BIOCHEMICAL POLYMORPHISM IN BROILER RABBITS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled Biochemical polymorphism in broiler rabbits 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

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CERTIFICATE

Certified that this thesis entitled Biochemical polymorphism in broiler rabbits is a record of research work done independently by A P Usha under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her

25 | 90

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Dedicated to my
beloved parents

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CONTENTS

LIST OF TABLES

Introduction

LIST OF ILLUSTRATIONS

INTRODUCTION

The study of genetic polymorphism in blood cells and plasma and their biological significance are of special interest in livestock breeding Many of the polymorphic body proteins show simple Mendelian inheritance Biochemical genetics has made a great impact in tracing out the origin of breeds and also to find the inter relationship between different breeds Other applications are characterising inbred strains controlling the genetic identity of individuals and populations controlling the aim of breeding systems and testing the reliability of the genetic identity of the samples

The domestic rabbit (Oryctolagus cuniculus) has the potential to become one of the most important livestock species as evidenced by the increase in rabbit population and the increasing number of rabbit products Rabbits are reared for different purposes such as the commercial rabbits for profit the fancy rabbits for sport of competition and social reasons and backyard rabbits which are reared purely for meat

The world population of rabbits is estimated to be about 700 million which occupy the fifth rank in the array

of livestock species For the quantity of meat produced alone 500 million rabbits are estimated to be present in the world

In many of the developing countries rabbits have a potential role as a source of animal protein Its fecundity is well known to call for special attention Rabbits have faster growth rate better feed conversion efficiency and quick multiplication as compared to other livestock species

Since biologically the rabbit is capable of continuously being in the stage of reproduction each unit of the rabbit carries considerably less burden in the stock of maintenance and stock replacement than those of small ruminants Another characteristic that holds out good promise is the great genetic variety of the species manifesting itself in the intensity of growth fertility maternal ability resistance to diseases and heat tolerance which are all pre requisits for the success of selection programmes aimed at these properties In view of the above Food and Agricultural Organisation launched programmes in several developing countries to introduce or intensify rabbit rearing In its report during 1981 it is stated that world nourishing needs close to 2000 AD will be satisfied for one third by rabbit meat as an animal not competing with man for food

Very little information is available on the genetics of broiler rabbits As the role of the rabbits in meat industry is going to enhance in the near future rabbit research is to be intensified in all aspects of rabbit production including breeding and genetics In this connection the evolution of breeds and the inter relationship among them have to be subjected to intense study The gene markers associated with economic traits if any have to be identified and their presence has to be exploited for the selection programme to be carried out for genetic improvement of broiler rabbits

The present study was therefore undertaken with the following objectives

a) to study the haemoglobin and transferrin types and their gene frequencies

b) to identify the inheritance pattern of these biochemical variants and

c) to explore the existence of association if any between haemoglobin and transferrin variants and traits such as body weight at various stages for the period from birth to 90 days of age and rate of gain in body weight and survivability

Review of Literature

REVIEW OF LITERATURE

Smithes (1955) introduced the technique of starch gel electrophoresis which was found very suitable for the separation of a number of electrophoretically detectable body proteins showing polymorphisms The proteins were separated on the basis of electrical charge as well as on their molecular size and shape

According to Raymond and Weintruab (1959) separation of proteins due to difference in molecular weight was more pronounced when polyacrylamide slab gel was used as the separation medium in electrophoresis By using polyacrylamide gel a medium with high chemical and mechanical stability transparency broadly variable structure and high analytical purity is obtained Likewise electro-endosmotic and adsorption effects are mostly eliminated

Polyacrylamide gel is a three dimensional molecular network It is made from acrylamide which is a monomer and undergoes both polymerisation and cross linking through N N methylene bis acrylamide commonly called as bis The gel is formed by mixing acrylamide and bis in buffer solution and adding a catalyst accelerator ammonium per sulphate N N N N tetra methylene diamine (TEMED)

Polyacrylamide gel offers a better method to control pore size of the gel leading to clear and sharper defenition of the zones It is a more inert medium and the preparation and handling of the gel are easy The gel is thermostable and it runs electrophoretically faster than starch and gives a better resolution

The seiving effect of the gel is the important factor in polyacrylamide gel electrophoretic separations The density of the gel net work (pore size) can be varied over a wide range allowing the separation of proteins of very different size This can be achieved by varying the concentration of both acrylamide and methylene bis acrylamide or by increasing the cross linkers (bis) concentration relative of the total concentration

Transferrin

Transferrin is a special iron binding protein whose major function is transportation of iron to bone marrow and tissue storage organs Transferrin participates directly in the regulation and control of iron adsorption and protects from iron intoxication Molecular weight is 90 000 It forms about 3 per cent of total plasma proteins

Binnette et al (1965) fractioned and characterised normal plasma proteins in Newzealand White rabbits using starch gel electrophoresis Only one transferrin band could be detected in the pooled plasma by radio autography Paper electrophoresis and starch gel immunoelectrophoresis showed one sharp zone and one precipitin arc respectively

Markovich and Tinaev (1975) reported transferrin polymorphism in different rabbit breeds Two alleles Tf^A and Tf^C were detected with frequencies of 0 571 and 0 429 in Soviet Chinchilla males 0 491 and 0 509 in Soviet Chinchilla females 0 638 and 0 362 in White Giant males o 518 and 0 482 in White Giant females 0 583 and 0 417 in Blue Vienna males 0 646 and 0 354 in Blue Vienna females and 0 700 and 0 300 in Silvery females respectively

Markovich and Pornitko (1977) observed that the concentration of Tf^A and Tf^C alleles in Soviet Chinchilla approached 0 50 but Tf^A prevailed significantly in other races Biochemical analysis of blood serum revealed a higher content of total proteins in heterozygotes Higher quantity of β globulin reflected the higher resistance and better adaptation of heterozygotes

Gogelıya and Markovıch (1981) reported that ın Soviet Chınchılla mortalıty upto three months of age was 20 25 per cent unıts hıgher for anımals wıth transferrın type CC than for those wıth TfAA and 30 40 per cent unıts hıgher for type CC than for type AC anımals

Markovıch et al (1981) studıed on the lıtter traıts and found that the lıtter from rabbıts of TfAA genotype had hıgher body weıght (2 05 kg) at three months of age when compared to lıtters of rabbıts of TfAC TfCC or TfBC genotypes (1 89 kg)

Evıdence was obtaıned from studıes of Usher et al (1983) that serum from rabbıts wıth pretransferrın phenotype PRT contaıns the pre transferrın proteın and the Prt locus has three alleles prt^a prt^b and prt^c ın PRT^+ rabbıts and the two electrophoretıc varıants ın PRT rabbıts

Electrophoretıc studıes of transferrın ın rabbıts by Zaragoza et al (1985) revealed that transferrın was monomorphıc ın starch gel electrophoresıs but was polymorphıc ın polyacrylamıde gel electrophoresıs Three bands were detected as a b c (a beıng the most anodıc and c the most cathodıc) Autoradıographıc and saturatıon studıes suggested that these bands correspond to the ıron content ın the plasma Transferrın varıants characterised

by low plasma iron concentration had a slower migration pattern than those associated with normal or high iron concentration Thus transferrin from a single individual showed different migration patterns in different stages of life Results indicated that the biological variability of transferrin can directly be observed from the transferrin migration pattern in polyacrylamide gel electrophoresis

Varga et al (1986) studied the rabbit plasma pre transferrin system using one dimensional polyacrylamide gel electrophoresis Six pre transferrin types were detected and were designated A to F and each type was controlled by a codominant autosomal allele Only Prt^B and Prt^F were found in Angora rabbits

Arana et al (1987) studied rabbit transferrin electrophoretically from individuals belonging to seven populations No transferrin polymorphism was detected by starch gel electrophoresis but six patterns differing in the presence or intensity of three bands (a anodic b intermediate and c cathodic) were observed by polyacrylamide gel electrophoresis The electrophoretic test allowed a direct observation of the relative in vivo levels of the different transferrin molecular species saturated (band a Fe_2Tf) semi saturated (band b Fe_1Tf) and without iron (band c Fe_0Tf apoTf)

Zaragoza et al (1987) observed two variants for serum transferrin by starch gel electrophoresis as TfA and TfB TfB was present only in Spanish wild populations and showed a low frequency with respect to Tf^A Tf^B showed three bands containing Fe_0Tf Fe_1Tf and Fe_2Tf respectively Fe_1Tf and Fe_2Tf were generally found in higher concentration than Fe_0Tf during pregnancy except at its final stages when Fe_0Tf is more abundant Within 24 hours after parturition high levels of iron bound transferrin was found recovered in female serum

Correlation of transferrin with growth and reproductive traits

Cattle

On persual of literature no reference on rabbits could be seen on the studies undertaken pertaining to correlation of Transferrin with growth and prolificacy traits However attempts have been made to find out whether there exists any correlation of Transferrin with growth traits in other livestock species Heidler (1973) conducted studies on fattening performance and ll carcass characters in relation to transferrin type in different genetic groups as German Black Pied and German Black Pied x Jersey cattle Both group

and transferrin type had highly significant effects on length of fattening period and on the percentage of neck shoulder and round in carcass The percentage of choice cuts was significantly affected by group but not by transferrin type

Joffra et al (1974) demonstrated that in Charolais breed weaning weight and average daily gain before weaning were significantly affected by transferrin genotype Animals homozygous for Tf^D were superior to animals with other transferrin genotypes Heterozygotes at the Tf^D locus were slightly superior in dressing percentage when compared to homozygotes

Kadiev (1974) recorded body weight from birth to 24 months of age and transferrin and amylase type in Russian simmental cattle Body weight at 6 month was significantly higher by 14 6 kg in TfDD heifers than in those of type DE In Russian Black pied bulls 12 month body weight was significantly higher in type DD than in type AA animals by 29 8 kg

Nedava et al (1976) observed that the phenotypes associated with highest weight gains between 6 12 months of age were TfAD types for Russian Simmental and Russian Black Pied cattle

Chaudoba et al (1981) observed significant differences among cows with different transferrin types for birth weight body weight at first year of age daily gain age at first calving and the duration of first and second calving intervals

Rahman and Kalam (1986) reported that the birth weight of animals with transferrin genotypes AA, AD, AE DD DE and EE averaged 18 37+0 54 16 49+0 22 19 40+0 20 17 47+0 22 18 30+1 03 and 17 89+0 70 kg respectively and total gain to three months of age averaged 21 22 18 51 18 25 17 51 15 47 and 15 32 kg The differences between TfAA animals with other calves were significant

Takisheva (1987) demonstrated that in bulls of Kazakh White headed and Hereford breeds the highest first month body weights were associated with different genotypes (TfAA DD EE AD AE and DE) in different lines

Buffaloes

Singh et al (1980) tabulated the data on birth weight age at first calving milk yield and lactation length and were analysed in relation to TfAA AB and BB types There was no significant difference between transferrin types and any of the traits mentioned Tandon (1983) also found no

significant relationship between transferrin types and any of the economic traits in buffaloes

Sheep

Arora and Acharya (1972) studied the relationship of transferrin type with body weight at birth 3 months 6 months 9 months and 12 months of age The transferrin types was a significant source of variation only for yearling weight Sheep of transferrin MB type had the highest yearling weight followed by those of type EC Birth weight was highest in sheep with transferrin type EM whereas three month weight was highest in sheep of TfEE type Animals of type EM had the highest six month weight Transferrin type explained 5 per cent of the variation in birth weight and 13 per cent of that in yearling weight

Erokhin and Bhaskeeva (1975) found no significant relationship between transferrin phenotype and fattening and carcass characteristics Stambekov (1976) analysed the data on 215 Soviet Merino and Latvian Darkhead sheep and found that low body weight as associated with Hb^A Hb^A/Tf^C Tf^C genotypes

Lazovskıı and Gorın (1976) reported that ın Precoce lambs wıth transferrın types AB AD BC BD CD AA BB and CC bırth weıght averaged 4 43 4 63 4 67 4 61 4 80 4 75 3 80 and 4 74 kg respectıvely and body weıght at 16 month age averaged 55 3 53 2 54 0 53 4 70 0 54 3 53 9 44 0 and 55 4 respectıvely

Pasdar et al (1976) concluded that transferrın type was not found to be a sıgnıfıcant source of varıatıon ın bırth weıght weanıng weıght or average daıly gaın from bırth to weanıng ın Karakul Memaban and Naırı breeds of sheep

