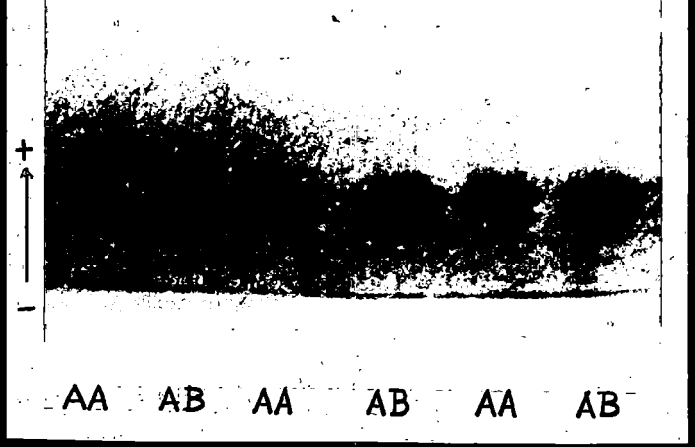
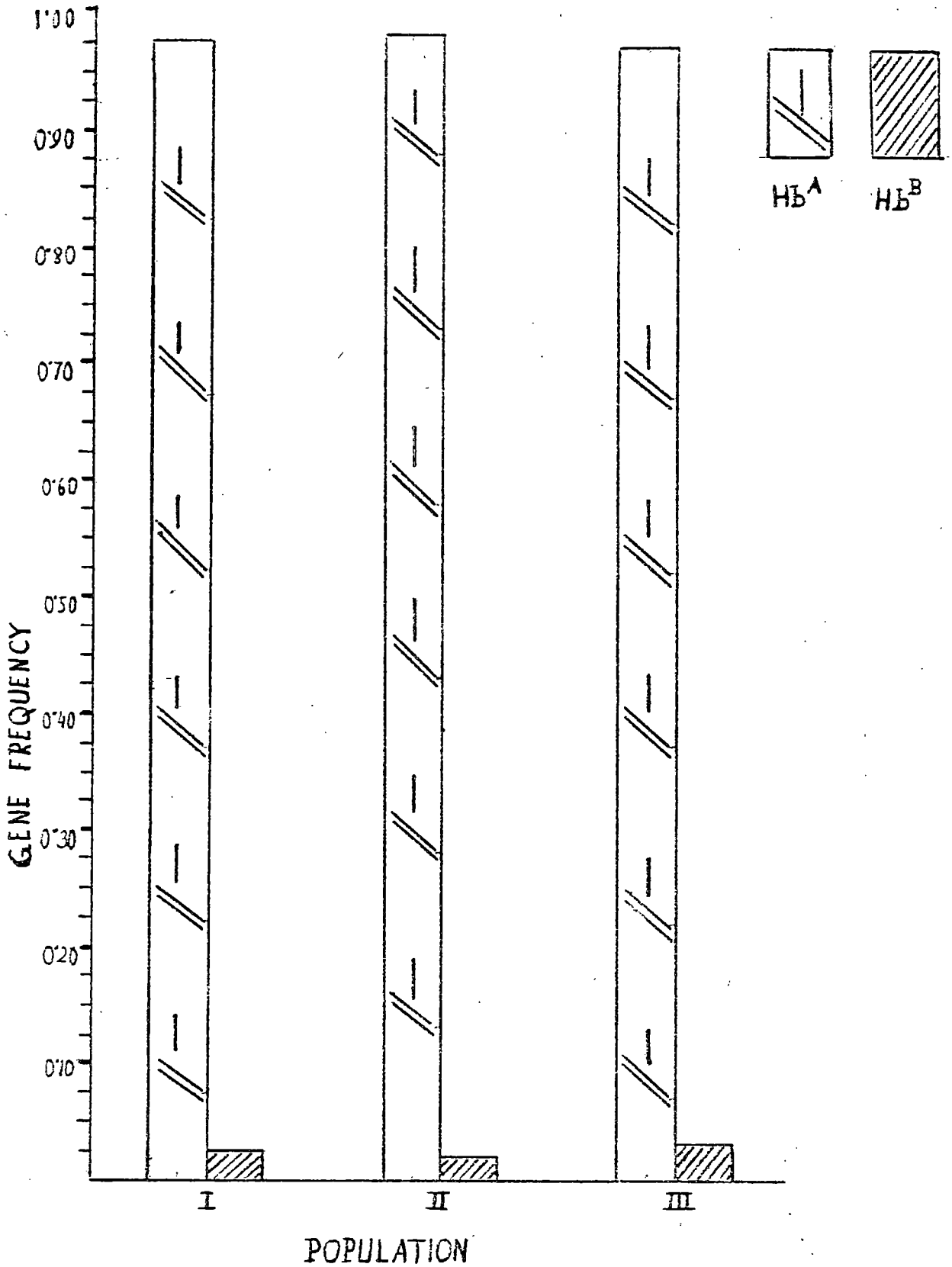


Fig.1. Stained starch-gel showing different haemoglobin phenotypes in goat.



● FIG.2 SHOWING HAEMOGLOBIN GENE FREQUENCIES IN DIFFERENT POPULATIONS ●

I MALABARI
II SAANEN HALFBRED
III ALPINE HALFBRED

Table 1. Phenotype frequencies and gene frequencies of haemoglobin types in Malabari goats and their exotic halfbreds.

Population	No. of animals	Phenotype frequencies			Gene frequencies	
		HbAA	HbAB	HbBB	Hb^A	Hb^B
Malabari	40	0.9500 (38)	0.0500 (2)	..	0.9750	0.0250
Saanen halfbred	72	0.9583 (69)	0.0417 (3)	..	0.9792	0.0208
Alpine halfbred	76	0.9342 (71)	0.0658 (5)	..	0.9671	0.0329

Figures in parentheses indicate the number of animals.

of goats with different haemoglobin phenotypes was calculated (Table 2). When compared with the observed number, a good agreement was obtained in all the genetic groups indicating that the populations were randomly mating and were in genetic equilibrium.

A comparison of gene frequencies among different genetic groups was done employing χ^2 test (Table 3).

It may be seen from table 3, that the frequencies of Hb^A and Hb^B genes in different genetic groups were not significantly different.

In this study, all matings between HbAA animals produced only HbAA offspring indicating that HbAA may be homozygous.

The association between the haemoglobin types and economic traits was not determined as the population was more homogenous.

Transferrin

Serum transferrin polymorphism was investigated in 188 goats belonging to three genetic groups viz. Malabari, Saanen halfbreds and Alpine halfbreds. The nomenclature followed in the present study was in accordance with Trehan et al. (1981).

The study revealed the presence of four transferrin phenotypes viz. TfAA, TfAB, TfBB and TfAC and three alleles

Table 2. Observed and expected number of animals with different haemoglobin types according to Hardy-Weinberg law.

Population	No. of animals	Haemoglobin phenotypes						χ^2	df
		HbAA		HbAB		HbBB			
		obs.	exp.	obs.	exp.	obs.	exp.		
Malabari	40	38	38.025	2	1.950	-	0.025	0.0263 NS	2
Saanen halfbred	72	69	69.036	3	2.933	-	0.031	0.0325 NS	2
Alpine halfbred	76	71	71.082	5	4.836	-	0.082	0.0877 NS	2

NS = Not significant.

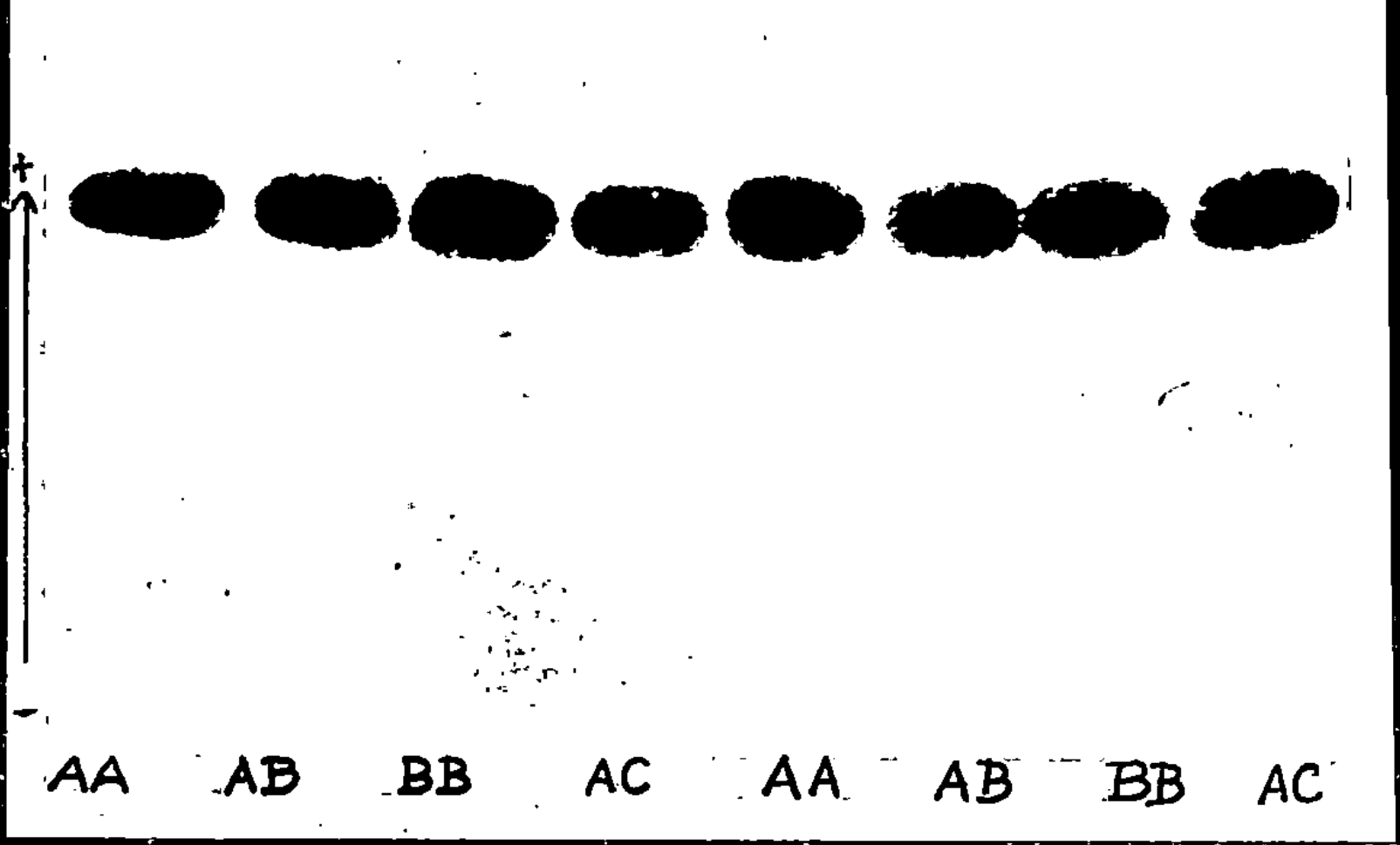
Table 3. Comparison of gene frequencies of Hb^A and Hb^B in Malabari goats and their exotic halfbreds.

