GENETIC STUDIES ON THE IMMUNE RESPONSE OF BROILER RABBITS

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THESIS

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DECLARATION

I hereby declare that this thesis entitled Genetic studies on the immune response of Broiler Rabbits is a bonafide record of research work done by me during the course of research and that this 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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Introduction

INTRODUCTION

The FAO expert consultation on rural poultry and rabbits held in Rome in 1981 emphasised that if the high rate of growth in meat consumption in future years was to be met much of the increase in production would have to come from short cycle animals such as rabbits and especially from animals kept by small scale farmers The potential of broiler rabbit industry thus appears to be tremendous comparing the biological efficiency prolificacy and growth rate of rabbits This potential would be as asset in humid developing tropics of low economic growth with limited pasture facilities for conventional livestock

With the above background a rabbit breeding research was undertaken at Kerala Agricultural University Mannuthy to evaluate the performance of pure bred temperate breeds viz Soviet Chinchilla and Newzealand White Local non descript type of rabbits and their crosses under the humid tropical climate of the State (Mukundan *et al*, 1992) The differences between two temperate breeds themselves were significantly different with Newzealand White showing a comparable performance to highly adapted Local non descript type under the humid tropics The suboptimal performance especially the high neonatal mortality and infections is suggestive of defect ve immune status and immune response augmented by tl e tropical stress among the temperate breeds

Immune response the strategic defense system in the fight against antigenic and microbial invasions is of primary importance to the survival and optimum performance of an animal Immune response may be broadly defined as the cellular and humoral responses of the body to certain intrinsic and extrinsic factors An animal s immune system basically consists of three major facets as phagocytosis cell mediated and humoral immunity which are performed respectively by macrophages T lymphocytes and B lymphocytes and each of these functions are specialised in the protection against some infections and scarcely effective or ineffective against others Inspite of the functional integration of these three cell types basically involved in the three immune functions they are distinct protagonists under separate polygenic control

Selection for immune responsiveness and disease resistance has often been ignored by animal geneticists because of the difficulty in measuring these traits Genetic considerations involved with selection and testing for disease resistance and immune responsiveness require the knowledge of associations between disease resistance immune responsiveness and production traits Serum gammaglobulin levels have often been associated with health better performance and survival of all species of livestock As early as 1960 Ross *et al* demonstrated that lines of Zebu cattle resistant to helminthiasis had higher serum gammaglobulin levels compared to susceptible lines Animals with higher antibody response to an antigenic challenge often had higher serum

gammaglobulin levels (Biozzi *et al* 1975 Halliday and Williams 1980) Many diseases including neoplasms unthriftness and neonatal mortality in several species of livestock have been associated with hypogammaglobulinaemia Humoral immune response to complex antigens like sheep red blood cells (SRBC) was complex of polygenic inheritance and associated with several bacterial and viral diseases Similarly cell mediated immune response to mitogens like phytohaemagglutinin, or contact sensitiser like 2 4 dinitrochlorobenzene (DNCB) were also considerably influenced by genetic group sex and sire The association between these cell mediated immune responses neoplastic diseases like Marek's disease in birds Jhones diseases Brucellosis Protozoal infections m livestock were often significant An understanding of the association of disease resistance immune responses and production traits is very important if future breeding efforts are to be employed to improve disease resistance and production simultaneously Resistance to diseases and specifically infectious diseases operates at several levels Many researchers have examined the approaches to selection for disease resistance Direct selection for disease resistance by challenge would be costly hazardous requires thorough standardisation of challenge to a particular disease and the maintenance of isolation facilities for this type of selection Indirect approaches to selection for genetic resistance to diseases have been proposed as the appropriate method and immune responsiveness has been suggested as a clear indicator of disease resistance

Genetics of immune responses and the feasibility of utilising immune response traits as markers in indirect selection for disease resistance have extensively been investigated in important species of livestock and poultry Though rabbits are endowed with tremendous potential as an alternate source of meat broiler rabbit production in humid tropics is hampered by high pre weaning mortality and high incidence of diseases like Coccidiosis Mange and Pneumonia contributing to lowered reproductive and growth performance Leitner *et al* (1992) have pointed out that defective immune status predisposes animals to high morbidity and mortality Any type of stress especially thermal stress is reported to have an immuno suppressant effect Adverse effect of tropical stresses on immune responsiveness might contribute to a lowered performance of temperate breeds of broiler rabbits It is interesting to note that genetic studies on immune responses and the feasibility of utilising immune response traits for selection to disease resistance and better performance of broiler rabbits are scanty though these studies offer valuable possibilities This background information necessitated a detailed study on the genetics of immune responses in broiler rabbits under the humid tropics and also an assessment of the relationship between immune responses diseases viability growth and reproduction in this species Immune responses to be assessed were serum gammaglobulin (SG) level humoral immune responses to Bovine Red Blood Cells (BRBC) cell mediated immune response (CMI) to phytohaemagglutinin M (PHA M) and to contact sensitizer 2 4 Din trochlorbenzene (DNCB) These studies were apparently

harmless to the health of breeding animals and hence would be of value as marker traits in selection

The present investigation was undertaken in two temperate broiler rabbit breeds namely Newzealand White and Soviet Chinchilla below one year of age maintained at the Centre for Advanced Studies in Animal Genetics and Breeding College of Veterinary and Animal Sciences with the following objectives

1 To assess the genetics of humoral and cell mediated immune responses in broiler rabbits

2 To assess the relationship between immune response traits with reproduction growth and viability

Review of Literature

REVIEW OF LITERATURE

Comparative biological economic and managemental attributes of rabbits indicate that they possess tremendous potential as an alternate source of meat in the developing humid tropics (Mukundan *et al* 1986) The production of one kg rabbit meat requires only one quarter of the feed energy needed to produce same amount of beef or lamb Though 30% more feed energy is needed to produce one kg of rabbit meat than is required for poultry rabbits have the economic advantage of thriving on feed stuffs rich in roughage (Lebas 1981) They grow rapidly with about 30 g per day during the pre weaning and post weaning periods and have a good meat to bone ratio compared to other livestock. In addition rabbit meat is having higher protein low fat and high mineral content (Schlolaut,1981)

Cross breeding experiments involving local non descript Soviet Chinchilla and Newzealand White rabbits clearly demonstrated that as far as viability and litter size at weaning are concerned Local non descript type was superior to the temparate breeds The performance of the two temparate breeds were much below their reproductive and productive potential (Mukundan *et al* 1992) The high pre weaving mortality of the two temparate breeds apparently appears to be a d rect effect of tropical stresses ncluding the high incidence of tropical diseases with the stress contributing to the increased disease incidence The significant

difference among the two temparate breeds themselves in viability and growth deserved a detailed investigation The high endemicity and prevalence of diseases like Coccidiosis Mange and Pneumonia might again contribute to the poor performance and reduced viability of temperate breeds The humid tropical climate often contributing substantially to the stress increasing the incidence of diseases and interfering with the immune response This situation necessitates a detailed analysis on the immune responses genetic analysis of immune response and its association with survivability diseases and growth

The immune system is a powerful tool in mammalian and avian homeostasis It has a function in the adaptation of individual animal and population to the environment and is a major component in specific disease resistance General resistance against diseases is the ability to resist any alteration of the state of the body by external causes (micro organisms or stress) which interrupts or disturbs proper performances The main characteristic of immune system is the ability to detect and resist antigenic invasions by maintaining antigenic integrity against viruses bacteria parasites or transformed malignant cells

There are two major categories of immune responses those involving the antibody which are called humoral immune responses and those that are

independant of antibody called cell mediated immune responses The pioneering works of Glick *et al* (1956) and Claman *et al.* (1966) led to an understanding of the cellular basis of dichotomy of immune system The production of antibody in humoral immune responses depends on the interaction of T cells B-cells and macrophages (Bach *et al* 1974 Unanue 1984) Cellular immunity is a function of many types of leucocytes including T-cells (Nabholz and Mc Donald 1983) Macrophages (Adams and Hamilton, 1984) NK cells (Herberman *et al* 1986) and LAK cells (Andriole *et al* 1985) In addition to cells of immune response there are many soluble mediators of immune response Primary molecules are antibody molecules synthesised by activated B cells Complement system (Reid and Porter 1981) the interferrons (Freidman and Vogel 1983) the interleukins (Smith 1984) and other lymphokines and monokines are soluble mediators of immune response Hormones prostaglandins and leukotrins also modify the immune responses Cheng and Lamont (1988) classified that immune responses consists of three major facets as phagocytosis cell mediated immunity and humoral immunity which are performed respectively by macrophages T lymphocytes and B lymphocytes Both humoral and cell mediated immunities are under independant genetic control and there exists an inverse relationship between genetic regulations of antibody responsiveness and macrophage activity (Cheng and Lamont 1988) The role of immune system in disease resistance is well established and the role of both non specific and immunologic specific

defense systems contribute to it substantially Non specific or innate immune mechanism operate through phagocytic leucocytes (neutrophils and macrophages) soluble mediators like lactoferrins lactoperoxidases thiocyanate system hydrogen peroxidase system lysozymes cationic proteins and complement proteins The specific or adaptive immune system consists of leukocytes and antibodies (Brian and Harp 1989) Three sets of genes are reported to modulate the response of vertebrate hosts to infections namely those controlling innate immunity those determining the specificity of acquired immune responses and those which affect the quality of acquired immunity (Doenhoff and Davis 1991)

The overall complex and dynamic interactions between the hosts immune response and its pathogens are controlled by many genes Wakelin (1989) has listed 16 distinct parameters of immune response to infection with Trichinella spiralis that are known to vary between strains of mice The strains selected for a particular response either in respect of resistance to one pathogen species (Windon and Dineen 1984) or for a more general enhanced immune response for high antibody production (Biozzi *et al* 1975) are not resistant against all pathogens Oosterlee (1981) has summarised that selecting for high resistance against diseases by using immune response characteristics cannot be performed on a single item He has concluded that a selection index in which macrophage

activity and humoral and cell mediated immunity are included might in future lead to an increase in disease resistance

Direct approaches to selection for disease resistance are summarised in Table 2 1

Table 2 1 Direct approaches to selection for disease resistance

Type of selection and method	Effects in production of breeding stock	Expression of disease resistance	Cost
Direct			
1 Observe breeding stock	0	Questionable	0
2 Challenge the breeding stock	Negative	Good	Low/high
3 Challenge the sibs or progeny	0	Good	Low/high
4 Challenge clones	0	Excellent	High

(Gavora and Spencer 1983 Rothschild 1985)

Direct selection by challenging the breeding stock sibs or progeny would be costly and adverse to the production Direct challenge requires the standardisation of level of challenge exposure to a particular disease and maintance for isolation facilities for this type of selection Selection difficulties

would arise if negative correlations exist between disease existance and production traits This would be augmented in multiple selection for several diseases An index approach would be useful requiring all the genetic correlations between the disease resistance and performance traits This may also cause a reduction in genetic progress in other traits because of increased total number of traits

Indirect selection for disease resistance have been proposed as the most viable approach for selection to disease resistance Immune responsiveness has been suggested as one of the best indicators of disease resistance (Biozzi *et al* 1980 Gavora and Spencer 1983 Buschmann *et al* 1985 Warner *et al* 1987) Early studies in mice (Biozzi *et al* 1980) have revealed that genetic control of antibody response to sheep red blood cells was moderately heritable and selection for immune response for one antigen may improve humoral immune response for other antigens They also investigated genetic control of cell mediated immune response Selection for immune response to sheep red blood cells did not improve cell mediated immunity suggesting independance of these traits Extensive research on similar lines have been conducted in poultry (Se gel and Gross 1980 VanDer Zijpp 1983)

Table 2 2 Indirect approaches to selection for genetic resistance to diseases

Type of selection and method	Effects in production of breeding stock	Expression of disease resistance	Cost
Indirect			
1 Vaccine challenge	0	Good	Low
2 In Vitro tests	0	Good	Low
3 Genetic Markers	0	Good	Low
Molecular Genetics			
Construct Resistant Genotype	0	Good	High

(Gavora and Spencer 1983 Rothschild 1985)

Immune response experiments in swine its genetic association with diseases and production has extensively been conducted by Buschmann *et al* (1985) Edorf Lilja *et al* (1985) and Meeker *et al* (1987) Studies in the immune response in cattle and sheep by Muggli *et al* (1987) have also shown similar trend as in poultry These immune response experiments have demonstrated considerable associations between immune responses diseases and several production traits

Among all l estock species it is well established that hypogammaglobulinaemia is associated with suboptimal performance neonatal infections and

high mortality Biozzi *et al* (1975) demonstratd that high antibody responder mice had higher serum gamma globulin level compared to low responders to SRBC Passive transfer of maternal antibodies has been demonstrated for survival and better performance of a new born mammal In lagomorpha like rabbits this passive transfer of immunity occurs *in utero* (Brambel 1970) Hypogamma globulinaemic and defective maternal transfer of passive mmunity have been associated with increased incidence of diseases and mortality in all major livestock species like cattle (Caldow *et al* 1988) and goat (Nandakumar and Raja 1983b)

Though rabbit has extensively been studied as a model in immunological research the research studies in the above discussed aspects of immune responses which are of importance in immunogenetic research and rabbit production are scanty This is especially true in the case of broiler Rabbits which might be due to the fact that rabbit is an emerging unconventional livestock Research reports on these areas of research are also extremely rare in rabbits

2 1 Serum gammaglobullin level

2 1 1 Gamma globulin status

The functional immune system comprises of cells ot bursal or bone marrow origin and cells of thymic origin The cells ot thymic origin (T lymphocytes) are concerned with cell mediated immunity The B lymphocytes

or cells of bone marrow origin on antigenic stimulation are capable of active division to produce plasma cells capable of antibody synthesis Antibodies are present in many tissues and fluids of the body Antibodies come under a family of related proteins called gammaglobulins with overlapping physico chemical properties In a strict sense immunoglobulins are gamma globulins committed to act against specific antigens though both terms are used synonymously It has been well established that sufficient levels of gammaglobulin is essentiall for health, better performance and survivial of cattle pigs sheep and goat (Bringole and Stott 1980 Yaguchi 1979 Ciupercescu 1977 Nandakumar and Raja, 1983b Caldow *et al.* 1988) Hypogamma globulinaemia and agammaglobulinaemia has been associated with immunodeficiency neonatal infections and heavy childhood mortality in man (Rosen 1975) Halliday and Williams (1980) reported that cows with normally high levels of serum Ig generally produced more antibodies in response to an antigenic challenge Low levels of serum Ig have been reported to be associated with many diseases mcludng neoplasms (Jacobs *et al* 1980)

Often younger animals had a lowerserum Ig level compared to older animals In cattle below 2 years of age Ig level was 29 133 mg/ml while in cattle above 2 years of age it was 36 211 mg/ml (Raja and Balakrishnan 1985) Nandakumar *et al* (1991) could observe a similar trend in goats The range in serum Ig level varied from 2 80 to 27 62 mg/ml in cattle (Mc Ewan *et al* 1970)

Biozzi *et al.* (1975) reported that Ig level in mice serum ranged between 3 15 mg/ml in low responder lines to 14 80 mg/ml in high responder lines Though rabbit has extensively been utilised in immunological research literature on immunoglobulin status its association with incidence of diseases growth and mortality are scanty compared to other livestock species This is more so in Broiler Rabbits Earlier reports on serum gamma globulin levels in rabbit indicated that 20 to 38% of serum proteins in rabbits were gammaglobulins (Allen and Watson 1958) Kozma *et al* (1967) reported that total serum protein value of rabbits were 4 3 to 7 3 g/100 ml and gammaglobulins accounted for 9 3 to 15 0% Kaneko and Cornelius (1970) reported that gamma globulin value may be 16 6+6 8% of serum proteins in rabbits

A neonatal mammal is incapable of mounting an immune response effectively It has to depend on the passive immunity provided by the mother for disease resistance and survival Based on the passive transfer of immunity from mother to neonates animals can be classified into three groups The first group comprises of lagomorphs and the transmission of passive immunity from mother to young one occurs *in utero* The neonates of second group consisting of ungulates receive their passive immunity viz colostrum of dam The third group consisting of dog cat rat mouse and guineapig etc derive their passive immunity both *in utero* and via colostrum of dam (Brambel 1970)

Brambel *et al* (1948) showed that immunity is transmitted in normal rabbits during second half of pregnancy The serum titer of new born rabbits approximate to those of the mothers According to them although foetal rabbit may synthesise small amounts of gammaglobulin majority is of maternal origin Autogenous production of gammaglobulins upto 4 weeks of post natal life is very slow and synthesis is only beginning to reach a significant level by then Aitken (1964) reported that Frossman haemolysin titre of new born young rabbits was approximately same as maternal titers and half life in young one was reported to be 8 to 9 days

2 1 2 Effect of breed and sex

The discovery of X linked agammaglobulmaemia in 1952 was only a prelude to the discovery of large number of deficiency states in immunological status At present almost all immunodeficiency states in man and animals have a genetic basis Allen and Watson (1958) reported that there were no differences in gammaglobulin level between different breeds of rabbits from a study based on small number of rabbits They also observed that sex do not have any influence on serum gamma globulin level Halliday (1968) observed significant breed differences in gamma globulin level in sheep with Merino lambs having higher serum gammaglobulin levels compared to Scottish Black face and Merino x Cheviot lambs Tennant *et al* (1969) reported that serum Ig levels in 1 5 day old Jersey calves were 30 mg/ml while it was only 13 0 mg/ml in

Holstein calves Penhale and Christie (1969) found a higher gamma globulin level in Indian breeds of cattle The differences between breeds in perinatal IgG_1 levels of calves were significant with Hereford calves showing 28 4 mg/ml while it was 38 9 mg/ml in Angus Breed of calves The differences between male and female calves were not significant Nair *et al* (1979) reported that Alpine x Beetal goats had significantly higher serum gammaglobulin level compared to Beetal goats Nandakumar *et al* (1991) observed that effect of genetic group was significant on serum gammaglobulin level in adult goats Similar studies on a large population basis is lacking among rabbit breeds

2 1 3 Sire effects and heritability

Roubik and Ray (1972) had found that effect of sire was significant on serum Ig level The heritability estimates of total gamma globulin level were 0 24 0 2 0 3 and 0 27 in 235 340 600 and 710 day old Hereford cattle Raja *et al* (1986) reported that the effect of sire was not significant on serum immunoglobulin level in goats

2 1 4 Effects on growth and litter traits

Halliday (1976) reported that there were significant correlations between body weight gain and Ig level in sera of calves For each mg of IgG there was an increase of 5 5 2 00 g in daily weight gain upto 42 day and in increase of 22 ± 80 g in total weight gain at 42 days Ciupercescu (1977) found a significant

negative correlation between body weight gain at 6 12 weeks and IgG and IgG concentration at 14 weeks (r 0 63 and 0 368 respectively) Caldow *et al* (1988) reported that there was no statistically significant relationship between plasma IgG concentration initial live weight or over all live weight

2 1 5 Effects on diseases and mortality

Allen and Watson (1958) studied the gamma globulin status of healthy and diseased rabbits They observed that rabbits with kidney lesions and chronic nephritis had a higher serum gammaglobulin ratio possibly due to the albuminurea associated with this disease Gay *et al* (1965) reported a high mortality rate in calves with hypogammaglobulinamia Ranatunga (1971) suspected that lack of passive transfer of immunity might contribute to heavy neonatal mortality in kids Fisher and Delafeunte (1971) reported a high incidence of deaths in neonatal calves with hypogammaglobulinaemia Thomas and Swaan (1973) reported a higher incidence of pneumonia and subsequent deaths in calves with lower levels of gammaglobulin in their serum Fisher *et al* (1976) found a hyper catabolism of immunoglobulins in dying calves leading to an intravascular depletion of Immunoglobulin A high level of immunoglobulins especially IgM protected calves from death due to neonatal salmonellosis Mc Guire *et al* (1976) reported that serum IgG concentration in calves below three weeks of age dying of infectious diseases were lower than that of clinically normal calves Fifty per cent of the dead calves had serum IgG concentration two standard deviations

below normal Nandakumar and Raja (1983b) found that neonatal kid mortality was often associated with hypogammaglobulmaemia Mortality rate of goat kid with hypogammaglobulinaemia was found to be 44 per cent

2 2 Humoral immune responses

The cellular basis of humoral immune response consists essentially of a phenomenon of multiplication and differentiation of T and B lymphocytes stimulated by the antigen processed by macrophages The selection of specific clone of lymphocyte is made by stereospecific combination of antigenic determinants with pre existing receptors on lymphocyte surface In B lymphocytes these receptors are immunoglobulins Intra cellular and inter cellular reactions are therefore integrated in the phenomenon of immune response The efficiency and co ordination of such a complex phenomenon are controlled and regulated at different levels by genetic controls Biozzi *et al* (1975) have attributed the general immune responsiveness as a polygenic trait determined by a group of about ten independent loci

The immune response to a multideterminant immunogen has not been reported to be the mere effect of additive effect of Ir genes for each antigenic determinants The rapid accumulation of experimental studies demonstrating the analogies between genetic control of specific and general antibody synthesis preludes the formulation in near future of a unified theory of genetic regulation of immune response (Biozzi *et al* 1985)

When an antigen was introduced into the animal body antibody production followed a characteristic pattern as

(1) the lag phase

(2) the logarithmic phase

(3) the plateau and

(4) the phase of decline

The initial production of antibodies after the first immunisation was markedly different from that of antibody production after the second immunisation The former is called primary immune response and the second is known as secondary or an anamnestic response The primary response was sluggish short lived and comprised mainly of 19S IgM immunoglobulins Secondary response was swift prolonged and composed mainly of 7S immunoglobulins (Park and Good 1974) The correlation between primary and secondary immune responses to complex antigen were highly significant (Burton *et al* 1989a)

Immune response to an antigen is influenced by several factors Antigen presentation site of entry response of antigen binding cells and regulation of response affect the immune response in birds (Tizard 1979) Environmental stresses are immunosuppressive in laboratory animals (Keller *et al* 1983) Protein malnutriti n impairs humoral immune response (Mathews *et al* 1972) The decline in antibody prod ction with advanced age has been studied in m ce

(Nordin and Makinodan 1974 Folch *et al* 1982) rats (Kunz *et al.* 1974) man (Nagel *et al* 1985) pigs (Hyldgaard Jensen, 1979) poultry (Mc Corkle and Glick, 1980 Munns and Lamont, 1991) and sheep (Watson and Gill 1991)

Biozzi *et al* (1975) concluded that the mammalian immune responses to complex immunogens such as sheep red blood cells (SRBC) are controlled by polygenic inheritance as evidenced by studies on mice using SRBC as test antigen Hyldgaard Jensen (1979) observed that the ability of swine to produce antibodies to standardised doses of human and bovine albumin were under genetic control The studies of Almid *et al.* (1980) on the quantitative antibody response to diphtheria toxoid in goats and Buschman s (1980) study on antibody response in pigs demonstrated that the antibody response could significantly be modified by selective breeding over two to three successive generations Aihara *et al* (1983) observed a dominant type of inheritance in inbred mice strains selected for high antibody response to human thyroglobulin when measured by ELISA

Santanna *et al* (1985) reported that lines of mice selected for high responsiveness to TNP LPS had higher response TI 1 of mice confirming that genes accumulated through selective breeding could modify responses to unrelated antigens According to Ferreira *et al* (1986) antibody responses of mice to rabbit gammaglobulin and bovine serum albumin were controlled by additive effect of several independent loci Gyles *et al* (1986) concluded that there existed

significant differences between breeding groups of chicken for antibody responses to different classes of antigens as Newcastle virus vaccine Infectious Bronchitis vaccine and SRBC Reynolds and Griffin (1986) observed that total antibody production was significantly impaired in ewes during gestation

According to Burton *et al* (1989a) humoral responses of calves to human red blood cells (HRBC) could be used as a marker trait of disease resistance in dairy calves Gross and Seigel (1990) concluded that antibody responses of individual chicken to SRBC were influenced by their heterophile lymphocyte ratios