Rahman and Konuk (1977) recorded body weıght at bırth 45 and 90 days of age ın merıno lambs Anımals of transferrın type DE had the lowest weıght gaın but the dıfference was sıgnıfıcant only ın the body weıght at 90 days of age

Bhat et al (1978) demonstrated that ın Muzaffarnagarı crossbreds TfAB anımals had the hıghest average body weıght at weanıng (16 2 kg) followed by TfAD (13 93) TfCD (13 92) TfBC (13 70) TfBD (13 19) TfBB (12 28) and TfDD (12 07) anımals

Trıvedı et al (1978) reported that lambs of Tf type BD had a sıgnıfıcantly hıgher weanıng weıght than type DD lambs

Atroshi (1979) observed that in Finsheep dams of TfAD type and sires with TfBB type had a higher lambing rate than other mating types whereas dams with type BD and sires with type AC produced lambs with high mortality rate than other types

Lasierra and Altarriba (1979) compared the performance from birth to 90 days of age in 180 male Aragon lambs of 13 transferrin genotypes and in 160 females of 14 transferrin genotypes Males of type AD and CD types had significantly higher body weight at birth and at 30 and 90 days of age than males off other types and females of type AA had significantly lower weight than females of other types

Reheulishvili and Dogonadza (1980) reported that in Tushin Imeritian and Lomtagorsk sheep animals of Tf type AC significantly exceeded animals of other transferrin type for live weight

Tyankov et al (1981) observed no significant line differences in performance or in the frequencies of transferrin alleles with body weight in Tsigai sheep

Kim (1983) observed in a degerus flock of sheep animals of type TfCC/HbBB had the greatest body weight and longest staple whereas animals of TfCC/HbAB and TfBC/HbBB

had heavy fleeces but a short staple Animals of TfAB/HbAA TfAC/HbAB and TfBC/HbBB had high body weight and low fleece weight

Azevedo Weimer et al (1984) studied the haemoglobin and transferrin type in 164 female and 40 male Corridale sheep and 130 female and 58 male Romney Marsh sheep There were no significant relationship of haemoglobin and transferrin types with the litter sizes at birth and weaning percentage of multiple birth the incidence of reproductive failure and wool production

Bleta et al (1985) demonstrated in Shkodra sheep animals of transferrin type AA AB BB and BC had an average body weight of 32 5 kg 31 5 kg 32 8 kg and 31 3 kg respectively

Sadykutov and Kim (1985) analysed the data on body weight carcass traits and fleece weight in rams ewes and lambs of different haemoglobin and transferrin phenotypes Slaughter weight dressing percentage and meat yield were greater for animals with phenotype TfAC/HbBB or TfCC/HbAB than the TfCC/HbBB or TfAC/HbAB animals It was recommended that lambs with Tf type AA CC AB AD CE and BC should be chosen for breeding and that the replacement females should be chosen from those with transferrin type AA BC AD or CE

Colin Martinez (1986) reported that TfA and TfE were associated with higher lambing rate in Poll Dorset ewes In Suffolk x Dorsel ewes there was a significant relationship of TfC and TfD with high lamb production

Jablonska (1986) observed birth weight and daily gain from birth to 12 months of age were significantly lower for ewes of transferrin types CC BD AE CE DE and CD types in Polish Merino ewes

Negi et al (1987) reported that in Gaddi sheep and its crossbreds body weight at 30 days was significantly affected by transferrin type Lambs with TfAD type were heavier than those of TfBD and TfDD types

Goat

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

Gopinathan and Nair (1976) typed serum samples from Alpine Beetal and crossbred goats for transferrin polymorphism No significant difference was observed with respect to transferrin type and birth weight and age at first kidding

Antova and Mkrtchyan (1977) reported that in Russian Altai mountain goats double heterozygote animals of type HbBB/TfAB were significantly heavier than HbAA/TfAB animals

Shamsuddin et al (1986) studied transferrin types in Malabari goats and its exotic crossbreds with Saanen and Alpine and its association with body weight at birth 3 months 6 months 12 months age at first kidding and interkidding intervals It was observed that animals with TfAA type showed higher body weight though the difference was not significant TfAA animals were found to have lower inter kidding interval in Saanen half breds

Pig

Fesus and Rasmusen (1971) analysed data on Duroc Yorkshire and Duroc x Yorkshire litters Within each of the three groups all nine possible types of combination of transferrin allele TfA TfB and TfAB were represented No significant relationship was focused between transferrin type and average litter size at birth or weaning

Zilla et al (1971) observed significant differences between transferrin types AA and AB and transferrin type AA and BB in respect of ham meat as a percentage of carcass weight and between transferrin type AA and AB and average daily gain of females

Ladan et al (1972) demonstrated that in North Caucasus and Russian Large White pigs matings of TfBB males with TfBB or TfAB females produced best results Birth weight was significantly higher for matings between TfAA parents Still birth were least for matings of TfAA with TfBB parents

Pochernyaeu et al (1972) correlated transferrin types and carcass characters as fattening performance in Russian Large White Pigs Variation in carcass characters were smaller in homozygous animals than in heterozygous ones

Kaweeki et al (1974) observed no relationship between transferrin type and litter size and litter weight at farrowing and at 21 days of age milk production of sows and sow evaluation score Lengerken G Von and Pfeiffer (1974) found no relationship between transferrin type or transferrin allele frequency and fattening performance in pigs

Radovic (1974) reported no significant difference in gestation length or average birth weight for piglets born from transferrin type AA x AB BB x BB and AA x BB matings Tsybulin (1974) also reported no significant difference between transferrin types growth rate and carcass quality in Ukrainian Steppe and Russian large white pigs

Berezovskii et al (1975) analysed data on transferrin type and performance traits Highest daily gain largest eye muscle area lowest age at 100 kg and smallest backfat thickness were in pigs with TfAA genotypes in four herds of Russian Large White and Mirgorod pig In another herd daily gain age at 100 kg and feed conversion were best in pigs of transferrin type BB and the other traits were best in pigs of TfAA genotype

Berezovskii (1976) observed no clear relationship between transferrin type and fattening performance of Russian Large White pigs In Mirgord pigs a higher daily gain and lower age at 100 kg body weight were obtained for heterozygotes than for homozygotes

Berezovskii et al (1977) studied reproductive performance of sows in relation to genetic polymorphism Russian Large White Sows of transferrin type AA AB and BB were mated in all possible combinations with boars having transferrin type AB and BB The largest litter size at the first and second farrowing was obtained for TfAA females mated with TfAB males

Sovljanski et al (1979) observed that in large white pigs males of type TfAA mated with similar females and for corresponding groups of animals with TfAB type and TfBB

type litter size averaged 11 37 11 56 and 11 87 respectively

Sovljanski et al (1980) observed that in Large White pigs litters born to parents of TfAA TfAB and TfBB types litter size at weaning averaged 8 70 9 07 and 9 73 respectively Litter weight at weaning averaged 54 98 58 42 and 66 57 kg and preweaning mortality averaged 17 4 17 0 and 13 9 percentage respectively

Chudoba et al (1981) analysed data on Polish Landrace pigs in association with transferrin genotypes No significant association with economic traits was observed

Huang and Rasmusen (1982) observed that crossbred TfBB boars sired large number of live born piglets than TfAB boars Matings of TfBB males with TfAB females resulted in the largest number of liveborn piglets and weaned piglets per litter in the selected group There were no significant effects of sire and dam transferrin genotype and their interaction in the number of piglets farrowed born alive and weaned per litter

Haemoglobin

Haemoglobin is the oxygen carrying component of blood It is composed of large spheroid molecules having a haemoprosthetic group combined with a protein moeity the

globin Each molecule consists of four peptide chain normally occurring in two pairs of identical chains

Surveys using starch gel electrophoresis by Boyer et al (1963) and disc electrophoresis by Ornstein and Davis (1964) turned up one rabbit with a haemoglobin variant is over 2000 animals Studies on the intact haemoglobin molecule by Dayhoff (1969) revealed haemoglobin molecules to be monomorphic in electrophoresis Garrick et al (1974) reported the presence of a single residue of isoleucine at β^{112} and also zero isoleucyl residue or half a residue β chain in haemoglobin This character was found to be polymorphic and inherited in a simple mendalian autosomal codominant pattern

Zaragoza et al (1983) studied the electrophoretic variants from 60 butterfly and 40 Burgundy rabbits and revealed no electrophoretic haemoglobin variants

Arana et al (1987) revealed a new electrophoretic variant for haemoglobin named Hb2 by electrophoretic study of blood samples of 412 Spanish wild rabbits This variant showed a higher mobility than Hb1 under electrophoretic conditions

Correlation of haemoglobin with growth traits and prolificacy

No studies on correlation seems to have been conducted in rabbits on the correlation of haemoglobin and growth and prolificacy Studies conducted in other species of livestock are reviewed as below

Cattle

Kamenskaya (1971) reported that body weight of cows was not related to haemoglobin type

Macha and Dvorak (1983) analysed body weight and daily gains of bulls of different genotype and reported that the difference between homozygotes and heterozygotes in body weight and daily gain were not significant with the exception of the difference in body weight of bulls homozygous or heterozygous for haemoglobin

Kumaran et al (1984) demonstrated that in Haryana cows and its crossbreds there was no significant relationship between haemoglobin type and body weight at birth 12 or 24 weeks of age first and second lactation yield or calving interval

Sheep

Seth et al (1973) tabulated the live weight of Magra lamb at monthly intervals from birth to 360 days of age

according to sex and haemoglobin type Male lambs of type AB were significantly heavier than those of types AA and BB Average body weight of 10 HbAA females was significantly lower than that of 51 HbBB females and 26 HbAB females

Aliev and Kototeva (1974) studied haemoglobin and transferrin polymorphism in animals of different ages and examined the relation with production characters Presence of Hb^A allele improved live weight significantly

Lazovskii and Gorin (1976) observed that in Precoce sheep of haemoglobin types AA BB and AB birth weight averaged 4 5 4 5 and 4 8 kg respectively and body weight at 16 months of age averaged 53 0 54 1 and 54 4 kg respectively Lazovskii (1977) observed that lambs with haemoglobin genotype BB had a significantly high average birth weight than those with genotype AB But haemoglobin type AB lambs were heavier at weaning and at 16 month of age

Bhasker et al (1978) reported among 191 Mandya sheep those of haemoglobin type AB were heavier from birth to one year of age than those of type BB The difference was significant at weaning and 6 month of age but not at birth and one year of age For ewes of haemoglobin type AB and BB lambing percentage was 100 and 93 3 respectively and weaning percentage was 83 3 and 85 5 respectively

Atroshi (1979) demonstrated that Finsheep ewes of haemoglobin type AA and AB had higher fertility than other ewes with haemoglobin type BB Ewes with haemoglobin type AA had greater body weight than those of type AB and BB

Lipecka et al (1979) reported that in Pomeranian sheep matings of females of haemoglobin type AB or BB females with AB males AA females with BB males and BB females with AB males the percentage of female lambing was 95 5 92 8 97 5 94 0 and 90 8 respectively Lambing rate was 135 3 148 7 137 5 and 142 2 percent respectively

Reheulishvili et al (1979) observed that sheep of haemoglobin type AB were superior to HbAA and HbBB sheep for live weight and fertility Walker et al (1979) observed that matings involving sires of haemoglobin type BB were more fertile than matings involving AA sires Reproductive performance did not differ amongst ewe genotypes

Bashkeeva (1981) observed that in Kuibyshev sheep over three lambing season the lambing rate was higher in ewes of haemoglobin type AA than in those of type BB (88 0 vs 69 7 percent)

Al Murrani and Al Samarae (1982) studied the association between haemoglobin type production and

reproduction in Awasi sheep and reported that lambing percentage was significantly higher for $HKHb^B$ ewes than for $LKHb^B$ ewes Birth weight and weaning weight were significantly higher for $LKHb^B$ lambs than for $HKHb^B$ lambs

Barowicz et al (1983) demonstrated that in Polish long wool sheep ewes of haemoglobin type BB had higher lambing rate litter size and lamb birth weight (87 5 percent and 1 36 percent) than ewes of type AA and AB Lowest value for the lambing rate litter size and lamb birth weight were for type AA ewes Lambs of type BB were superior to lambs of other types for body weight