Allele	Genetic group			χ^2	df
	Malabari	Saanen halfbred	Alpine halfbred		
Hb^A	0.9750	0.9792	0.9671	2.55 NS	2
Hb^B	0.0250	0.0208	0.0329	0.29 NS	2

NS = Not significant.

Tf^A, Tf^B and Tf^C. The alleles are thus designated based on the order of decreasing anodal mobilities. Phenotypes TfBC and TfCC were not observed in the population that was studied. Phenotypes TfAA and TfBB were represented by two bands each on the starch gel. Faster band of TfBB corresponded with the slower band of TfAA. Phenotypes TfAB and TfAC were represented by three and four bands each respectively (Fig.3). In TfAA and TfBB types, the faster band stained lighter than the slower band. In TfAB phenotype the fastest band was weakly stained whereas the other two bands were deeply stained. In TfAC phenotype, the bands one and three were weakly stained and the bands two and four deeply stained. The diagramatic representation of different observed transferrin phenotypes on the basis of number and mobility of bands is shown in Fig.4.

The phenotype frequencies and gene frequencies of transferrin types in different genetic groups are shown in table 4. In Malabari goats the frequency of TfAA, TfAB and TfBB phenotypes was 0.2250, 0.4500 and 0.3250 respectively. Phenotype TfAC was not observed in this breed. In Saanen x Malabari crossbreds the frequencies of TfAA, TfAB, TfBB and TfAC were 0.2500, 0.4583, 0.1945 and 0.0972 respectively. The frequencies of TfAA, TfAB, TfBB and TfAC in Alpine x Malabari crossbreds were 0.2631, 0.5132, 0.1974 and 0.0263 respectively.



ig.3. Stained starch-gel showing different transferrin phenotypes in goat.

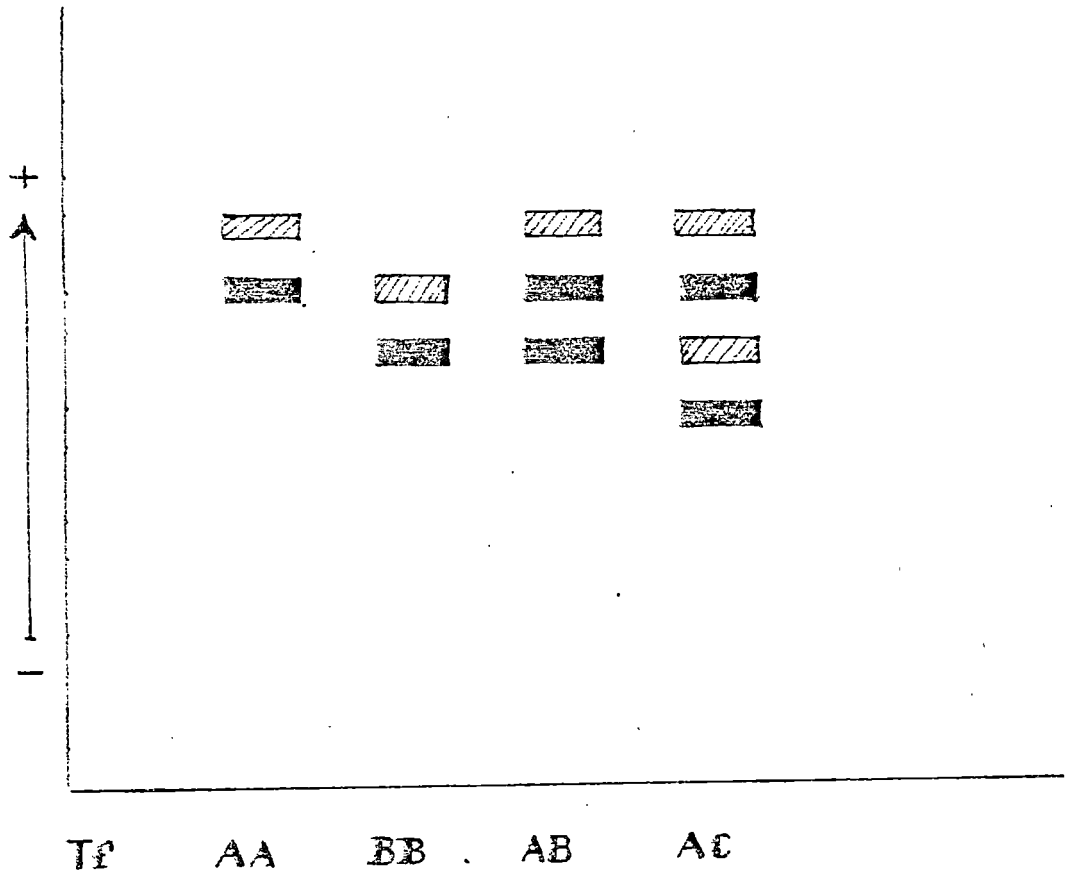


FIG. 4 DIFFERENT OBSERVED TRANSFERRIN PHENOTYPES ON THE BASIS OF NUMBER AND MOBILITY OF BANDS

Table 4. Phenotype frequencies and gene frequencies of transferrin types in Malabari goats and their exotic halfbreds.

Population	No. of animals	Phenotype frequencies						Gene frequencies		
		TfAA	TfAB	TfBB	TfAC	TfBC	TfCC	Tf^A	Tf^B	Tf^C
Malabari	40	0.2250 (9)	0.4500 (18)	0.3250 (13)	-	-	-	0.4500	0.5500	0.0000
Saanen halfbred	72	0.2500 (18)	0.4583 (33)	0.1945 (14)	0.0972 (7)	-	-	0.5278	0.4236	0.0486
Alpine halfbred	76	0.2631 (20)	0.5132 (39)	0.1974 (15)	0.0263 (2)	-	-	0.5329	0.4539	0.0132

Figures in parentheses indicate the number of animals.

The gene frequencies of Tf^A, Tf^B and Tf^C in Malabari goats were 0.4500, 0.5500 and zero respectively. The frequencies of corresponding alleles were 0.5278, 0.4236 and 0.0486 in Saanen halfbreds and 0.5329, 0.4539 and 0.0132 in Alpine halfbreds respectively. The diagramatic representation of gene frequencies in different genetic groups is shown in Fig.5.

Comparison of the gene frequencies among different genetic groups, presented in table 5 did not show significant difference.

The observed and expected values were compared in order to assess whether the populations were in genetic equilibrium and whether these populations were mating at random with respect to transferrin genes (Table 6). A good agreement was obtained between the observed and expected values in all the populations.

The results of matings between various transferrin types are presented in table 7. Mating of TfBB x TfBB produced only TfBB offspring and the observed number was the same as expected in Mendelian inheritance. In mating between TfAB x TfAA, out of 8 offspring, 3 were of TfAA and 5 were of TfAB type. The expected number of TfAA and TfAB individuals in the offspring were 4 and 4 respectively. The difference was not significant.