2 2 1 Humoral immune response status

Hylgaard Jensen (1979) observed that peak antibody titers to bovine and human albumin was obtained 2 3 weeks after primary immunisation in pigs and the primary antibody response were influenced by the adjuvant and dose of antigen Seigel and Gross (1980) reported that additive genetic variation was noticed for high and low antibody titers at five days after SRBC inoculation VanDer Zijpp and Leenstra (1983) found that mean total antibody titer to SRBC was highest on seventh day after primary immunisation According to VanDer Zijpp *et al.* (1983) on day three and seven of post injection of chicken following primary immunisation random size effect was not significantly different from day zero Selection for primary antibody response could be based on total

antibody titer at day five of post injection Ubosi *et al.* (1985) reported that following fourth day of primary injection of chicken with SRBC differences in response could be noticed Peak value was reached at 6 days in all populations following primary immunisation with SRBC

According to Burton *et al* (1989a) peak primary antibody response was observed in calves by day seven to fourteen following HRBC inoculation Miller *et al* (1991) reported that peak antibody titer to SRBC occurred in chicken on day six or seven following primary immunisation

Mouton *et al* (1988) reported that mean antibody titer to SRBC was 6 6+1 8 log in mice resistant to *salmonella typhimurium* while it was 8 1+2 8 log in susceptible ones Burton *et al* (1989a) found that peak primary titer to HRBC in calves was 4 465 log

Pinard *et al* (1992) reported a selection experiment wh ch generated high and low response lines to SRBC in chicken The mean post primary antibody titer was 4 73 log in the base population After 9 generations of selection the antibody titer was 10 67 log in high response group and 1 94 log in low responder lines

2 2 2 Effect of breed and sex

VanDer Zijpp (1978) reported significant breed strain differences in humoral immune response of poultry to SRBC In a comparative study involving *Bos taurus* and *Bos indicus* cattle Banyard and Morris (1980) observed that *Bos indicus* cattle elicited a higher antibody response to Keyhole Limpet haemocyanin (KLH) Differences among genetic groups resulted in significant variation for total antibody titers to SRBC in poultry Lamont and Smith (1984a) reported significant breed differences in antibody producing capacity of poultry against SRBC and *Brucella abortus*

Rothschild *et al* (1984) found significant breed differences in antibody responsiveness of pigs to inactivated *B bronchiseptica* The response was also influenced by dam Okabayashi *et al* (1987) pointed out that line differences in antibody responses to SRBC were polygenic in poultry There were considerable variations between and within populations of poultry (Peleg *et al.* 1985)

Ubosi *et al* (1985) found significant population differences in response of chicken to SRBC The peak response titer to SRBC occurred at the same time in all lines and populations Buschman (1986) found significant differences among different breeds of swine to humoral immune responses to different antigens Muggli *et al* (1987) reported no breed differences among Angus

Hereford and Red Poll calves to *Infectious Bovine Rhinotracheitis* virus (IBR) 60 days post vaccination

White Leghorn chicken showed significant sub line differences in their humoral antibody response to GAT (Glutamic acid^{60} Alanine^{30} Tyrosine^{30}) (Cheng and Lamont 1988) Petrovsky *et al* (1988) found significant breed differences among White Leghorn Rhode Island Red and Rhode Island White breeds of poultry in their antibody response to *Brucella abortus* and SRBC Buschman and Meyer (1990) found that immune response of swine to tetanus toxoid was significantly influenced by breed

Layer chicken lines differed in their humoral immune response to SRBC's (Genzel and Wiegend 1990) Benda *et al.* (1990) also observed significant breed difference among poultry for their humoral immune response to SRBC Dunnington *et al* (1992) evolved high and low antibody producing lines to SRBC in White Leghorns and White Plymouth Rock Antibody responses to *Newcastle disease* virus was consistently higher in high responding lines

Nguyen (1983) investigated the effect of sex on the immune response to chicken red blood cells in sheep He found that mean haemagglutinin titers of young females were higher than that of young males though the differences between groups were not significant No sex related differences were found in

antibody response to sheep red blood cells *Brucella abortus* or rabbit erythrocytes in chicken (McCorkle and Glick, 1980 VanDer Zijpp *et al* 1986) Leitner *et al* (1989) reported that response to SRBC in chicken is significantly influenced by sex with a female superiority contributing to the increased survival of female birds

2 2 3 Sire effects and heritability

Compared with an estimate of 0 43 for primary immune response by Claringbold *et al* (1957) Biozzi *et al* (1970) estimated the heritability of antibody response to SRBC in mice to be 0 36

In a study involving the humoral response of sheep to chicken RBC Nguyen (1983) found that antibody titer of sires varied from 4 Log_2 and 8 Log_2 The regression coefficient of sire was 0 41 indicating that effect of sire was significant on the antibody response The heritability estimate approached 0 82 Lie *et al* (1983) reported that in cattle sire families and not sires differed significantly in their antibody response to human serum albumin and synthetic peptides VanDer Zijpp (1983) reported that heritability of immune response to SRBC were 0 26 and 0 14 in White Leghorn and White Plymouth Rock breed at day 7 post immunisation. In beef cattle Muggli *et al* 1987 found a heritability of 0 21±1 2 for antibody response to *Infectious Bovine Rhinotracheitis* virus

Burton *et al* (1989a) estimated the heritability by paternal half sib correlation analysis and found that peak titers are more heritable for antibody response in calves to human red blood cell and ovalbumin They could get a heritability estimate of 0 4 and 0 34 respectively for HRBC and ovalbumin Leitner *et al* (1992) found that heritability of immune response to *E coli* vaccination in low response group was 0 35 and high response group was 0 21

Pinard *et al.* (1992) estimated the heritability of 5th day antibody titer to SRBC challenge in chicken as 0 31 Kean *et al* (1994a) found that heritability of antibody response to *Mycoplasma gallisepticum* was 0 06 and 0 01 for high and low responder lines respectively The heritability for antibody response to *Pasturrella multocida* was 0 44

2 2 4 Effects on growth and litter traits

It is generally believed that fast growing poultry strains are genetically less resistant to disease Han and Smyth (1972) observed that selection for increased growth rate in broilers resulted in an increased susceptibility to Marek s disease Seigel and Gross (1980) demonstrated that a line selected for low antibody response to SRBC had significantly higher 4 weeks body weight than either unselected control or high antibody response line VanDer Zijpp (1983) reported that the correlation between live weight and haemagglutinin antibody titers to

SRBC indicated a negative genetic relationship In beef cattle Muggli *et al* (1987) reported that there were no significant correlations between immune response traits and growth traits

In pigs earlier studies of Huang (1977) found that there was no association between immune response and early growth Meeker *et al* (1987) showed that there exists a negative association between humoral immune response traits and growth rate in pigs

Leitner *et al* (1992) observed no significant association between humoral immune response to *E coli* at 10 days of age and growth traits Kean *et al* (1994b) reported that there were no significant associations between immune response traits juvenile and adult body weights age at first egg 32 weeks egg weight and rate of egg production in chicken

2 2 5 Effects on diseases and mortality

In the analysis of humoral immune response to SRBC in mice Biozzi *et al* (1975) found that high responder mice were more susceptible to *Salmonella typhimurium* infections Similar results were found in *Yersinia pestis* infection There was a quicker destruct on of T_4 bacteriophages and a slower rate of growth of *Listeria monocytogenes* n low responder groups Gross *et al* (1980) reported that chicken selected for ability to produce high antibody titers

to SRBC showed stronger antibody response to *Newcastle disease* virus and were more resistant to *Mycoplasma gallisepticum Eimeria necatrix Splenomegalia* virus and feather mites They were less resistant to *E coli* and *Staphylococcus aureus* The line of chicken selected for non persistence of antibody response to SRBC were more susceptible to all infectious agents

Covelli *et al* (1989) showed that mice selected for high antibody response to SRBC and *Salmonella* flagellar antigens had lower incidence of lymphomas Dunnington *et al* (1986) selected chicken for high and low antibody titer to SRBC The low responder lines were more susceptible to Mareks disease Mouton *et al.* (1988) described that innate resistance to intra cellular pathogens were higher in mice selected for low immune response in terms of antibody production This was due to faster antigen catabolism in macrophages of these lines The mice selected for higher immune response in lines of antibody production had stronger innate or acquired resistance to all infections that could be cleared by means of antibody production

Burton *et al* (1989a) showed that diarrhoea prevalence was negatively correlated with high primary antibody response against HRBC Chicken selected for four generations of early high antibody response to *Escharichia coli* showed greater resistance to challenge with *E coli* (Pitcovski *et al* 198.)) Larsgaard (1990) noticed improved health status in goats selected for high immune response

Lillehoj (1991) observed that in bred strains of chicken having higher antibody response and T-cell response had reduced susceptibility to *Eimeria tenella* infection Pinard *et al* (1992) could demonstrate that mortality rates on challenge with virulent Marek's disease virus was high in low immune response group to SRBC

As early as 1983 VanDer Zijpp (1983) showed that the lines of chicken with high antibody response to SRBC had a lower mortality rate Covelli *et al* (1989) found the mice selected for high antibody response to SRBC had a higher life span Dunnington *et al* (1986) selected chicken for 12 generation for high and low antibody response Lines selected for low antibody titer had higher cumulative mortality

Lines of mice selected for high antibody responses to SRBC as measured by ELISA had a positive correlation with life span (Covelli *et al* 1989) Chicken selected for four generations for early high antibody response *E coli* and Newcastle disease virus vaccinations had a lower mortality rate (Pitcovsky *et al* 1989) According to Leitner *et al* (1989) broiler chicken having higher antibody responses to *E coli* vaccination had lower mortality rates when challenged with pathogenic *E coli* Leitner *et al* (1992) reported that birds with high antibody titer to *E coli* vaccination ten days post vaccination had the lowest morbidity and mortality rate when challenged with pathogenic *E coli*

2 3 Cell mediated immune responses

A large number of genes or genetic factors influence the cell mediated immune responses They include (1) genes that impact on acquired immunity but are not antigen specific such as cytokine genes (2) genes that influence primarily innate or non specific immunity Genes controlling the mitogenic responses come under first category Knudtson *et al.* (1990) found that IL 2 production and mitogemc response to concanavalin A (Con A) were not always associated suggesting that more than one gene or more than one mechanism were likely to influence the mitogenic response of T lymphocytes Numerous factors differentiate genetic differences in acquired or innate cell mediated immune responses The response for these differences are likely to relate to a variety of genes including those determining cytokines cytokine receptors or the adhesion proteins The cellular T lymphocyte dependant immune response has also been reported to be polygenically regulated Stiffel *et al* (1977) selected mice on the basis of lymphocyte stimulation by using phytohaemagglutinin (PHA) as mitogen After 6 generations a 3 8 times difference could be observed between high and low responder groups to PHA

Several in vivo tests have been standardised to assess the cell mediated immune response and T cell function by employing phytohaemagglutinin (PHA) and chemicals like 2 4 d nitrochlorobenzene in animals (Hod in *et al* 1978 Rajan *et al* 1981) Wilkie *et al* (1991) examined the cutaneous response to

contact allergen dinitrochlorobenzene (DNCB) and mitogens phytohaemagglutinin (PHA) and concanavalin A (Con A) in atopic and normal dogs The immune response to contact allergens such as DNCB results in a type IV or delayed type hyper sensitivity (DTH) reaction following percutaneous absorption of the hapten in sensitised animals Sensitisation with DNCB has been widely used to assess the function of human cell mediated immune response (Friedmann *et al* 1983)

In vivo T lymphocyte response has also been evaluated by intra dermal injection of mitogens This is believed to provoke a delayed type hypersensitivity reaction without the need for prior sensitisation by polyclonal stimulation of lymphocytes (Wilkie *et al* 1991)

According to Elber and Morton (1970) DNCB skin sensitisation test could be used as one of the most reliable tests to assess the CMI status of humans by measuring increased double skin fold thickness According to Palival *et al* (1984) among the *in vivo* DTH reactions with PHA DNCB and Johnin DNCB test was found to be better for assessing CMI response of cattle

Tiwary and Goel (1985) confirmed the efficacy of DNCB skin test in assessing the cell mediated immune response of chicken comparing with lymphocyte transformation tests and graft versus host reaction (GVH)

Repeatability of T cell dependant cellular parameters in pigs were reported to be high (Buschman 1986) According to Burton *et al* (1989b) measurements of double skin fold thickness to DNCB challenge in calves could be used as a DTH reaction to assess the cell mediated immune response and could find use as a marker trait in selection for disease resistance

2 3 1 Cell mediated immune response status

Trindle *et al* (1980) measured the CMI response in mule deer fawns (*Odocoileus hemionus*) at the age of one week using DNCB skin sensitisation test Newly hatched turkey poults demonstrated DTH response to PHA and Freunds adjuvant containing *Mycobactarium* Two week old poults had a higher DTH than eight week old poults (Mc Corkle *et al* 1984) DTH reactions of fowls to human gammaglobulin were more intense at six to twelve weeks of age than at three weeks of age (Watable and Glick, 1983) Edelman *et al* (1986) reported that differences between T cell reactivity in immunocompetent normal chicken and transplantable fibrosarcoma bearing chicken could be readily detected *in vivo* at an age of three to four weeks using PHA Wattle test

Warner (1987) studied the CMI response by DTH reaction to DNCB in dogs He observed that younger dogs had a higher CMI response than aged dogs Paulik and Urzula (1989) found a higher CMI response to Dinitrofluorobenzene (DNFB) in calves aged 11 months than in younger calves Corner and

Deloach (1990a) reported that in chicken CMI response could be elicited in young birds of 10 14 days of age by sensitising with *Mycobacterium tuberculosis* and challenging with tuberculin intradermally By using PHA CMI could be assessed as early as three to fourteen days of age (Cornier and Deloach 1990b)

Rajan *et al.* (1982) found that increase in skin thickness following DNCB challenge in pigs were 6 07+0 38 and 4 71±0 56 mm at 24 and 48 hours post challenge respectively

The skin thickness following DNCB challenge averaged 0 607+0 036 mm at 24 hours in challenge (Tiwary and Goel 1985) The cutaneous response to DNCB and PHA M in dogs as indicated by increased skin thickness was 0 536+0 262 and 0 777+0 362 mm respectively (Wilkie *et al.* 1991)

2 3 2 Effect of breed and sex

In broiler chicken CMI response to Diphtheria toxoid varied between different genetic stocks (Klesius *et al.* 1977) Significant breed differences were seen in CMI response of chicken to PHA test (VanDer Zijpp 1983 Lamont and Smith 1984) Breed differences were also reported for CMI responses in pigs (Buschman 1986) Cheng and Lamont (1988) found significant sub line differences in birds for CMI responses as assessed by PHA test According to Benda *et al* (1990) significant breed differences were noticed in cell med iated immune response of fowl when assessed by wattle injection with SRBC

Cheng and Lamont (1988) reported that there existed significant differences between male and female chickens in the T cell response to PHA M with females having a higher CMI over males Leitner *et al* (1989) showed that females showed an earlier and greater T cell response to a purified protein derivative of *Mycobacterium avium*

2 3 3 Sire effects and heritability

Stiffel *et al* (1977) found that effect of sire on the T lymphocyte dependent immune response is significant They selected mice on the basis of lymphocyte stimulation by phytohaemagglutinin as a mitogen After six generations a 3 8 times greater difference between high and low responder lines could be observed Heritability estimate for T cell response to PHA was 0 28+0 08 Lie *et al* (1983) reported significant differences between sire families in cattle in their CMI responses Cheng and Lamont (1988) found that haplotype differences were significant on phagocytic index and T cell response to PHA and sire family differences were significant on T cell response Cheng *et al* (1991) reported that heritability of T cell response to PHA measured by wing web assay was only 0 06 0 07 in base population while the combined data for first generation for this trait gave a heritability of 0 12-0 14 Kean *et al* (1994b) reported that heritability of cell mediated immune responses to PHA was 0 15 in chicken

2 3 4 Effects on growth and litter traits

Reports on the association of cell mediated immune responses and production traits and growth rate are scanty The role of cell mediated immunity especially T cell immunity have been found to be important in several diseases like coccidiosis which adversely affect growth rate in animals and birds (Rose *et al* 1990)

2 3 5 Effects on diseases and mortality

Brown *et al* (1967) studied the efficacy of DNCB skin tests in untreated Hodgkin s disease patients and found that DNCB sensitisation could be used as one of the most reliable skin tests in evaluating CMI status of patients by measuring the double skin fold thickness Chicken that were to develop clinical Marek's disease had significantly lower CMI response compared to resistant birds It was also observed that the correlations between high CMI response and several other diseases were significant (Chauhan *et al.* 1984) Palwal *et al* (1984) observed that CMI responses to DNCB were markedly lower in Johne s disease affected cattle Tiwary and Goel (1985) produced CMI deficient chicken by thymectomy and inoculation of antithymocyte serum These birds had a reduced CMI response in terms DTH response to DNCB challenge Edelman *et al* (1986) found that the CMI response of chicken bearing transplantable fibrosarcoma were totally inadequate without any response in the form of inadequate wattle swelling when assessed by PHA test

Burton *et al* (1989b) could not find any significant effect of CMI as assessed by cutaneous response to DNCB on the incidence of naturally occurring diarrhoea and pneumonia in calves Rose *et al* (1990) reported that lymphocyte responses contributed considerably to coccidiosis in chicken Desmukh *et al* (1990) reported significant increase in CMI responses of kids naturally infected with goat pox when assessed by DNCB test Dogs with atopic dermatitis had a lower CMI responses to DNCB contact sensitivity and PHA skin test (W ilkie *et al* 1991)

2 4 Associations between immune response traits

Biozzi *et al* (1975) showed that there was no association between immune response to SRBC and T cell response to PHA However total Ig level was found to be associated with immune response to SRBC Muggli *et al* (1987) showed that IgG_1 level in calves were correlated with pre and post vaccination titer to IBRV vaccination Cheng and Lamont (1988) found that there existed a significant negative correlation between phagocytic index and T-cell response to PHA especially among female chicken Mouton *et al* (1988) reported that vaccination response of high responder lines to SRBC may be as high as 200 times compared to low responders They also reported that innate resistance to inter cellular pathogens were higher in low antibody response lines owing to the differences in macrophage activity in two l nes ant gen catabolism being faster in low respo se lines Cheng *et al* (1991) found that the genetic correlation between im mune response to *Pasteurella multocida* Mycoplasma *gallisepticum*

and the T cell responses as measured by PHA test were negative Similarly the association between phagocytic activity and T cell response was also negative Pollock *et al* (1991) recorded significant positive correlation between IgG_1 IgG_2 IgA and the cutaneous response to keyhole limpet haemocyanin (KLH) Parmentier *et al* (1994) observed that the dissimilarity of immune response to BSA in high and low responder lines to SRBC in chicken suggest that selection for enhanced response to one antigen may not influence the improvement in immunity to another antigen

Materials and Methods

MATERIALS AND METHODS

One hundred and thirty five adult breeding rabbits of both sexes belonging to two temperate broiler breeds viz Newzealand White and Soviet Chinchilla within the age group of 6 12 months maintained at Rabbit Breeding Unit of the Centre for Advanced Studies in Animal Genetics and Breeding Kerala Agricultural University formed the experimental animals They were maintained under optimum identical conditions of feeding and management The immune response traits were assessed during the periods between February and May 1994 The colony of experimental animals were monitored for a period of one year from January 1994 onwards for the incidence of naturally occurring diseases like coccidiosis Mange and pneumonia The mortality of adult rabbits due to infectious diseases were recorded Only apparently healthy animals were chosen for the study The first litter performance of the does included in the study was recorded The litter traits studied were litter size at birth and weaning preweaning kit mortality litter weight at birth and weaning

Body weight of all the experimental animals were recorded at the beginning of the experiment Ten ml of blood collected from each animal was allowed to clot and left standing upright at 4°C for 24 hours before being centrifuged at 1500 rpm for fifteen minutes The serum samples were stored in tightly capped storage vials at 20°C for analyses of gammaglobulin level preimmunisation titers to Bovine Red Blood Cells (BRBC) and Frossman antibody titer to SRBC

3 1 Measurement of serum gamma globulin level

Zinc Sulphate Turbidity Test (ZSTT) developed by Mc Ewan *et al* (1970) and routinely used in immunoglobulin analysis of farm animals was chosen as the method of estimation of gammaglobulin level

3 1 1 Zinc sulphate turbidity test procedure

Zinc sulphate turbidity test procedures described by Mc Lwan *et al* (1970) was followed with suitable modifications A working solution of zinc sulphate was prepared by diluting 4 1 ml of 5 per cent solution of zinc sulphate ($ZnSO_4$ $7H_2O$) to one litre of freshly boiled and cooled double distilled water to give a final concentration of about 205 mg of zinc sulphate per litre of water

Test tubes were arranged in three rows on the rack The number of tubes in each row depended on the number of samples to be tested For convenience of observation the first two rows of tubes were termed test tubes and the third row of tubes were named control tubes Six ml of working solution of zinc sulphate was poured into each of the test tubes A similar volume of distilled water was poured into the control tubes Using a precision pipette 0 1 ml of the serum sample diluted to 1 in 2 with distilled water was pipetted into each of the tubes

in a single column with a label corresponding to the serum The tubes were shaken well and allowed to stand at room temperature for an hour The turbidity developed in each tube was read in a spectrocalorimeter (Spectronic 20) at a wave length of 595 nm The adjustments was made against zinc sulphate solution The tubes were shaken for redistribution of precipitate The reading of the control was subtracted from the average readings of the test solutions to arrive at the optical density of each individual serum sample The optical density values were converted into gammaglobulin concentration (mg/ml) of serum with the help of prediction equations developed from standard curve

3 1 2 Preparation of standard curve

Rabbit gammaglobulin (Sigma Chemical Co St Louis USA) was dissolved in normal saline solution to give a concentration ranging from 0 to 60 mg/ml These solutions were diluted to 1 in 2 with distilled water The standard solutions were subjected to zinc sulphate turbidity test To arrive at the net OD values the value obtained for the control was subtracted from the average of observed value of test solutions The net optical density values are presented in Table 2 1 which are the averages of 3 replications From the table values a log linear prediction equation was prepared which could be used to predict any optical density value to gamma globulin concentration (mg/ml)

Table 3 1 Optical density values for preparation of standard curve

Concentration of gamma globulin (mg/ml)	Optical density value
0	0
2	0 045
4	0 098
6	0 146
12	0 221
18	0 294
24	0 345
30	0 402
36	0 446
42	0 521
48	0 574
54	0 628
60	0 687

3 1 3 Prediction equation

$$Y = 1.086657 + 5.006X$$

where Y the logarithm of predicted gamma globulin level in unknown serum

X the logarithm of optical density value for the serum

The antilogarithm of Y was found to measure the gammaglobulin level (mg/ml) in unknown serum The coefficient correlation between actual and predicted values were 0 92 Logarithmic transformation was necessary to avoid the bias at lower and higher optical density values

3 2 Humoral immune responses

3 2 1 Test antigen preparation

Bovine red blood cells (BRBC) were chosen as the test antigen since they were complex and apparently harmless antigens Five hundred ml of blood was collected from a single cow in anticoagulant (sodium citrate 1 0 g sodium chloride 0 25 g and distilled water upto 50 ml) and was washed thrice in sterile phosphate buffered saline (PBS 0 01 M pH 7 2) by repetitive centrifugation (1500 rpm for 10 minutes) and was resuspended in fresh sterile PBS to get a final concentration of 20% (V/V) and stored at 4°C in sterile glass containers until used for immunization/antibody titration

3 2 2 Administration of antigen

For immunisation test antigen was injected intravenously at the rate of 1 ml per kilogram body weight through marginal ear vein

3 2 3 Harvest of serum for monitoring the immune response

From blood samples collected at days zero seven fourteen and twenty one days post immunisation sera were separated and stored in tightly capped storage vials at 20°C until used

3 3 Serology

3 3 1 Frossman antibody assay

Naturally occurring antibodies (Frossman antibodies) in rabb t serum to sheep red blood cells (SRBC) was assessed in 96 welled microtitre plates

(Laxbro Pune) by standard microhaemagglutination test procedures using 2 per cent SRBC in PBS as test antigen (Hines 1985) The antibody titres were recorded as the highest dilution of serum giving a visible positive haemagglutination

3 3 2 Rabbit anti BRBC titre assay

Rabbit serum antibody titre to BRBC was titrated by microhaemolytic test as described by Hines (1985) The test was carried out in 96 welled microtitre plates (Laxbro Pune) 0 05 ml of diluted serum was added to the wells followed by 0 025 ml of 2% suspension of BRBC in PBS 0 025 ml of fresh rabbit serum was added as source of complement The microtitre wells were covered and plates vigorously shaken Readings of the tests were taken after 4 hours of incubation at 30°C The extent of haemolysis was read as follows