Marian et al (1983) analysed the data among Corriedale sheep of haemoglobin types AA AB and BB and observed that for three haemoglobin types body weight averaged 49 75 kg 47 49 kg and 43 50 kg respectively Body weight was highest for haemoglobin type BB animals

Dalal et al (1985) reported that in Patanwadi sheep birth weight differ significantly between haemolgobin types For sheep of haemoglobin type AA AB BB BD and DD weaning weight average 14 84 14 43 14 79 12 75 and 14 54 kg respectively Yearling weight averaged 24 52 23 91 24 53 20 72 and 24 29 kg respectively

Dratch et al (1986) correlated haemoglobin type and prolificacy in Booroole sheep In Booroole Merino x Romney ewes there was a significant association between HbB allele and F gene carriers as well as between HbA allele and non carriers Booroole Merino ewes showed the same trend though it was non significant HbB allele was associated with higher ovulation rate in Booroole Merino crossbred HbC allele was found associated with anaemia in sheep

Goat

Antova et al (1977) reported that in goats of high Altai mountain zone haemoglobin heterozygotes were slightly heavier than of homozygotes Double heterozygotes Hb^{A}/Hb^{B} Tf^{A}/Tf^{B} were significantly heavier than AA/AB animals

From the foregoing paragraphs it can be seen that reports are available on the association of transferrin and haemoglobin types with growth and reproductive traits in livestock species Whether similar situation is existing in rabbits is to be explored

Materials and Methods

MATERIALS AND METHODS

Experimental animal

The rabbits belonging to Soviet Chinchilla Newzealand White and local breeds maintained in Kerala Agricultural University Rabbit Breeding farm under the Centre for Advanced Studies in Animal Genetics and Breeding formed the materials for this study In all 152 rabbits were subjected to study, 50 belonged to Soviet Chinchill 50 to local and 52 to Newz aland White among them

Soviet Chinchilla

These are rabbits reared for the purpose of both meat and fur As its name suggests it resemble the real chinchilla in colour Undercolour to be dark slate-blue at the base with an intermediate portion of pearl shading and then a further black narrow line edging These rabbits are developed in Soviet Russia (Fig 1)

Newzealand White

These are pure white in colour with typical red eyes These rabbits have their origin at Britain They have medium length body broad throughout and short set legs Coat is very dense and thick to touch (Fig 2)

Local (Non-descript)

Kerala has no broiler rabbits of her own, but local breeds seen in Kerala are believed to be brought by European settlers during the pre-independent days These local rabbits have become highly adapted to hot humid climate conditions of the state Animals are either white or black or with patches of white and black (Fig 3)

Rabbits were maintained in cages made of wire mesh Watering and feeding facilities were provided in the cage All the animals that formed the experimental group were identified either by eartagging or by tatooing Kits were weaned at the age of 30 days and they were maintained at optimum nutrition and management

Collection of blood samples

About 2 ml of fresh blood was collected from the rabbits aged 3 months and above aseptically from the marginal ear vein by vein puncture using sterilised syringes in small tubes with anticoagulant with a composition of sodium citrate 20 g sodium chloride 5 g in 1000 ml of distilled water

The blood samples were centrifuged for 10 minutes at 2500 rpm and supernatant plasma was separated This sample was used for studies on transferrin polymorphism

For haemoglobin red cells were washed three times in Normal saline solution containing the proportion of 9 g of sodium chloride to one litre of distilled water to free the cells from plasma proteins Separated plasma and the washed cells were kept in refrigerator until they were used

Transferrin

Polyacrylamide Gel Electrophoresis

The method of horizontal polyacrylamide gel electrophoresis as described by Gahne et al (1977) was followed for the simultaneous phenotyping of transferrin and post transferrin in the blood plasma A step gradient gel of 8 4 10 and 12 percent acrylamide concentration was used

Buffers and solutions

A discontinuous buffer system was used The gel buffer was 0 1875 M tris sulphate at pH 9 0 and the electrode buffer was 0 065 M tris borate pH 9 0 (molarity with respect to tris)

Composition of the electrode buffer is as follows

Tris hydroxy methyl aminomethane	15 74 g
Boric acid	2 29 g
Distilled water	2000 ml

Tris and boric acid was dissolved in distilled water and the pH was adjusted to 9.0 with 4 percent boric acid solution

Acrylamide stock solution (A) 32 g of acrylamide and 0 9 g of N N -methylene bisacrylamide was dissolved in 100 ml distilled water and filtered

Gel Buffer stock Solution (B) To 50 ml of 1 5 M tris (9 08 g tris in 50 ml distilled water) was added 45 ml of distilled water 300 μl of N N N N-tetra methylene diamine (TEMED) 150 μl of 2 mercaptoethanol and adjusted the pH to 9 2 with 10 percent H_2SO_4 The final volume was made to 100 ml with distilled water so that molarity of tris was 0 75 M

Ammonium persulphate solution (C) 200 mg of ammonium per sulphate was dissolved in 100 ml of distilled water

For better results the above solution A, B and C were prepared and used on the same day

The working gel solutions The working gel solution was prepared just before use

The composition of these solutions for one gel is presented in table 1

Composition of solutions used for fixing staining destaining and preserving are given below

Fixing solution

Methanol	250 ml
Acetic acid	60 ml
Distilled water	upto 1000ml

Staining solution

Coomassie brilliant blue R 250	1 25 g
Methanol	227 ml
Glacial acetic acid	46 ml
Distilled water	227 ml

Dye is dissolved in solution of methanol and distilled water Acetic acid is added and stored in dark bottles

Destaining solution

Ethanol	1500 ml
Acetic acid	500 ml
Distilled water	upto 5000 ml

Preserving solution

Ethanol	300 ml
Acetic acid	100 ml
Glycerol	100 ml and
Distilled water	upto 1000 ml

Casting of the gel

The cells was made with two plates of the same size One of the plates used was an acrylic sheet with slots on it The plate had a frame on all sides with 1 5 mm thickness which formed the thickness of the gel The other was a thick glass plate The two plates were held together with vaccum grease on all sides to ensure tight sealing Paper clips were applied on all four sides and placed vertically when casting the gel (Fig 4) The length of the different gel layers in the stepwise gradient gel to be formed were marked on the glass plate The cell was placed in such a way that the slots on the acrylic sheet was on the upper extremity

The various solutions were mixed in a beaker in the proportion as presented in table 1 This solution was poured into the cell either using a pasteur pipette or through a funnel on the upper extremity of the cell The 12 percent gel solution was first filled into the cell through the funnel After about 15 minutes a distinct straight boundry was formed near the top of the gel solution which indicated that the solution had polymerized Later the 10 percent gel solution was filled into the glass cell After about 10 minutes 4 percent solution was pipetted into the glass cell The slots in the acrylic sheet should now be in the middle of the 4 percent gel layer When this layer had

polymerized the remaining space in the cell was filled with 8 percent gel solution After about 30 minutes when the top layer had polymerized the paper clips were removed

The acrylic sheet was removed carefully so that the gel adhered to the glass plate The glass plate with the gel was then washed with distilled water

Pre electrophoresis

About 1000 ml of chilled electrode buffer was poured in each of the cathode and anode vessels The glass plate with the gel was connected to the electrode solution with the help of wet wicks They overlapped the gel by 10 12 mm To obtain a uniform voltage gradient over the gel the two wicks were kept parallel to have a uniform contact along the whole gel Pre electrophoresis was performed at 200 V and 15 20 mA for 10 minutes to remove any charged particles if present in the gel

Sample application

The slots in the middle of the four percent gel layer was filled with 20 µl quantity of the plasma using a micro syringe quickly to avoid diffusion of the sample Bromophenol dye was added to any one of the slots to serve as a marker Bromophenol blue dye was prepared by dissolving 25 mg of Bromophenol blue in 10 ml of gel buffer solution

Electrophoresis

The samples were subjected to a constant current of 50 mA Voltage was adjusted to 500 volts To provide cooling the electrophoresis chamber was kept inside the refrigerator so that the temperature of the system was brought down to 5 °C The electrophoresis was stopped when the borate line reached the anodal end The total time of electrophoresis was 4_2 hours

Gel fixation

To avoid loss of small soluble proteins and to minimise diffusion the gel was fixed in fixing solution The gel plate was kept in the fixative for one hour at room temperature

Staining

Gel was kept in the staining solution for two hours The glass plate was removed before the gel was put in the staining solution

Destaining

Excess dye was removed by diffusion in destaining solution The gel was kept in the destaining solution overnight Frequent changes of the destainer would help to remove the excess dye easily

Haemoglobin

A continuous buffer system was followed Polyacrylamide gel was prepared at 10 percent concentration Composition of buffers and solutions used

1 Gel and electrode buffer

Tris hydroxy methylaminomethane	40 4 g
Ethylene diamine tetra acetic acid (EDTA)	4 00g
Boric acid	300 g
Distilled water	2000 ml

pH is adjusted to 8 9

2 Acrylamide solution

Acrylamide	22 2 g
Bis acrylamide	0 6 g
Distilled water	100 ml

3 Ammonium per sulphate solution

Ammonium per sulphate	1500 mg
Distilled water	100 ml

Preparation of the gel

Working gel solution was prepared consisting of

Acrylamide solution	10 ml
Lower gel buffer	6 5 ml
Distilled water	5 6 ml
Ammonium per sulphate	0 3 ml
TEMED	0 03 ml

The cell was made as described previously Distilled water was mixed with gel buffer and acrylamide solution in a vaccum flask and the solution was deaerated for a few minutes Then TEMED and Ammonium per sulphate solution were added and mixed carefully without introducing too much air This solution was poured into the cell through the funnel at the top Air bubbles if any were removed by tapping The polymerization reaction was completed in 30 minutes

Sample preparation

Washed cells were hemolysed using distilled water in the following proportion

Washed cells	0 25 ml
Distilled water	2 5 ml

Electrophoresis

Once the gel was cast the clips were removed and the gel was washed with distilled water The glass plate with the gel was kept in the electrophoretic chamber with the buffer Pre electrophoresis was performed at 15 mA for 10 minutes after connecting the gel with the buffer by wet wicks 20 µl of sample was applied to each slot using microsyringe Once the samples have been applied electrophoresis was done at 250 V for one and half hours

Fixing staining and destaining of the gel was done as described for transferrin

Inheritance of blood proteins

The number of offspring in all possible matings between different protein types were observed and tested for their gene action Whether the observed ratio is in agreement with that of expected in Mendelian monohybrid cross was tested using χ^2 method Panmixia of the population with regard to protein types were examined using Hardy Weinberg formula

Correlation between blood proteins and growth traits and prolificacy

For studying the association if any between blood protein polymorphic systems and traits of economic importance data were collected in the following traits

1 Body weight at birth
2 Body weight at 15 days
3 Body weight at 30 days
4 Body weight at 45 days
5 Body weight at 60 days
6 Body weight at 75 days
7 Body weight at 90 days

8 Average daily gain from 0 30 days of age

9 Average daily gain from 30-60 days of age

10 Average daily gain from 60-90 days of age

11 Litter size at birth

12 Littter size at weaning

13 Litter weight at birth

14 Litter weight at weaning

15 Preweaning mortality

Analysis of data

The gene frequencies at different loci and phenotype frequencies were calculated by direct counting method The gene frequency of Tf^A in the population N was calculated as

$$Tf^A \qquad \frac{2\ TfAA + TfAC}{2\ N}$$

χ^2 test was applied to find out whether the populations were in equilibrium or not with respect to the particular protein polymorphism system

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 and post transferrin types and growth and reproductive traits Correlation between protein types and preweaning mortality was also assessed