In TfAB x TfBB and its reciprocal mating, the observed number

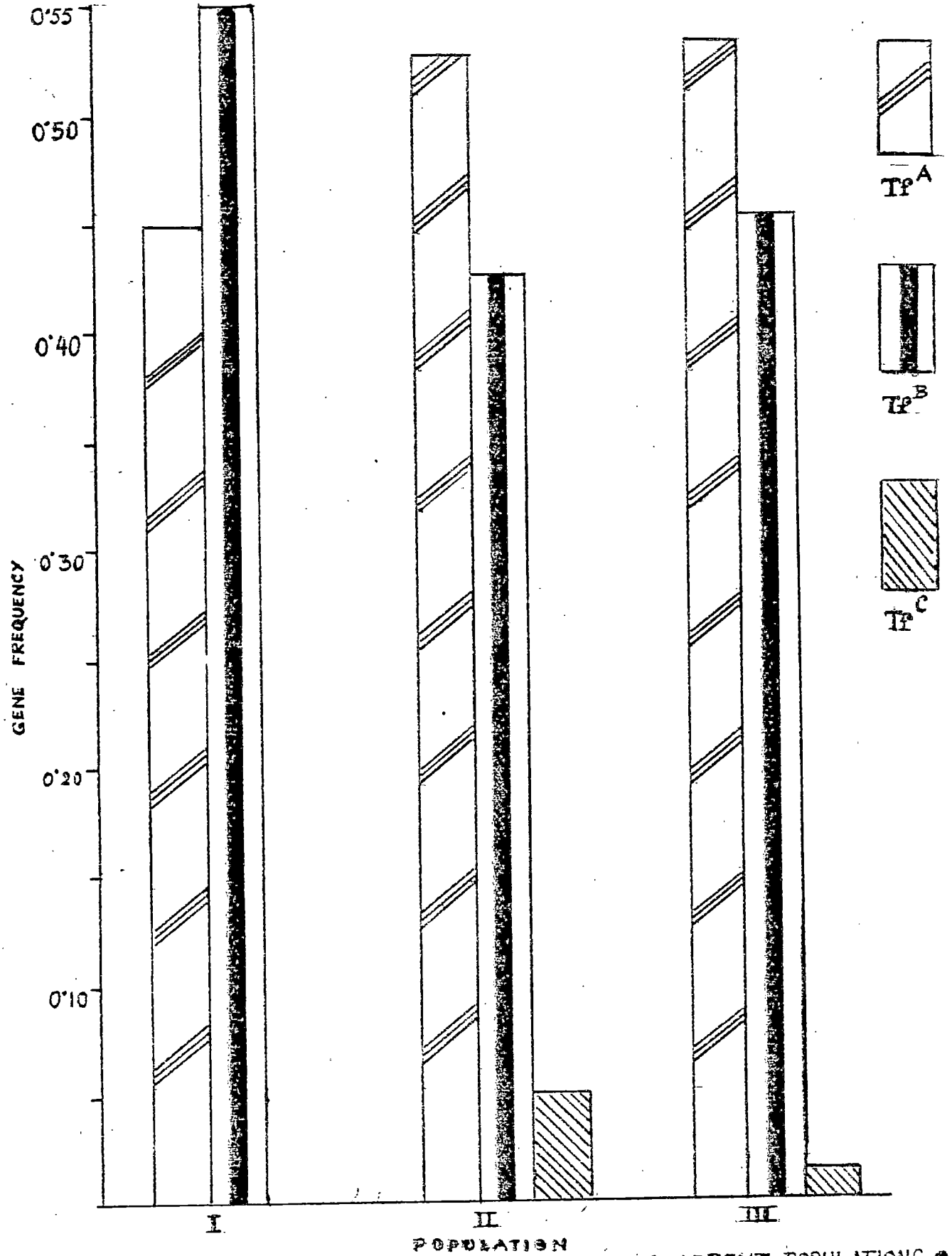


FIG.5 SHOWING TRANSFERRIN GENE FREQUENCIES IN DIFFERENT POPULATIONS

I MALABARI

II SAANEN HALFBRED

III ALPINE HALFBRED

Table 5. Comparison of transferrin gene frequencies in Malabari goats and their exotic halfbreds.

Allele	Genetic group			χ^2	df
	Malabari	Saanen halfbred	Alpine halfbred		
Tf^A	0.4500	0.5278	0.5329	4.12 NS	2
Tf^B	0.5500	0.4236	0.4539	2.87 NS	2
Tf^C	--	0.0486	0.0132	4.48 NS	2

NS = Not Significant.

Table 6. Observed and expected number of animals with different transferrin types according to Hardy-Weinberg law.

Population	No. of animals	Transferrin phenotypes							
		TfAA		TfAB		TfBB		TfAC	
		obs.	exp.	obs.	exp.	obs.	exp.	obs.	exp.
Malabari	40	9	8.100	18	19.800	13	12.100	-	-
Saanen halfbred	72	18	20.060	33	32.194	14	12.919	7	3.694
Alpine halfbred	76	20	21.580	39	36.770	15	15.660	2	1.070

(contd.....)

(Contd. table 6)

Population	No. of animals	Transferrin phenotypes				χ^2	df
		TfBC		TfCC			
		obs.	exp.	obs	exp.		
Malabari	40	-	-	-	-	0.3306 NS	2
Saanen halfbred	72	-	2.963	-	0.170	6.4139 NS	5
Alpine halfbred	76	-	0.910	-	0.010	2.0070 NS	5

NS - Not Significant.

Table 7. Segregation of transferrin types in offspring from different matings.

Mating classes	No. of matings	No. of offspring		Transferrin phenotypes TfAA	TfAB	TfBB	TfAC	TfBC	χ^2	df
BB x BB	5	5	obs.	-	-	5	-	-		
			exp.	-	-	5	-	-		
AB x AA	8	8	obs.	3	5	-	-	-	0.50	1
			exp.	4	4	-	-	-	NS	
AB x BB BB x AB	12	12	obs.	-	7	5	-	-	0.33	1
			exp.	-	6	6	-	-	NS	
AB x AB	10	10	obs.	1	7	2	-	-	1.80	2
			exp.	2.5	5	2.5	-	-	NS	
AC x AA	4	4	obs.	1	-	-	3	-	1.00	1
			exp.	2	-	-	2	-	NS	
AC x AB	6	6	obs.	3	1	-	2	-	3.33	3
			exp.	1.5	1.5	-	1.5	1.5	NS	

NS = Not Significant.

of offspring with TfAB and TfBB types were not significantly different from that expected.

When TfAB individuals were mated between themselves, the observed number of offspring with phenotype TfAA, TfAB and TfBB was not significantly different from that of the normal 1:2:1 ratio.

Similarly, non-significant differences between observed and expected offspring with different transferrin phenotypes were observed in matings between TfAC x TfAA and TfAC x TfAB.

The coat colours of all the animals were recorded to see whether there was any association between coat colours and transferrin types. The results are presented in table 8. The association between these two factors was studied using χ^2 test for the 4 x 4 table. The value of the χ^2 showed that there was no association between coat colours and transferrin types.

The mean values of all the traits with different transferrin types in all the genetic groups are presented in table 9.

The analyses of variance for different economic traits in Malabari goats are given in table 10. It may be seen from table 10 that first lactation yield (120 days) and peak yield were significantly affected by the transferrin types ($P < 0.05$). The critical differences presented in table 13 indicated that TfAA

Table 8. Observed and expected numbers of animals with different coat colours in different transferrin types.

Tf types \ Coat colour	Black	White	Brown	Mixed	Total	χ^2	df
TfAA	10 (11.75)	13 (15)	17 (14.25)	7 (6)	47		
TfAB	27 (22.50)	24 (28.72)	26 (27.29)	13 (11.49)	90	11.11 NS	9
TfBB	10 (10.50)	17 (13.40)	12 (12.73)	3 (5.36)	42		
TfAC	0 (2.25)	6 (2.87)	2 (2.73)	1 (1.15)	9		
Total	47	60	57	24	188		

Figures in parentheses indicate expected numbers of animals.

NS = Not Significant.

Table 9. Mean values with standard error of some economic traits with different transferrin types.

Genetic group - Malabari

Transferrin types	Body weight (kg) at birth	at 3 months	at 6 months	at 12 months	Age at 1st kidding (days)	1st lactation yield (120 days) (lit)	Peak yield (lit)	Inter kidding interval (days)
TfAA	1.80 ±0.11 (9)	6.01 ±0.38 (9)	10.03 ±0.86 (9)	16.87 ±1.30 (9)	557.83 ±56.83 (6)	55.18 ±8.62 (6)	0.95 ±0.18 (6)	372.20 ±18.60 (5)
TfAB	1.51 ±0.09 (18)	5.31 ±0.29 (18)	9.27 ±0.41 (18)	14.88 ±0.72 (18)	603.06 ±31.68 (16)	40.78 ±2.86 (16)	0.62 ±0.05 (16)	383.10 ±4.28 (10)
TfBB	1.57 ±0.11 (13)	4.91 ±0.36 (13)	8.10 ±0.45 (13)	13.46 ±0.87 (13)	606.40 ±30.15 (10)	37.44 ±3.57 (10)	0.59 ±0.06 (10)	416.00 ±33.60 (5)

(contd....)

Genetic Group - Saanen halfbred.

(Table 9 contd...)

Trans-ferrin types	Body weight (kg) at birth	at 3 months	at 6 months	at 12 months	Age at 1st kidding (days)	1st lactation yield (120 days) (lit)	Peak yield (lit)	Inter kidding interval (days)
TfAA	2.35 ±0.15 (17)	6.83 ±0.43 (17)	11.09 ±0.77 (15)	18.77 ±1.05 (15)	535.26 ±22.41 (15)	65.84 ±10.14 (15)	0.87 ±0.09 (15)	326.00 ±17.85 (6)
TfAB	1.89 ±0.08 (27)	6.66 ±0.32 (27)	10.81 ±0.69 (23)	18.78 ±0.80 (23)	542.10 ±25.93 (19)	59.14 ±5.87 (19)	0.84 ±0.07 (19)	347.46 ±12.41 (15)
TfBB	1.90 ±0.12 (14)	6.10 ±0.30 (14)	10.16 ±0.62 (14)	16.98 ±0.75 (14)	564.92 ±30.85 (14)	56.33 ±5.79 (14)	0.79 ±0.06 (14)	380.63 ±11.40 (11)

(contd.....)

(Table 9 contd...) Genetic group - Alpine halfbred.

Transferrin types	Body weight (kg) at birth	at 3 months	at 6 months	at 12 months	Age at 1st kidding (days)	1st lactation yield (120 days) (lit)	Peak yield (lit)	Inter kidding interval (days)
TfAA	2.02 ±0.11 (18)	6.21 ±0.42 (18)	10.20 ±0.57 (15)	17.72 ±0.82 (15)	648.64 ±29.60 (11)	63.58 ±7.31 (11)	0.98 ±0.10 (11)	382.88 ±23.20 (9)
TfAB	1.92 ±0.09 (36)	6.90 ±0.32 (36)	10.63 ±0.32 (31)	17.39 ±0.48 (31)	634.89 ±23.21 (28)	55.92 ±4.41 (28)	0.90 ±0.06 (28)	352.59 ±16.27 (22)
TfBB	1.72 ±0.13 (15)	6.19 ±0.56 (15)	10.10 ±1.14 (11)	18.74 ±1.48 (11)	565.22 ±34.62 (9)	43.47 ±4.04 (9)	0.64 ±0.06 (9)	274.14 ±21.07 (7)

Figures in parentheses indicate the number of observations.