0 All wells intact and settled at bottom Supernatant was clear

1 Nearly twenty per cent of cells were lysed Supernatant was reddish coloured

2 Nearly 50% of the cells were lysed The intact cells formed a small button or ring at the bottom Supernatant was red

3 Nearly 90% of the cells were lysed Supernatant was bright red which on shaking became cloudy

4 All cells were lysed Whole liquid was bright red and retained the brightness even after shaking

The antibody titre was recorded as the highest dilution of serum giving reaction to the extent of 2

3 4 Cell mediated immune response

The cell mediated immune responses of broiler rabbits were assessed by cutaneous responses to contact allergen dinitro chlorobenzene (DNCB) and to the intradermal injection of phytomitogen phytohaemagglutinin M (PHA M)

3 4 1 PHA skin test

In vivo T lymphocyte response to PHA M was assessed as described by Wilkie *et al* (1991) with suitable modifications A site on the lateral thorax was clipped and cleaned with 70% alcohol The skin thickness of double skin fold was measured using a Harpenden skin fold calliper Phytohaemagglutinin M (PHA M) (Sigma Chemicals St Louis USA) was dissolved in sterile saline and diluted to contain 50μ g in 0 1 ml To ensure uniformity of reagent, the prepared solution was kept frozen at 30°C until half an hour before use A 0 1 ml quantity of this solution was injected intra dermally using a 25 gauge needle As a control 0 1 ml of sterile saline was injected at a separate site The skin thickness was recorded at 24 48 and 72 hours after injection The increase in skin thickness was expressed in mm and tabulated

3 4 2 Cutaneous sensitivity to DNCB

Cutaneous response to DNCB was assessed as described by Wilkie *et al* (1991) A 2 per cent (wt/vol) solution of 2 4 dinitro chlorobenzene (DNCB) (SRL laboratories Bombay) in acetone was prepared freshly every two weeks An area of skin of about 4 cm^2 on the dorsal thorax was clipped and cleaned with 70% alcohol A metal ring of about 1 cm diameter was placed on the clipped area and 0 1 ml of DNCB solution was applied drop by drop into the area circumscribed by the metal ring and was blown dry Two weeks later a different site on dorsal thorax was prepared as before and 0 05 ml of 1 per cent (wt/vol) solution of DNCB in acetone was applied as before The skin thickness at the site was measured prior to challenge and at 24 48 and 72 hours post challenge The post challenge increase in skin thickness in mm was determined

3 5 Assessment of body weights litter traits and disease incidence

3 5 1 Body weight

Adult body weight in kilograms was recorded for each of the 135 experimental rabbits in the beginning of the experiment

3 5 2 Disease incidence

Colony of rabbits were closely monitored for a period of one year from January 1994 for the incidence of naturally occurring diseases like coccidiosis mange and pneumonia The mortality of adult rabbits due to diseases were also

recorded Regular screening of the colony for the incidence of clinical signs of Mange was carried out Those animals showing clinical signs of Mange were scored as 1 and those without any clinical signs of Mange were recorded as 0 The colony was observed for the clinical signs of coccidiosis and the experimental animals were screened for faecal oocyst output Those animals having faecal oocyst output were recorded as 1 and those animals showing no faecal oocyst were scored as 0 The colony was also monitored for the clinical signs of pneumonia Those animals which died due to diseases were also recorded

3 5 3 Litter traits

The first kindling performance of the rabbit does were studied The litter size at birth and at weaning were noted The preweaning mortality percentage for each kindling was worked out from the litter size at birth and at weaning The litter weight at birth and at weaning were recorded

3 6 Statistical analyses

Antibody titres to BRBC and Frossman antibody titre to SRBC were transformed to log of antibody titre plus one so that antibody response measured were normally distributed (Burton *et al* 1989a) The preweaning mortality percentages were subjected to Arc sine transformation for making the distribution normal Breed wise mean and standard error for each of the traits under study were worked out

Animals were grouped into 5 classes based on the adult body weight The following were the groups based on body weight

Table 3 2 Classification of adult rabbits based on body weight

Class	Classification criteria
1	Mean + I S D
2	Class 1 + I S D
3	Class 2 + I S D
4	Class 1 I S D
5	below class 4

Least squares analyses (Harvey 1975) were performed on serum gammaglobulin level in three separate steps in an attempt to distinguish the effect of breed sex sire and adult body weight classes (Model 1) Model 2 was designed to test the effect on litter traits adjusted for Model 1 effects and Model 3 was designed to test the effects on mange coccidiosis and adult mortality adjusted for Model 1 effects

Model 1

$Y_{ijk} = \mu + B_i + S_j + SR_{ij} + B_k + wt + e$

where

Y_{ijkl}	serum gamma globulin level of Y_{ijkl}^{h} rabbit
μ	The overall population mean
B_i	effect of i^{th} breed (i 1 2)
Sx_j	effect of sex of rabbit (j 1 2)
SR_k B	effect of k^{th} sire in i^{th} breed
wt	effect of l^{th} body weight class(l 1 2 5)
e_{ijkl}	error

Model 2

Model 2 was used to test the effect of gammaglobulin level on litter traits

Y_{ijklpq} $\mu + B_i + SR_k$ B $+ wt_l + SB_p$ $sw_q + e_{ijkl}$

where all terms are as defined in Model 1 except

SB_p	litter size at birth (p 2 9)
sw_q	litter size at weaning (q 0 8)

Model 3

This model was used to test the effect of gammaglobulin level on diseases and mortality

Y_{ijmno} $\mu + B_i + Sx + SR_k$ B $+ wt + Mg_m + Cc_n + Mt$ $+ e_{ijmno}$

where all terms are as defined in Model 1 except

Mg_m – incidence of mange (0 1)

Cc_n – incidence of coccidiosis (0 1)

Mt_o – incidence of mortality (0 1)

Least squares analyses (Harvey 1975) were performed using similar three models on the transformed antibody titre to BRBC Frossman antibodies to SRBC Cutaneous response to phytomitogen PHA M and contact sensitizer DNCB Each of the immune response traits studied namely gammaglobulin level, $1+\log_e$ transformed Frossman antibody titre to SRBC $1+\log_e$ transformed antibody responses to BRBC at 1st 2nd and 3rd week Cutaneous responses to PHA M at 0 24 48 and 72 hours and DNCB challenge at 0 24 48 and 72 hours were tested using the above three models to assess the effect of breed, sex sire and body weight on the traits and the effect of these immune response traits on the incidence of diseases and litter traits

Sire and error components of variance were used to estimate paternal half sib heritabilities for each of the immune response traits studied The progeny belonged to 28 sires with an average of 4 83 progeny per sire Approximate standard errors were computed from variance covariance matrix of sire and error variance components The phenotypic correlation between different immune response traits were worked out The correlations between immune response traits and adult body weight was estimated The correlation between immune response traits of females and their litter traits including litter weight at birth, at weaning and pre weaning mortality were estimated

Results

RESULTS

Breedwise mean and standard errors for adult body weights litter size at birth, litter size at weaning preweaning mortality litter weight at birth and litter weight at weaning are presented in Table 4 1 Adult body weight averaged 2 9 kg in Newzealand White and 2 86 kg in Soviet Chinchilla The litter size at birth litter size at weaning and preweaning mortality rates were 5 63 3 67 and 41 9 per cent respectively in Newzealand White In Soviet Chinchilla it was 5 56 3 96 and 39 6 per cent respectively The litter weight at birth averaged 342 69 g in Newzealand White and 340 85 g in Soviet Chinchilla The weaning litter weights were 1636 67 g in Newzealand White and 1830 09 g in Soviet Chinchilla breed Breedwise incidence of mange coccidiosis and adult mortality are documented in Table 4 2 In Newzealand White breed the incidence of mange coccidiosis adult mortality were 56 41 42 31 and 7 35 per cent respectively The Soviet Chinchilla group had 56 00 per cent incidence of mange 49 33 per cent incidence of coccidiosis and an adult mortality rate of 14 43 per cent During the period of study no incidence of pneumonia could be detected among adult rabbits

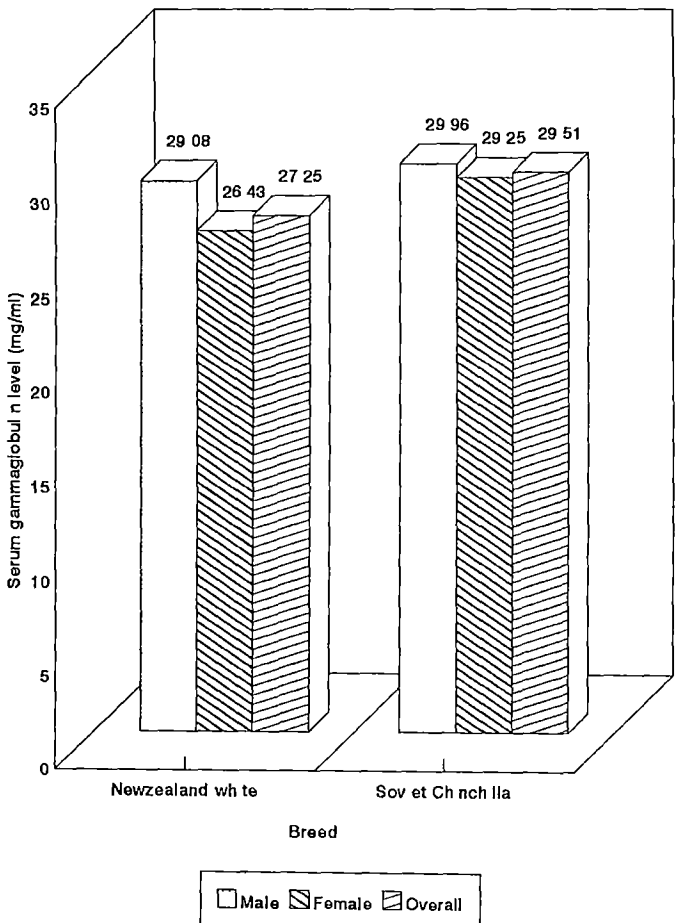
Table 4 1 Mean and standard error of adult body we ght l tter size at birth weaning pre weaning mortality litter weight at birth and weaning

Parameter	Breed					
	n	Newzealand White		n	Soviet Chinchilla	
		Mean	SE		Mean	SE
Adult body weight (kg)	68	2 900	0 025	67	2 860	0 027
Litter s ze at birth	47	5 630	1 650	42	5 560	1 290
L tter size at weaning	47	3 670	1 660	42	3 960	1 430
P eweaning mortal ty (percent)	47	41 900	2 590	42	33 580	2 390
L tter weight at b rth (g)	47	342 690	8 810	42	340 850	8 020
L tter weight at veaning (g)	47	1636 670	103 850	42	1830 090	93 790

Table 4 2 Breedwise percentage incidence of mange coccidiosis and adult mortality among broiler rabbits

Parameter	Newzealand White (68)	Soviet Chinchilla (67)	Overall (135)
Incidence of mange	56 41	56 00	56 20
Incidence of Coccidiosis	42 31	49 33	45 79
Pneumonia	Nil	Nil	Nil
Adult mortality	7 35	14 43	10 86

Fig 4 1 SERUM GAMMAGLOBULIN LEVEL IN BROILER RABBITS



4 1 Serum gammaglobulin level (SG level)

4 1 1 Serum gammaglobulin status

Table 4 3 details the data on serum gammaglobulin status among the broiler rabbits The mean serum gammaglobulin level in broiler rabbits was 28 59+1 48 mg/ml

4 1 2 Effect of breed and sex

From Table 4 3 it can be seen that among Newzealand White the gammaglobulin level ranged between 9 64 and 84 67 mg/ml with a mean value of 27 25+2 94 mg/ml The value for bucks and does were 29 08 mg/ml and 26 43 mg/ml respectively In Soviet Chinchilla the SG levels ranged from 9 13 to 78 5 mg/ml with an average of 29 51 2 99 mg/ml bucks having 29 96±3 91 mg/ml and does 29 51+2 96 mg/ml The data are graphically represented in Fig 4 1

Analysis of variance for the effect of breed and sex on serum gammaglobulin level presented in Table 4 4 revealed that the effect of breed on serum gammaglobulin level was significant (P 0 0482) with Soviet Chinchilla having a higher SG level It could be observed that the effect of sex on serum gammaglobulin level was not significant among broiler rabbits Least squares means for the effect of breed and sex are presented in Table 4 5

Table 4 3 Serum gammaglobulin status in Broiler Rabbits

Breed	Sex	No of Animals (n)	Gamma globulin level mg/ml			
			Range		Mean	SE
Newzealand White	Female	47	9 64	72 9	26 43	2 40
	Male	21	10 88	84 70	29 08	4 15
	Overall	68	9 64	84 70	27 25	2 94
Soviet Chinchilla	Female	42	10 88	78 58	29 25	2 45
	Male	25	9 13	76 13	29 96	3 91
	Overall	67	9 13	78 58	29 51	2 99
Overall		135	9 13	84 70	28 59	1 48

Table 4.4 Least squares analysis of variance for the effect of breed, sex, adult body weight and sire on serum gammaglobulin level

Source	df	MS	Probability
Breed	1	306 354*	0.0482
Sex	1	15 910 NS	0.9480
Adult body weight	4	123 919 NS	0.7965
Sires within Newzealand White breed	16	298 403 NS	0.4604
Sires within Soviet Chinchilla breed	10	323 381 NS	0.3785
Error	102	297 669	

NS Not significant * Significant at 5% level

Table 4 5 Least squares means for the effect of breed sires within breed sex and adult body weight classes on serum gammaglobulin level (mg/ml) in broiler rabbits

Classes	n	Mean	SE
Breed (P 0 0482)*			
Newzealand White	68	24 3936	4 8519
Soviet Chinchilla	67	27 4586	4 9070
Sires within Newzealand White (P 0 4604) NS			
1	4	35 2755	1 4481
2	4	19 9307	9 9335
3	3	12 3189	11 4610
4	2	50 8402	13 4269
5	2	10 3477	13 4870
6	5	26 7755	8 9313
7	7	27 5660	8 3872
8	4	24 6698	10 1631
9	7	19 9713	8 3186
10	8	20 0108	7 7062
11	6	38 1860	9 3321
12	3	30 5767	11 6370
13	4	27 9757	10 1013
14	2	21 0265	13 4671
15	2	22 3982	13 4319
16	3	14 6695	11 7207
17	2	16 1232	8 3041

Contd

Table 4 5 contd

Sires within Soviet Chinchilla	(P 0 3785) NS		
1	12	25 9022	14 5882
2	2	38 0782	7 2911
3	4	16 6483	13 4830
4	3	37 5822	10 2082
5	9	28 6387	10 7758
6	3	41 2076	7 6092
7	4	11 6207	10 8582
8	5	33 0774	10 2134
9	14	28 9662	9 0470
10	4	21 9492	6 3329
11	7	18 3533	9 7521
Sex	(P 0 9480)NS		
Female	89	27 4832	4 1428
Male	46	28 3653	7 0457
Body weight classes	(P 0 7965) NS		
1	39	27 1307	4 0292
2	27	32 2782	4 3910
3	1	16 0457	20 9789
4	55	28 6508	3 4047
5	13	25 5250	5 3048

* Significant at 5% level NS Not significant

4 1 3 Sire effects and heritability

Effect of sires within breed on SG level are presented in Table 4 4 It could be observed that the effect of sires within breed was not significant on serum gammaglobulin level Least squares means for the effect of sires within breed are documented in Table 4 5 Heritability estimate of serum gammaglobulin level by paternal halfsib analysis is given in Table 4 28 The heritability estimate in the present study was 0 1259+0 073

4 1 4 Effect on growth and litter traits

Analysis of variance for the effect of body weight classes on serum gammaglobulin level are presented in Table 4 4 The effect of body weight classes was not significant on SG level Least squares means for the effect of body weight classes on serum gammaglobulin level are elaborated in Table 4 5 The correlation between adult body weight and SG (0 193) was not significant (Table 4 30)

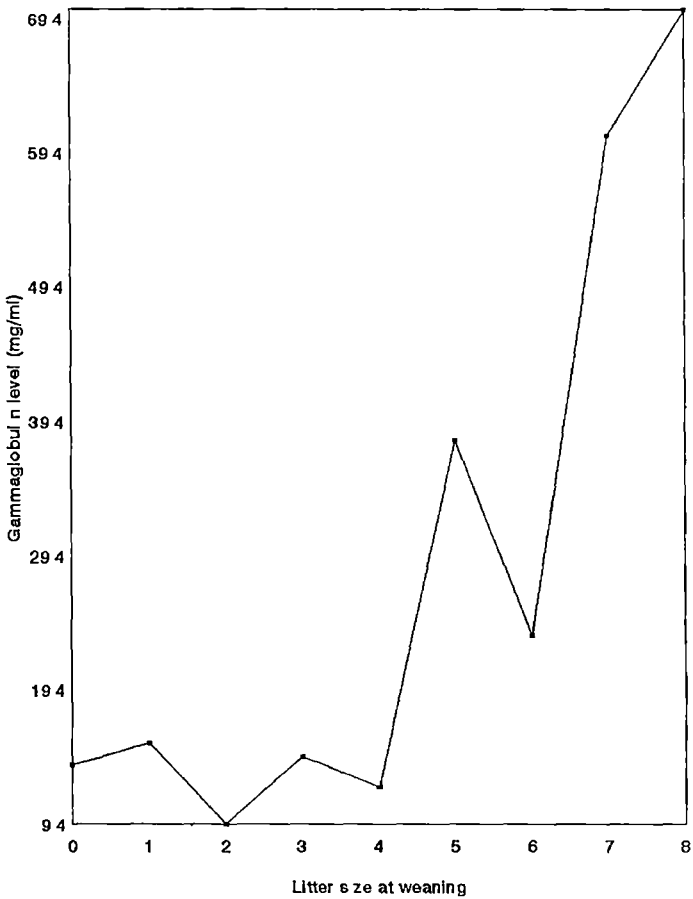
Least squares means for the effect of serum gammaglobulin level on litter size at birth and at weaning are documented in Table 4 6 The effect of SG level was not significant on litter s ze at birth But the effect of SG level

Table 4 6 Least squares means for the effect of serum gammaglobulin level on the litter traits in broiler rabbits

Independant variable	n	Gammaglobulin level mg/ml	
		Mean	SE
Litter size at birth (P 0 1893)NS			
2	3	28 8610	9 6919
3	7	39 1820	8 2622
4	11	37 0730	8 0239
5	11	29 7209	7 4362
6	32	35 0765	6 5786
7	18	35 2466	7 7029
8	5	29 1428	11 9438
9	2	28 1820	17 0875
Litter size at weaning (P 0 0004)**			
0	4	13 8388	9 1164
1	3	15 5044	11 6388
2	14	9 4248	7 0249
3	28	14 4923	6 9536
4	12	12 1713	7 0039
5	10	38 0581	7 5034
6	14	23 4813	7 4853
7	3	60 7542	16 0428
8	1	70 07926	16 9404

NS Not significant ** Significant at 1% level

Fig 4 2 EFFECT OF SERUM GAMMAGLOBULIN LEVEL OF THE DOE ON THE LITTER SIZE AT WEANING



was highly significant (P 0 004) on litter size at weaning When SG level of the dam was 13 8388 9 116 mg/ml the litter size at weaning was 0 The does with mean SG level of 38 0581 7 5034 mg/ml weaned 5 kits and does which weaned 7 kits had a SG level of 60 7542+16 0428 mg/ml The association between these two traits is represented by Fig 4 2

Correlations between SG level with preweaning mortality litter weight at birth and litter weight at weaning are documented in Table 4 30 The correlation between SG level and preweaning mortality was found to be highly significant (P < 0 001) The negative correlation of ( )0 430 between preweaning mortality and serum gammaglobulin level of the doe showed the negative relationship between these two traits The correlation between litter weight at birth and serum gammaglobulin level of the doe (0 244) was also significant (P 0 016) There existed a highly significant (P < 0 01) correlation (r 0 561) between litter weight at weaning and maternal serum gammaglobulin level

4 1 5 Effect on diseases and mortality

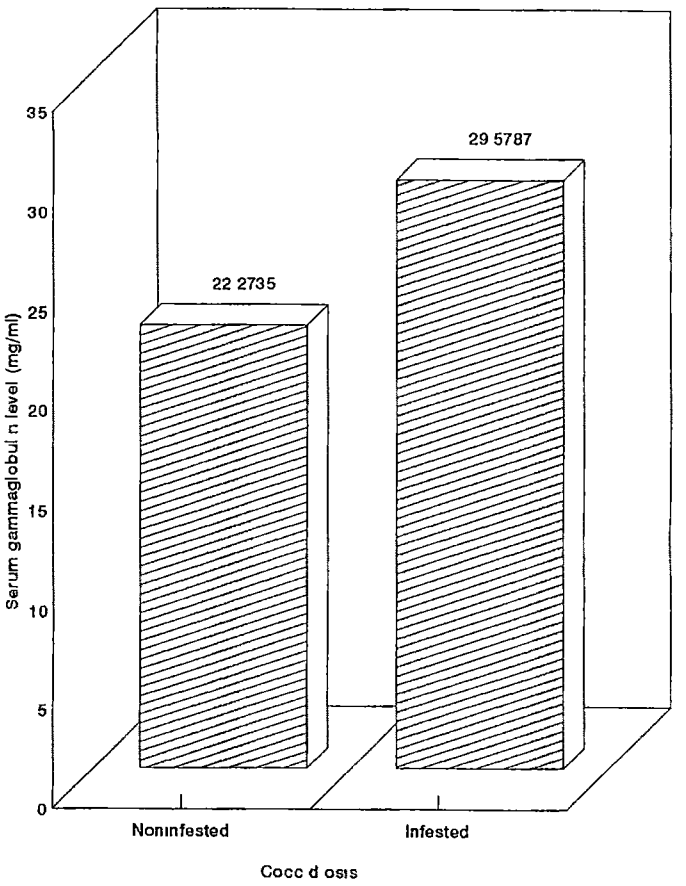
The least squares means for the effect of serum gammaglobulin level on the incidence of manse cocc dios s and adult mortality are shown in Table 4 7 The effect of serum gamma globulin level was not found to be

Table 4 7 Least squares means for the effect of serumgammaglobulin level on the incidence of mange coccidiosis and adult mortality in broiler rabbits

Independant variable	n	Serum gamma globulin level mg/ml	
		Mean	SE
Mange	(P 0 2408)NS		
No	57	23 9359	5 3048
Yes	78	27 9163	4 9629
Coccidiosis	(P 0 0440)*		
No	82	22 2735	5 1370
Yes	53	29 5787	5 2058
Adult mortality	(P 0 7189)NS		
No	121	26 9005	4 3578
Yes	14	24 9517	6 5308

NS Not significant * Significant at 5% level

Fig 4 3 ASSOCIATION BETWEEN SERUM GAMMAGLOBULIN LEVEL AND COCCIDIOSIS IN BROILER RABBITS



significant on the incidence of mange and adult mortality Serum gammaglobulin level had a significant (P 0 0440) effect on the incidence of coccidiosis Those rabbits showing coccidial oocyst output had a mean serum gammaglobulin level of 29 5787+5 7058 mg/ml while those rabbits with no faecal oocyst output had a mean serum gammaglobulin level of 22 2735 5 1370 mg/ml The effect of SG level on the incidence of coccidiosis is graphically represented by Fig 4 3

4 2 Humoral immune responses

4 2 1 1 Frossman antibody titer status to SRBC

Data on the Frossman antibody titer ($1+\log_e$) to SRBC in rabbit sera are documented in Table 4 8 The overall Frossman antibody titer to SRBC ranged between 1 693 and 5 159 with a mean value of 2 776 0 0 070