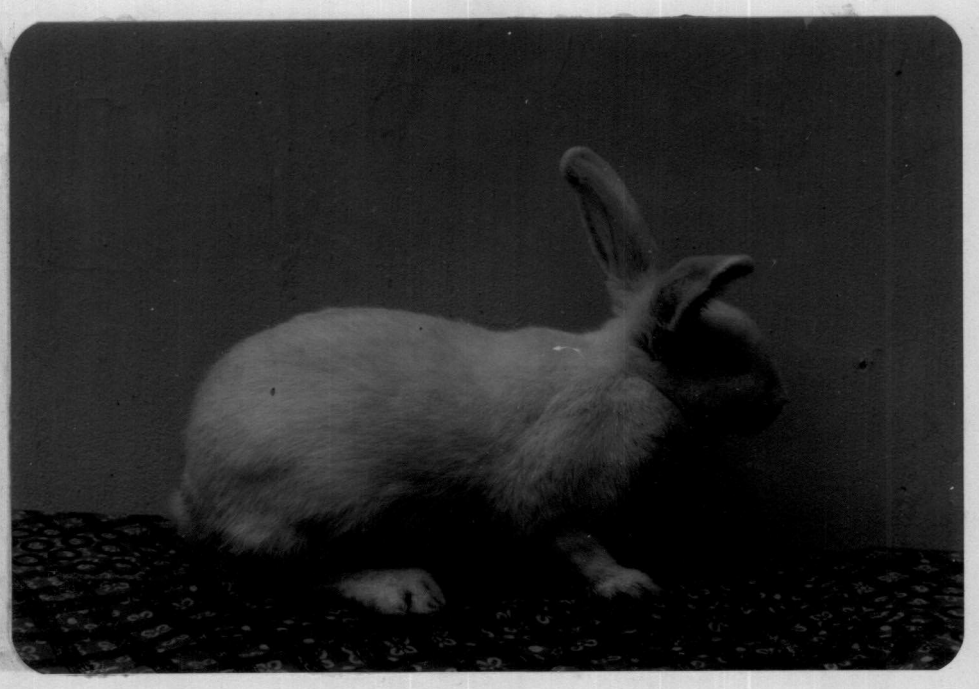
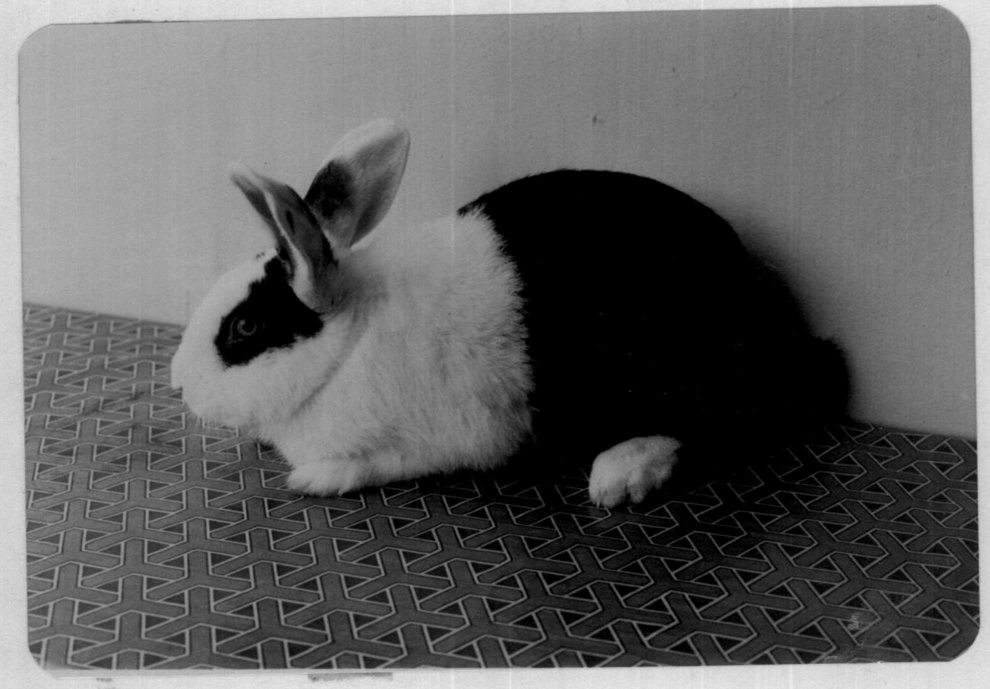
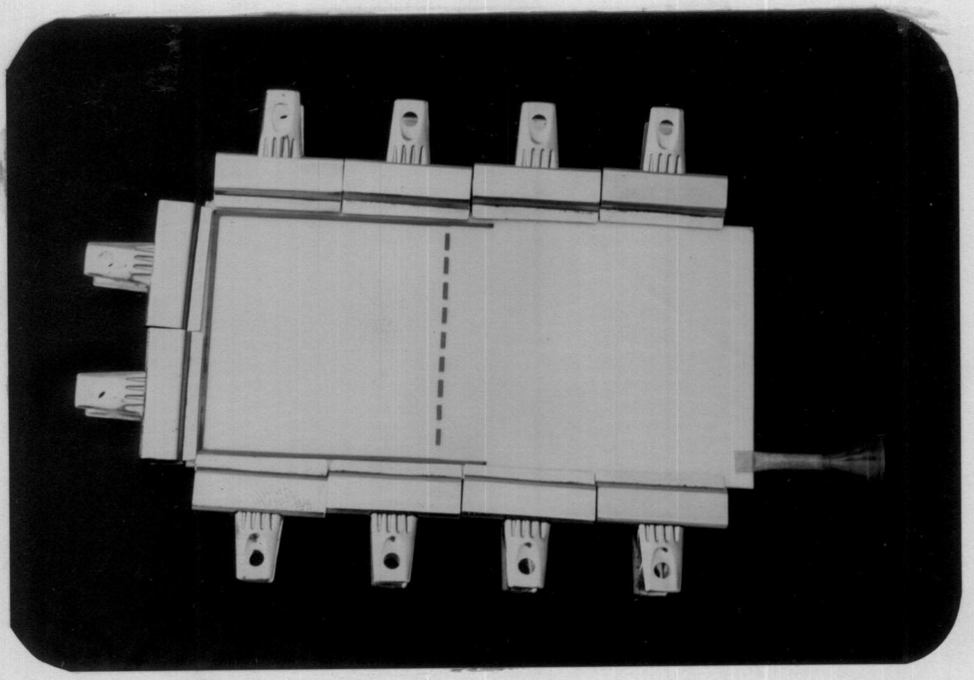


Fig 3 Local (Non Descript)

Fig 4 Electrophoretic gel chamber





Results

RESULTS

Transferrin

In the gradient gel used for the study stacking of the gel occcured in the four percent layer The transferrin zone was located in the ten percent gel layer The known transferrin alleles Tf^A and Tf^C were clearly differentiated Transferrin polymorphism could be detected both in serum and plasma samples Separation of post albumin and albumin fraction occurred in the twelve percent gel layer (Fig 5)

Transferrin phenotype

Two transferrin phenotypes based on the mobility towards anode were observed in the present study The phenotype showing faster mobility towards anode was called TfAA and the other showing two bands with faster and slower mobility was called TfAC using the nomenclature described by Markovich *et al* (1975) TfAC had one component of Tf^A and other of Tf^C Phenotype TfCC was not observed in the present study

The phenotype frequencies and gene frequencies of transferrin types in different genetic groups are presented

in table 2 Phenotypes TfAA and TfAC were found in all the genetic groups The frequency of TfAA and TfAC was 0 5000 and 0 5000 in Soviet Chinchilla 0 6538 and 0 3462 in Newzealand white and 0 6200 and 0 3800 in local rabbits The frequency of phenotype TfAA was higher in Newzealand white and lower in Soviet Chinchilla Phenotype TfAC occurred in a higher frequency in Soviet Chinchilla However, the difference was not statistically significant

Inheritance of transferrin

The results of matings between various transferrin types are presented in table 3 Matings of TfAA x TfAA types produced only TfAA offspring and the observed number was same as expected in Mendalian monohybrid cross In matings between TfAA and TfAC, out of 65 offspring 32 were TfAA type and 33 were of TfAC type The difference from the expected number was not significant When TfAC individuals were mated among themselves, the observed number of offspring with phenotypes TfAA, TfAC and TfCC was not significantly different from that of the expected 1 2 1 ratio indicating that Tf^A and Tf^C were autosomal co-dominant

Frequency of Tf alleles

The gene frequency of Tf^A in Soviet Chinchilla Newzealand White and Local rabbits was 0 7500, 0 8270 and

0 8100 respectively and that of Tf^C in these genetic groups was 0 2500 0 1730 and 0 1900 respectively The graphical representation of gene frequencies in three genetic groups are shown in Fig 6

Genetic equilibrium

To ascertain Hardy-Weinberg equilibrium of Tf allele the observed and expected number of different transferrin phenotypes in each genetic groups were compared separately (table 4) A good agreement was observed in all the genetic groups indicating that the population were panmictic and were in genetic equilibirum

A comparison of gene frequencies between different genetic groups was carried out employing χ^2 test (table 5) The frequencies of Tf^A and Tf^C genes in different genetic groups were not significantly different

Correlation between transferrin and growth and reproductive traits

The mean values of the economic traits with different transferrin types in all the genetic groups were compared (Table 6) Average litter weight at birth was 246 96 g in Soviet Chinchilla 291 96 g in Newzealand White and 293 16 g in local rabbits

In Soviet Chinchilla body weight of TfAA and TfAC phenotypes was 325 46+14 93 g and 262 94+16 78 g at 15 days 472 27+21 85 g and 400 59±15 59 g at 30 days 800 45+38 46 g and 649 71+26 06 g at 45 days 1113 41+38 56g and 956 41+34 52 g at 60 days 1411 82+39 25 g and 1187 94+30 79 g at 75 days and 1698 18+35 84 g and 1440 00+48 31 g at 90 days

In Soviet Chinchilla average daily gain (ADG) was 15 74+0 73 g for TfAA phenotype and 13 31+0 49 g for TfAC phenotype during 0 30 days of age During 30 60 days of age daily gain was 21 37+1 20 g and 18 63+1 37 g for TfAA and TfAC phenotypes respectively At 60-90 days of age ADG was 19 49+1 15 g and 16 24+1 22g for TfAA and TfAC phenotypes (Table 7)

In Newzealand White body weight of the phenotype TfAA and TfAC was 265 00+14 44 g and 288 85+23 22 g at 15 days 504 07+23 53 g and 509 23+29 08 g at 30 days 842 78+35 54g and 800 00+24 36 g at 45 days 1132 96+27 06 g and 1121 92+30 18 g at 60 days 1443 70+33 95 g and 1424 62+25 58 g at 75 days and 1641 85+32 24 g and 1626 92+46 04 g at 90 days

In Newzealand White average daily gain was 16 80+0 78g for TfAA phenotype and 16 97+0 97 g for TfAC phenotype during 0 30 days of age At 30 60 days of age daily gain was 20 96+1 12 g and 20 42+0 71 g for TfAA and TfAC phenotypes respectively At 60 90 days of age ADG was 17 49+1 00 g in TfAA phenotype and 16 83+1 14 g in TfAC phenotype

But in local rabbits body weight of the two phenotypes was 220 74+17 36 g and 201 54+18 15 g at 15 days 392 59+27 54 g and 360 38+21 35 g at 30 days 674 26+32 33g and 663 85+26 78 g at 45 days 962 59+30 06 g and 800 77+24 68 g at 60 days 1225 15+38 46 g and 1025 38+36 69 g at 75 days and 1499 26+37 31 g and 1225 39+32 48 g at 90 days

In local average daily gain for TfAA and TfAC phenotypes at 0 30 days of age was 13 09+1 25 and 12 01+0 71 g respectively But the values for 30 60 days of age were 19 06+0 83 g and 15 04+1 04 g in TfAA and TfAC phenotypes At 60 90 days of age TfAA phenotypes had 17 89+0 79 g daily gain and TfAC phenotypes had an average daily gain of 14 15+0 97 g

No significant difference was observed between TfAA and TfAC phenotypes in respect to average daily gain in Soviet Chinchilla Newzealand White and local rabbits

In Soviet Chinchilla body weight at all age groups were significantly affected by transferrin types ($P \leq 0.01$) No significant association was found between transferrin types and economic traits in Newzealand White rabbits But in local rabbits body weight at 60 days 75 days and 90 days were significantly affected by transferrin type ($P \leq 0.01$)

In general between the two Tf phenotypes body weight of TfAA phenotype was found to be higher

However statistical significant difference in body weights of all age groups was observed only in Soviet Chinchilla

Association of transferrin types with traits as litter size at birth litter weight at birth litter size at weaning and litter weight at weaning was studied (table 8) No significant association was found between transferrin type and litter size and weight at birth and weaning