Table 10. Analyses of variance for different economic traits in Malabari goats.

10(a). Body weight at birth.

Source	df	SS	MSS	F
Between transferrin types	2	0.49	0.25	1.78 NS
Error	37	5.29	0.14	

NS = Not Significant.

10(b). Body weight at 3 months.

Source	df	SS	MSS	F
Between transferrin types	2	6.40	3.20	2.53 NS
Error	37	46.64	1.26	

NS = Not Significant.

10(c). Body weight at 6 months.

Source	df	SS	MSS	F
Between transferrin types	2	21.32	10.66	2.88 NS
Error	37	136.74	3.69	

NS = Not Significant.

(contd.....)

Table 10 (contd...)

10(d). Body weight at 12 months.

Source	df	SS	MSS	F
Between transferrin types	2	61.79	30.89	2.88 NS
Error	37	396.47	10.71	

NS = Not Significant.

10(e). Age at first kidding.

Source	df	SS	MSS	F
Between transferrin types	2	10615.00	5307.50	0.37 NS
Error	29	419560.00	14467.59	

NS = Not Significant.

10(f). First lactation yield (120 days)

Source	df	SS	MSS	F
Between transferrin types	2	1268.05	634.02	3.44 *
Error	29	5348.16	184.42	

* Significant at 5% level.

(contd.....)

Table 10 (contd...)

10(g). Peak yield.

Source	df	SS	MSS	F
Between transferrin types	2	0.60	0.30	5.00 *
Error	29	1.78	0.06	

* Significant at 5% level.

10(h). Inter kidding interval.

Source	df	SS	MSS	F
Between transferrin types	2	5401.10	2700.55	1.47 NS
Error	17	31139.70	1831.74	

NS - Not significant.

type was significantly different from TfAB and TfBB type with respect to first lactation yield and peak yield. Animals with TfAA type had significantly higher first lactation yield and higher peak yield than animals with other transferrin types. Though not significant, animals with TfAA type showed higher body weights at birth, 3 months, 6 months and 12 months than animals with other Tf types. As regards to age at first kidding and inter kidding interval, the TfAA phenotype showed a favourable trend.

In Saanen halfbred goats, body weight at birth and inter-kidding interval was found to be significantly different with transferrin types (Table 11). The critical differences presented in table 13 indicated that TfAA type was significantly different from TfAB and TfBB types for body weight at birth. For interkidding interval TfAA type was significantly different from TfBB type, but the difference between TfAA and TfAB types was not significant. Animals with TfAA type had significantly higher body weight at birth (2.35 $\pm$ 0.15 kg) and lower inter-kidding interval (326.00 $\pm$ 17.85 days) than animals with other Tf types. Although no significant association between Tf types and other economic traits was observed, a positive trend was exhibited by TfAA type in all the body weights except at 12 months. The animals with TfAA type kidded earlier than the animals with other Tf types. First lactation yield and peak

Table 11. Analyses of variance for different economic traits in Saanen halfbred.

11(a). Body weight at birth.

Source	df	SS	MSS	F
Between transferrin types	2	2.53	1.27	5.08 **
Error	55	13.68	0.25	

** Significant at 1% level.

11(b). Body weight at 3 months.

Source	df	SS	MSS	F
Between transferrin types	2	4.42	2.21	0.87 NS
Error	55	139.45	2.53	

NS = Not Significant

11 (c). Body weight at 6 months.

Source	df	SS	MSS	F
Between transferrin types	2	6.63	3.32	0.38 NS
Error	49	430.64	8.79	

NS = Not Significant.

(contd....)

Table 11 (Contd.)

11(d). Body weight at 12 months.

Source	df	SS	MSS	F
Between transferrin types	2	32.90	16.45	1.23 NS
Error	49	655.56	13.38	

NS = Not Significant.

11(e). Age at first kidding.

Source	df	SS	MSS	F
Between transferrin types	2	7013.34	3506.67	0.31 NS
Error	45	508599.66	11302.21	

NS = Not Significant.

11(f). First lactation yield (120 days).

Source	df	SS	MSS	F
Between transferrin types	2	706.60	353.30	0.40 NS
Error	45	39497.40	877.72	

NS = Not Significant.

(contd...)

Table 11 (Contd...)

11(g) Peak Yield.

Source	df	SS	MSS	F
Between transferrin types	2	0.04	0.02	0.20 NS
Error	45	4.51	0.10	

NS = Not Significant.

11(h) Interkidding interval.

Source	df	SS	MSS	F
Between transferrin types	2	13125.92	6562.96	3.39 *
Error	29	56224.28	1938.77	

* Significant at 5% level.

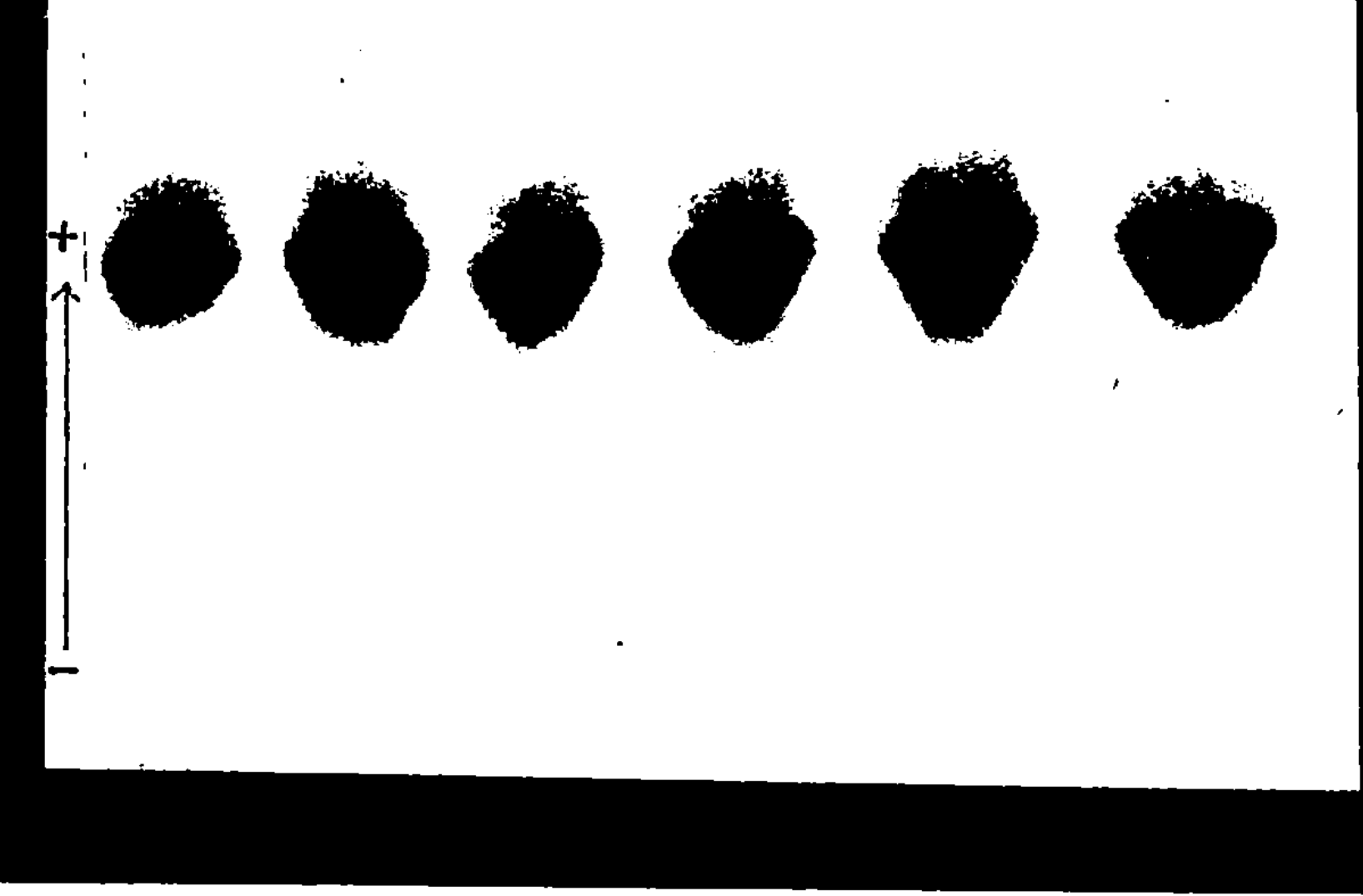
yield were highest in animals with TfAA type though not significant.

In Alpine halfbred goats, significant difference was observed between transferrin phenotypes in their peak yield and interkidding interval (Table 12). The critical differences presented in table 13 indicated that TfAA and TfAB types were significantly different from TfBB type with respect to peak yield and interkidding interval. Animals with TfAA and TfAB having the peak yield of 0.98 ± 0.10 and 0.90 ± 0.06 lit. respectively were significantly superior than animals with TfBB type with peak yield of 0.64 ± 0.06 lit. Animals with TfBB type had significantly lower interkidding interval (274.14 ± 21.07 days) than that of animals with other Tf types. Other economic traits were not found to be significantly different among transferrin types.

Albumin

One hundred and eightyeight goats belonging to three genetic groups viz. Malabari, Saanen halfbreds and Alpine halfbreds were typed for albumin polymorphism.