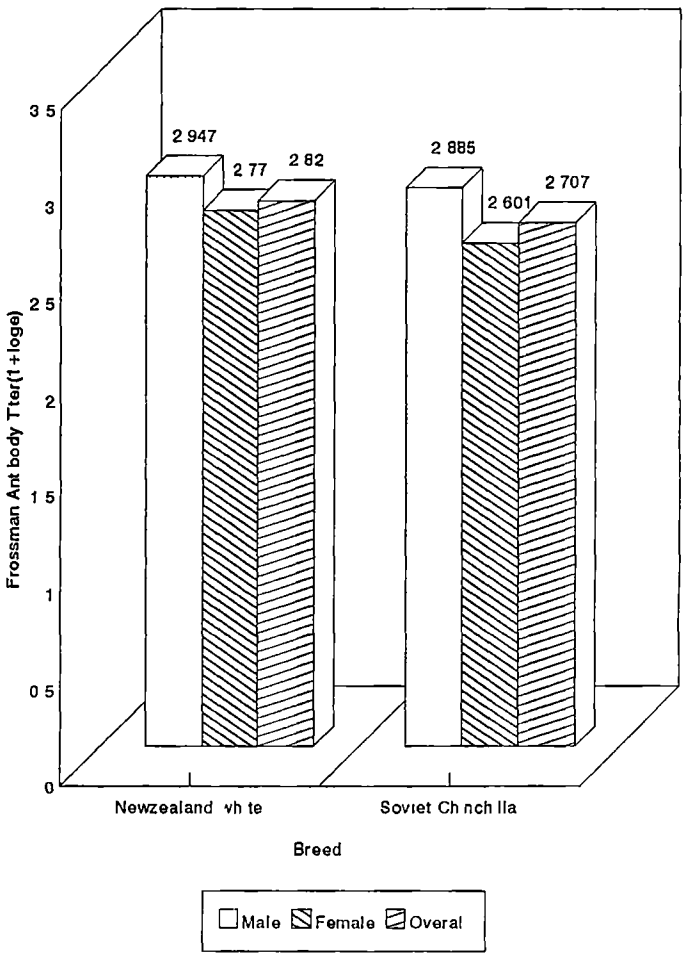
4 2 1 2 Effect of breed and sex

Frossman antibody titer ($1+\log$) to SRBC among the two different breeds and among the two sexes within breeds are documented in Table 4 8 The value ranged between 1 693 and 4 666 in both the breeds with a mean value of ? 825 0 139 in Newzealand White and 2 707 0 139 n Soviet Ch nchilla breed Among Newzealand Wh te bucks the mea t ter was ? 947 0 ?s1 and among does it was ? 770 0 089 The bucks f Sov et

Table 4 8 Frossman Antibody titer to SRBC in Broiler Rabbits

Breed	Sex	No of Animals (n)	Frossman Antibody titer 1 + $\log_e$ of titer			
			Range		Mean	SE
Newzealand White	Female	47	1 693	4 466	2 770	0 089
	Male	21	1 693	5 159	2 947	0 251
	Overall	68	1 693	5 159	2 825	0 139
Soviet Chinchilla	Female	42	1 693	4 666	2 601	0 114
	Male	25	1 693	4 666	2 885	0 181
	Overall	67	1 693	4 666	2 707	0 139
Overall		135	1 693	5 159	2 766	0 070

Fig 4 4 FROSSMAN ANTIBODY TITER TO SRBC AMONG BROILER RABBITS



Chinchilla had a mean value of 2 885 0 181 and does had a mean titer of 2 601+0 1140 Data are graphically represented by Fig 4 4

Least squares analysis of variance for the effect of breed and sex on the Frossman antibody titer to SRBC are presented in Table 4 9 It was found that the effect of breed and sex were not significant on Frossman antibody titer to SRBC Least squares means for the effect of breed and sex are given in Table 4 10

4 2 1 3 Sire effects and heritability

Effect of sires within breeds are documented in Table 4 9 It could be observed that sires had no significant effect on Frossman antibody titer to SRBC Least squares means for the effect of sires within breed are presented in Table 4 10 Heritability estimate by paternal halfsib analysis are given in Table 4 28 The heritability estimate for Frossman antibody titer to SRBC was found to be 0 360+0 248

4 2 1 4 Effect on growth and litter traits

Analysis of variance for the effect of adult body weight classes on Frossman antibody titer are presented in Table 4 9 It could be seen that adult body weight classes exerted no significant effect on Frossman antibody titer

Table 4 9 Least squares analysis of variance for the effect of breed sex adult body weight and sire on the naturally occuring antibodies (Frossman antibody) to SRBC

Source	df	MS	Probability
Breed	1	0 2951 NS	0 6318
Sex	1	0 9412 NS	0 2841
Adult body weight	4	0 1972 NS	0 8986
Sires with in Newzealand White breed	16	0 3345 NS	0 9630
Sires within Soviet Chinchilla breed	10	0 4644 NS	0 7861
Error	102	0 7385	

NS Not significant

Table 4 10 Least squares means for the effect of breed sires within breed sex adult body weight classes on the Frossman antibody titer ($1+\log_e$) to SRBC among broiler rabbits

Classes		n	Mean	SE
Breed	(P	0 6318)NS		
Newzealand White		68	2 5736	0 3672
Soviet Chinchilla		67	2 4542	0 3270
Sires within Newzealand White	(P	0 9630)NS		
1		4	2 4686	0 5453
2		4	2 2977	0 5185
3		3	2 9262	0 5982
4		2	2 4824	0 7008
5		2	2 8994	0 7039
6		5	2 4801	0 4662
7		7	3 1246	0 4378
8		4	3 1334	0 5305
9		7	2 7175	0 4342
10		8	2 3421	0 4022
11		6	2 6975	0 4871
12		3	2 3447	0 6074
13		4	2 6692	0 5272
14		2	2 3433	0 7029
15		2	2 3927	0 7010
16		3	2 1196	0 6018
17		2	2 3129	0 7614

Contd

Table 4 10 contd

Sires within Soviet Chinchilla	(P 0 7861) NS		
1	12	2 2929	0 3840
2	2	2 1001	0 7100
3	4	1 9363	0 5281
4	3	2 5286	0 5674
5	9	2 3358	0 4006
6	3	2 3264	0 5717
7	4	2 5047	0 5378
8	5	2 5759	0 4764
9	14	2 7788	0 3335
10	4	2 8838	0 5135
11	7	2 7323	0 4372
Sex	(P 0 2841)NS		
Female	89	2 7408	0 2767
Male	46	2 8462	0 3684
Body weight classes	(P 0 8986)NS		
1	39	2 7193	0 2959
2	27	2 7059	0 3090
3	1	1 8513	1 0919
4	55	2 7409	0 2747
5	13	2 5519	0 3690

NS Not significant

to SRBC in broiler rabbits Least squares means for the effect of body weight classes on Frossman antibody titer to SRBC are presented in Table 4 10

Least squares means for the effect of Frossman antibody titer on litter size at birth and litter size at weaning are elaborated in Table 4 11 It could be observed that Frossman antibody titer among the does had no significant effect on their litter size at birth or litter size at weaning The correlations between Frossman antibody titer with adult body weight litter weight at birth litter weight at weaning and preweaning mortality are documented in Table 4 30 The correlation between Frossman antibody titer with all the litter traits were small and non significant

4 2 1 5 Effect on diseases and mortality

Least squares means for the effect of Frossman antibody titer on mange coccidiosis and adult mortality are presented in Table 4 12 It could be observed that Frossman antibody titer to SRBC exerted no significant effect on the incidence of mange coccidiosis and adult mortality

4 2 2 Humoral immune response to bovine red blood cells (BRBC)

4 2 2 1 Antibody response to BRBC

Data on antibody titer ($1+\log_e$) of broiler rabbits to BRBC immunisation are documented in Table 4 13 None of the rabbits showed

Table 4 11 Least squares means for the effect of Frossmans antibody to SRBC on the litter traits in Broiler Rabbits

Independant variable	n	Frossman antibody titer to SRBC (1+log)	
		Mean	SE
Litter size at birth (P 0 6523)NS			
2	3	1 3419	0 5512
3	7	2 1730	0 4470
4	11	2 1285	0 4291
5	11	2 4276	0 3839
6	32	2 1770	0 3142
7	18	2 4019	0 4046
8	5	2 9539	0 7079
9	2	3 1338	1 0515
Litter size at weaning (P 0 5856)NS			
0	4	1 9023	0 5099
1	3	2 9776	0 6871
2	14	2 5536	0 3511
3	28	2 2343	0 3453
4	12	2 4317	0 3494
5	10	2 5008	0 3892
6	14	2 7637	0 3878
7	3	1 4729	0 9827
8	1	2 2932	1 0419

NS Not significant

Table 4 12 Least squares means for the effect of Frossman antibodies to SRBC on the incidence of mange coccidiosis and adult mortality in broiler rabbits

Independant variable	n	Frossman antibodies	
		Mean	SE
Mange	(P 0 7496)NS		
No	57	2 5414	0 3443
Yes	78	2 4863	0 3308
Coccidiosis	(P 0 3763)NS		
No	82	2 4327	0 3376
Yes	53	2 5951	0 3404
Adult mortality	(P 0 6933)NS		
No	121	2 5684	0 3078
Yes	14	2 4594	0 3954

NS Not significant

naturally occurring antibodies to bovine red blood cells (BRBC) The preimmunisation titer of all the adult rabbits of both sexes in two breeds under study was 0 One week post primary immunisation the antibody titer rose to a mean value of 4 594+0 083 with a range of 2 386 and 6 545 The mean antibody titer was the highest at one week post immunisation The mean antibody titer began to decline thereafter reaching a mean value of 4 425±0 086 and the range in antibody titer remained the same The lowest mean antibody titer was at the third week with a mean value of 4 311±0 089 and the range in titer value remained the same as for the first week

4 2 2 2 Effect of breed and sex

Breed and sex wise data on antibody response to BRBC are documented in Table 4 13 Among the breeds and sexes naturally occurring haemolysins to BRBC could not be detected as evidenced by a preimmunisation titer of 0 The antibody titer range remained the same for both sexes of the two breeds from first to third week post immunisation The highest mean antibody titer ($1+\log_e$) was observed at first week post immunisation in both the Newzealand White and Soviet Chinchilla The mean antibody titer at first week post immunisation was 4 445±0 163 in Newzealand White with a mean value of 4 348±0 147 in does and 4 664+0 198 in bucks

Table 4 13 Antibody response to Bovine RBC in Broiler Rabbits

Breed	Sex	Animal No	Pre immunisation titer			1+log$_e$ of titer			1+log$_e$ of titer			1+log$_e$ of titer		
						I week			II week			III week		
			Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE
Newzealand White	Female	47	0 0	0	0	2 386 6 545	4 348	0 147	2 386- 6 545	4 156	0 149	2 386- 6 545	3 861	0 150
	Male	21	0 0	0	0	3 079 6 545	4 664	0 198	3 079 6 545	4 433	0.222	2 386 6 545	3 971	0 204
	Overall	68	0 0	0	0	2 386 6 545	4 445	0 163	2 386- 6 545	4.245	0 172	2 386 6 545	3 895	0 178
Soviet Chinchilla	Female	42	0 0	0	0	3 079 6 545	4 730	0 136	3 079 6 545	4 565	0 141	3 079 6 545	4.284	0 151
	Male	25	0 0	0	0	2 386 6 545	4 771	0 200	2 386- 6 545	4 688	0 203	2 386 6 545	4 4 10	0 223
	Overall	67	0 0	0	0	2 386 6 545	4 745	0 160	2 386- 6 545	4 611	0 164	2 386 6 545	4 311	0 178
Overall		135	0 0	0	0	2 386 6 545	4 594	0 083	2 386- 6 545	4 425	0 086	2 386- 6 545	4 311	0 089

Table 4 14 Least squares analysis of variance for the effect of breed, sex adult body weight and sire on the antibody response to bovine red blood cells

Source	df	I week		II week		III week	
		MSS	Probability	MSS	Probability	MSS	Probability
Breed	1	0 0061 NS	0 9297	0 1968 NS	0 6402	1 0994 NS	0 0757
Sex	1	0 6013 NS	0 4105	0 6617 NS	0 4004	0 0930 NS	0 8881
Adult body weight	4	1 5097 NS	0 0684	1 0519 NS	0 2175	0 8383 NS	0 3750
Sires within Newzealand White breed	10	2 1790 **	0 0070	2 2019**	0 0030	2 2214 **	0 0080
Sires within Soviet Chinchilla breed	10	1 0558 NS	0 1247	1 4612 *	0 0367	1 4207 NS	0 0677
Error	107	0 6695		0 7165		0 7828	

*Significant at 5% level ** Significant at 1% level NS Not Significant

Table 4 15 Least squares means for the effect of breed, sires within breed sex and adult body weight classes on the antibody response to BRBC during the first, second and third week post immunisation

Classes	n	Antibody response to BRBC (1+log$_e$)					
		Ist week		IInd week		IIIrd week	
		Mean	SE	Mean	SE	Mean	SE
Breed		(P = 0 9292)NS		(P = 0 6402)NS		(P 0 0752)NS	
Newzealand White	68	4.2747	0 3390	4 1939	0 3370	3 7195	0 2800
Soviet Chinchilla	67	4 3325	0 3019	4 3186	0 3008	3 9641	0 2541
S res within Newzealand White		(P 0 0020)**		(P 0 0030)**		(P 0 0080)**	
1	4	4 8043	0 5029	4 3799	0 5226	3 8446	0 5411
2	4	4.2717	0 4781	4 4419	0 4969	3 5751	0 5145
3	3	3 55ɔɔ	0 5516	3 2491	0 5733	2 8144	0 5936
4	2	3 2083	0 6462	5 3004	0 6716	5 0676	0 6954
5	2	3 4249	0 6491	3 6171	0 6746	3 0493	0 6900
6	5	3 7868	0 4298	3 6587	0 4467	3 3796	0 4626
7	7	4 9781	0 4036	5 07ɔ4	0 4195	4 4642	0 4344
8	4	5 8972	0 4891	5 9788	0 ɔ08ɔ	5 5955	0 5764
9	7	3 409ɔ	0 4003	3 4713	0 4161	3 0158	0 4308
10	8	3 4649	0 3709	3 6749	0 ɔ854	3 15ɔ7	0 3991
11	6	3 389ɔ	0 4497	3 7161	0 5668	3 3145	0 4834

Contd

Table 4 15 contd.

12	3	4.2628	0 5600	4 2081	0 5821	3 7789	0 6027
13	4	4 8070	0 4861	4 9298	0 5052	4 4018	0 5232
14	2	4 4209	0 6482	3 9052	0 6736	3 0378	0 6975
15	2	3 7520	0 6464	3 5806	0 6718	3 0155	0 9657
16	3	3 8776	0 5641	3 5712	0 5862	3 4020	0 6070
17	2	4 8529	0 7021	4 5818	0 7297	4 3219	0 7556
Sires within Soviet Chinchilla		(P	0 1242)NS	(P	0 0367)*	(P = 0 0672)NS	
1	12	4 4239	0 354	4 4249	0 3673	3 9555	0 3777
2	2	4 1072	0 6547	4 ?885	0 679?	4 1366	0 6984
3	4	3 8718	0 4869	3 7684	0 5052	3 4?33	0 5194
4	3	3 817ɔ	0 523?	3 ?837	0 5428	3.2005	0 5581
5	9	4 3880	0 3695	4 3152	0 3833	3 9897	0 3941
6	9	3 7740	0 527ɔ	3 6799	0 5470	3.2225	0 5624
7	4	4 7795	0 4959	4 7877	0 5145	4 7092	0 5290
8	5	3 7257	0 439ɔ	3 8707	0 4557	3 3460	0 4685
9	14	4 9431	0 307ɔ	5 0538	0 3190	4 7428	0 3?80
10	4	4 9329	0 4736	4 9186	0 4913	4 4543	0 5051
11	7	4 8936	0 403ɔ	5 1133	0 4183	4 3?47	0 4301

Contd

Table 4 15 contd

Sex		(P	0 6013)NS	(P = 0 4004)NS		(P	0 8881)NS
Female	89	4 4456	0 4864	4 2867	0 5460	3 9684	0 4634
Male	46	4 4884	0 5641	4 3464	0 4837	4.2318	0 6325
Body weight classes		(P	0 0684)NS	(P = 0 2175)NS		(P = 0 3750)NS	
1	39	4 0860	0 2732	3 9257	0 2689	3 7256	0 2086
2	27	4 5289	0 2853	4 3313	0.2823	3 9534	0 2274
3	1	4 0503	1 0069	4 6237	1 0470	3 6255	1 0866
4	55	4 6182	0 2537	4 3666	0.2472	4 1380	0 1763
5	13	4 2344	0 3406	4 0342	0 3477	3 7666	0 3060

S gnif cant at 5% le el ** S gnf can at 1% level NS Not s gnif cant

Ig 4 5 ANTIBODY RESPONSE TO BRBC IN NEW ZEALAND WHITE RABBITS

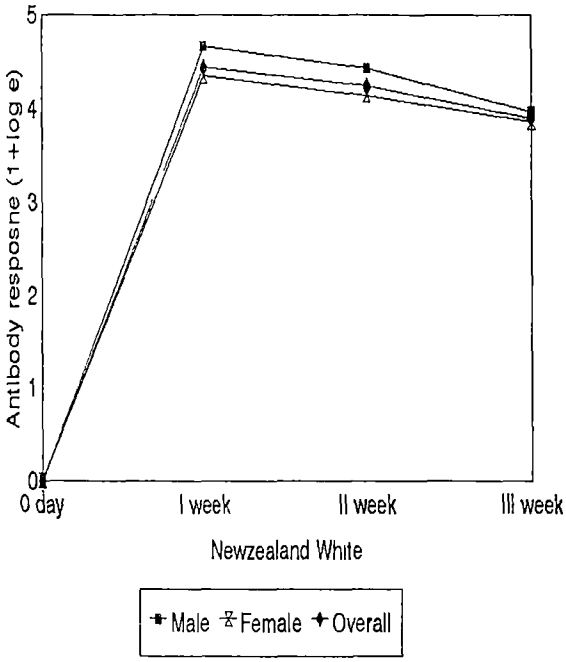
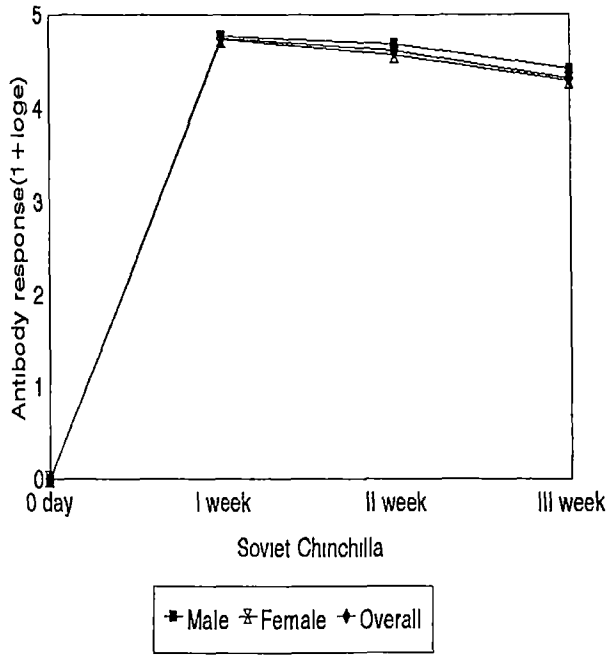


Fig 4 6 ANTIBODY RESPONSE TO BRBC IN SOVIET CHINCHILLA RABBITS



The mean antibody titer atfirst week in Soviet Chinchilla was 4 745 0 160 with an average value of 4 730±0 136 in does and 4 771±0 200 in bucks

The mean antibody titer ($1+\log_e$) to BRBC at second week post immunisation was 4 245+0 164 in Soviet Chinchilla Among Newzealand White a mean antibody titer of 4 156±0 149 and 4 433±0 222 were observed in does and bucks respectively Antibody titer in Soviet Chinchilla does averaged 4 565+0 141 and in bucks it was 4 688+0 203

At third week post immunisation the mean antibody titer was 3 895±0 156 in Newzealand White and 4 311+0 178 in Soviet Chinchilla Newzealand White does had an average antibody titer of 3 86±0 150 and bucks had 3 971±0 240 at three weeks post immunisation the mean antibody titer at third week among Soviet Ch nchilla does was 4 284+0 151 and it was 4 410±0 223 among bucks Data are graphically represented in Fig 4 5 and Fig 4 6

Analyses of variance for the effects of breed and sex on antibody response to BRBC are documented in Table 4 14 The effect of breed and sex was not found to be significant on the antibody response to BRBC at the first second or third week post immunisation Least squares means for the effect

of breed and sex on the antibody response to BRBC are presented in Table 4 15

4 2 2 3 Sire effects and heritability

Least squares analyses of variance for the effect of sires within breeds are presented in Table 4 14 The effect of sires within Newzealand White breed was found to be highly significant on the antibody response to BRBC at first week (P = 0 002) second week (P 0 003) and at third week (P 0 008) However the sire effect was not found to be significant on the antibody response to BRBC at the first week (P 0 1242) post immunisat on in Soviet Chinchilla Here again the effect of sire on antibody response at second week post immunisation was significant (P 0 0367) and was near significant level at third week (P 0 0672) Least squares means for the effect of sires within breeds for antibody response to BRBC are presented in Table 4 15 Heritability estimates of the antibody titer at first week second week and third week are documented in Table 4 28 The heritability estimates were very high with values of 0 922 0 637 0 940 0 712 and 0 907 0 732 respectively for the first second and third week antibody titer to BRBC

4 2 2 4 Effect on body weight and litter traits

Analysis of variance for the effect of body weight groups on antibody response to BRBC is presented in Table 4 14 Though the effect of body

weight classes on antibody titer at first week approached near significant level (P 0 0684) it was not found to be significant at second and third week antibody responses Least squares means for the effect of body weight classes on antibody response to BRBC are documented in Table 4 15 Correlation between adult body weight and antibody titers at first second and third week are documented in Table 4 30 The correlations between adult body weight with antibody titer at first week [r ( ) 0 244 P = 0 015] second week [r ( ) 0 224 P 0 026] and third week [r ( ) 0 216 P 0 032] were all negative and significant indicating that response to BRBC was less in heavier adults

Least squares means for the effect of antibody response on the litter size at birth and litter size at weaning are presented in Table 4 16 The effect of antibody response at first second and third week was not found to be significant on the litter size at birth and litter size at weaning

The correlations between antibody titer at first second and third week post immunisation with the litter weight at birth litter weight at weaning and preweanmg mortality are documented in Table 4 30 No significant correlation could be observed between the antibody titer to SRBC and the litter traits like litter weight at birth litter weight at weaning and preweanmg mortality rate All the correlations were small and non significant

Table 4 16 Least squares means for the effect of antibody response to BRBC on the litter traits in broiler rabbit does

Independent variable	n	Antibody response to BRBC (1+log$_e$ of titer)					
		I week		II week		III week	
		Mean	SE	Mean	SE	Mean	SE
Litter size at birth		(P 0 7432)NS		(P 0 6446)NS		(P 0 9476)NS	
2	3	3 4866	0 7402	3 6796	0 7453	3 5956	0 7938
3	7	4 1181	0 6138	4 1604	0 6265	3 5310	0 6564
4	11	4 5750	0 5923	4 5043	0 6060	3 9987	0 6331
5	11	4 3625	0 5388	4 5078	0 5570	4 2824	0 5747
6	32	4 6260	0 4584	4 8324	0 4837	4 2172	0 4868
7	18	4 1711	0 5632	4 3187	0 5795	3 9460	0 6014
8	5	4 8210	0 9342	4 2176	0 9299	4 5956	1 4721
9	2	5 4040	1 3669	5 0066	1 3463	4 2680	1 0041

Contd

Table 4 16 contd

Litter size at weaning		(P 0 6958)NS		(P 0 4943)NS		(P 0 6559)NS	
0	4	3 9209	0 6897	3 5403	0 6977	3 3652	0 7390
1	3	5 6543	0 9081	5 6124	0 9050	5 2417	0 9760
2	14	4 1312	0 5006	4 0794	0 5220	3 6542	0 5331
3	28	4 3829	0 4940	4 1013	0 5159	3 7551	0 5257
4	12	4 2499	0 4987	4 1108	0 5203	3 8603	0 5309
5	10	4 5524	0 5450	4 3048	0 5627	4 1299	0 5815
6	14	4 5728	0 5433	4 2437	0 5611	3 7288	0 5797
7	3	3 4329	1 2796	3 8031	1 2621	3 3347	1 3779
8	1	5 1743	1 3546	5 8352	1 3340	5 4195	1 4589