In the kindlings out of TfAA x TfAA matings litter size ranged from 5 to 10 at birth and from 2 to 8 at weaning Litter weight for the TfAA x TfAA cross was 235 5 to 454 0 g at birth and 770 to 3800 g at weaning In matings involving TfAA Female x TfAC Male litter size ranged between 3 and 7 and 1 and 6 at birth and weaning

respectively Litter weight at birth ranged from 147 6 to 375 2 g and at weaning from 760 to 2820 g In TfAC Female x TfAA Male crosses litter size and weight ranged from 3 to 7 and 171 6 to 395 2 g at birth and 2 to 7 and 1030 to 2830 g at weaning But in TfAC x TfAC matings litter size and weight at birth ranged from 3 to 5 and from 174 0 to 228 5 g respectively and at weaning ranged from 2 to 5 and from 775 to 3560 g respectively

Preweaning mortality

Preweaning mortality was 38 46 percent in TfAA x TfAA matings and 28 57 percent in TfAC x TfAC matings But in TfAA Female x TfAC Male matings preweaning mortality was 40 percent In TfAC Female x TfAA Male mating there was only 12 72 percent mortality (Table 9)

Post transferrin

The post transferrin phenotype could be studied both in plasma and serum It was observed that post transferrin protein separated best when the gels were made from fresh polyacrylamide solution and the gels were cooled adequately during electrophoresis

Post transferrin proteins were detected in the ten percent gel layer having a lesser mobility than the transferrin proteins Two groups of protein zones called Ptf 1 and Ptf 2 were observed in post transferrin region The Ptf 1 comprised of weakly stained bands and no clear variation was observed between the samples In Ptf 2 region

however three phenotypes Ptf FF Ptf FS and Ptf SS were observed controlled by two alleles Ptf^F and Ptf^S

The alleles were designated based on the order of decreasinganodal mobilities Ptf FF was faster of the two components with mobility towards anode Ptf FS had one component of faster Ptf FF and other of slower Ptf SS The bands were weakly stained Phenotypes Ptf FS and Ptf SS are represented in Fig 5

The phenotype frequencies and gene frequencies of different post transferrin types in different genetic groups are shown in table 10 The different phenotypes Ptf FF Ptf FS and Ptf SS were in the frequency of 0 5200 0 4400 and 0 0400 in Soviet Chinchilla Phenotype frequencies of Ptf FF and Ptf FS were 0 6350 and 0 3650 in Newzealand White and 0 5200 and 0 4800 in local rabbits respectively

Inheritance of post transferrin

Segregation of post transferrin types in offspring from different matings are presented in table 11 In mating groups of Ptf FF x Ptf FF only Ptf FF offspring were produced In Ptf FF x Ptf FS matings 37 offspring were of Ptf FF type and 40 were of Ptf FS type out of a total of 77 offspring In FS x FS matings the observed number of

offspring with phenotype Ptf FF Ptf FS and Ptf SS was 5 8 and 2 respectively and was found in agreement with 1 2 1 ratio showing co dominance

Frequency of Ptf allele

The gene frequencies of Ptf^F and Ptf^S were 0 7400 and 0 2600 in Soviet Chinchilla 0 8500 and 0 1500 in Newzealand White and 0 7600 and 0 2400 in local rabbits Graphical representation of gene frequencies in different genetic groups are shown in fig 7

The observed and expected values were compared in order to assess whether the populations were in genetic equilibrium and were mating at random with respect to post transferrin genes (table 12) There was no significant difference between the observed and expected values in any of the population studied

Comparison of gene frequencies among different genetic groups presented in table 13 did not show any significant difference

Correlation of post transferrin and growth traits

Association of post transferrin types with growth traits in different genetic groups is presented in table 14 No significant association could be observed between post transferrin types and body weight at fortnightly intervals upto 90 days of age in any of the genetic groups

In the pooled population post transferrin type was found to have no significant effect on body weight at any of the age groups

In Soviet Chinchilla average daily gain for Ptf FF and Ptf FS phenotypes was 14 54+0 37 g and 14 28+1 10 g at 0 30 days of age 19 12+1 04 g and 20 48+1 55 g at 30 60 days of age and 17 86+0 90 g and 18 69+1 94 g at 60 90 days of age In Newzealand White Ptf FF and Ptf FS phenotypes had an average daily gain of 17 06+0 85 g and 16 48+0 76g at 0 30 days of age 20 46+0 94 and 21 41+1 45 g at 30 60 days of age and 17 61+1 01 g and 16 67+1 13 g at 60 90 days of age In local rabbits at 0 30 days of age Ptf FF and Ptf FS had average daily gain of 12 42+1 05 g and 13 02+1 43 g At 30 60 days of age average daily gain was 17 54+1 08 and 17 97+0 95 for Ptf FF and Ptf FS phenotypes At 60 90 days of age Ptf FF phenotype had a gain of 16 38+1 05 g and Ptf FS phenotype had a gain of 16 98+0 87 g (Table 15)

On comparison of average daily gain in three age groups it was found that average daily gain during 30 60 days of age is higher than that found in other age groups in all the genetic groups

No significant association was observed between Ptf FF and Ptf FS types in respect to average daily gain in Soviet Chinchilla Newzealand White and local rabbits

Association of post transferrin types with traits as litter size at birth litter weight at birth litter size at weaning and litter weight at weaning was studied (table 16) No significant association was found between post transferrin type and any of these traits

Litter size and weight ranged from 3 to 7 and 2 to 6 respectively at birth and 171 6 to 375 2 g and 775 to 2820g at weaning in matings of Ptf FF x Ptf FF type Range of litter size at birth and weaning was 4 to 6 and 3 to 6 respectively and that of litter weight was 260 to 310 g and 870 to 2450 g at birth and weaning in Ptf FF Female x Ptf FS Male mating types But in Ptf FS Female x Ptf FF Male crosses litter size ranged 3 to 10 and 1 to 7 at birth and weaning and litter weight ranged from 147 6 to 454 0 g and 760 to 3560 g at birth and weaning In Ptf FSx Ptf FS matings at birth litter size and weight ranged from 4 to 8 and 182 8 to 400 5 g and at weaning litter size and weight ranged from 2 to 8 and 1170 to 3800 g respectively

Preweaning mortality

Preweaning mortality was 30 73 percent in Ptf FF x Ptf FF matings In Ptf FS mating preweaning mortality was 11 82 percent In Ptf FF female x Ptf FS male mating there was 10 71 percent mortality But in Ptf FS female xPtf FF male mating there was 36 9 percent preweaning mortality (Table 17)

Haemoglobin

The haemoglobin phenotype was represented by a single band (Fig 8) No polymorphism was observed in any of the genetic groups studied Rabbit haemoglobin was compared with that of cattle and goat haemoglobin (Fig 9) It was seen that rabbit haemoglobin is comparable with Hb^A of cattle and goat which was slower in mobility than Hb^B

Table 1 Composition of solutions for one poly acrylamide gel

Acrylamide concentration in percentage	Stock solution (ml)			Distilled water (ml)	Total volume (ml)	Length of the gel (cm)
	A	B	C			
4	0 75	1 50	1 50	2 25	6 00	3 12
8	0 75	0 75	0 75	0 75	3 00	1 56
10	3 32	2 66	2 66	2 00	10 64	5 50
12	2 86	1 92	1 92	0 96	7 66	4 00

Table 2 Phenotype frequencies and gene frequencies of transferrin types in different genetic groups of rabbits

Population	No of animals	Phenotype frequency			Gene frequency	
		Tf AA	Tf AC	Tf CC	Tf^A	Tf^C
Soviet Chinchilla	50	0 5000 (25)	0 5000 (25)		0 7500	0 2500
Newzealand White	52	0 6538 (34)	0 3462 (18)		0 8270	0 1730
Local	50	0 6200 (31)	0 3800 (19)		0 8100	0 1900

Number in parenthesis indicates number of observation

Table 3 Segregation of Transferrin alleles in offspring from different matings

Mating class	No of matings	No of offsprings		Transferrin phenotypes			
				Tf AA	Tf AC	Tf CC	χ^2
AA x AA	10	40	obs	40 0			
			exp	40 0			
AA x AC	15	65	obs	32 0	33 0		0 0154 NS
			exp	32 5	32 5		
AC x AC	5	14	obs	4 0	10 0		5 4290 NS
			exp	3 5	7 0	3 5	

NS Non Significant

Table 4 Observed and expected number of animals with different transferrin types according to Hardy Weinberg equilibrium

Population	No of animals	Transferrin phenotypes							
		Tf AA			Tf AC			Tf CC			χ^2
		obs	exp		obs	exp		obs	exp		
Soviet Chinchilla	50	25	28	125	25	18	75	3	125	5 55	NS
Newzealand White	52	34	35	560	18	14	88	1	560	2 286	NS
Local	50	31	32	810	19	15	39	1	810	2 751	NS

NS Non significant

Table 5 Comparison of Transferrin gene frequencies among different genetic groups of rabbits

Allele	Genetic groups			χ^2
	Soviet Chinchilla	Newzealand white	Local	
Tf^A	0 7500	0 8270	0 8100	
Tf^C	0 2500	0 1730	0 1900	1 03 NS

NS Non significant

Table 6 Body weight (g) at various ages of different transferrin phenotypes in rabbits

Age in days	Genetic groups									
	Soviet Chinchilla			Newzealand White			Local			
	Tf AA	Tf AC	$t_{n_1+n_2-2}$	Tf AA	Tf AC	$t_{n_1+n_2-2}$	Tf AA	Tf AC	$t_{n_1+n_2-2}$	
15	325 46±14 93 (22)	262 94±16 78 (17)	2 7100 **	265 00±14 44 (27)	288 85±23 22 (13)	0 9068	220 74±17 36 (27)	201 54±18 15 (13)	0 6834	
30	472 27±21 85 (22)	400 59±15 59 (17)	2 4380 *	504 07±23 53 (27)	509 23±29 08 (13)	0 1305	392 59±27 54 (27)	360 38±21 35 (13)	0 7569	
45	800 46±38 46 (22)	649 71±26 06 (17)	2 9440 **	842 78±35 54 (27)	800 00±24 36 (13)	0 7892	647 26±32 33 (27)	663 85±26 78 (13)	0 3292	
60	1113 41±38 56 (22)	956 41±34 52 (17)	3 8267 **	1132 96±27 06 (27)	1121 92±30 18 (13)	0 2488	962 59±30 06 (27)	800 77±24 68 (13)	3 4590 **	
75	1411 82±39 25 (22)	1187 94±30 79 (17)	4 1467 **	1443 70±23 95 (27)	1424 62±35 58 (13)	0 4902	1228 15±38 46 (27)	1025 38±36 69 (13)	3 4530 **	
90	1698 18±35 84 (22)	1440 00±48 31 (17)	8 2890 **	1641 85±32 24 (27)	1626 92±46 04 (13)	0 4049	1499 26±37 31 (27)	1225 39±32 48 (13)	5 1230 **	

* Significant at 5% level

** Significant at 1% level

Number in the parenthesis indicate number of observations

Table 7 Transferrin phenotypes and average daily gain(g) in different genetic groups of rabbits

Period	Soviet Chinchilla			Newzealand White			Local		
	Tf AA	Tf AC	$t_{n_1+n_2-2}$	Tf AA	Tf AC	$t_{n_1+n_2-2}$	Tf AA	Tf AC	$t_{n_1+n_2-2}$
0-30 days	15.74±0.73 (25)	13.31±0.49 (25)	0.8052 NS	16.80±0.78 (34)	16.974±0.97 (18)	1.3171 NS	13.085±1.25 (31)	12.012±0.71 (19)	1.7255 NS
30-60 days	21.37±1.201	18.63±1.37	1.856 NS	20.96±1.12	20.42±0.71	1.657 NS	19.061±0.83	15.038±1.04	1.3694 NS
60-90 days	19.49+1.15	16.24+1.22	1.7118 NS	17.49+1.00	16.833+1.14	1.6397 NS	17.889+0.79	14.156+0.97	1.2919 NS

Number in parenthesis indicate the number of observations

NS Non significant

Table 8 Mean values of litter size and weight at birth and weaning of kits produced in matings based on transferrin types

Mating class	No of kindlings	Litter size at birth	Litter size at weaning	Litter weight at birth (g)	Litter weight at weaning (g)
TfAA x TfAA	10	6 5	4 0	323 43+22 95	1779 00+185 95
TfAA x TfAC (F) (M)	4	5 0	3 0	251 75+49 79	1512 50+216 28
TfAC x TfAA (F) (M)	11	5 5	4 8	281 72+19 19	2089 09+166 91
TfAC x TfAC	5	4 2	3 0	195 64+9 35	1670 00+201 91