The albumin phenotype was represented by two bands on the starch gel (Fig.6). No polymorphism was observed in any of the genetic groups studied.



ig.6. Stained starch-gel showing albumin phenotypes in goat.

Table 12. Analyses of variance for different economic traits in Alpine halfbred.

12(a). Body weight at birth.

Source	df	SS	MSS	F
Between transferrin types	2	0.78	0.39	1.56 NS
Error	66	16.52	0.25	

NS = Not Significant.

12(b). Body weight at 3 months.

Source	df	SS	MSS	F
Between transferrin types	2	8.30	4.15	1.12 NS
Error	66	245.18	3.71	

NS - Not Significant.

12(c). Body weight at 6 months.

Source	df	SS	MSS	F
Between transferrin types	2	3.25	1.62	0.29 NS
Error	54	303.63	5.62	

NS = Not Significant.

(contd....)

Table 12 (contd...)

12(d). Body weight at 12 months.

Source	df	SS	MSS	F
Between transferrin types	2	14.91	7.45	0.67 NS
Error	54	595.96	11.04	

NS = Not Significant.

12(e). Age at first kidding.

Source	df	SS	MSS	F
Between transferrin types	2	41046.21	20523.10	1.56 NS
Error	45	590082.79	13112.95	

NS = Not significant.

12(f). First lactation yield (120 days).

Source	df	SS	MSS	F
Between transferrin types	2	2024.77	1012.39	2.09 NS
Error	45	21734.44	482.99	

NS = Not significant.

(contd...)

Table 12 (contd...)

12(g). Peak yield.

Source	df	SS	MSS	F
Between transferrin types	2	0.64	0.32	4.00*
Error	45	3.67	0.08	

* Significant at 5% level.

12(h). Interkidding interval.

Source	df	SS	MSS	F
Between transferrin types	2	49329.13	24664.57	4.80 *
Error	35	179651.07	5132.89	

* Significant at 5% level.

Table 13. Comparison of mean values between transferrin types in different genetic groups.

Genetic group - Malabari

Transferrin types	Mean values	
	First lactation yield (lit.)	Peak yield (lit.)
TfAA	55.18	0.95
TfAB	40.78	0.62
TfBB	37.44	0.59
CD (P<0.05) to compare		
AA and AB	13.29	0.24
AA and BB	14.34	0.26
AB and BB	11.19	0.20

Genetic group - Saanen halfbred

Transferrin types	Mean values	
	Body weight at birth (kg)	Interkidding interval (days)
TfAA	2.35	326.00
TfAB	1.89	347.46
TfBB	1.90	380.63
CD (P<0.05) to compare		
AA and AB	0.30	43.49
AA and BB	0.36	45.69
AB and BB	0.32	35.74

(contd....)

Table 13 (contd...)

Genetic group - Alpine halfbred.

Transferrin types.	Mean values	
	Peak yield (lit)	Inter kidding interval (days)
TfAA	0.98	382.88
TfAB	0.90	352.59
TfBB	0.64	274.14
CD ($P < 0.05$) to compare		
AA and AB	0.20	57.54
AA and BB	0.25	73.29
AB and BB	0.22	63.11

Amylase

The electrophoretic picture of amylase phenotype is shown in Fig.7. The amylase phenotype was represented by a single band on the starch gel. No polymorphism was observed in any of the genetic groups studied.

Heterozygosity

The genetic variability measured by the average heterozygosity per locus for three genetic groups of goats viz. Malabari, Saanen halfbred and Alpine halfbred is presented in table 14. Maximum heterozygosity was observed at the transferrin locus, in all the genetic groups, highest being in Saanen halfbreds (0.5396) followed by Alpine halfbreds (0.5098) and Malabari (0.4950) goats. The average heterozygosity was also found highest in Saanen halfbreds (0.2902) followed by Alpine halfbreds (0.2867) and Malabari (0.2719) goats.

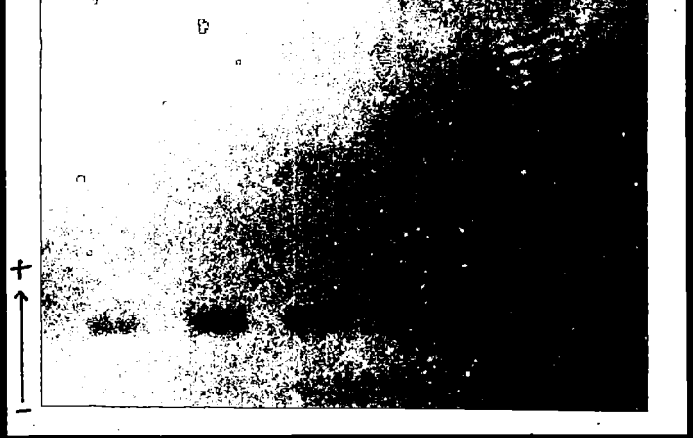


Fig.7. Stained starch-gel showing amylase phenotypes in goat.

DISCUSSION

DISCUSSION

Haemoglobin

In the Malabari breed of goats and their Saanen halfbreds and Alpine halfbreds, an investigation of gene-determined-electromorphs of blood protein using starch-gel-electrophoresis revealed the presence of two haemoglobin phenotypes HbAA and HbAB controlled by Hb^A and Hb^B alleles. Out of the three possible phenotypes HbBB was not observed in any of the genetic groups. This finding is in agreement with those reported by Naik (1975), Goel and Nair (1976), Singh et al. (1977) and Baruah and Bhat (1980). However, Khanolker et al. (1963) and Joshi et al. (1975) reported the existence of HbBB phenotype in indigencus goats atleast in a very low frequency.

In the present study the frequency of Hb^A allele was higher in Malabari goats (0.9750). Khanolker et al. (1963), Joshi et al. (1975), Naik (1975), Goel and Nair (1976), Singh et al. (1977) and Baruah and Bhat (1980) also reported very high frequency of Hb^A allele in some Indian breeds of goats.

Watanabe et al. (1965) reported high frequency of Hb^A allele in Saanen goats (Japanese Saanen 0.915; Saanen from Switzerland 1.00). Goel and Nair (1976) reported higher frequency of Hb^A (0.88) in Alpine goats. In the present study Saanen halfbred and Alpine halfbred goats also had higher frequency of Hb^A (0.9792

and 0.9671 respectively). Considering the higher frequency of allele Hb^A in Indian breeds as well as exotic breeds, a higher frequency of Hb^A allele was naturally expected in the Saanen halfbred and Alpine halfbred goats. The present results are in agreement with the earlier report of Goel and Nair (1976), who have found a higher frequency of Hb^A allele (0.94) in Alpine x Beetal crosses.

A good agreement was obtained between the observed and expected haemoglobin phenotypes in all the genetic groups. Therefore, it can be concluded that these populations were in Hardy-Weinberg equilibrium with respect to gene frequency and phenotype frequency. This was expected as the selection was not done on the basis of haemoglobin types of the animals. Baruah and Bhat (1980) also observed genetic equilibrium with respect to haemoglobin types in Jamnapari, Black Bengal and Barbari goats.

Comparison of the frequencies of Hb^A and Hb^B alleles among the three genetic groups showed significant similarity in allelic frequencies at Hb locus. This may be attributed to the similarity in Hb locus of exotic and Indian breeds.

In the present study all matings between HbAA animals produced only HbAA offspring indicating that HbAA may be homozygous. Other matings point out that Hb^A and Hb^B alleles may be co-dominant.

Association between haemoglobin types and some traits of economic importance was not studied, as the number of animals in HbAB phenotype was too small to draw any valid conclusion.

High frequency of HbAA phenotype, compared to the frequency of HbAB in all the populations of three genetic groups studied, indicates homogenity in goat population with regard to haemoglobin locus. This finding is in contrast with that reported in cattle, in which the phenotype frequencies did not show wide difference (Khanna et al. 1970).

Transferrin

Studies on transferrin polymorphism in Malabari, Saanen halfbred and Alpine halfbred goats revealed the existence of four phenotypes viz. TfAA, TfAB, TfBB and TfAC, controlled by three alleles Tf^A, Tf^B and Tf^C. The phenotype TfAC was observed only in Saanen halfbred and Alpine halfbred goats with low frequency. Phenotypes TfBC and TfCC were not observed in any of the three genetic groups. TfAB had the highest frequency in all the genetic groups (Malabari 0.4500, Saanen halfbreds 0.4583 and Alpine halfbreds 0.5132). In Malabari goats the frequency of TfBB (0.3250) was more than that of TfAA (0.2250). In Saanen halfbred goats the frequency of TfAA (0.2500) was more than that of TfBB (0.1945) and TfAC (0.0972). In Alpine halfbred goats also the frequency of TfAA (0.2631) was more than that of TfBB (0.1974) and TfAC (0.0263).

Table 14. Heterozygosity in different genetic groups.