NS Not significant

4 2 2 5 Effect on diseases and mortality

Least squares means for the effect of antibody response to BRBC on the incidence of mange coccidiosis and adult mortality are detailed in Table 4 17 The effect of antibody response to BRBC at first second and third week after primary immunisation was not found to be significant on the incidence of mange coccidiosis and adult mortality in broiler rabbits

4 3 Cell mediated immune responses

4 3 1 Cutaneous response to intradermal injection of phytomitogen PHA M

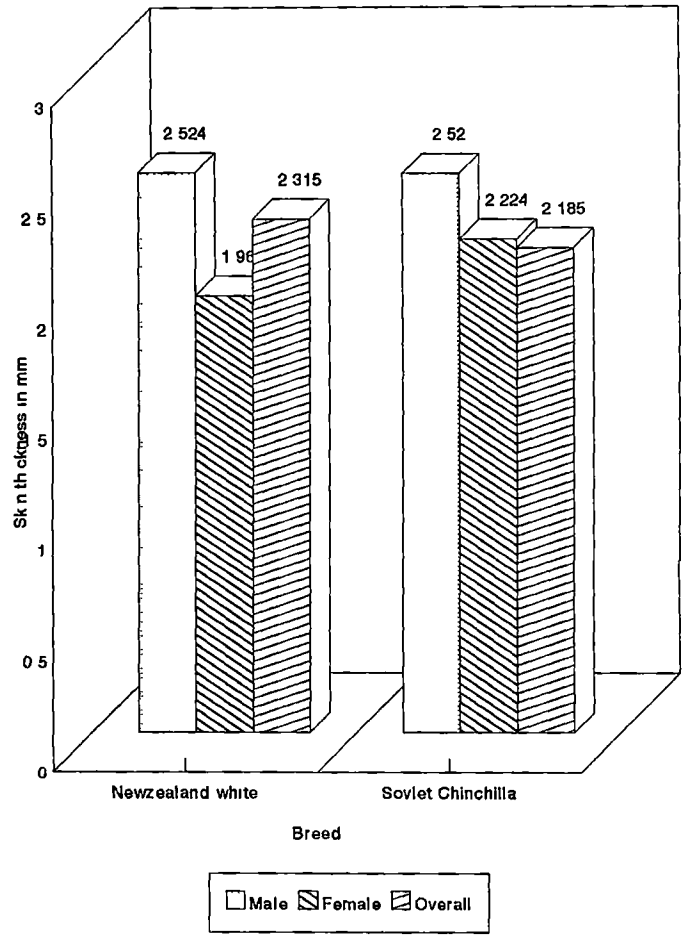
4 3 1 1 Cutaneous response status

Data on the cutaneous response to intradermal injection of PHA M are documented in Table 4 18 The preinjection skin thickness ranged between 1 00 and 3 50 mm with a mean value of 2 1850+0 0429 mm The PHA response at 24 hours as evidenced by increase in skin thickness post injection of PHA M ranged between 0 5 and 4 5 mm with a mean value of 2 259 0 0726 mm The PHA response at 48 hours ranged from 0 00 to 3 00 mm with a mean value of 1 5440+0 0565 mm At 72 hours post injection the PHA response ranged between 0 and 2 5 mm with a mean value of 0 778+0 046 mm PHA response was the highest at 24 hours post injection and the lowest at 72 hours post injection

Table 4 17 Least squares means for the effect of antibody response to Bovine Red Blood Cells on the incidence of mange coccidiosis and adult mortality in broiler rabbits

Independent variable		n	Antibody response to Bovine Red Blood Cells (1+log$_e$ of titer)					
			I week		II week		III week	
			Mean	SE	Mean	SE	Mean	SE
Mange			(P 0 1243)		(P = 0 1299)		(P = 0 1884)	
	No	57	4 4266	0 3179	4 3828	0 3180	3 9576	0.2747
	Yes	78	4 1805	0 3053	4 1297	0 3043	3 7261	0 2570
Coccidiosis			(P = 0 1232)		(P = 0 3862)		(P 0 3950)	
	No	82	4 4346	0 3117	4 3379	0 3113	3 9210	0 2661
	Yes	53	4 1726	0 3142	4 1797	0 3140	3 7626	0 2696
Adult mortality			(P = 0 1659)		(P = 0 1573)		(P 0.2987)	
	No	121	4 4809	0 2841	4 4476	0 2811	3 9879	0 2257
	Yes	14	4 1263	0 3649	4 0650	0 3690	3 6958	0 3383

Fig 4 7 PRE INJECTION SKIN THICKNESS AMONG BROILER RABBITS



4 3 1 2 Effect of breed and sex

Breed and sexwise data on PHA response at 24 48 and 72 hours are documented in Table 4 18 The pre injection skin thickness of Newzealand White rabbits ranged from 1 00 to 3 5 mm with mean value of 2 140 0 072 mm Newzealand White does had a skin thickness range of 1 00 to 3 5 mm with a mean of 1 968±0 0514 mm The skin thickness among Newzealand White bucks ranged between 2 00 and 3 5 mm with a mean value of 2 524+0 112 The pre injection skin thickness in Soviet Chinchilla rabbits ranged from 1 00 and 3 5 mm In this breed also bucks had a higher skin thickness ranging from 1 5 to 3 5 mm with a mean of 2 520+0 106 mm while the skin thickness in does ranged between 1 00 and 3 00 mm with a mean of 2 048+0 0656 mm (Fig 4 7)

PHA response at 24 hours ranged between 0 50 and 4 50 mm in Newzealand White breed with a mean increase in thickness of 2 235+0 153 mm The mean PHA response at 24 hours in Newzealand White does was 2 362+0 146 mm and in bucks it was 1 952+0 169 mm Among rabbits of Soviet Chinchilla PHA response at 24 hours varied from 0 50 to 4 50 with a mean value of 2 259±0 07626 mm The mean PHA response in does was 2 340±0 125 mm and bucks was 2 143 0 119 mm

Table 4 18 Cutaneous response to intradermal injection of PHA M in Broiler Rabbits (Skin thickness in mm)

Breed	Sex	n	Pre injection skin thickness			Post injection increase in skin thickness								
						24 hours			48 hours			72 hours		
			Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE
Newzealand White	Female	47	1 000-3 500	1 968	0 051	0 500 4 500	2 362	0 146	0 000 3 000	1 672	0 110	0 000-2 000	0 980	0 078
	Male	21	2 000-3 500	2 524	0 112	0 500 3 500	1 952	0 169	0 000 2 500	1 310	0 127	0 000-1 500	0 548	0 103
	Overall	68	1 000 3 500	2 140	0 072	0 500 4 500	2 235	0 153	0 000 3 000	1 560	0 115	0 000-2 000	0 847	0 086
Soviet Chinchilla	Female	42	1 000 3 000	2 048	0 066	1 500 3 500	2 340	0 125	0 500 3 000	1 620	0 117	0 000-2 500	0 780	0 158
	Male	25	1 500-3 500	2 520	0 106	0 500 3 500	2 143	0 120	0 500 2 500	1 476	0 090	0 000-1 500	0 655	0 073
	Overall	67	1 000 3 500	2 224	0 081	0 500 3 500	2 217	0 122	0 500 3 000	1 530	0 100	0 000 2 500	0 702	0 105
Overall		135	1 000-3 500	2 185	0 043	0 500 4 500	2 259	0 073	0 000 3 000	1 544	0 065	0 000 2 500	0 778	0.046

Ig 4 8 PHA RESPONSE IN NEW ZEALAND WHITE RABBITS

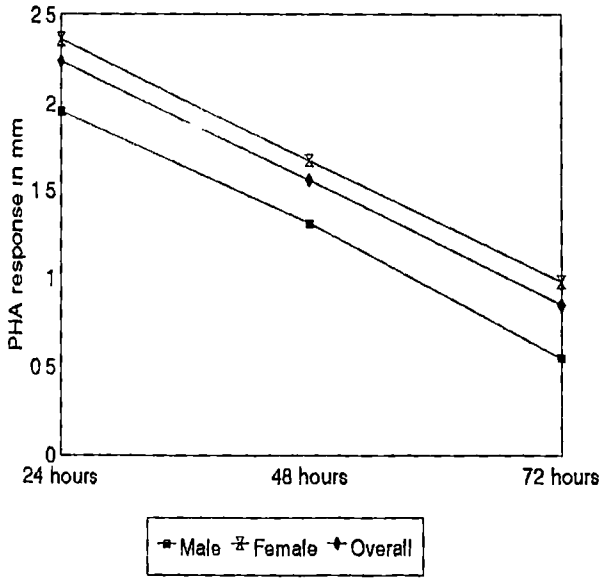
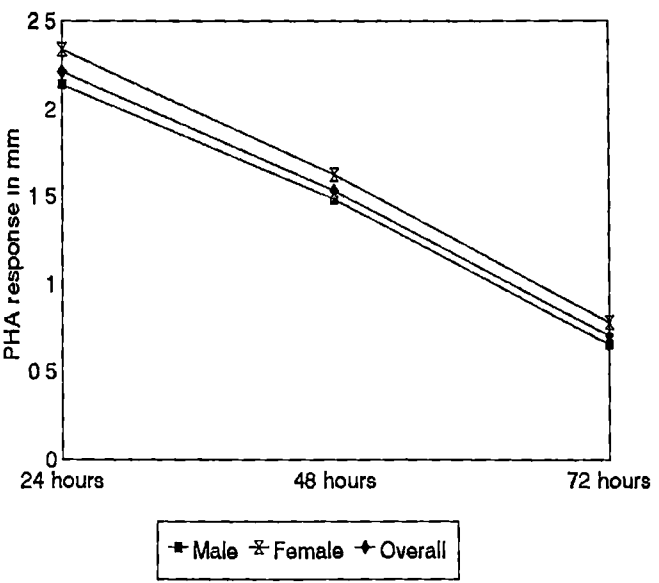


Fig 4 9 PHA RESPONSE IN SOVIET CHINCHILLA RABBITS



PHA response at 48 hours ranged between 0 00 and 3 00 mm in both the breeds with a mean value of 1 560±0 115 mm in Newzealand White and 1 53±0 10 mm in Soviet Chinchilla Newzealand White does had a mean PHA response of 1 672+0 110 mm at 48 hours while in bucks it was 1 310±0 127 mm Among Soviet Chinchilla does the mean PHA response at 48 hours was 1 620+0 117 mm and bucks had a mean value of 1 476+0 09 mm

At 72 hours the PHA response ranged from 0 to 2 mm in Newzealand White and between 0 and 3 5 mm in Soviet Chinchilla Among Newzealand White rabbits the average PHA response at 72 hours was 0 847+0 086 mm with a mean value of 0 980±0 078 mm in does and 0 548±0 130 mm in bucks Average PHA response at 72 hours in Soviet Chinchilla rabbits was 0 702±0 105 mm with a mean value of 0 780+0 158 mm in does and 0 655±0 073 mm in bucks Data are represented graphically in Figs 4 8 and 4 9

Analysis of variance for the effect of breed and sex on PHA response at 24 48 and 72 hours are presented in Table 4 19 The effect of breed was not found to be significant on skin thickness or PHA response at 24 48 and 72 hours post injection The effect of sex was found to be highly

Table 4 19 Least squares analysis of variance for the effect of breed, sex, adult body weight and sire on the dermal response to phytomitogen PHA M

Source of variation	df	0 hour (Pre injection)		24 hours Post injection)		48 hours (Post injection)		72 hours (Post injection)	
		MSS	Probability	MSS	Probability	MSS	Probability	MSS	Probability
Breed	1	0 0376 NS	0 9 32	0 4461 NS	0 7671	0 0836 NS	0 8570	0 0458 NS	0 9065
Sex	1	3 6375 **	0 0000	3 8897 *	0 0013	2 0146**	0 0080	2 5981 **	0 0000
Adult body weight	4	0 173 NS	0 4569	0 4 94 NS	0 5941	0 1687 NS	0 7879	0 0145 NS	0 9920
Sire within Newzealand White breed	16	0 1672 NS	0 5876	1 5955 **	0 0060	0 6750 NS	0 0580	0 4811 *	0 0143
Sire within Some Chinchilla breed	10	0.2169 NS	0 3347	0 9097 NS	0 0984	0 3634 NS	0 5202	0 3243 NS	0 1870
Error	102	0 1889		0 5451		0 3961		0 2304	

** Significant at 1% level NS Not significant

significant (P < 0.001) on the initial skin thickness with males having thicker skin. The effect of sex was found to be highly significant on PHA response at 24 hours (P = 0.0013), 48 hours (P = 0.008) and at 72 hours (P < 0.001) post injection with does having a higher PHA response at 24, 48 and 72 hours. Least squares means for the effect of breed and sex are presented in Table 4.20.

4.3.1.3 Sire effects and heritability

Analysis of variance for the effect of sires within breed on the skin thickness and PHA response at 24, 48 and 72 hours post injection are presented in Table 4.19. The effect of sires within breed was not found to be significant on preinjection skin thickness in both the breeds. The effect of sires was found to be highly significant on the PHA response at 24 hours (P = 0.006) and 72 hours (P = 0.01431) in Newzealand White and sire effect approached 5 per cent level of significance on PHA response at 48 hours (P = 0.058).

The sire effect was not found to be significant on PHA response at 24, 48 and 72 hours post injection in Soviet Chinchilla breed of rabbits. Least squares means for the effect of sires within breeds on skin thickness and PHA responses are detailed in Table 4.20.

Table 4.20 Least squares means for the effect of breed, sires within breed, sex and adult body weight classes on the pre injection skin thickness and PHA responses at 24 48 and 72 hours post injection

Classes	n	Pre injection skin thickness		PHA response at 24 hours		PHA response at 48 hours		PHA response at 72 hours	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Breed		(P 0 9332) NS		(P 0 7671) NS		(P 0 8570) NS		(P = 0 9065)NS	
Newzealand White	68	2 1266	0 8032	2 1224	0 7928	1 5635	0 5422	0 8128	0 6643
Soviet Chinchilla	67	2 1750	0 6982	2 2211	0 6909	1 5895	0 4736	0 7527	0 5781
Sires within Newzealand White		(P 0 5876)NS		(P 0 0060)**		(P = 0 0580)NS		(P 0 0143)**	
1	4	2.2573	0 4585	0 9002	0 5721	0 7924	0 4469	0 1874	0 4238
2	4	2 2946	0 4359	2 7046	0 5439	1 6?06	0 4249	0 6571	0 4029
3	3	1 9375	0 5029	1 4242	0 6276	1 48?7	0 4902	0 3786	0 4648
4	2	2 1550	0 589?	2 2915	0 735?	1 6952	0 5744	0 9552	0 5446
5	?	2 ?152	0 5920	1 8096	0 7385	1 3915	0 5769	0 5068	0 5470
6	5	1 8266	0 3919	2 7634	0 4890	1 8706	0 3820	1 2289	0 3622
7	7	2 1800	0.2680	2 4132	0 459?	1 7778	0 3587	0 9171	0 340?
8	4	2 3196	0 4460	2 8140	0 5560	1 9431	0 4347	1 1480	0 4122
9	7	1 9809	0 ɔ650	2 1096	0 4555	1 5766	0 3558	0 8445	0 3374

Contd

Table 4 20 contd.

10	8	2 1829	0 3382	2 7685	0 4219	1 7845	0 3296	1 0131	0 3125
11	6	2 0527	0 4095	3 4699	0 5110	2 2163	0 3992	1.2972	0 3785
12	3	1 9943	0 5107	2 8703	0 6372	2 4731	0 4978	1 3782	0 4720
13	4	2 0897	0 4433	1 7752	0 5531	1 2436	0 4321	0 8562	0 4097
14	2	2 8857	0 5910	1 1007	0 7374	0 7803	0 5760	0 1395	0 5462
15	2	2.2693	0 5894	1 1163	0 7355	0 6876	0 5745	0 3036	0 5448
16	3	1 8426	0 5143	1 9719	0 6418	1 3210	0 5013	0 8473	0 4754
17	2	1 6675	0 6402	2 4271	0 7988	1 9222	0 6240	1 4388	0 9517
Sires within Soviet Chinchilla		(P	0 3347) NS	(P = 0 0984)NS		(P = 0 5202)NS		(P	0 1870) NS
1	12	2.2676	0 3607	2 5867	0 4300	1 8267	0 3295	0 7789	0 3255
2	2	1 4534	0 6670	3 1635	0 7950	2 4363	0 6094	1 7644	0 6019
3	4	2 0862	0 4960	2 0919	0 5913	1 7065	0 4532	0 6598	0 4477
4	3	1 8750	0 5330	1 5108	0 6354	0 8330	0 4870	0 2951	0 4811
5	9	2.2797	0 3764	1 8304	0 4487	1 4270	0 3439	0 4966	0 3397
6	3	3 1013	0 5771	2 0507	0 6405	1 6124	0 4907	0 4904	0 4847
7	4	2 5410	0 5052	1 6637	0 6077	1 4734	0 4616	0 5446	0 4560
8	5	2 3654	0 4475	2 0777	0 5354	1 4000	0 4089	0 7761	0 4039

Contd

Table 4 20 contd.

9	14	2.2128	0 3132	2 3214	0 3734	1 5865	0 2862	0 6629	0 2827
10	4	2 3736	0 4224	2 7506	0 5750	1 5421	0 4407	0 8290	0 4354
11	7	2.2815	0 4108	2 4359	0 4896	1 5462	0 3753	0 6816	0 3707
Sex		(P = 0 000)**		(P = 0 0013)**		(P 0 0080)**		(P 0 000)**	
Female	89	1 9847	0 6842	2 3562	0 5318	1 6485	0 4854	0 9146	0 3652
Male	46	2 5216	0 8837	2 0843	0 8675	1 4524	0 5625	0 6472	0 3570
Body weight classes		(P 0 4569)NS		(P 0 5241)NS		(P = 0 7879)NS		(P 0 9920)NS	
1	39	2 1788	0 7023	2 3845	0 6878	1 6859	0 4674	0 7969	0 5790
2	27	2 7804	0 7038	2 2743	0 6919	1 5734	0 4717	0 8104	0 5811
3	1	2 4174	0 8810	2 0190	1 1198	1 5773	0 8810	0 6440	0 8224
4	55	2 0832	0 7001	2 1318	0 6815	1 5244	0 4608	0 8118	0 5758
5	13	1 9043	0 7112	2 0497	0 7123	1 5166	0 4929	0 8507	0 5918

* S gnificant at 5% level

** S gnificant at 1% level

NS Not signif cant

Heritability estimates of pre injection skin thickness and the PHA response at 24 48 and 72 hours post injection are presented in Table 4 28 The heritability estimates were 0 7637 0 4260 0 8600+0 6230 0 6700+0 4040 and 0 6370+0 3080 respectively

4 3 1 4 Effect on body weight and litter traits

Analysis of variance for the effect of body weight classes on skin thickness and PHA responses at 24 48 and 72 hours are documented in Table 4 19 Least squares means for the effect of body weight classes on skin thickness and PHA responses are presented in Table 4 20 Body weight classes were found to have no significant effect on the initial skin thickness or PHA responses at 24 48 and 72 hours

The least squares means for the effect of skin thickness and PHA responses at 24 48 and 72 hours on the litter size at birth and litter size at weaning are presented in Table 4 21 The effect of skin thickness was found to be significant on litter size at birth (P 0 0448) and litter size at weaning (P 0 0377) The effect of PHA responses at 24 48 and 72 hours was not significant on litter size at birth and litter size at weaning For a litter size of 2 at birth the mean skin thickness was 2 4177 0 2915 mm When the litter

Table 4 21 Least squares means for the effect of cutaneous response o intra dermal PHA M injection on the litter traits in broiler rabb t does

Independent variable	n	Increase in skin thickness (mm)							
		0 hour (Pre injection thickness)		24 hours Post injection		48 hours Post injection		72 hours Post njection	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Litter size at birth		(P 0 0448)*		(P=0 5972)NS		(P 0 5996)NS		(P 0 5455)NS	
2	3	2 4177	0.2915	2 5786	0 7457	1 8050	0 5854	0 9334	0 4310
3	7	2 3610	0.2494	? 0825	0 6340	1 5659	0 4851	0 7847	0 3580
4	11	2 4678	0.2424	2 4303	0 61ɔ3	1 8263	0 4681	0 8877	0 3456
5	11	2 4ɔ74	0.2252	2 8976	0 569?	2 1279	0 4256	I 2002	0 3147
6	32	2 ?147	0.2000	2 6323	0 5018	1 7051	0 3618	0 8566	0.2684
7	18	1 8?37	0 ?3?9	3 1078	0 590?	2 1355	0 4450	1 2680	0 3280
8	5	1 ɔ144	0 3581	I 3363	0 9?13	0 4435	0 7391	0 2337	0 5432
9	2	1 9019	0 5106	1 8551	1 3?1ɔ	0 3157	1 0819	0 0876	0 7940

Contd

Table 4 2 1 contd

Litter size at weaning		(P 0 0377)*		(P 0 2857)NS		(P 0 3139)NS		(P 0 6942)NS	
0	4	2 0729	0.2745	2 9122	0 7008	1 1469	0 5453	0 5861	0 4018
1	3	2 0710	0 3490	2 6203	0 8976	1 8241	0 7185	0 8050	0 5282
2	14	1 71o5	0.2131	2 3391	0 5369	1 5141	0 3953	0 8495	0.2927
3	28	1 9665	0.2110	1 6394	0 531o	0 3952	0 3900	0 4540	0 2888
4	1?	2 1445	0.2125	1 6829	0 535o	1 0102	0 3938	0 4968	0 2916
5	10	2 40?8	0.2271	2 12?1	0 574o	1 5131	0 4o05	0 6626	0 3182
6	14	2 2659	0.2265	1 2767	0 5 o1	0 6861	0 4?92	0 3324	0 3173
7	3	2 ?885	0 4796	3 2823	1.240?	2 6176	1 0128	1 5667	0 7434
8	1	2 3775	0 5062	3 4104	1 3099	? 2083	1 0722	1 0765	0 7868

* Significant at 5% level ** Significant at 1% level NS Not Significant

Fig 4 10 EFFECT OF PRE INJECTION SKIN THICKNESS ON THE LITTER SIZE AT BIRTH IN BROILER RABBITS

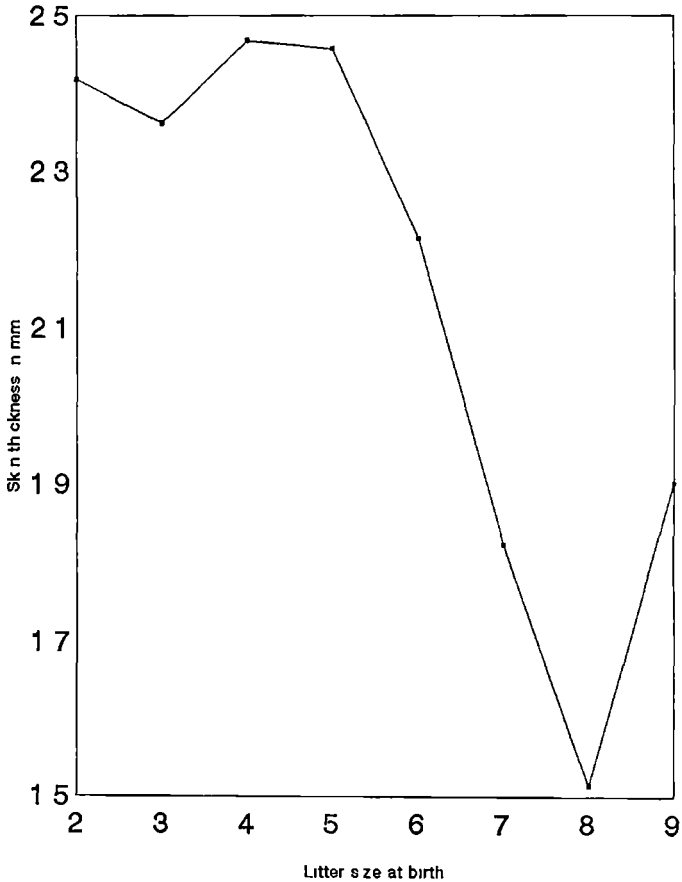
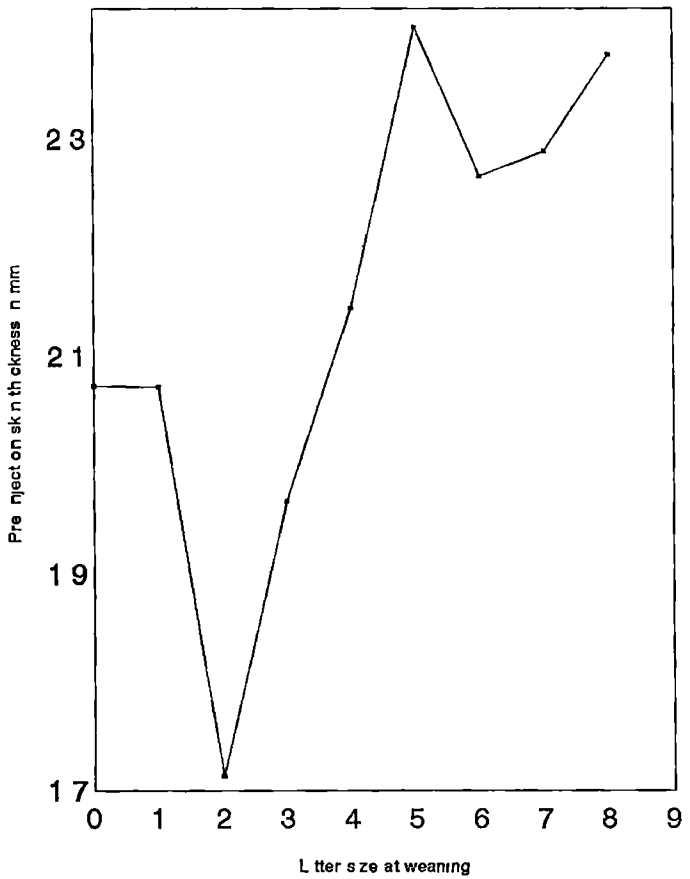