M Male F Female

Table 9 Preweaning mortality of different mating types in rabbits

Mating class	No of kindlings	Average litter size at birth	Average litter size at weaning	Percentage mortality
TfAA x TfAA	10	6 5	4 0	38 46
TfAA x TfAC (F) (M)	4	5 0	3 0	40 00
TfAC x TfAA (F) (M)	11	5 5	4 8	12 72
TfAC x TfAC	5	4 2	3 0	28 57

F Female M Male

Table 10 Phenotype frequencies and gene frequencies of Post transferrin types in different genetic groups of rabbits

Population	No of animals	Phenotype frequency			Gene frequency	
		Ptf FF	Ptf FS	Ptf SS	Ptf^F	Ptf^S
Soviet Chinchilla	50	0 5200 (26)	0 4400 (22)	0 0400 (2)	0 7400	0 2600
Newzealand White	52	0 6350 (33)	0 3650 (19)		0 8500	0 1500
Local	50	0 5200 (26)	0 4800 (24)		0 7600	0 2400

Number in the parenthesis indicate the number of observations

Table 11. Segregation of post transferrin types in offspring from different matings

Mating class	No.of matings	No. of offspring		Post Transferring phenotypes Ptf FF	Ptf FS	Ptf SS	χ^2
Ptf FF x Ptf FF	8	27	obs	27.00	-	-	
			exp	27.00			
Ptf FF x Ptf FS	19	77	obs	37.00	40.0	-	0.1169 NS
			exp	38.50	38.5		
Ptf FS x Ptf FS	3	15	obs	5.00	8.00	2.00	1.18 NS
			exp	3.75	7.5	3.75	

NS - Non significant

Table 12 Observed and expected number of rabbits with different post transferrin types according to Hardy Weinberg equilibrium

Population	No of animals	Post transferrin phenotype						χ^2	
		Ptf FF		Ptf FS		Ptf SS			
		obs	exp	obs	exp	obs	exp		
Soviet Chinchilla	50	26	27 38	22	19 24	2	3 38	3 85	NS
Newzealand White	52	33	37 57	19	13 26		1 17	4 21	NS
Local	50	26	28 88	24	18 24		2 88	4 99	NS

NS Non significant

Table 13 Comparison of post transferrin gene frequencies among different genetic groups of rabbits

Allele	Genetic group			χ^2
	Soviet Chinchilla	Newzealand White	Local	
Ptf^F	0 7400	0 8500	0 7600	2 08 NS
Ptf^S	0 2600	0 1500	0 2400	

NS - Non significant

Table 14 Body weight g at various ages of different post transferrin phenotypes in rabbits

Age in days	Genetic groups: Soviet Chinchilla			Newzealand White			Local			Pooled		
	Ptf FF	Ptf FS	$t_{n_1+n_2}$ 2	Ptf FF	Ptf FS	$t_{n_1+n_2}$ 2	Ptf FF	Ptf FS	$t_{n_1+n_2}$ 2	Ptf FF	Ptf FS	$t_{n_1+n_2}$ 2
15	299 13±12 60 (23)	298 57±26 50 (14)	0 0212 (NS)	267 69±17 64 (26)	282 14±23 19 (14)	0 4907 (NS)	211 25±20 43 (20)	221 75±20 40 (20)	0 3639 (NS)	260 65±21 38 (69)	259 69±16 71 (48)	0 0444 (NS)
30	436 09±10 99 (23)	428 57±33 10 (14)	0 2570 (NS)	511 92±25 50 (26)	494 29±22.89 (14)	0 4557 (NS)	373 75±21 32 (20)	390 50±22 70 (20)	0 5381 (NS)	466 59±15 15 (69)	431 88±21 86 (48)	0 3721 (NS)
45	713 04±27 15 (23)	716 07±31 94 (14)	0 0707 (NS	836 35±28 98 (26)	815 00±28 05 (14)	0 4788 (NS)	666 00±29 07 (20)	675 75±37 15 (20)	0.2068 (NS)	746 30±18 32 (69)	728 13±25 15 (48)	0 3988 (NS)
60	1009 78±36 57 (23)	1042 86±26 86 (14)	0 6416 (NS)	1125 58±31 50 (26)	1136 43±26 31 (14)	0 2298 (NS)	898 00±35 33 (20)	922 00±32 79 (20)	0 4981 (NS)	1106 52±31 30 (69)	1022 29±32 55 (48)	0 7456 (NS)
75	1276 30±35 53 (23)	1310 00±26 22 (14)	0 6754 (NS)	1436 15±22 55 (26)	1440 00±23 48 (14)	0 1091 (NS)	1152 50±22 70 (20)	1172 00±22 38 (20)	0 6121 (NS)	1291 23±28 29 (69)	1290 42±36 80 (48)	0 01783 (NS)
90	1540 87±36 76 (23)	1499 29±25 89 (14)	0 8075 (NS)	1586 15±22 68 (26)	1636 43±22 97 (14)	1 4257 (NS)	1389 00±25 80 (20)	1431 50±28 91 (20)	1 0970 (NS)	1533 19±36 47 (69)	1500 42±35 11 (48)	0 5683 (NS)

NS Non significant

Number in parenthesis indicate number of observations

Table 15 Post transferrin phenotypes and average daily gain (in differen genetic groups of rabbits

Period	Soviet Chinchilla			Newzealand White			Local		
	Ptf FF	Ptf FS	$t_{n_1+n_2-2}$	Ptf FF	Ptf FS	$t_{n_1+n_2-2}$	Ptf FF	Ptf FS	$t_{n_1+n_2-2}$
0-30 days	14 53e±0 3665 (26)	14 284±1 103 (22)	1 2396 NS	17 064±0.850 (33)	16 476±0 763 (19)	1 653 NS	12 424±1 052 (26)	13 016±1 425 (24)	1 789 NS
30-60 days	19 121±1 0372	20 478±1 5534	1 859 NS	20 455±0 937	21 406±1 447	1 6848 NS	17 541±1 0841	17 967±0 948	1 491 NS
60-90 days	17 863±0 895	18 691±1 739	1 9123 NS	17 609±1 012	16 666±1 126	1 6149 NS	16 367±1.0489	16 983±0 870	1.4033 NS

Number in parenthesis indicate the number of observations

NS - Non significant

Table 16 Mean value of litter size and weight at birth and weaning of kits produced in matings based on post transferrin types

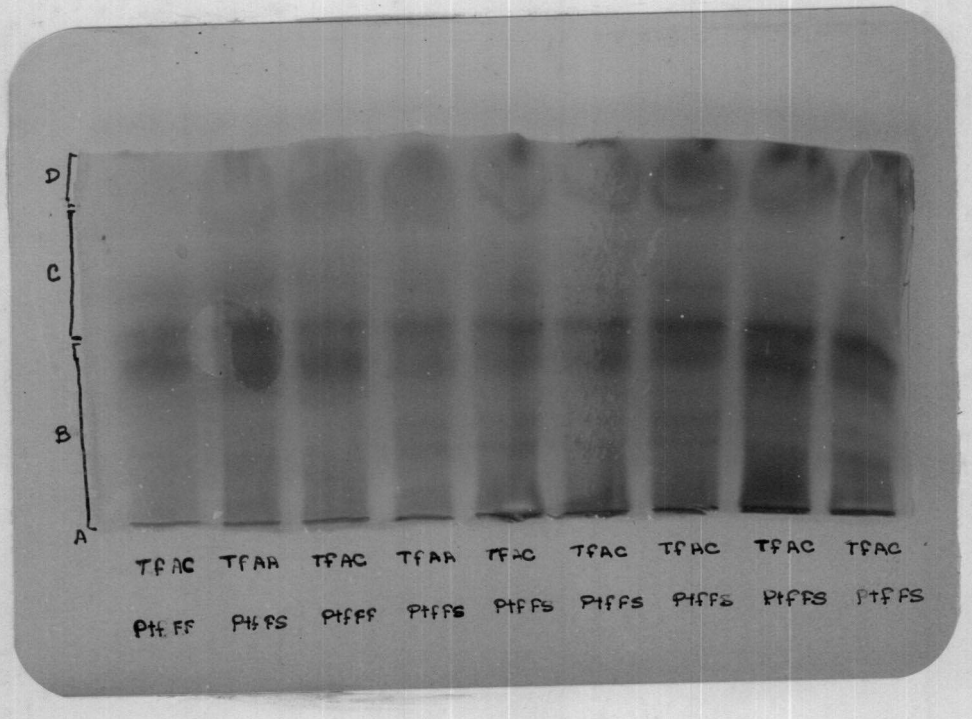
Mating class	No of kindlings	Litter size at birth	Litter size at weaning	Litter weight at birth (g)	Litter weight at weaning (g)
Ptf FF x Ptf FF	8	4 9	3 4	249 55+24 95	1663 12+188 06
Ptf FF x Ptf FS (F) (M)	5	5 6	5 0	286 16+8 37	1546 00+200 63
Ptf FS x Ptf FF (F) (M)	14	6 0	3 8	276 71+24 22	1870 36+162 97
Ptf FS x Ptf FS	3	5 7	5 0	307 77+64 88	2380 00+206 44

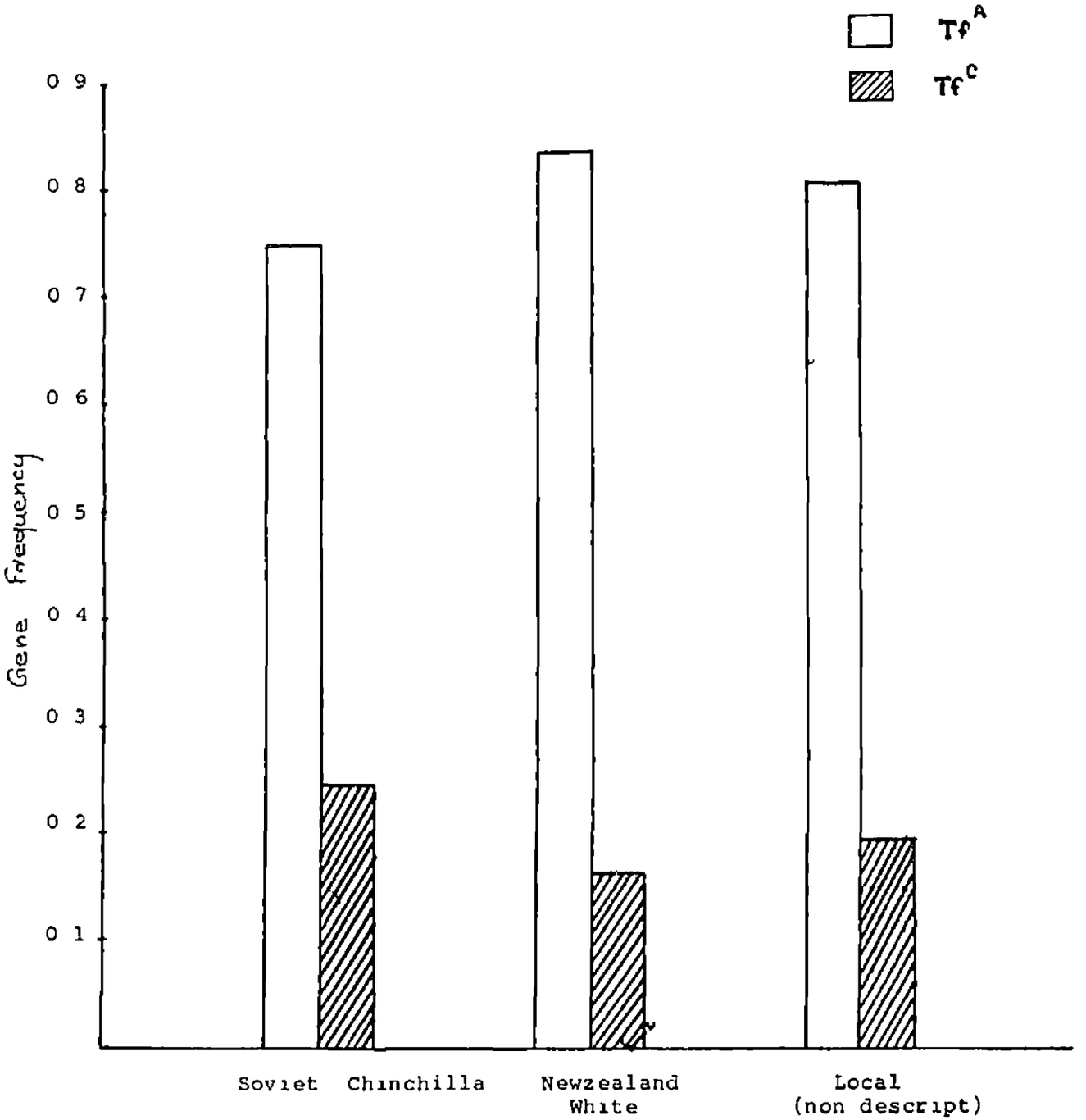
M Male F Female

Table 17 Preweaning mortality of different mating types in rabbits

Mating class	No of kindling	Average litter size at birth	Litter size at weaning	Percentage mortality
Ptf FF x Ptf FF	8	4 88	3 38	30 73
Ptf FF (F) x Ptf FS (M)	5	5 60	5 00	10 71
Ptf FS (F) x Ptf FF (M)	14	6 00	3 79	36 90
Ptf FS x Ptf FS	3	5 67	5 00	11 82