Genetic group	Heterozygosity at different loci				Average heterozygosity
	Hb	Tf	Alb	Am	
Malabari	0.0488	0.4950	-	-	0.2719
Saanen halfbred	0.0408	0.5396	-	-	0.2902
Alpine halfbred	0.0636	0.5098	-	-	0.2867

Juneja and Choudhury (1970) observed three transferrin phenotypes in Barbari and Beetal goats. Singh et al. (1977) reported the presence of two transferrin variants Tf^A and Tf^B and three transferrin phenotypes TfAA, TfAB and TfBB in Beetal, Barbari and their crosses. They also observed high frequency of TfAB phenotype in Barbari and Barbari x Beetal crosses and higher frequency of TfBB in Beetal goats. Baruah and Bhat (1980) reported the presence of three transferrin phenotypes TfAA, TfAB and TfBB in Jamnapari, Black Bengal and Barbari goats. They also reported a higher frequency of TfAB type in all the three breeds, except in Jamnapari followed by TfBB and TfAA type. In Jamnapari goats TfBB type had highest frequency followed by TfAB and TfAA type. Trehan et al. (1981) reported the existence of three phenotypes TfAA, TfAB and TfBB in Beetal, Nubian and Alpine x Beetal goats and five phenotypes viz. TfAA, TfAB, TfBB, TfAC and TfBC in Alpine goats. In Saanen x Beetal goats two phenotypes TfAA and TfAB were observed. All the Saanen goats tested were of TfAA phenotype. Except Beetal all the other breeds had highest frequency of TfAB type followed by TfAA and TfBB type. In Beetal the frequency of TfBB type was highest followed by TfAB and TfAA type. It can therefore be postulated that a substantial number of goats of both Indian breeds and their exotic crosses are heterozygous with respect to transferrin locus. The absence of TfBC and TfCC phenotypes might be due to the rarity of Tf^C allele.

In the present study, the frequency of Tf^B allele was higher than that of Tf^A in Malabari goats, whereas in Saanen halfbred and Alpine halfbred goats Tf^A allele had the highest frequency followed by Tf^B and Tf^C. These findings are in agreement with the earlier reports of Juneja and Choudhury (1970), Singh et al. (1977), Baruah and Bhat (1980) and Trehan et al. (1981), who also reported higher frequency of Tf^B allele in Indian goats and that of Trehan et al. (1981) who additionally reported higher frequency of Tf^A allele in Saanen and Alpine cross-breds. High frequency of Tf^A allele in exotic breeds was also reported by Salerno et al. (1968), Tjankov (1972) and Odermatt (1973).

Among the three genetic groups, the allele Tf^C was found only in exotic cross-breds. The presence of Tf^C was not reported in any of the Indian breeds, whereas its presence has been reported by Osterhoff and Wardcox (1972) in Angora and Boer breeds, Watanabe and Suzuki (1973) in native goats of Korea, Phillipines and Thailand and Garzon Garrido-Espiga et al. (1976) in Granada goats. Trehan et al. (1981) reported the existence of Tf^C allele in Alpine goats. The presence of Tf^C in Saanen halfbreds and Alpine halfbreds in the present study indicate the inheritance of the gene from Saanen and Alpine bucks.

Each allele is represented by two bands on the starch gel.

Similar observations were made by Ashton and McDoughall (1958) while studying B-globulin polymorphism in goat. The β-globulins were later on shown to be transferrins by labelling with Fe^{59} by Suzuki and Watanabe (1968).

Phenotype TfAB is represented by three bands, the middle was common and the other two bands were of each allele. Phenotype TfAC indicated the presence of the third allele Tf^C. Phenotype TfAC was represented by four bands. It can be assumed that allele Tf^C is also co-dominant and is represented by two bands. The faster band of Tf^C corresponded with the slower band of allele Tf^B. From the above discussion it can be concluded that TfAA, TfAB, TfBB and TfAC had Tf^A Tf^A, Tf^A Tf^B, Tf^B Tf^B and Tf^A Tf^C as genotypes respectively, and these genotypes were controlled by three alleles viz. Tf^A, Tf^B and Tf^C.

In pedigree studies, it was observed that no progeny possessed any transferrin variant unless possessed by either one or both parents. The absence of significant difference between the observed and expected number of offspring in each mating indicates that the genes controlling the transferrins follow the simple Mendelian inheritance. Since no segregation was observed in TfBB x TfBB mating, it can be concluded that TfBB is homozygous. Other pedigree suggest that, the transferrin polymorphism was controlled

atleast by three co-dominant alleles viz. Tf^A, Tf^B and Tf^C. This is in agreement with the observations of Osterhoff and Wardcox (1972), Watanabe and Suzuki (1973) and Trehan et al. (1981).

It was observed that the transferrin types were not significantly different from their number expected assuming the population in Hardy-Weinberg equilibrium. Hence, it can be concluded that, these genetic groups were in Hardy-Weinberg equilibrium with respect to transferrin locus. Comparison of the gene frequencies of Tf^A, Tf^B and Tf^C revealed that the differences of their frequencies among the three genetic groups were extremely narrow indicating no genetic diversity existed between these genetic groups with respect to transferrin locus.

No association was observed between coat colours of the goats and their transferrin types. Coat colour of animals might therefore, be independent of transferrin types.

Studies on the association of transferrin types with some economic traits in Malabari goats showed that differences in first lactation yield and peak yield of different transferrin types were significant ($P \leq 0.05$). Animals with TfAA phenotype had significantly higher first lactation yield and higher peak yield than animals with other transferrin phenotypes. Other economic traits were not found to be significantly related to transferrin types.

In Saanen halfbred goats, body weight at birth and inter-kidding interval were found to be significantly affected by transferrin types. Animals with TfAA phenotype had significantly higher body weight at birth and lower interkidding interval than animals with other transferrin phenotypes. No association was observed between transerrin types and other economic traits.

In Alpine halfbred goats, peak yield and interkidding interval were found to be significantly different with transferrin types. Animals with TfAA and TfAB types having peak yield of 0.98 ± 0.10 and 0.90 ± 0.06 lit respectively, were significantly superior than animals with TfBB phenotype with peak yield of 0.64 ± 0.06 lit. Animals with TfBB type had significantly lower interkidding interval (274.14 ± 21.07 days) compared to that of animals with other transferrin phenotypes. Other economic traits were not found to be related to the transferrin types.

To conclude, animals with TfAA phenotype were found to be superior than animals with other Tf types in birth weight, first lactation yield and peak yield in all the genetic groups, whereas such a trend could not be seen with regard to other economic traits uniformly in all the genetic groups. However, TfAA type was found to be superior in Malabari and Saanen halfbred goats as regards to age at first kidding and body weights at birth, 3 months and 6 months. But, this trend was not seen in Alpine

halfbred goats in which superiority was exhibited by TfAB type in body weights at 3 months and 6 months and by TfBB type in body weight at 12 months and age at first kidding.

Albumin

Polymorphism in albumin was not observed in any of the three genetic groups of goats presently studied, although two albumin variants Alb^A and Alb^B have been reported by Watanabe and Suzuki (1967) in Japanese goats and Salerno et al. (1968) in South Italian goats. All the samples in the present study showed two bands, the slower band was densely stained as compared to the faster band which was lighter. Similar situation was reported by several workers in Indian goats (Juneja and Choudhury, 1970; Singh et al., 1977; Bhat and Baruah, 1980 and Arora and Khanna, 1982).

Albumin polymorphism could not be observed in exotic breeds such as Norwegian goats, Alpine goats and Hungarian goats (Fesus et al., 1983). As regards to albumin, the three genetic groups were homogenous.

Amylase

Polymorphism in amylase system was not observed in the present study in any of the three genetic groups of goats. Each amylase phenotype was represented by a single band on the starch gel.

Amylase polymorphism was first described in goats by Fetchter and Pretorius (1970) and Osterhoff and Wardcox (1972) in Angora goats. Of the two amylase variants Am^A and Am^B, the frequency of Am^B was very low. Fesus et al. (1983) also reported a low frequency of Am^B(0.004) in Hungarian native goats.

The present findings are in agreement with those of Juneja and Choudhury (1970), Singh et al. (1977) and Arora and Khanna (1982) who could not observe amylase polymorphism in Barbari, Beetal and Black Bengal goats.

Bhat and Baruah (1980) reported the presence of two amylase variants Am-1 and Am-2 in Jamnapari and Barbari goats. The frequency of Am-2 was very low in both the breeds (0.0051 and 0.02 in Jamnapari and Barbari respectively). Most of the exotic breeds of goats studied so far did not exhibit polymorphism at this locus (Meyer, 1967; Tjankov, 1972; Osterhoff and Wardcox, 1972 and Kunz, 1974).

Heterozygosity

Polymorphism in a population reflects genetic variability. The variation in the populations enables to practice selection and breeding, for if none exists, there would be little scope for selection for further improvement. Rendel (1967) suggested that blood groups and protein variants might prove to be very

useful tools for estimating variability between the populations. Such an estimate of divergence would help to choose parents for cross-breeding in order to exploit heterosis or to select desirable segregants.

In the present study Saanen halfbred goats had the highest average heterozygosity (0.290) followed by Alpine halfbreds (0.286) and Malabari (0.271). Maximum heterozygosity, though non-significant, was observed at the transferrin locus in all the genetic groups. Nandakumaran et al. (1982) also reported similar findings in cross-bred cattle. Heterozygosity at the haemoglobin locus was very low in all the populations, which has caused the average heterozygosity to be low. Pirchner et al. (1971) reported that animals heterozygous at the transferrin locus occurred more than the homozygous animals in Australian breeds.

The finding that genetic divergence measured in terms of heterozygosity, was similar in Malabari breed and its two cross-bred groups strengthens the belief that the Malabari goat is a mixture of two or more types of goats of Indian as well as foreign origin.

SUMMARY

SUMMARY

Blood samples collected from goats maintained in the farm under All India Coordinated Research Project on Goats for Milk of the Kerala Agricultural University, Mannuthy, formed the materials for this study. These blood samples were typed employing horizontal starch-gel-electrophoresis to study the polymorphism of haemoglobin, transferrin, albumin and amylase. Inter and intra population variability was also studied. In all 188 goats comprising 40 Malabari, 72 Saanen x Malabari (halfbred) and 76 Alpine x Malabari (halfbred) were involved in the present study.

Statistical analysis on the association between transferrin phenotypes and some economic traits namely (1) birth weight, (2) body weight at 3 months, (3) body weight and 6 months, (4) body weight at 12 months, (5) age at first kidding, (6) first lactation yield (120 days), (7) peak yield and (8) interkidding interval was carried out to identify their use as indicators of selection in goats.