Fig 4 11 EFFECT OF PRE INJECTION SKIN THICKNESS ON THE LITTER SIZE AT WEANING AMONG BROILER RABBITS



size at birth was 7 the mean skin thickness was 1 8237+0 2329 mm and for a litter size of 8 the mean skin thickness was 1 5144 0 3581 mm The relationship between these two traits are graphically represented by Fig 4 10

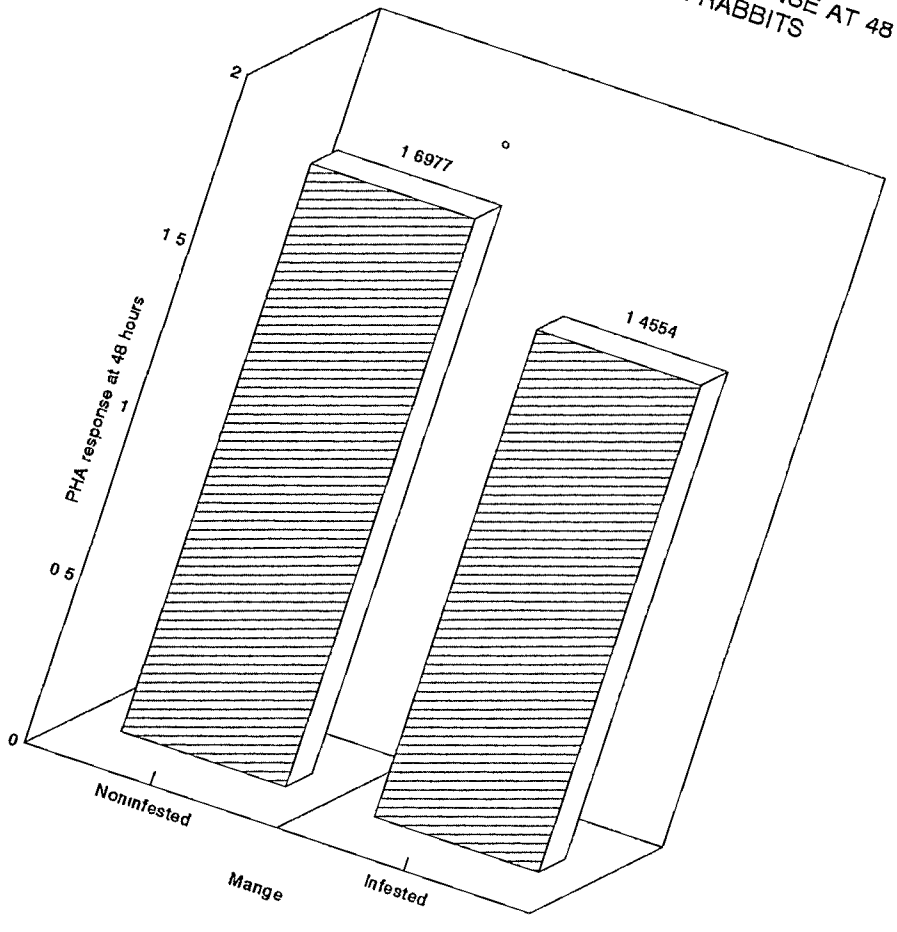
The effect of skin thickness was significant on litter size at weaning (P 0 0377) When the doe weaned no litter the mean skin thickness was 2 07299±0 2475 mm At a weaning litter size of 3 the mean skin thickness was 1 9665+0 2110 mm When the doe weaned 4 kits the mean skin thickness was 2 1445+0 2125 mm and when the litter weaned was 6 the mean skin thickness was 2 2659+0 2265 mm The association between these two traits are shown in Fig 4 11

Correlation between the skin thickness and PHA responses at 24 48 and 72 hours with adult body weight litter weight at birth litter weight at weaning and preweaning mortality are documented in Table 4 30 All the correlations were small and not significant Generally the correlations between litter weight at birth and at weaning with the skin thickness and PHA response at 24 48 and 72 hours were negative though not significant

4 3 1 5 Effect on diseases and mortality

Least squares means for the effect of skin thickness and PHA responses at 24 48 and 72 hours post injection on the incidence of mange coccidiosis

Fig 4 12 ASSOCIATION BETWEEN PHA RESPONSE AT 48 HOURS AND MANGE IN BROILER RABBITS



and adult mortality are presented in Table 4 22 The preinjection skin thickness had no significant effect on the incidence of mange coccidiosis and adult mortality

The PHA responses at 24 and 72 hours post injection was also found to have no significant effect on the incidence of mange coccidiosis and adult mortality The PHA response at 48 hours was also not significant on the incidence of coccidiosis and adult mortality However the PHA response at 48 hours had a significant effect (P 0 0505) on the incidence of mange The mean PHA response at 48 hours was 1 4454+0 479 mm in rabbits with the incidence of mange while it was higher with a mean of 1 6977+0 4837 mm in animals which did not have mange infestation (Fig 4 12)

4 3.2 Contact sensitivity to 2,4 dinitrochlorobenzene

4 3 2 1 Contact sensitivity status

Data on contact sensitivity to DNCB at 24 48 and 72 hours post challenge are presented in Table 4 23 The increase in post challenge skin thickness at 24 hours ranged between 0 50 and 6 50 mm with a mean value of 3 5850±0 0761 mm Contact sensitivity at 48 hours ranged from 0 50 and 4 50 mm with a mean value of 1 796 0 063 mm The range in contact sensitivity at 72 hours post challenge was between 0 00 and 3 00 mm with an average value of 1 085+0 0522 mm

Table 4 22 Least square means for the effect of dermal response to PHA M on the incidence of Mange Coccidiosis and adult mortality in broiler rabbits

Independent variable		n	Skin thickness (mm) to intradermal injection of PHA M							
			0 hours Pre injection		24 hours Post injection		48 hours Post injection		72 hours Post injection	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mange			(P 0 9891)NS		(P = 0 1836)NS		(P = 0 0505)*		(P = 0 4471)NS	
	No	57	2 1502	0 7080	2.2687	0 7036	1 6977	0 4839	0 8193	0 5872
	Yes	78	2 1514	0 7064	2 0748	0 6990	1 4554	0 4791	0 7463	0 5848
Coccidiosis			(P = 0 7886)NS		(P = 0 0680)NS		(P 0 0721)NS		(P = 0 2478)NS	
	No	82	2 1384	0 7072	2 0300	0 7013	1 4585	0 4815	0 7238	0 5861
	Yes	53	2 1633	0 7075	2 3135	0 7322	1 6946	0 4825	0 8418	0 5865
Adult mortality			(P = 0 3774)NS		(P 0 6479)NS		(P = 0 6899)NS		(P 0 7575)NS	
	No	121	2 2133	0 7037	2 1187	0 6915	1 5374	0 4713	0 7591	0 5810
	Yes	14	2 0884	0 7148	2 2248	0 7223	1 6151	0 5023	0 8065	0 5971

NS Not s gnificant * Significant at 5% level

4 3 2 2 Effect of breed and sex

Breed and sexwise data on contact sensitivity to DNCB at 24 48 and 72 hours post challenge are detailed in Table 4 23 The contact sensitivity 24 hours post challenge ranged between 2 00 and 6 50 m with a mean value of 3 638±0 170 mm in Newzealand White rabbits with an average value of 3 585+0 171 mm in does and 3 929+0 167 mm in bucks The contact sensitivity 24 hours post challenge in Soviet Chinchilla ranged from 0 50 and 6 00 mm with a breed average of 3 478+0 142 mm and a mean value of 3 381+0 142 mm in does and 3 640+0 201 mm in bucks

The contact sensitivity at 48 hours post challenge ranged between 0 5 and 4 0 mm with a mean value of 1 883±0 112 mm in Newzealand White Newzealand White does had a mean contact sensitivity of 1 830±0 100 mm and bucks had a mean value of 2 00±0 138 mm The contact sensitivity 48 hours post challenge ranged between 0 50 and 4 50 mm with a mean value of 1 769+0 133 mm in Soviet Chinchilla rabbits Does of this breed had a mean value of 1 738±0 138 mm while the average value of bucks was 1 660+0 125 mm

The contact sensitivity at 72 hours post challenge ranged from 0 00 and 3 00 mm in Newzealand White rabbit with a mean value of 1 1770+0 0173 mm Does of this breed had a mean value of 1 192+0 088 mm and bucks had

Table 4 23 Contact sensitivity to percutaneous challenge with DNCB in broiler rabbits

Breed	Sex	n	Skin thickness (mm)								
			24 hours post challenge			48 hours post challenge			72 hours post challenge		
			Range	Mean	SE	Range	Mean	SE	Range	Mean	SE
Newzealand Wh te	Female	47	2 000 6 500	3 585	0 171	0 500-4 000	1 830	0 100	0 000 3 000	1 192	0 088
	Male	21	2 500 5 000	3 929	0 167	1 000 3 500	2 000	0 138	0 500 2 000	1 142	0 034
	Overall	68	2 000 6 500	3 638	0 170	0 500-4 000	1 883	0 112	0 000 3 000	1 177	0 071
Sov et Chinchilla	Female	42	1 500 6 000	3 381	0 142	0 500-4 500	1 738	0 138	0 000 3 000	1 074	0 102
	Male	25	0 500 5 000	3 640	0 201	0 500 2 500	1 660	0 125	0 000 2 000	0 940	0 116
	Overall	67	0 500 6 000	3 478	0 234	0 500-4 500	1 709	0 133	0 000 3 000	0 993	0 107
Overall		135	0 500 6 500	3 585	0 076	0 500-4 500	1 796	0 063	0 000 3 000	1 085	0 057

Fig 4 13 CONTACT SENSITIVITY TO DNCB IN NEW ZEALAND WHITE

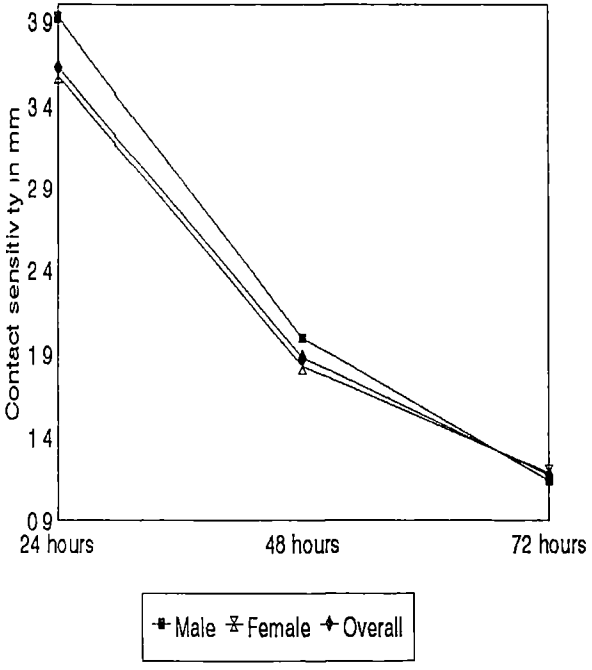
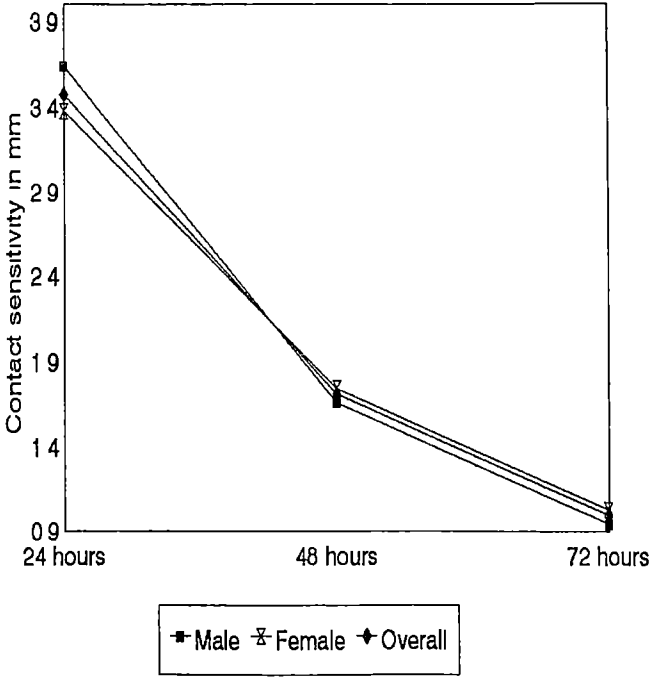


Fig 4 14 CONTACT SENSITIVITY TO DNCB IN SOVIET CHINCHILLA



1 142+0 034 mm contact sensitivity at 72 hours The contact sensitivity at 72 hours post challenge in Soviet Chinchilla rabbits ranged between 0 00 and 3 00 mm with a mean of 0 993±0 107 mm Does of Soviet Chinchilla had a mean contact sensitivity of 1 02±0 102 mm at 72 hours while it was 0 940±0 116 mm in bucks (Figs 4 13 and 4 14)

Analysis of variance for the effects of breed and sex on the contact sensitivity to DNCB at 24 48 and 72 hours post challenge are presented in Table 4 24 The effect of breed and sex was not found to be significant on the contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge Least squares means for the effect of breed and sex on the contact sensitivity to DNCB are detailed in Table 4 25

4 3 2 3 Sire effects and heritability

Analysis of variance for the effects of sires within breeds on contact sensitivity to DNCB at 24 48 and 72 hours post challenge are detailed in Table 4 24 The effect of sires was not found to be significant on the contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge in Newzealand White rabbits In Soviet Chinchilla breed of rabbits also the effect of sires was not found to be significant on 24 and 72 hours post challenge contact sensitivity to DNCB But the effect of sires was found to

Table 4.24 Least squares analysis of variance for the effect of breed, sex, adult body weight and sire on the contact sensitivity to DNCB

Source of variation	df	24 hours (Pos challenge)		48 hours (Pos challenge)		72 hours (Pos challenge)	
		MSS	Probability	MSS	Probability	MSS	Probability
Breed	1	0.153 NS	0.7437	1.0725 NS	0.2760	0.7747 NS	0.1597
Sex	1	0.8912 NS	0.3192	0.4868 NS	0.3812	0.1612 NS	0.6194
Adult body weight	4	0.8540 NS	0.3577	0.1797 NS	0.8377	0.3850 NS	0.3376
Sires within Newzealand White breed	16	0.7892 NS	0.4399	0.4706 NS	0.5256	0.4042 NS	0.2757
Sires within Soviet Chinchilla breed	10	0.6791 NS	0.6146	1.285	0.0082	0.5531 NS	0.1027
Error	102	0.7717		0.4991		0.3348	

* Significant at 5% level ** Significant at 1% level NS Not significant

Table 4 25 Least squares means for the effect of breed, sires within breed, sex and adult body weight classes on the contact sensitivity (mm) at 24 48 and 72 hours post-challenge to DNCB

Classes	n	Contact sens tivity at 24 hours		Contact sensitivity at 48 hours		Contact sensitivity at 72 hours	
		Mean	SE	Mean	SE	Mean	SE
Breed		(P = 0 7437) NS		(P = 0 2760) NS		(P = 0 1597) NS	
Newzealand White	68	3 5227	0 4663	1 9316	0 2935	1 1973	0 1836
Soviet Chinchilla	67	3 4213	0 4109	1 7281	0 2614	1 0225	0 1666
Sires within Newzealand White		(P = 0 4399)NS		(P = 0 5256)NS		(P = 0 2757)NS	
1	4	3 6130	0 5472	2 4820	0 4379	1 5590	0 3548
2	4	3 0967	0 5202	1 8006	0 4163	1 1277	0 337ɔ
3	3	3 6940	0 6002	3 112ɔ	0 4803	1 9088	0 3892
4	2	2 7091	0 7032	2 061?	0 5627	1 42?2	0 4560
5	2	2 7617	0 7032	1 6499	0 5652	0 9994	0 4580
6	5	3 6ɔ8?	0 4677	1 991?	0 3743	1 4029	0 3033
7	7	3 445?	0 4392	1 8015	0 3515	1 2447	0 ?842
8	4	4 1ɔ98	0 5322	2 0? 18	0 4259	1 1768	0 3451
9	7	3 0964	0 4356	1 86ɔɔ	0 3486	1 1780	0 ?8?5
10	8	4 ? 14	0 4036	1 795ɔ	0 32?9	1 4481	0 ?617

Contd

Table 4.25 contd.

11	6	3 7789	0 4887	1 6546	0 3911	1 5798	0 3170
12	3	4 7175	0 6094	2 1010	0 4877	1 0256	0 3952
13	4	3 3105	0 5290	2 0796	0 4233	1 1814	0 3430
14	2	3.2207	0 7053	1 7240	0 5644	0.2163	0 4573
15	2	3 5319	0 7034	1 3168	0 5629	0 3292	0 4562
16	3	3 7736	0 6138	1 6148	0 4912	1 4352	0 3980
17	2	3 1066	0 7640	1 7666	0 6114	1 4226	0 4954
Sires within Soviet Chinchilla		(P	0 6146)NS	(P	0 0082)**	(P = 0 1027)NS	
1	12	3 1253	0 3902	1 5186	0 3083	0 8199	0 ?476
2	2	3 9248	0 7216	1 1418	0 5700	1 0808	0 4579
3	4	3 9576	0 5367	2 7100	0 4239	1 6098	0 3405
4	3	3 8336	0 5767	2 7189	0 4555	1 4794	0 3659
5	9	3 3935	0 4072	2 0556	0 3217	1 2368	0 2584
6	3	2 7498	0 5811	0 9237	0 4590	0 6?68	0 ?687
7	4	3 6143	0 5466	1 5853	0 4318	0 7?52	0 3468
8	5	2 7078	0 4841	1 8289	0 3825	0 6581	0 3072
9	14	3.2203	0 3389	1 7254	0 ?677	1 1861	0 ?150

Contd

Table 4 25 contd.

10	4	3 6391	0 5219	1 0448	0 4123	0 6863	0 3312
11	7	3 4681	0 4444	1 7545	0 3510	1 1385	0 2820
Sex		(P = 0 3192)NS		(P = 0 3812)NS		(P 0 6194)NS	
Female	89	3 4261	0 4327	1 6654	0 2654	1 0483	0 2863
Male	46	3 6420	0 5640	1 8435	0 2860	0 9963	0 1487
Body weight classes		(P = 0 3577)NS		(P 0 8377)NS		(P 0 3376)NS	
1	39	3 6275	0 3901	1 7348	0 ?362	0 9842	0 1368
2	27	3 7373	0 3996	1 8810	0 2468	1 2720	0 1491
3	1	3 1787	1 0911	1 7349	0 8769	1 1651	0 7125
4	55	3 7516	1 3752	1 8561	0 ?191	1 1505	0 1156
5	13	3 0648	0 4449	1 9421	0 2953	0 9779	0 ?006

* S gnificant at 5% of level ** S gnificant at 1% level NS Not s gnificant

be highly significant (P = 0 0082) on the contact sensitivity to DNCB at 48 hours post challenge in Soviet Chinchilla rabbits Least squares means for the effect of sires within breed on the contact sensitivity to DNCB are elaborated in Table 4 25

Heritability estimates of contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge are presented in Table 4 28 The heritability estimates were moderate with 0 3820 0 2036 0 5490+0 3182 and 0 3039+0 2815 respectively for 24 48 and 72 hours

4 3 2 4 Effect on body weight and litter traits

Analysis of variance for the effect of body weight classes on contact sensitivity at 24 48 and 72 hours to DNCB challenge is presented in Table 4 24 Body weight classes were not found to have any significant effect on contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge Least squares means for the effect of body weight classes on contact sensitivity to DNCB are presented in Table 4 25

Least squares means for the effect of contact sensitivity to DNCB challenge at 24 48 and 72 hours on the litter size at birth and at weaning are detailed in Table 4 26 Contact sensitivity at 24 48 and 72 hours post

Table 4 26 Least squares means for the effect of contact sensitivity to DNCB on the li ter traits in broiler rabb t does

Independent variables	n	24 hours Post challenge		48 hours Post challenge		72 hours Post challenge	
		Mean	SE	Mean	SE	Mean	SE
Litter size at birth		(P = 0 8093)		(P = 0 0559)		(P=0 2426)	
2	3	3 1184	0 7336	1 2547	0 6317	0 6416	0 5218
3	7	3 0411	0 5950	1 6792	0 5253	0 4897	0 4320
4	11	3 2454	0 5712	1 6360	0 5073	0 9010	0 4168
5	11	3 2566	0 5109	0 9353	0 4624	0 6338	0 3787
6	32	3 7446	0 4182	1 7156	0 3952	0 8129	0 3214
7	18	3 9867	0 5386	2 2643	0 4828	1 3898	0 3961
8	5	3 8828	0 9422	1 8089	0 7994	1 5730	0 6594
9	2	3 4234	1 3996	0 3327	1 1613	0 ?557	0 9658

Contd

Tale 4 26 contd

Litter size at weaning		(P = 0 1317)		(P 0 9136)		(P 0 3066)	
0	4	4 7525	0 6786	1 5471	0 5892	1 1978	0 4860
1	3	4 0151	0 9143	1 5931	0 7734	0 7733	0 6410
2	14	3 6974	0 4673	1 5642	0 4304	1 2095	0 3515
3	28	3 096	0 4596	1 3469	0 4248	0 9349	0 3467
4	12	3 4456	0 4651	1 4434	0 4287	1 0262	0 3501
5	10	3 1705	0 5179	1 5771	0 4675	1 2402	0 3830
6	14	2 7315	0 5161	0 9510	0 4661	0 2827	0 3819
7	3	3 6068	1 3079	2 1185	1 0874	0 9420	0 9041
8	1	3 7813	1 3867	1 0773	1 1509	0 9715	0 9571

NS Not Significant * S gnif cant at 5% level

challenge was not found to have any significant effect on litter size at birth and litter size at weaning

Correlation between contact sensitivity at 24 48 and 72 hours post challenge with adult body weight litter weight at birth litter weight at weaning and preweaning survivability are presented in Table 4 30 Correlation between contact sensitivity at 24 hours and preweaning mortality were found to be significant (r 0 217 P 0 03) The correlation between litter weight at birth with the contact sensitivity at 48 hours post challenge was found to be highly significant (r 0 262 P 0 009) All other correlations were small and non significant