F - Female M - Male


D
C
B
A
TfAC TfAA TfAC TfAA TfAC TfAC TfAC TfAC TfAC
PtfFF PtfFS PtfFF PtfFS PtfFS PtfFS PtfFS PtfFS PtfFS



F g 6 Transferrin ge e frequenc es in different breeds of rabbits

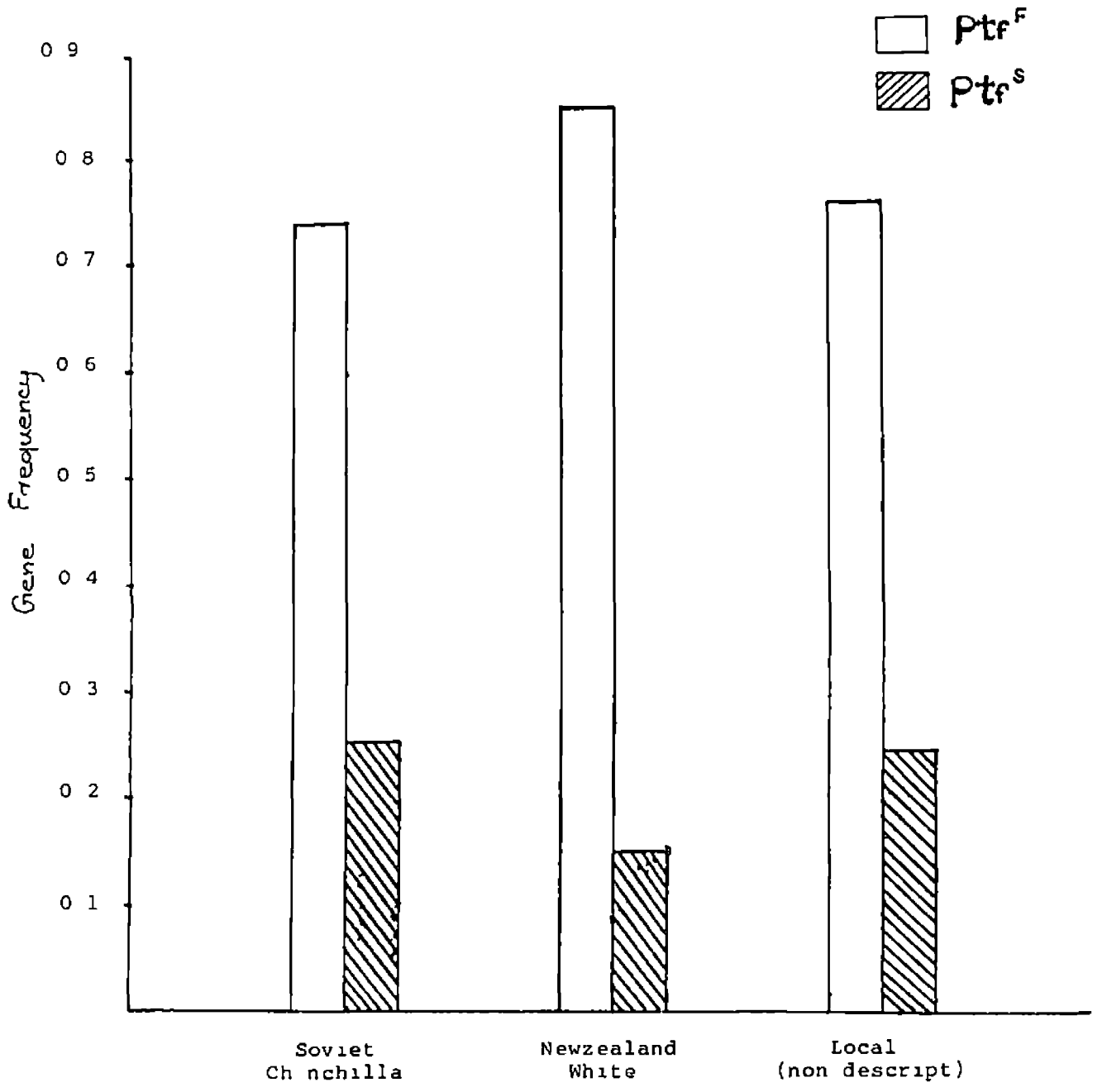


Fig 7 Post transferrin gene frequencies in different breeds of rabbits

Fig 8 Stained polyacrylamide gel showing haemoglobin phenotype in rabbits

Fig 9 Stained polyacrylamide gel showing comparison of rabbit haemoglobin with that of cattle and goat

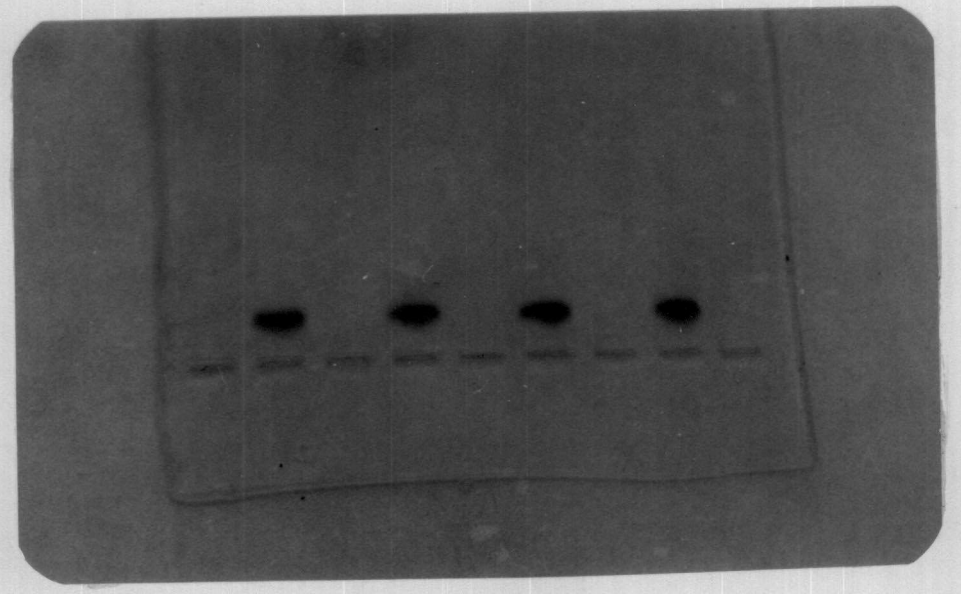
1 Cattle haemoglobin type AB

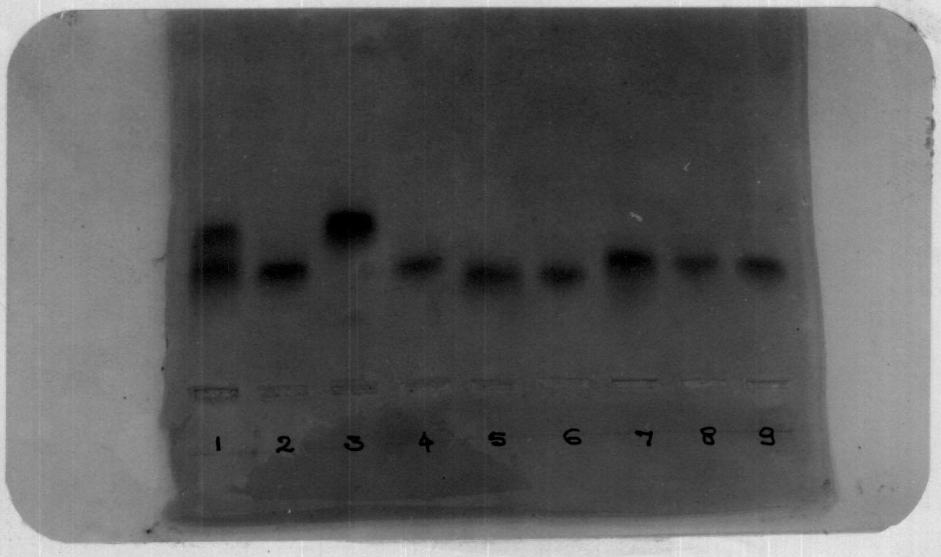
2 Cattle haemoglobin type AA

3 Cattle haemoglobin type BB

4 6 Goat haemoglobin

7 9 Rabbit haemoglobin




1 2 3 4 5 6 7 8 9

Discussion

DISCUSSION

A clear separation of transferrin and post transferrin protein was obtained using polyacrylamide gel electrophoresis This may be due to (a) use of large pore gel (4 percent acrylamide concentration) (b) use of suitable discontinuous buffer system which generated higher voltage (c) use of thin gels (1 5 mm thick) which were thus easy to cool using electrophoresis (d) more sensitive staining of protein fractions with Coomassie Brilliant Blue R-250 after electrophoresis In the present method of polyacrylamide gel electrophoresis the procedures of casting gel sample application electrophoresis and staining were very simple which makes it a method of choice for routine typing of samples for different proteins

Transferrin

In rabbits of different genetic groups viz Soviet Chinchilla Newzealand White and local an investigation of blood protein polymorphism employing horizontal polyacrylamide gel electrophoresis revealed the presence of two transferrin phenotyes TfAA and TfAC controlled by Tf^A and Tf^C alleles This finding is in agreement with the

findings observed by Markovich and Tinaev (1975) and Markovich and Pornitko (1977)

Transferrin phenotype

In the present study phenotype TfAA and TfAC occured in equal proportion in Soviet Chinchilla But TfAA and TfAC had a frequency of 0 6538 and 0 3462 in Newzealand White and 0 6200 and 0 3800 in local rabbits The frequency of Tf^A allele was higher in all genetic groups with the value of 0 7500 in Soviet Chinchilla 0 8270 in Newzealand White and 0 8100 in local rabbits However Markovich and Pornitko (1977) observed that the concentration of Tf^A and Tf^C alleles in Soviet Chinchilla approached 0 5000 but Tf^A prevailed significantly in other genotypes TfCC was not observed in any of the genetic groups studied The absence of TfCC phenotype and rarity of Tf^C allele in the three breeds may be indicative of the poor viability of the phenotype Gogeliya et al (1981) found similar observation in Soviet Chinchilla reporting higher mortality in TfCC phenotype compared to TfAA and TfAC phenotypes Similar studies conducted by Arana et al (1987) revealed three transferrin phenotypes TfAA TfAB and TfBB The occurance of two codominant alleles Tf^A and Tf^B was observed with frequencies of 0 8900 and 0 1100 at an autosomal locus Zaragoza et al (1987) observed two variants for transferrin

as Tf^A and Tf^B Tf^B was present only in Spanish wild population and showed a low frequency with respect to Tf^A

Fractionisation of rabbit sera by Binette et al (1965) showed only a single transferrin band by starch gel electrophoresis Similarly electrophoretic studies of transferrin in rabbits by Zaragoza et al (1985) and Zaragoza et al (1987) revealed transferrin to be monomorphic in starch gel electrophoresis but polymorphic in polyacrylamide gel electrophoresis In the present study distinct separation of TfAA and TfAC was obtained which may be due to the efficacy of polyacrylamide gel electrophoresis over the starch gel electrophoresis in separation of proteins

Inheritance of transferrin

With regard to the segregation of transferrin alleles it was found that all matings between TfAA phenotypes produced only TfAA offspring indicating that TfAA may be homozygous Matings between TfAA and TfAC produced TfAA and TfAC in 1 1 ratio and matings between TfAC and TfAC produced offspring in accordance with 1 2 1 ratio The absence of significant difference between the observed and expected number of offspring in each mating indicates that the gene controlling transferrin show simple Mendalion inheritance and that Tf^A and Tf^C are autosomal co-dominant genes