Haemoglobin

Two haemoglobin variants, the faster Hb^A and slower Hb^B and two haemoglobin phenotypes HbAA and HbAB were identified. HbBB phenotype was absent in all the three genetic groups of goats.

The phenotype frequency of HbAA in Malabari, Saanen halfbred and Alpine halfbred goats was 0.9500, 0.9583 and 0.9342 respectively and that of HbAB in these three genetic groups was 0.0500, 0.0417 and 0.0658 respectively.

The gene frequency of Hb^A in Malabari, Saanen halfbred and Alpine halfbred goats was 0.9750, 0.9792 and 0.9671 respectively and that of Hb^B in these three genetic groups was 0.0250, 0.0208 and 0.0329 respectively.

The population of Malabari breed of goats and their two exotic halfbreds were in Hardy-Weinberg equilibrium as far as the haemoglobin locus was concerned.

The differences in the allelic frequencies at Hb locus among the different genetic groups were not significant.

The phenotypes HbAA bred true and hence, they were homozygous.

Transferrin

Four transferrin phenotypes namely TfAA, TfAB, TfBB and TfAC controlled by three co-dominant alleles Tf^A, Tf^B and Tf^C in the descending order of mobilities towards anode were observed. Phenotypes TfBC and TfCC were not observed in any of the three genetic groups of goats.

In Malabari goats the frequencies of TfAA, TfAB and TfBB types were 0.2250, 0.4500 and 0.3250 respectively. TfAC type was not found in Malabari goats. The frequencies of TfAA, TfAB, TfBB and TfAC types were 0.2500, 0.4583, 0.1945 and 0.0972 in Saanen halfbred goats and 0.2631, 0.5132, 0.1974 and 0.0263 in Alpine halfbred goats respectively. The frequency of TfAB type was higher in all the genetic groups.

The gene frequencies of Tf^A, Tf^B and Tf^C in Malabari goats were 0.4500, 0.5500 and zero respectively. Three Tf alleles namely Tf^A, Tf^B and Tf^C were revealed in the populations of crossbred goats with a preponderance of Tf^A allele. The frequencies of Tf^A, Tf^B and Tf^C were 0.5278, 0.4236 and 0.0486 in Saanen halfbreds and 0.5329, 0.4539 and 0.0132 in Alpine halfbreds respectively. Tf^C allele was not observed in Malabari breed.

The population of these three genetic groups were in Hardy-Weinberg equilibrium with respect to transferrin locus and inter population variability was extremely narrow.

The autosomal co-dominant mode of inheritance for Tf alleles was demonstrated by analysis of segregation patterns observed in pedigrees.

Significant association was observed between the TfAA phenotype and economic traits such as birth weight, first lactation yield and peak yield.

Albumin and amylase

No polymorphism was observed for the albumin and amylase systems indicating that the population of three genetic groups were in homogenous condition.

Heterozygosity

The highest average heterozygosity was recorded in Saanen halfbreds (0.2902) followed by Alpine halfbreds (0.2867) and Malabari (0.2719) indicating similarity in genetic divergence. This finding strengthens the belief that the Malabari breed is a mixture of two or more types of goats of Indian as well as foreign origin.

Among the four biochemicals of blood studied, transferrin reflected a great scope for serving as a genetic marker to be used in selection of goats for improved milk production.

REFERENCES

REFERENCES

Antova,N. YA. and Mkrtchyan,SH.A. (1977). Blood protein polymorphism and its relationship with economic traits in the high Altai Mountain zone. Biokhimicheskie osnovy selektsii ovets, Moscow. USSR Kolos : 109-111. (Cited in Anim. Breed. Abstr. 46 (10) : 5002).

Arora,R.L. and Khanna,N.D. (1982). Annual Scientific Report, 1982. Division of Animal Gen. IVRI, Izatnagar (Cited by Arora,R.L. (1983). The different blood groups and biochemical polymorphism in goats. Presented at Summer Institute on Immunogenetics and Biochemical Polymorphism in Domestic Animals held at IVRI, Izatnagar, 6th June to 5th July, 1983).

Ashton,G.C. (1958). A genetic mechanism for thread protein polymorphism in cattle. Nature, Lond. 182 : 65 - 66.

Ashton,G.C. and McDougall,E.I. (1958). Beta-globulin polymorphism in cattle, sheep and goat. Nature, Lond. 182 : 945 - 946.

Bannister,J.V., Bannister,W.H., Wilson,J.B., Lam,H., Millar,A. and Huisman,T.H.J. (1979). The structure of goat haemoglobins. V.A. fourth β chain variant with decreased oxygen affinity at a high frequency in Malta. Haemoglobin. 3 (1) : 57 - 75. (Cited in Anim. Breed. Abstr. 48(8) : 1925).

Bernhardt,D. (1964). Electrophoretic investigations on haemoglobins of goats, dogs, cats and minks. Dtsch. tierarztl. Wschr. 71 : 461 - 462 (Cited in Anim. Breed. Abstr. 33 (3) : 2528).

Bhat,P.P. and Baruah,P. (1980). Note on the genetics of enzyme and serum protein polymorphism in three breeds of Indian goats. Indian J. Anim. Sci. 50(3) : 290 - 293.

Baruah,P. and Bhat,P.P. (1980). Note on the genetics of haemoglobin and transferrin polymorphism in three breeds of Indian goats. Indian J. Anim. Sci. 50(7) : 576 - 579.

Boyer,S.H. (1967). Quantitative disparity between haemoglobins. Natural models for the analysis of the control of protein biosynthesis. J. Hered. 58 : 279 - 282.

Braide,V. and Enyenihi,U.K. (1969). Haemoglobin types in some Nigerian goat breeds. Res. Vet. Sci. 10 : 309 - 310.

Buvanendran,V., Sooriyamoorthy,T., Ogunsusi,R.A. and Adu,I.F. (1981). Haemoglobin polymorphism and resistance to helminths in Red sokoto goats. Trop. Anim. Hlth. Prod. 13 (4) : 217 - 221.

Dahlqvist,A. and Thomson,D.L. (1963). Separation and characterisation of two rat intestinal amylases. Biochem. J. 89 : 272 - 277.

Efremov,G. and Braend,M. (1965). Haemoglobins, transferrins and albumins of sheep and goats. In blood groups of animals. Proc. 9th Eur. Anim. Blood. Grp. Conf. Prague, 1964 : 313 - 320. (Cited by Boruah,P. (1978). M.V.Sc. thesis, Rohilkhand University, Bareilly).

Enyenihi,U.K. (1974). Phenotype and gene frequencies of polymorphic haemoglobins of Nigerian goat breeds. Res. Vet. Sci. 17 (3) : 360 - 363.

Fesus,L., Varkonyi,J. and Ats,A. (1983). Biochemical polymorphism in goats with special reference to the Hungarian Native breeds. Anim. Blood Grps. biochem. Genet. 14 (1): 1 - 6.

Fetchter,H. and Pretorius,G. (1970). Serum amylase types in Angora goats. Anim. Blood Grps. biochem. Genet. 1 : 63.

Gahne,B.J., Rendel,J. and Venge,O. (1960). Inheritance of β-globulins in serum and milk from cattle. Nature, Lond. 186 : 907 - 908. (Cited by Boruah,P. (1978). M.V.Sc. thesis, Rohilkhand University, Bareilly).

Garzon Garrido-Espiga,R., Zarazaga Burillo,I., Vallejo Vicente,M. and Rodero Frunganillo,I. (1976). Biochemical polymorphism in Granada goats. Archivos de Zootecnia. 25 (98) : 147 - 170. (Cited in Anim. Breed. Abstr. 45 (4): 1964).

Goel,K.C. and Nair,P.G. (1976). Biochemical polymorphism in haemoglobin and transferrin of goats. In Proceedings of the 2nd workshop on All India Coordinated Research Project on Goat Breeding held at N.D.R.I., Karnal, 22 - 23 March, 1976.

Gopinathan,N. and Nair,P.G. (1976). Genetic studies on haemoglobin and transferrin polymorphism in goats and their relationship with production traits. In Proceedings of the 2nd workshop on All India Coordinated Research Project on Goat Breeding held at NDRI, Karnal, 22 - 23 March, 1976.

Hesselholt,M., Larsen,B. and Neilsen,B. (1966). Studies on serum amylase systems in swine, horses and cattle. Abarsberetn. Inst. Sterilitets - forskin. K. Vet. - Og Landbohjsk (Kbh): 78 - 80. (Cited by Boruah,P. (1978). M.V.Sc. thesis, Rohilkhand University, Bareilly).

Joshi,S.C., Rawat,J.S. and Pandey,M.D. (1975). Haemoglobin polymorphism in goats. Curr. Sci. 44 (18) : 673.

Juneja,R.K. and Choudhury,R.P. (1970). Annual report for the year, 1970, U.P.A.U. Pantnagar (Cited by Singh et al., 1977).

Khanolker,V.R., Naik,S.N., Boxi,A.J. andBhatia,H.M. (1963). Studies on haemoglobin variants and glucose - 6 - phosphate dehydrogenase in Indian sheep and goats. Experimentia 19 : 473 (Cited by Fesus et al. (1983).

Khanna,N.D., Chet Ram, Tandon,K.N. and Prabhu,S.S. (1970). Studies on biochemical polymorphism in bovines. 1. Haemoglobin variations in Hariana breed of cattle. J. Genet. 60 : 159 - 163 (Cited by Nandakumaran,B. (1976). M.V.Sc. thesis, Agra University, Agra).