4 3 2 5 Effect on diseases and mortality

Least squares means for the effect of contact sensitivity at 24 48 and 72 hours post challenge on the incidence of mange coccidiosis and adult mortality are detailed in Table 4 27 The contact sensitivity at 24 hours post challenge to DNCB was highly significant (P 0 0014) on the incidence of mange The mean skin thickness of rabbits with mange infestation at 24 hours post challenge was 3 1969±0 4157 mm while in non infested rabbits the increase in skin thickness was much higher with a mean value of 3 7471+0 4258 mm Contact sensitivity to DNCB at 48 hours post challenge

Table 4 27 Least square means for the effect of contact sensitivity to DNCB on the incidence of mange coccidiosis and adult mortality in broiler rabbits

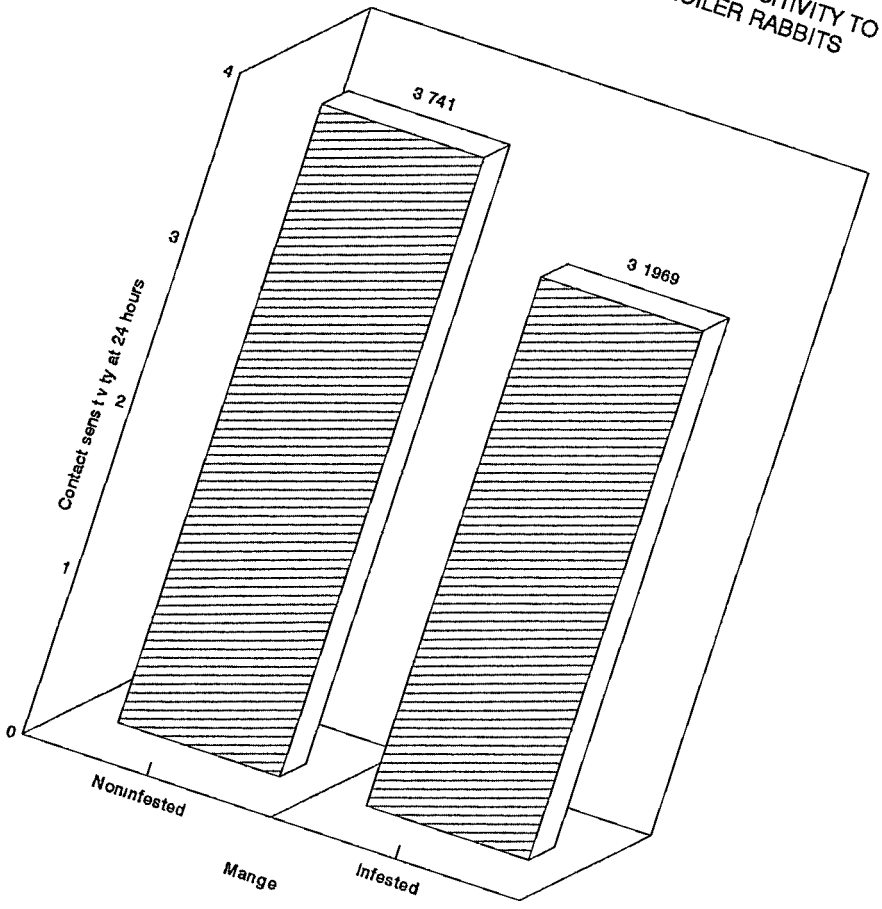
Independent variable	n	Contact sensitivity to DNCB (mm) skin thickness							
		0 hours Pre challenge		24 hours Post challenge		48 hours Post challenge		72 hours Post challenge	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mange		(P = 0 9891)NS		(P = 0 0014)**		(P 0 0702)NS		(P 0 5575)NS	
No	57	2 1502	0 7080	3 7471	0 4258	1 9564	0 2754	1 1441	0 1801
Yes	78	2 1514	0 7064	3 1969	0 4157	1 7032	0 2644	1 0759	0 1686
Coccidios s		(P 0 7886)NS		(P = 0 1985)NS		(P 0 1733)NS		(P 0 1435)NS	
No	82	2 1384	0 7072	3 3573	0 4208	1 9306	0 2700	1 1995	0 1745
Yes	53	2 1633	0 7075	3 5867	0 4229	1 7292	0 2722	1 0203	0 1768
Adult mortality		(P 0 3724)NS		(P = 0 8712)NS		(P = 0 6083)NS		(P = 0 3345)NS	
No	121	2 2133	0 7037	3 4937	0 3987	1 7730	0 2459	1 0710	0 1480
Yes	14	2 0884	0 7148	3 4503	0 4658	1 8868	0 3167	1 1988	0 2218

NS No Significant ** S gnif cant at 1% level

Table 4 28 Heritability estimates of immune response traits

Immune response trait	Heritability ± SE
Serum gammaglobulin level	0 1259+0 0731
Frossman antibody to SRBC	0 360+0 2480
Antibody response to BRBC	
Ist week	0 9200+0 6368
IInd week	0 9400±0 7120
IIIrd week	0 9067±0 7320
Cutaneous response to PHA M	
Skin thickness	0 7637±0 426
24 hours post injection	0 8600+0 6230
48 hours post injection	0 6700 0 4040
72 hours post injection	0 6370+0 3080
Contact sensitivity to DNCB	
24 hours post challenge	0 3820+0 2036
48 hours post challenge	0 5490+0 3182
72 hours post challenge	0 3039+0 2815

Fig 4 15 ASSOCIATION BETWEEN CONTACT SENSITIVITY TO DNCB AT 24 HOURS AND MANGE IN BROILER RABBITS



also approached near significance level (P = 0 0702) on the incidence of mange The mean contact sensitivity at 48 hours in non infested rabbits was 1 965+0 2644 mm while it was only 1 7032+0 2644 mm in mange infested rabbits (Fig 4 15) The effect of contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge was found to have no effect on the incidence of coccidiosis and adult mortality

4 4 Correlation between immune response traits

Correlations between different immune response traits are detailed in Table 4 29 Correlation of 0 271 between serum gammaglobulin level and Frossman antibody titer ($1+\log_e$) was highly significant ($P < 0\ 01$) Serum gammaglobulin level was not significantly associated with any other immune response trait Frossman antibody titer to SRBC had highly significant ($P \leq 0\ 01$) correlation with antibody titer to BRBC immunisation at first week (r 0 358) second week (r 0 384) and at third week (r 0 358) Frossman antibody titer to SRBC was not found to have significant correlation with other immune response traits Correlations among the antibody titer to BRBC at first week, second week and third week were highly significant ($P \leq 0\ 01$) Correlation between first and second week antibody titer to BRBC was 0 931 first and third week antibody titer to BRBC was 0 866 and between second and third week antibody titer to BRBC was 0 871

Table 4 29 Correlation between immune response traits

		1	2	3	4	5		7	8	9	10	11	12
Gammaglobulin level	(1)	1											
Frossman antibody to SRBC	(2)	0 274**	1										
I week	(3)	0 110	0 358**	1									
II week	(4)	0 113	0 384**	0 931**	1								
III week	(5)	0 121	0 358**	0 8 **	0 871**	1							
Skin thickness	(6)	0 057	0 128	0 1330	0 139	0 089	1						
Cutaneous response to PHA M at 24 hrs	(7)	0 055	0 041	0 115	-0.033	0 070	-0 337**	1					
48 hours	(8)	0 025	0 125	0 007	0 085	0 1 2	-0 348*	0 879	1				
72 hours	(9)	-0 040	0 079	0 101	-0.035	0 054	-0 511*	0 743*	0 779**	1			
Contact sensitivity to DNCB 24 hours	(10)	0 001	0 057	0 033	0 045	0 078	0 138	0 25 **	0 20 *	0 122	1		
48 hours	(11)	0 081	0 055	0 087	0 041	0 0 8	0 089	0.23 *	-0 111	0 187	0 433**	1	
72 hours	(12)	0 029	0 050	0 035	0 031	0 007	0 142	0 1 9	0 197*	0 152	0 472 *	0 505**	1

* Significant at 5% level ** Significant at 1% level

Table 4 30 Correlation between immune response traits adult body weight, litter weight at birth, litter weight at weaning and preweaning mortality

Immune response trait	Correlations			
	Adult body weight	Litter weight at birth	Litter weight at weaning	Preweaning mortality
Gammaglobulin level	0 193	0.241* (P = 0 016)	0 561** (P = 0 000)	0 430** (P = 0 000)
Frossman antibody to SRBC	0 167	0 110	0 174	0 086
Antibody titer to BRBC at I week	0 244* (P 0 015)	0 038	0 117	0 021
Antibody titer to BRBC at II week	0 224* (P = 0 026)	0 010	0 056	0 009
Antibody titer to BRBC at III week	0 216* (P = 0 032)	-0 003	0 130	0 041
Skin thickness	0 119	-0 008	0 006	0 029
Cutaneous response to PHA at 24 hours	0 030	-0 178	0 132	0 055
Cutaneous response to PHA at 48 hours	0 017	0 165	0 122	0 077
Cutaneous response to PHA at 72 hours	0 0>5	-0 193	0 074	0 007
Contact sensitivity to DNCB at 24 hours	-0 037	0 072	0 061	0.217* (P = 0 030)
Contact sensitivity to DNCB at 48 hours	0 017	0 262** (P 0 009)	0 178	0 049
Contact sensitivity to DNCB at 7? hours	0 056	0 151	0 107	0 07?

* Significant at 5% level ** Significant at 1% level

The correlations between preinjection skin thickness and PHA response at 24 48 and 72 hours post was negative and highly significant (P ≤ 0 01) The correlation between skin thickness and PHA response at 24 hours was ( ) 0 377 between skin thickness and PHA response at 48 hours was ( ) 0 348 and at 72 hours was ( ) 0 511 The correlation among PHA responses at 24 48 and 72 hours was highly significant (P ≤ 0 01) The correlation between 24 hour PHA response and 48 hour PHA response was 0 819 The correlation between PHA response at 24 hours and 72 hours was 0 743 and correlation between 48 and 72 hours was 0 779

PHA response at 24 hours was significantly (P ≤ 0 05) correlated with contact sensitivity at 24 hours (r = 0 256) Contact sensitivity at 24 hours was significantly (P ≤ 0 05) correlated with PHA response at 48 hours (r 0 206)

Contact sensitivity at 48 hours was significantly (P ≤ 0 05) correlated with PHA response at 24 hours (r = 0 236) and contact sensitivity at 72 hours was significantly (P ≤ 0 05) correlated with PHA response at 48 hours (r = 0 197)

Correlations among contact sensitivity at 24 48 and 72 hours post challenge were highly significant ($P \leq 0.01$) Contact sensitivity at 24 hours had a correlation of 0.433 with contact sensitivity at 48 hours Correlation between contact sensitivity at 24 hours and 72 hours was 0.472 The correlation between contact sensitivity at 48 hours with 72 hours was 0.565

Discussion

DISCUSSION

The effect of humid tropical stress on the performance reproduction and survival of the two temperate breeds viz Newzealand White and Soviet Chinchilla appears to be substantial The average adult body weights of the breeds observed in the present study were much below the reported adult body weights of 3 5 to 5 0 kg for the above breeds Litter size at birth litter size at weaning and pre weaning survivability were much below the optimum reported performance for the two breeds under temperate climate (Lebas 1983 Mukundan *et al* 1986) The high endemicity of rabbit diseases like mange coccidiosis along with the suboptimal performance of the broiler rabbit breeds might be a direct contribution of tropical stresses including the thermal stress and high prevalence of diseases It would be pertinent to point out that any type of stress especially thermal stress leads to immunosuppression lowered immune responsiveness and high endemicity of diseases and suboptimal performance (Keller *et al.* 1983 Leitner *et al* 1992) The following parts of this discussion critically analyses the genetics of five immune traits viz serum gamma globulin status Frossman antibody titre to SRBC antibody response to BRBC cutaneous response to phytomitogen PHA M and contact sensitivity to DNCB along with their association with adult body weights litter traits neonatal survivability and the incidence of diseases and adult mortality

5 1 Serum gammaglobulin level

5 1 1 Gammaglobulin status

Zinc sulphate turbidity test is simple with a possibility of simultaneous handling of several samples with minimum loss of accuracy in a short time Mc Beath *et al.* (1971) showed that the correlation between zinc sulphate turbidity test results and single radial immunodiffusion test is very high (r 0 99) indicating that this test provides accuracy and reliability in addition to being simple rapid and economical Fisher and Martinez (1976) and Caldow *et al* (1988) also reported that Zinc sulphate turbidity test provided a near perfect estimate of serum gammaglobulin level

Range in serum gammaglobulin was from 9 13 to 84 70 mg/ml with a mean value of 28 59 mg/ml among broiler rabbits As early as 1958 Allen and Watson found that 20 to 38 per cent of serum proteins in rabbits were gamma globulins based on a study of small number of laboratory rabbits Present results are also in agreement with the reports of Kozma *et al* (1967) and Kaneko and Cornelius (1970) who found that total serum protein values ranged between 4 3 to 7 3 g/100 ml and gammaglobulins constitute 16 6+6 8 per cent of serum protein in rabbits and the above studies were also based on a small number of laboratory rabbits The results of the present study using comparative large number of animals concurs with above reports

5 1 2 Effect of breed and sex

Results indicate that Soviet Chinchilla breed of rabbits was found to have a significantly ($P = 0.048$) higher serum gammaglobulin level (29.51 +2.99 mg/ml) compared to Newzealand White breed (27.25 +2.94 mg/ml). This is in contrast to the reports of Allen and Watson (1958) who could find no significant effect of breed on serum gammaglobulin level in laboratory rabbits. Perhaps it may be due to small number of animals used in the study. Effect of breed was found to be significant on serum gammaglobulin level in cattle (Muggli *et al.* 1987), sheep (Halliday *et al.* 1968) and goats (Nandakumar *et al.* 1991).

Effect of sex was not found to be significant on the serum gammaglobulin level in broiler rabbits. Though conducted on a limited number of laboratory rabbits, Allen and Watson (1958) also could not find any significant effect of sex on serum gammaglobulin level. This view is further supported by the findings of Muggli *et al.* (1987) who reported that sex had no effect on serum gammaglobulin level of calves.

5 1 3 Sire effects and heritability

Effect of sires within breeds was not found to be significant on the serum gammaglobulin level in broiler rabbits. Observations of Jensen and Christensen (1976) and Raja and Balakrishnan (1980) in cattle fully endorse this finding. Raja *et al.* (1986) showed that effect of sire was not significant on serum gammaglobulin level in goats.

Heritability estimate of 0 1259+0 073 obtained in the present study is in close proximity with the heritability estimates of 0 12 reported for serum gammaglobulin level in cattle (Jensen and Christensen, 1975) The results are suggestive of a low to medium heritability for serum gammaglobulin level

5 1 4 Effect on body weight and litter traits

Adult body weight was not found to have any significant effect on serum gammaglobulin level and the correlation between these two traits was not significant This observation is in agreement with the finding of Caldow *et al* (1988) who could find no significant relationship between IgG and overall live weight in cattle It is apparent that serum gammaglobulin level is unlikely to have any significant correlation with adult body weight in the normal gammaglobulin range Hypogammaglobulinaemic or agammaglobulinaemic animals would have either failed to reach normal adulthood or would have been culled due to chronic diseases and unthriftness

Serum gammaglobulin level in rabbit does was highly significant (P 0 004) on litter size at weaning The does with high serum gammaglobulin level were found to wean more kits When the litter size at weaning was 0 the serum gammaglobulin level averaged 13 838 mg/ml in the dams When the litter size at weaning was 7 the mean serum gammaglobulin level of dam was 60 7542 mg/ml At this point it would be interesting to note that correlation between

serum gammaglobulin in the doe and the preweaning mortality of litter were highly significant ($P < 0.001$) and negative ($r = -0.430$). Piecing together these two information it could be construed that higher serum gammaglobulin level in the doe reduces the preweaning mortality of the litter augmenting the litter size at weaning. The serum gammagloublins of the doe are transmitted passively to the rabbit kits in utero itself and that too in the second half of pregnancy with the serum titer of neonate approximating that of the rabbit doe (Brambel *et al* 1948; Brambel 1970). Aitken (1964) also reported that titer of Frossman haemolysin in neonatal serum equalled that of maternal serum. Thus rabbit kits of dams with high serum gammaglobulin level appears to receive sufficient quantities of gammaglobulin in utero itself. Since a neonatal rabbit kit is incapable of mounting an immune response effectively those rabbit kits which are hypogammaglobulinaemic succumbs to neonatal infections which might lead to a high preweaning mortality. It has been well documented that defective transfer of passive immunity and neonatal hypogammaglobulinaemia is associated with heavy neonatal infections and preweamng mortality in cattle (Fisher *et al* 1976) sheep (Ciupercescu *et al* 1977) and goats (Nandakumar and Raja 1986). Though such reports are not available from broiler rabbits it is only logical to assume that neonatal mortality in rabbit kits should be associated with hypogammaglobulinaemia from the above observations.

Litter weight at birth had a significant (≤ 0 016) correlation (r 0 244) with maternal serum gammaglobulin level The correlation of 0 561 between maternal serum gammaglobulin level and litter weight at weaning was highly significant (P ≤ 0 01) A high maternal serum gammaglobulin might have provided better health viability and growth to the developing foetuses since passive transmission of immunity to foetuses was reported to occur *in utero* in the second half of gestation itself in rabbits (Brambel *et al* 1948 Brambel 1970) and those dams having higher serum gammaglobulins in their sera might transmit more gammaglobulins to their foetuses This better passive immune status of the new born kits might offer them with better disease resistance viability and growth leading to a significantly higher litter weight at weaning The studies from cattle (Halliday *et al.* 1976) and sheep (Ciupercesu *et al.* 1977) indicated a strong and highly significant positive correlation between serum gammaglobulin level and growth rate upto weaning in neonates

The above research findings offer promising possibility of utilisation of maternal serum gammagloublin level as an indirect indicator of high litter size at weaning low preweaning mortality and high litter weights at birth and at weaning

5 1 5 Effect on diseases and mortality

Serum gammaglobulin level was not found to be significantly associated with the incidence of mange and adult mortality However incidence of

coccidiosis was found to be significantly (P 0 044) associated with serum gammaglobulin level Those rabbits having coccidial oocyst output had a higher serum gammaglobulin level

5 2 Humoral immune responses

5 2 1 Frossman antibody titer to SRBC

5 2 1 1 Fross antibody titer status

Though there are reports on the presence of Frossman s haemolysins in the sera of adult rabbits (Aitken 1964) no systematic approaches have been made to investigate on the status mode of inheritance and association with economic traits or diseases The present investigation could confirm the presence of Frossman s antibodies to SRBC in the sera of all adult broiler rabbits The titer ($1+\log_e$) ranged from 1 693 to 5 159 with a mean of 2 776 Aitken (1964) also described the presence of Frossman s haemolysins to SRBC in the sera of all adult rabbits

5 2 1 2 Effect of breed and sex

Effect of breed and sex was not found to be significant on the Frossman antibody titer The mean titer in Newzealand White was 2 825 and in Soviet Chinchilla it was 2 707 Though not significant bucks had a higher titer compared to does This appears to be the first approach towards resolving the effect of breed and sex on this trait in broiler rabbits as no similar reports were available

5 2 1 3 Effect of sire and heritability

The effect of sires were not found to be significant on this trait and the heritability estimate approached 0 360±0 248

4 2 1 4 Effect on growth and litter traits

It was found that Frossman antibody titer had no significant effect on adult body weight litter size at birth or litter size at weaning Similarly the correlation between Frossman antibody titer litter weight at birth and litter weight at weaning were not significant This study thus revealed that Frossman antibody titer to SRBC among broiler rabbits did not have any significant influence on adult body weight litter size at birth litter size at weaning preweaning mortality litter weight at birth and litter weight at weaning

5 2 1 5 Effects on diseases and mortality

The Frossman antibody titer ($1+\log_e$) was not found to exert significant influence on the incidence of diseases like coccidiosis and mange and in adult mortality

The obscure nature of the Frossman antibody titer to SRBC the antigenic sources and mechanisms which lead to the formation of such natural antibodies against unrelated antigens without immunisation require further elucidation before any further research approaches are to be undertaken in this line The

antigenic sources which elicit antibody formation or the antibody molecules themselves at present appear not to be influenced by breed sex sire nor have any significant associations with litter traits disease resistance traits adult mortality

5 2 2 Humoral immune responses to Bovine red blood cells (BRBC)

5 2 2 1 Antibody response to BRBC

Naturally occurring antibodies to bovine red blood cells (BRBC) could not be detected in adult rabbit as against the presence of Frossman antibodies to SRBC This was evident from 0 titer to BRBC in preimmunised rabbit sera The higher antibody titer ($1+\log_e$) was observed at first week post immunisation This titer began to decline gradually towards second week and was the lowest at third week.