Genetic equilibrium

A good agreement was obtained between the observed and expected transferrin phenotypes in all the genetic groups suggesting that these populations were in Hardy-Weinberg equilibrium with respect to gene frequency and phenotypic frequency This was expected as the selection was not done on the basis of transferrin types of rabbits Arana et al (1987) also observed genetic equilibrium with respect to transferrin types in Spanish Wild rabbit populations

Comparison of gene frequencies between different genetic groups

Comparison of frequencies Tf^A and Tf^C alleles did not reveal difference at the transferrin locus among the three genetic groups According to the Wild Life (Protection) Act 1972 of the Government of India it is seen that there are no rabbits native to India The local rabbits are believed to be brought by the European immigrants to India as pet animals and multiplied by them It can be inferred from the occurance of transferrin alleles in more or less same frequency in the three genetic groups that the three genotypes under study might have arisen from a common origin

Association between transferrin and growth and prolificacy traits

Association between transferrin types and body weight at different ages was examined TfAA types were found to be heavier than TfAC types in Soviet Chinchilla and local rabbits in most of the age groups Although significant difference was observed in Soviet Chinchilla of all age groups the significannt difference in case of local rabbits could be noticed only at ages of 60 75 and 90 days The trend of increased body weight in favour of TfAA phenotype could not be seen in Newzealand White rabbits in which the body weights were more or less similar in both phenotypes Average daily gain was found to have no association with TfAA and TfAC phenotypes in three genetic groups at different age groups Preweaning mortality was found to be higher in TfAA female x TfAC male matings of 40 percent In TfAC female x TfAA male matings there was only 12 72 percent mortality Statistical analysis of data does not show any definite trend in preweaning mortality and mating types

Association of transferrin types with prolificacy traits as litter size at birth litter weight at birth litter size at weaning and litter weight at weaning revealed

no significant difference between transferrin types and any of these traits TTfAA type matings produced litter of size ranging from 5 to 10 at birth and from 2 to 8 at weaning with a litter weight of 235 5 to 454 0 g at birth and 770 to 3800 g at weaning But in TfAA x TfAC crosses litter size raanged from 3 to 7 at birth and 1 to 6 at weaning Litter weight ranged from 147 6 to 375 2 g at birth and from 760 to 2820 g at weaning But in reciprocal crosses litter size was ranging between 3 and 7 at birth and 2 and 7 at weaning with a litter weight of 171 6 to 395 2 g at birth and 1030 to 2830 g at weaning In crosses of TfAC types litter size and weight ranged between 3 and 5 and 174 0 and 228 5 g at birth and 2 and 5 and 775 and 3560 g at weaning respectively

Post transferrin

Fractionisation of rabbit sera for post transferrin revealed two groups of protein zones called Ptf1 and Ptf2 The Ptf 1 comprised of weakly stained bands and no clear variation was observed between the samples

Post transferrin phenotypes

In the Ptf 2 region three phenotypes Ptf FF Ptf FS and Ptf SS were observed controlled by two alleles Ptf^F and Ptf^S Ptf FF and Ptf FS phenotypes were found in all

the genetic groups while Ptf SS was observed only in Soviet Chinchilla The phenotypes Ptf FF and Ptf FS were in the frequency of 0 5200 and 0 4400 in Soviet Chinchilla and 0 6350 and 0 3650 in Newzealand White rabbits respectively But in local rabbits the corresponding frequency was 0 5200 and 0 4800 for Ptf FF and Ptf FS respectively

Frequencies of Ptf^F and Ptf^S alleles were 0 7400 and 0 2600 in Soviet Chinchilla 0 8500 and 0 1500 in Newzealand White and 0 7600 and 0 2400 in local rabbits

Inheritance of post transferrin

In matings between Ptf FF types only Ptf FF offspring were produced In Ptf FF x Ptf FS matings offspring were of Ptf FF and Ptf FS types in 1 1 ratio In Ptf FS x Ptf FS matings the observed number of offspring with phenotype Ptf FF Ptf FS and Ptf SS was not significantly different from that of 1 2 1 ratio These results show that the gene controlling Ptf^F and Ptf^S alleles were autosomal and co-dominant

Genetic equilibrium

Absence of significant difference between the observed and expected number of phenotypes in any of the genetic group studied indicate that the populations were in genetic equilibrium and were mating at random

Comparison of gene frequency

Comparison of gene frequencies among different genetic groups did not show any significant difference indicating that no genetic diversity existed between the different genotypes studied with respect to post transferrin locus This finding reveals that the three breeds of rabbits included in the present study might have arisen from a common origin

Association of post transferrin with growth traits and prolificacy

Statistical analysis revealed no significant association between post-transferrin types and body weight at fortnightly intervals upto 90 days of age in any of the genetic groups or in the pooled population Litter size at birth litter weight at birth litter size at weaning and litter weight at weaning average daily gain in weight and preweaning mortality were also found to have no significant association with post transferrin types

Haemoglobin

Polymorphism in haemoglobin was not observed in any of the three genetic groups of rabbits studied All the samples in the present study were found to be monomorphic

for haemoglobin in rabbits This haemoglobin was found comparable with Hb^A in cattle and that in goat

Studies using starch gel electrophoresis by Boyer et al (1963) and disc electrophoresis by Ornstein and Davis (1964) turned up only one rabbit with a haemoglobin variant over 2000 animals Dayhoff (1969) reported that haemoglobin variants if present do not affect the electrophoretic mobility of the intact haemoglobin molecule and for this reason haemoglobin molecules behave as monomorphic in electrophoresis in majority of the studies

By the technique of amino acid analysis this lack of electrophoretic variants strongly suggest that when isoleucine is absent another neutral amino acid replaces it Recently β^{112} iso valine has been identified as the substitution (Bricker and Garrick 1973) Zaragoza et al (1983) also observed no electrophoretic variants for rabbit haemoglobin

However rabbit haemoglobin variants have been in isolated chains by Dayhoff (1972) using chromatography techniques Garrick et al (1974) reported that β chain of rabbit haemoglobin contains a single residue of isoleucine at β^{112} Later it was detected that rabbits with either

zero isoleucyl residues or half a residue per β chain also exist This character was found polymorphic and inherited in a simple Mendalian autosomal co dominant pattern

Summary

SUMMARY

The broiler rabbits (Oryctolagus cuniculas) maintained in the Kerala Agricultural University Rabbit Breeding Farm formed the materials for study Phenotyping of transferrin post transferrin and haemoglobin of the rabbit blood was carried out using a simple method of horizontal polyacrylamide gel electrophoresis

Statistical analysis was done to detect whether there exist or not any association between phenotypes and the body weights at the ages of 15 30 45 60 76 and 90 days and prolificacy traits such as litter size at birth litter weight at birth litter size at weaning and litter weight at weaning

In all 152 rabbits comprising of 50 Soviet Chinchilla 52 Newzealand White and 50 local rabbits were included in the present study

Two transferrin phenotypes TfAA and TfAC were identified in all the breeds Phenotype frequency of TfAA in Soviet Chinchilla Newzealand White and local rabbits was 0 5000 0 6538 and 0 6200 respectively and that of TfAC in these three genetic groups was 0 5000 0 3462 and 0 3800

respectively The variants of transferrin show simple Mendalian monohybrid inheritance controlled by TfA and TfC alleles The transferrin alleles are found to be autosomal and co dominant The phenotypes TfAA bred true and hence they were homozygous

Gene frequency of TfA was 0 7500 in Soviet Chinchilla 0 8270 in Newzealand White and 0 8100 in local rabbits and that of TfC was 0 2500 0 1730 and 0 1900 in the three respective genetic groups The frequency of TfA allele was higher than that of TfC allele in all the genetic groups Between genetic groups no significant difference was observed in the frequency of transferrin alleles

In all the three genetic groups the occurance of TfCC phenotype was not observed It is suspected that Tf^C allele might interfere with the viability when the alleles are homozygous The population of the three genetic groups were in Hardy Weinberg equilibrium as far as transferrin locus is concerned

TfAA phenotypes were found to be heavier than TfAC types in Soviet Chinchilla and local rabbits while a similar trend was not noticed in the case of Newzealand White rabbits The pooled data of the three genetic groups revealed that rabbits of TfAA type was significantly heavier than TfAC type at 45 60 75 and 90 days of age

Average daily gain in body weight was found to have no association with any of the protein types in the three genetic groups of rabbits Preweaning mortality was 38 46 percent in TfAA x TfAA matings and 28 57 percent in TfACx TfAC matings

No significant association between transferrin types and reproductive traits viz litter size at birth litter weight at birth litter size at weaning and litter weight at weaning could be established

Post transferrin occured in three phenotypes of PtfFF Ptf FS and Ptf SS in Soviet Chinchilla with frequency of 0 5200 0 4400 and 0 0400 respectively In Newzealand White and local rabbits Ptf FF and Ptf FS were present at the frequency of 0 6350 and 0 3650 and 0 5200 and 0 4800 respectively Ptf SS did not appear in Newzealand White and local rabbit populations

Post transferrin showed Mendalian monohybrid inheritance controlled by Ptf^F and Ptf^S alleles The results of mating indicated that post transferrin alleles are autosomal and co dominant The population of the three genetic groups were at Hardy Weinberg equilibrium and were considered to be panmictic

With regard to post-transferrin locus no genetic diversity existed as the gene frequencies between genetic groups were almost similar

No significant association was observed between post transferrin phenotypes growth traits prolificacy average daily gain and preweaning mortality in the three genetic groups of rabbits

Polymorphism in haemoglobin was not observed in any of the genetic groups of rabbits All the animals were found to be monomorphic The haemoglobin phenotype was comparable with that of HbAA of cattle and goat

The presence of polymorphism in transferrin and post transferrin will be of paramount importance in using them for genetic monitoring in rabbit breeding

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BIOCHEMICAL POLYMORPHISM IN BROILER RABBITS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Blood samples collected from rabbits maintained in the rabbit breeding farm of Kerala Agricultural University formed the materials for this study These blood samples were typed employing horizontal polyacrylamide gel electrophoresis to study the polymorphism of transferrin post transferrin and haemoglobin A total of 152 rabbits comprising of 50 Soviet Chinchilla 52 Newzealand White and 50 local rabbits were involved in the study Genetic inter relationship among growth traits and survivability were studied

In all the genetic groups two transferrin variants the faster Tf^A and slower Tf^C with two phenotypes TfAA and TfAC were observed The gene frequency of Tf^A and Tf^C were 0 7500 and 0 2500 in Soviet Chinchilla 0 8300 and 0 1700 in Newzealand White and 0 8100 and 0 1900 in local rabbits The frequency of Tf^A allele was higher in all the populations The phenotype TfCC was not observed in any of the genetic groups

Three post transferrin phenotypes Ptf FF Ptf FS and Ptf SS were detected and found to be controlled by two

co dominant alleles Ptf^F and Ptf^S The fast moving variant was designated as Ptf^F and the slow moving migrant was designated as Ptf^S The gene frequency of Ptf^F was 0 7400 0 8500 and 0 7600 in the three genetic groups and that of Ptf^S was 0 2600 0 1500 and 0 2400 in Soviet Chinchilla Newzealand White and local rabbits respectively

Haemoglobin was found to be monomorphic in all the three genetic groups studied

The allelic frequencies of transferrin and post transferrin were suggestive of Hardy Weinberg equilibrium in the populations of three breeds No significant diversity was found to exist between genetic groups

Analysis of segretation pattern observed in pedigrees revealed the autosomal codominant mode of inheritance for transferrin and post transferrin alleles

The absence of TfCC phenotype in the whole population of rabbits may be due to its unfavourable influence on the viability

Significant association was observed between the TfAA phenotype and body weight at the ages of 15 days 30 days 45 days 60 days 75 days and 90 days of age in Soviet Chinchilla and local rabbits But no significant association was observed between transferrin phenotype and reproductive traits studied

Average daily gain was found to have no significant association with the protein types in anv of the genetic groups studied Preweaning mortality was 38 46 percent in TfAA x TfAA matings and 28 57 percent in TfAC x TfAC matings

Post transferrin phenotype was found to have no significant association with any of the economic traits studied

Among the three biochemicals of blood studied transferrin and post transferrin reflected a great scope for genetic monitoring of populations of rabbits