Kunz,H. (1974). Blood groups and biochemical polymorphic protein systems in Appenzell, verzasca and Valais Black neck goats. Thesis, Berne University, Switzerland, (1974) (Cited in Anim. Breed. Abstr. 43 (7) : 2966) 56 pp.

Lee,J.H. (1975). Studies on serum albumin types in goats using starch-gel-electrophoresis. Korean J. Vet. Res. 15 (1) : 19 - 22 (Cited in Anim. Breed. Abstr. 45 (5): 2358).

McIndoe,L.M. (1962). Occurrence of two plasma albumins in domestic fowls. Nature, Lond. 195 : 253.

Meyer,H. (1967). On serum amylase polymorphism in various animal species. Birrl. Miinch. tierarztl. Wschr. 80 : 469 - 471 (Cited in Anim. Breed. Abstr. 37(1) : 247).

Mostaghni,K. (1979). A note on haemoglobin types and some blood minerals of goats (Capra hircus) in Iran. Indian J. Anim. Sci. 49 (10) : 857 - 858.

Naik,S.N. (1975). Haemoglobin polymorphism in some Indian domesticated and wild ruminants. Indian J. Hered. 7 : 23 - 30.

Nandakumaran,B., Tandon,S.N. and Khanna,N.D. (1982). Genetic heterozygosity and genetic distances between four cross-bred populations of cattle employing blood protein polymorphism system. Indian J. Dairy Sci., 35 (1) : 13 - 17.

Nei,M. and Roychoudhury,A.K. (1974). Sampling variances of heterozygosity and genetic distance. Genetics 76 : 379 - 390. (Cited by Nandakumaran,B. (1976). M.V.Sc. thesis. Agra University, Agra).

Odermatt,K. (1973). Blood groups and biochemical polymorphic systems in Toggenburg and Grisons striped goats. Thesis Berne University, Switzerland (1973). pp.58. (Cited in Anim. Breed. Abstr. 42 (5) : 1828).

Osterhoff,D.R. and Wardcox,I.S. (1972). Serum polymorphism in three South African goat breeds. Proc. XIIth Eur. conf. Anim. Blood Grps. Biochem. Polymor. (Budapest, 1970) : pp. 576 - 582 (Cited by Boruah, P.(1978). M.V.Sc. thesis Rohilkhand University, Bareilly).

Osterhoff,D.R., OP'T Hof,J. and Coubrough,R.I. (1972). Biochemical polymorphism and the aborting Angora goats. In VIIth International Congress on Animal Reproduction and Artificial Insemination, Munich, 1972 : 1972 II 1199 - 1203 (Cited in Anim. Breed. Abstr. 41 (10) : 4452).

Pirchner,F., Chakrabarti,S., Erlacher,J., Schleger,W. and Rohrbhcher,H. (1971). Heterozygosity and fertility in cattle. Dt. tierarztl. Wschr. 78 : 111 - 114 (Cited in Anim. Breed. Abstr. 40 : 4330).

Poulik,M.D. (1957). Starch-gel-electrophoresis in a discontinuous system of buffers. Nature, Lond. 180 : 1477 - 1478 (Cited by Boruah, P. (1978). M.V.Sc. thesis, Rohilkhand University, Bareilly).

Pouling,L., Itano,H.A., Singur,S.J. and Wells,I.C.(1949). Sickle cell anaemia, a molecular disease. Science 110 : 543 - 548.

Rendel,J. (1967). Studies of blood groups and protein variants as a means of revealing similarities and differences between animal populations. Anim. Breed. Abstr. 35 (3) : 371 - 383.

Salerno,A., Mountemurro,N. and Lafflitto,A. (1968). Researches on protein polymorphism in goat population of South Italy. Eur. Proc. Conf. Anim. Blood and Biochem. Polymorph (Warsaw, 1968) : 517 - 520. (Cited in Anim. Breed. Abstr. 39(1)649).

Schmid,D.O. and Kunz,H. (1974). Foetal goat haemoglobin and its persistence in the first week after birth. Zentralblatt fur Veterinariedicin (1974) 21 B Heft 9 : 729 - 732 (Cited in Vet.Bull. 45 : 4092).

Singh,H., Tandon,S.N., Joshi,J.D. and Khanna,N.D. (1977). Studies on some blood protein polymorphisms in indigenous goats. Indian Vet. J. 54 (11) : 884 - 887.

Smithies,O. (1955). Zone electrophoresis in starch gels, group variations in the serum proteins of normal human adults. Biochem. J. 61 : 629.

Smithies,O. (1957). Variations in human serum β-globulin. Nature. Lond. 180 : 1482 - 1483.

Snedecor,G.W. and Cochran,W.G. (1967). Statistical methods. Oxford & IBH Publishing Co., New Delhi, 6th Ed. pp. 230 - 263.

Suzuki,S. and Watanabe,S. (1968). Studies on the serological constitution of goats. Proc. 11th Eur. conf. Anim. Bld. Grps. biochem. Polymor. (Warsaw, 1968) pp: 513 - 515 (Cited by Trehan et al., 1981).

Tjankov,S. (1972). Polymorphism of some serum protein systems in goats. Proc. XIIth Eur. Conf. Anim. Bld. Grps. biochem. Polymor. (Budapest, 1970) pp: 575 - 578 (Cited by Boruah,P. (1978), M.V.Sc. thesis, Rohilkhand University, Bareilly).

Trehan,K.S., Nair,P.G. and Nair,K.G.S. (1981). Transferrin polymorphism in some exotic breeds, an Indian breed of goat and their cross-breds. Indian J. Anim. Sci. 51 (1) : 48 - 55.

Watanabe,S., Nozawa,K. and Suzuki,S. (1965). Studies on the transferrin of goat 1. Typing of transferrin of goat serum by starch-gel-electrophoresis. Proc. Japan Acad. 41 : 326 - 331. (Cited in Anim. Breed. Abstr. 34 (1) : 427).

Watanabe,S. and Suzuki,S. (1966). Studies on the transferrin of goat. II. Inheritance mode of serum transferrin types. Proc. Japan Acad. 42 : 178 - 183. (Cited in Anim. Breed. Abstr. 35 (3) : 2701).

Watanabe,S. and Suzuki,S. (1967). Studies on serum albumin polymorphism in goats. Jap. J. Zootech. Sci. 38 : 487 - 494. (Cited in Anim. Breed. Abstr. 36(2) : 1636).

Watanabe,S. and Suzuki,S. (1973). Studies on the transferrins of goats. 3. Evidence for a third transferrin allele. Anim. Blood Grp. Biochem. Genet. 4 (1) : 23.

Watanabe,S., Tsunoda,K. and Suzuki,S. (1979). On the polymorphism of haemoglobin on some native goats in Asia. J. Agric. Sci. Japan. 23 (3-4) : 255 - 259 (Cited in Anim. Breed. Abstr. 47 (12) : 6141).

.....

GENETIC STUDIES ON POLYMORPHISM OF SOME BLOOD PROTEINS IN GOATS

By

A. K. SHAMSUDDIN

ABSTRACT OF A THESIS

submitted in partial fulfilment of the
requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Breeding and Genetics
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy - Trichur

1984

ABSTRACT

Blood samples collected from goats maintained in the farm under All India Coordinated Research Project on Goats for Milk of Kerala Agricultural University, Mannuthy, formed the materials for this study. These blood samples were typed employing horizontal starch-gel-electrophoresis to study the polymorphism of haemoglobin, transferrin, albumin and amylase. In all 188 goats comprising 40 Malabari, 72 Saanen x Malabari (halfbred) and 76 Alpine x Malabari (halfbred) were involved in the study. Inter and intra population variability was studied. Genetic interrelationship among some growth, production and reproduction traits viz. body weights at birth, 3 months, 6 months and 12 months, age at first kidding, first lactation yield (120 days), peak yield and interkidding interval was determined.

Two haemoglobin variants, the faster Hb^A and slower Hb^B with two phenotypes HbAA and HbAB were observed. The gene frequency of Hb^A in Malabari, Saanen halfbred and Alpine halfbred goats was 0.9750, 0.9792 and 0.9671 respectively and that of Hb^B in these three genetic groups was 0.0250, 0.0208 and 0.0329 respectively. The frequency of Hb^A allele was higher in all the populations.

Four transferrin phenotypes TfAA, TfAB, TfBB and TfAC controlled by three co-dominant alleles Tf^A, Tf^B and Tf^C were

observed. The fast moving variant was designated as Tf^A followed by Tf^B and Tf^C. In Malabari goats TfAC was not observed. The frequency of TfAB type was higher in all the genetic groups. The gene frequencies of Tf^A, Tf^B and Tf^C in Malabari goats were 0.4500, 0.5500 and zero respectively. Tf^C allele was not observed in Malabari goats. Three Tf alleles namely Tf^A, Tf^B and Tf^C were revealed in the crossbred populations with a preponderance of Tf^A allele. The frequencies of Tf^A, Tf^B and Tf^C alleles in Saanen halfbreds were 0.5278, 0.4236 and 0.0486 and in Alpine halfbreds were 0.5329, 0.4539 and 0.0132 respectively.

The allelic frequencies of haemoglobin and transferrin loci were suggestive of Hardy-weinberg equilibrium in all the three population of goats. Magnitude of inter population variability among the three genetic groups was negligible.

The autosomal co-dominant mode of inheritance for Tf alleles was demonstrated by analysis of segregation patterns observed in pedigrees.

Significant association was observed between the TfAA phenotype and economic traits such as birth weight, first lactation yield and peak yield.

Polymorphism was not observed for the albumin and amylase systems.

Maximum heterozygosity was observed at the transferrin locus. Highest average heterozygosity was exhibited by the Saanen halfbred goats.

Among the four biochemicals of blood studied, transferrin reflected a great scope for serving as a genetic marker to be used in selection of goats for improved milk production.