The mean antibody titer at first, second and third week, post immunisation were 4 594 4 425 and 4 111 respectively The magnitude of antibody titer ($1+\log_e$) closely agrees with the antibody titer obtained in calves against human red blood cells (Burton *et al* 1989a) following primary immunisation Pinard *et al* (1992) could also get a peak primary antibody response ($1+\log_e$) of 4 73 in chicken against SRBC

As in the present study the highest antibody titer was obtained on the 7th day following primary immunisation in chicken with SRBC (Vander Zijpp and Laenstra, 1983) Burton *et al* (1989a) also observed that the peak antibody titer

against human red blood cell was at day seven of post immunisation The decreasing trend in antibody titer from second week onwards was evident here also Thus broiler rabbit sera appears to have no naturally occurring antibodies against BRBC and the highest antibody titer to BRBC was found to be at seven days following primary immunisation The trend in antibody response to BRBC in broiler rabbit is in full agreement with the trend observed in young calves to immunisation with human red blood cells (Burton *et al.* 1989a) and in chicken to SRBC (Pinard *et al* 1992)

4 2 2 2 Effect of breed and sex

The effect of breed and sex was not found to be significant on the antibody response to BRBC during the first second and third week following primary immunisation in broiler rabbits In general the effect of breed was reported to be significant on the humoral responses to SRBC in poultry (Vander Zijpp 1978 Lamont and Smith 1984a Ubozzi *et al.* 1985) and humoral immune response to specific antigens in cattle (Banyard and Morris 1980) and the antibody responses to different antigens in pigs (Rothschild *et al* 1984 Buschman 1986) Peleg *et al.* (1985) reported a considerable within breed variation in antibody responses to antigens in poultry However the present study is in agreement with the report of Muggli *et al* (1987) who could find no significant effect of breed on the antibody response to infectious bovine rhinotracheitis virus. The absence of significant breed differences in the antibody

responses to BRBC among broiler rabbit breeds is worth speculating The absence of significant breed differences may simply be dismissed as a species specific phenomena or a result specific to this study only with similar results demonstrated by Muggli *et al* (1987) This can also be attributed to the considerable within breed variation in humoral response to BRBC which overlaps the breed effects as discussed by Peleg *et al* (1985) The population structure of the rabbit colonies of two breeds which was developed from only a few rabbits especially Soviet Chinchilla colony use might also have reduced the breed effects in present study It is to be elucidated whether the humid tropical stress might have had an immunosuppressant effect so that finer resolutions in immune response characteristic of the breed were not fully expressed

The effect of sex was not found to be significant among broiler rabbits in the antibody response to BRBC This finding is in full agreement with Nguyen (1983) who could find no significant effect of sex on the antibody response to chicken erythrocytes in sheep Research results from poultry also indicate that sex of the bird had no significant effect on the humoral responses to SRBC (McCorkle and Glick, 1980 Vander Zijpp *et al.* 1986) But this view is contradicted by Leitner *et al* (1989) who could find a significant effect of sex on the response to SRBC in chicken and have attributed the female superiority in survival due to this heightened immune response in females They point out that difference in antibody response between male and female could be resolved by

them using ELISA, as against common haemolytic and agglutination techniques used by others However that appears to be the only report which have attributed the effect of sex of the bird on the humoral immune responses as significant

5 2 2 3 Sire effects and heritability

The effect of sires was found to be highly significant on the antibody response to BRBC in Newzealand White breed during the first second and third weeks following primary immunisation However in Soviet Chinchilla the effect of sires was found to be significant only on the antibody response at second week post immunisation and reached near significance during third week after immunisation The significant effect of sire on the antibody response fully agrees with the finding of Nguyen (1983) who could observe that the effect of sire was significant on antibody responses to chicken RBC in sheep Lie *et al.* (1983) and Burton *et al* (1989a) also could observe that effect of sire was significant on the antibody responses in cattle Thus the highly significant effect of sires on antibody response in Newzealand White and the significant effect of sire during second and third weeks post immunisation in Soviet Chinchilla once again uphold the view of Biozzi *et al* (1975) that mammalian immune responses to complex immunogens such as SRBC were polygenic in inheritance This further strengthens the opinion of Buschman (1980) that antibody responses could be modified by selective breeding and views of Ferriera *et al.* (1986) that antibody responses were controlled by additive effect of several independent loci

Heritability estimates of antibody responses to BRBC during first second and third week post primary immunisation were 0 922 0 637 0 940±0 712 and 0 907+0 732 respectively In general heritability estimates reported for antibody responses were high and agrees with the present result Nguyen (1983) found a heritability estimate of 0 83 for peak antibody responses in sheep to chicken erythrocytes From these high heritability estimates it appears that strong genetic control exists for the clonal expression of committed B cells contributed partly by macrophage activity and antigen restriction

5 2 2 4 Effect on body weight and litter traits

The effect of body weight classes was not found to be significant on the antibody responses at first second and third week post immunisation However the correlations between adult body weight and antibody responses during first second and third week following primary immunisation to BRBC were negative and significant Thus it appears that an increase in body weight in adult rabbits is associated with a reduced antibody response to BRBC This result concurs with the views of Vander Zijpp (1983) and Meeker *et al* (1987) who could find a negative association between adult body weight and antibody responses in chicken and pigs respectively

The effect antibody response to BRBC during first second and third week following primary immunisation with BRBC was not found to be significant on

the litter size at birth and litter size at weaning Similarly there existed no significant correlation between antibody titres during first second and third week post immunisation with litter weight at birth litter weight at weaning and preweaning mortality This finding is thus in agreement with the reports of Muggli *et al* (1987) who found no correlations between antibody responses and growth traits in beef cattle Leitner *et al* (1992) and Kean *et al.* (1994a) found no associations between immune response traits age at first egg 32 weeks egg production and rate of egg production in chicken

5 2 2 5 Association with diseases and mortality

The effect of antibody responses on first second and third week following primary immunisation with BRBC was not found to be significant on the incidence of mange coccidiosis and adult mortality in rabbits Studies in poultry have confirmed the highly significant association between several diseases and antibody responses to complex antigens (Gross *et al.* 1980 Leitner *et al* 1992) But those diseases were not the types encountered in adult broiler rabbits as coccidiosis and mange

5 3 Cell mediated immune responses

5 3 1 Cutaneous response to phytomitogen, PHA M

5 3 1 1 Cutaneous response status

The T lymphocyte response has been evaluated by intradermal injection of mitogens like PHA M Thus is believed to provoke a delayed type

hypersensitivity reaction without the need for prior sensitization by polyclonal stimulation of lymphocytes

There is a paucity of information on the cutaneous cell mediated immune response status among broiler rabbits The mean preinjection skin thickness was 2 185 0 043 mm The increase in skin thickness averaged 2 259 mm at 24 hours 1 544 mm at 48 hours and 0 778 mm at 72 hours The highest increase in skin thickness was seen at 24 hours post injection which began to decline thereafter This observation is in agreement with the finding of Wilkie *et al* (1991) They reported that intradermal injection of PHA M provoked a delayed type hypersensitivity reaction without prior sensitization by polyclonal stimulation of lymphocytes

5 3 1 2 Effect of breed and sex

Effect of breed was not significant on skin thickness or cutaneous response to intradermal injection of PHA M at 24 48 and 72 hours post injection The effect of sex was found to be significant on initial skin thickness PHA response at 24 48 and 72 hours post injection The mean preinjection skin thickness in bucks was 2 524 mm and 2 520 mm in Newzealand White and Soviet Chinchilla respectively while in does it was 1 968 and 2 048 mm respectively This showed that preinjection skin thickness was higher in males compared to females The PHA response at 24 48 and 72 hours post injection was highest in does with a

mean of 2 362 1 672 and 0 980 mm respectively in Newzealand White and 2 259 1 620 and 0 780 mm respectively in Soviet Chinchilla breeds Bucks of Newzealand White had 1 952 1 310 and 0 548 mm skin thickness respectively at 24 48 and 72 hours post injection Soviet Chinchilla bucks had 2 143 1476 and 0 655 mm skin thickness respectively at 24 48 and 72 hours post injection of PHA M

Previous reports on the CMI response to PHA M indicate that there existed a significant effect of breed on the PHA response in chicken (Lamont and Smith 1984) and in pigs (Buschman 1980) The present observation on the non significant effect of breed on CMI responses as assessed by PHA response is contrary to the above reports

The significant higher PHA response of does over the bucks is in full agreement with the reports of Cheng and Lamount (1988) and Leitner *et al* (1989) from poultry They could also find a female dominance in the cell mediated immunity to intradermal PHA M injection and they have concluded that this female superiority might explain the higher survival and longevity of females

5 3 1 3 Sire effects and heritability

Effect of sires within breed was significant in the CMI to intradermal injection of PHA M in broiler rabbits The effect of sire on the pre injection skin

thickness was not significant Effect of sire on PHA response at 24 and 72 hours was highly significant and the level of significance approached 5 per cent at 48 hours post injection in Newzealand White However in Soviet Chinchilla effect of sires on the PHA response at 24 48 and 72 hours post injection was not found to be significant The effect of sire on the T lymphocyte dependant immune responses in mice were reported to be significant (Stiffel *et al* 1977) Lie *et al* (1983) has also arrived at similar conclusions in cattle The present observation on the significant effect of sire in Newzealand White is in full agreement with the results of above studies The non significant effect of sires on the PHA responses in Soviet Chinchilla is baffling This further is indicative of the genetic structure of the colony of Soviet Chinchilla rabbits used in the present study The present colony was raised from every few ancestors which might have resulted in narrowing down of the genetic base of the colony with little variability between animals resulting in non significant effects due to sires as in the case of results obtained for antibody response to BRBC

Heritability estimates of pre injection thickness PHA response at 24 48 and 72 hours post injection were 0 764+0 426 0 860 0 623 0 670+0 404 and 0 637+0 308 respectively Stiffel *et al.* (1977) obtained a heritability estimate of 0 28 while Cheng *et al.* (1991) could find a heritability of 0 06 0 07 for PHA responses in mice and chicken respectively In the present study the heritability estimate of the peak PHA responses was the highest demonstrating the effect of a genetic component on the PHA responses in broiler rabbits

5 3 1 4. Effect on body weight and litter traits

The pre injection skin thickness was found to be highly significant on the litter size at birth and litter size at weaning A reduced preinjection thickness was associated with high litter size at birth and low litter size at weaning This association is worth detailed investigation

PHA responses at 24 48 and 72 hours post intradermal injection of PHA M were not found to be associated with adult body weight litter size at birth and at weaning pre weaning mortality litter weight at birth and litter weight at weaning

5.3 1 5 Effects on diseases and mortality

Preinjection skin thickness or PHA responses at 24 and 72 hours post injection had no significant effect on the natural occurrence of mange coccidiosis or adult mortality However, the cell mediated immune response to intradermal injection of PHA M at 48 hours was found to have a significant effect on the natural incidence of mange Rabbits which contracted mange had a lower PHA response at 48 hours post injection than non-infested rabbits

Results of this study possibly point out to the feasibility of utilising dermal response to intradermal injection of PHA M at 48 hours as a marker trait in selecting rabbits for resistance to mange Rabbits with prolonged or persistent

response to PHA-M were found to have mange resistance in this study indicating that PHA response at 48 hours injection apparently appears to be a better marker than PHA response at 24 hours or peak PHA response In a similar study in dogs Wilkie *et al.* (1979) found a deficient cutaneous response to PHA P in healthy puppies from a kennel with a high prevalence of demodectic mange This is suggestive of cell mediated immune response playing a significant role in conferring mange resistance Coccidiosis resistant phenotype in chicken and mice have been attributed to lymphocyte response and CD4+ T helper cells are reported to play a major role in initiation and expression of coccidiosis resistance (Rose *et al* 1990 Wakelin 1989) Though not significant a strong trend is observed in the present study on the association between PHA responses and coccidiosis

5 3 2 Contact sensitivity to 2,4,Dinitrochlorobenzene

5.3 2 1 Contact sensitivity status

The immune response to contact allergens such as DNCB resulted from a type IV or delayed type hypersensitivity reaction (DTH) following percutaneous absorption of the hapten in sensitized individuals Sensitization with DNCB has been widely used to assess the function of human (Friedman *et al* 1983) and canine (Wilkie *et al* 1979) cell mediated immune response

The contact sensitivity to DNCB averaged 3 585 1 796 and 1 085 mm respectively at 24 48 and 72 hours post challenge The highest contact sensitivity

was recorded at 24 hours post challenge Wilkie (1991) also recorded maximum skin thickness at 24 hours of challenge by percutaneous application of DNCB in dogs Contact sensitivity to DNCB in the present study began to drop after 24 hours post challenge The lowest value was observed at 72 hours

5 3 2 2 Effect of breed and sex

The effect of breed and sex was not found to be significant on contact sensitivity to DNCB at 24 48 and 72 hours post challenge Reports on the effect of breed and sex on contact sensitivity to DNCB are scanty Several reports have attributed the significant effect of breed and sex on cell mediated immune responses to mitogens like PHA M, and basic differences have been reported between DTH reactions to mitogen like PHA M and contact sensitivity to DNCB challenge (Wilkie *et al.* 1991) The mechanisms involved in operation of PHA response and contact sensitivity cause marked differences in the reaction even in the same animal for these two responses Contact sensitivity operates via Langerhan s cells and affects the presensitised lymphocytes

5 3 2 3 Sire effects and heritability

Effect of sires within breeds was not found to be significant on the contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge in Newzealand White and at 24 and 72 hours post challenge in Soviet Chinchilla But the contact sensitivity to DNCB challenge at 48 hours post challenge was found to be highly significant in Soviet Chinchilla

Nonsignificant effect of sire on contact sensitivity may be attributed to the genetic mechanism involved in the development of contact sensitivity or it might be species or colony effect

Heritability estimates of contact sensitivity to DNCB at 24 48 and 72 hours post-challenge were 0 382+0 204 0 549 0 318 and 0 304±0 282 respectively The heritability estimates for cell mediated immune responses to intradermal injection of PHA M in mice has been reported to be 0 28 by Stiffel *et al* (1977)

5 3 2 4 Effect on body weight and litter traits

Body weight was found to have no effect on contact sensitivity to DNCB challenge at 24 48 and 72 hours Litter size at birth or litter size at weaning were also not found to be influenced by contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge

Contact sensitivity of the dam at 24 hours post challenge was found to be significantly associated with an increased preweaning mortality of kits Litter weight at birth was also found to be highly correlated with the contact sensitivity to DNCB challenge at 48 hours Results indicate that a higher cell mediated immune response of the doe as measured by contact sensitivity to DNCB challenge reduces the preweaning viability and increases litter weight of

neonates Dams with a persistent contact sensitivity reaction appeared to have a higher litter weight at birth

5 3 2 5 Effect on diseases and mortality

The effect of contact sensitivity to DNCB challenge at 24 48 and 72 hours post challenge had no significant effect on the incidence of coccidiosis or adult mortality among broiler rabbits The contact sensitivity to DNCB at 24 hours post challenge had a significant effect on mange infestation Non infested rabbits had a mean higher skin thickness compared to infested rabbits at 24 hours post challenge The effect of contact sensitivity to DNCB at 48 hours post challenge was also near significant on the incidence of mange The association between contact sensitivity and diseases appears to be related to the nature and actiology of disease Reduced contact sensitivity to DNCB was highly associated with several neoplasia (Brown *et al* 1967) Jhones disease (Paliwal *et al* 1984) and atopic dermatitis in dogs (Wilkie *et al* 1991) No associations were reported between DNCB skin sensitivity diarrhoea and pneumonia in young calve (Burton *et al* 1989b) The present results fully agree with the findings of Wilkie *et al* (1979) on the higher incidence of demodectic mange in dogs with a lowered CMI response to PHA M This result might be exploited on the development of rabbit strains which are more resistant to mange

Though coccidiosis resistance has been attributed to lymphocyte responses in chicken (Rose *et al.* 1990) and CD4+ T helper cells are reported to play a major role in the initiation and expression of resistance (Wakelin, 1991) no significant association could be observed between naturally occurring coccidiosis in rabbits and contact sensitivity to DNCB challenge Further investigations on the coccidial species, species and host defenses are required before a final conclusion on coccidiosis resistant phenotype in rabbit is to be established

5.4. Correlation between immune response traits

Serum gammaglobulin level was found to have a highly significant positive correlation of 0 274 with Frossman antibody titer to SRBC Correlation between serum gammaglobulin level, antibody response to BRBC and cell mediated responses were not significant Biozzi *et al* (1975) could establish highly significant positive correlations between total immunoglobulin level and antibody response to SRBC in mice Muggli *et al.* (1987) could also establish a correlation between antibody responses and total IgG_1 level in calves The significant correlation between total gammaglobulin level and the Frossman antibody titer to SRBC thus is in full agreement with the above observations As against the reports of Biozzi *et al* (1975) and Muggh *et al.* (1987) no significant correlation could be observed between total gammaglobulin level and antibody response to BRBC in broiler rabbits But it is relevant to note that Frossman antibody titer to SRBC had highly significant positive correlation with antibody

response to BRBC at first second and third week post immunisation It is also pertinent to point out again that correlations between gammaglobulin level and Frossman antibody were significant This again leads to the conclusions of Biozzi *et al* (1975) Halliday and Williams (1980) also reported a similar phenomenon of high antibody response in cows with high serum gammaglobulin level These background information lead to an assumption that higher serum gammaglobulin levels are associated with increased antibody responses to specific antigens and might explain the high incidence of diseases and even neoplasia associated with low serum gammaglobulin level in animals (Jacobs *et al* 1980) These relationships might possibly explain the high preweaning survivability of kits of does with high serum gammaglobulin level

The present study revealed highly significant correlations between antibody responses to BRBC at first, second and third week post immunisation This correlations were as expected since the mechanisms controlling antibody synthesis to BRBC are the same during first second and third week. All other correlations between antibody responses to BRBC with other immune traits like PHA response and contact sensitivity to DNCB was not significant Correlation between antibody response to BRBC during first week with PHA responses at 24 48 and 72 hours were negative though not significant Similarly antibody response to BRBC during second week was also negatively correlated with PHA responses at 24 and 72 hours though not significant These observations fully concur with

response to BRBC at first second and third week post immunisation It is also pertinent to point out again that correlations between gammaglobulin level and Frossman antibody were significant This again leads to the conclusions of Biozzi *et al* (1975) Halliday and Williams (1980) also reported a similar phenomenon of high antibody response in cows with high serum gammaglobulin level These background information lead to an assumption that higher serum gammaglobulin levels are associated with increased antibody responses to specific antigens and might explain the high incidence of diseases and even neoplasia associated with low serum gammaglobulin level in animals (Jacobs *et al* 1980) These relationships might possibly explain the high preweaning survivability of kits of does with high serum gammaglobulin level

The present study revealed highly significant correlations between antibody responses to BRBC at first second and third week post immunisation This correlations were as expected since the mechanisms controlling antibody synthesis to BRBC are the same during first second and third week All other correlations between antibody responses to BRBC with other immune traits like PHA response and contact sensitivity to DNCB was not significant Correlation between antibody response to BRBC during first week with PHA responses at 24 48 and 72 hours were negative though not significant Similarly antibody response to BRBC during second week was also negatively correlated with PHA responses at 24 and 72 hours though not significant These observations fully concur with

the views of Biozzi *et al* (1975) who could find no associations between immune response to SRBC and T cell response to PHA The findings of Mouton *et al* (1988) and Cheng *et al* (1991) strongly suggest that antibody responses to antigens and cell mediated immunity might be negatively associated and faster antigen catabolism by the macrophages might lead to a lowered antibody responses in low responder lines

The correlations between skin thickness and PHA responses at 24 48 and 72 hours were found to be highly significant and negative The exact reasons for this association is not clear Does had a highly significant and lower preinjection skin thickness compared to bucks in the study It is further interesting to note that present study and several other reports indicate a higher cell mediated immunity in females This observations are suggestive of a sex related mode of inheritance for both these traits with males having an increased skin thickness while females are endowed with an increased CMI The negative correlation between the preinjection skin thickness and CMI might partly explain the effect of skin thickness on litter size at birth and litter size at weaning As expected the correlations between PHA responses at 24 48 and 72 hours were highly significant since the mechanisms responsible for the responses at 24 48 and 72 hours remain the same Similarly the PHA response at 24 and 48 hours were significantly correlated with the contact sensitivity to DNCB at 24 48 and 72 hours The correlation between PHA response at 72 hours with contact sensitivity

was not significant The correlations between PHA response and contact sensitivity to DNCB indicate that both these responses are T cell immunity indices The absence of significant correlation between PHA response at 72 hours is suggestive of decline in PHA response which has been nearly tapered to preinjection skin thickness by 72 hours Though both PHA responses and contact sensitivity to DNCB are indices of cell mediated immunity there exist obvious differences between the DTH to PHA M and contact sensitivity to DNCB and these differences possibly explain the differences obtained in this study between the two responses

Summary

SUMMARY

Immune responsiveness has been suggested as one of the best indicators of disease resistance and indirect selection for disease resistance has been proposed as the most viable approach With this back ground a detailed research analysis on the genetics of immune responses and their associations with the incidence of diseases mortality litter traits and growth among broiler rabbits of Soviet Chinchilla and Newzealand white breed were attempted Immune traits assessed were serum gammaglobulin (SG) level Frossman antibody titer to SRBC antibody responses to BRBC delayed type hypersensitivity (DTH) reactions to phytomitogen PHA M and contact sensitivity to DNCB challenge

SG level among broiler rabbits ranged between 9 13 and 84 70 mg/ml Mean SG level of 29 51 mg/ml among Soviet Chinchilla was significantly higher (P 0 048) than Newzealand Whites with a mean of 27 25 mg/ml The differences in SG level among males and females were not significant Sires within breed exerted no significant effect on SG level Heritability was estimated to be 0 1259

Association between adult body weight and SG level was not significant SG level had no significant effect on litter size at birth But the association between SG level and litter size at weaning was highly significant (P 0 004)

the negative correlation of ( )0 430 of maternal SG level with pre weaning mortality was highly significant Maternal SG level was significantly correlated with litter weight at birth The correlation of maternal SG level with litter weight at weaning (P = 0 561) was highly significant Associations between SG level among broiler rabbits with the incidence of mange and adult mortality was not significant However an increase in SG level was significantly (P = 0 0440) associated with the incidence of naturally occurring coccidiosis

This study could confirm the presence of Frossman antibody to SRBC in adult rabbit sera The titre ($1+\log_e$) ranged from 1 693 to 5 159 with a mean of 2 776 Frossman antibody titer in adult rabbits was not influenced by breed or sex Sire effect was not significant in this trait and the estimated heritability was 0 360 Adult body weight or litter traits among broiler rabbits were not significantly affected by Frossman antibody titer to SRBC Correlation of maternal Frossman antibody titer with litter weights at birth and at weaning or pre weaning mortality was not significant Adult mortality incidence of coccidiosis or mange were not influenced by the Frossman antibody titer

Absence of naturally occurring antibodies to BRBC among adult broiler rabbits was established in this study as evidenced by pre immunisation titer of zero to BRBC in all the rabbits tested Antibody titers to BRBC ($1+\log_e$) were 4 594 4 425 and 4 111 respectively during the first second and third week post

immunisation Maximum antibody response was at first week which began to decline gradually Antibody response to BRBC during the first second and third week post immunisation were not influenced by breed and sex among rabbits under this study Antibody responses to BRBC during the first second and third week among Newzealand White rabbits had a highly significant influence of sire Among Soviet Chinchilla rabbits antibody response to BRBC was not found to be influenced by sires during first and third week though the effect of sire was significant at second week post immunisation The highly significant correlations of ( ) 0 244 ( )0 224 and ( ) 0 216 respectively between the antibody responses during first, second and third week with the adult body weights are suggestive of lowered humoral immune responses associated with increased body weight

No significant associations could be observed between antibody responses to BRBC and litter traits among broiler rabbits Antibody response to BRBC was not found to be significantly associated with the incidence of coccidiosis mange and adult mortality

Pre injection skin thickness averaged 2 140 mm in Newzealand White and 2 224 mm among Soviet Chinchilla rabbits PHA responses at 24 48 and 72 hours post injection averaged 2 259 1 544 and 0 778 mm respectively Breed had no significant effect on the skin thickness or on the PHA responses at 24 48 and 72 hours among broiler rabbits Males had a significantly higher pre injection

skin thickness PHA responses at 24 48 and 72 hours post injection were significantly higher in females demonstrating a female superiority for the DTH responses to PHA M Sire effect on the pre injection skin thickness was not significant Effect of sires within breed on PHA responses was highly significant at 24 and 72 hours and approached near significant levels at 48 hours in Newzealand White rabbits Among Soviet Chinchilla the sire effects on PHA responses at 24 48 and 72 hours were not significant Pre injection skin thickness and PHA responses at 24 48 and 72 hours post injection had heritability estimates of 0 7637 0 8600 0 6700 and 0 6370 respectively

Pre injection skin thickness or PHA responses at 24 48 and 72 hours had no significant influence on adult body weights A thicker pre injection skin was significantly associated with a lowered litter size at birth and a high weaning litter size PHA responses at 24 48 and 72 hours had no significant effect on litter traits and pre weaning mortality Incidence of body mange was significantly higher in rabbits with a lowered PHA response at 48 hours Pre injection skin thickness or PHA responses at 24 48 and 72 hours had no significant effect on other diseases or adult mortality

Post challenge contact sensitivity to DNCB at 24 48 and 72 hours averaged 3 585 mm 1 796 mm and 1 085 mm respectively Contact sensitivity to DNCB at 24 48 and 72 hours was not significantly influenced by breed or sex

of rabbits Effect of sires within breed was not significant on contact sensitivity at 24 48 and 72 hours post challenge in Newzealand White and at 24 and 72 hours post challenge among Soviet Chinchilla rabbits Contact sensitivity at 48 hours post challenge was highly significant in Soviet Chinchilla Her tability estimates of 0 3820 0 5490 and 0 3039 respectively were obtained for contact sensitivity to DNCB challenge at 24 48 and 72 hours Adult body weights were not significantly associated with contact sensitivity to DNCB at 24 48 and 72 hours post challenge Litter size at birth litter size and weight at weaning had no significant correlation with contact sensitivity at 24 48 and 72 hours post challenge among the does significantly increased the pre weaning kit mortality and increased the litter weight at birth

Increased contact sensitivity at 24 hours significantly reduced the incidence of naturally occurring body mange among broiler rabbits Contact sensitivity to DNCB at 48 hours post challenge was also near significant on the incidence of body mange Incidence of coccidiosis and adult mortality was not found to be associated with contact sensitivity to DNCB challenge at 24 48 and 72 hours

SG level had a highly significant positive correlation of 0 271 with Frossman antibody titer to SRBC Correlation of Frossman antibody titre with antibody responses to BRBC during the first second and third week post immunisation was highly significant There existed a highly significant negative

correlation between skin thickness and PHA responses at 24 48 and 72 hours Correlations among PHA responses at 24 48 and 72 hours were highly significant Contact sensitivity reactions to DNCB challenge at 24 48 and 72 hours had also highly significant correlations among them Correlations of contact sensitivity to DNCB challenge at 24 48 and 72 hours with PHA responses at 24 48 and 72 hours were also significant

Selection based on maternal serum gammaglobulin level for enhanced pre weaning survivability and growth appears to be feasible Further researches on coccidial species in question and host defenses are required before any conclusion on coccidiosis resistant phenotype based on SG level is to be established Differences in sire effects among breeds for PHA responses and antibody response to BRBC is suggestive of the genetic structure of the Soviet Chinchilla colony derived from a few rabbits Associations between skin thickness PHA responses and weaning litter size prompt us to a speculation that enhanced maternal PHA responses are associated with lowered weaning litter size Increased incidence of body mange among rabbits with low PHA responses at 48 hours and low contact sensitivity to DNCB at 24 hours post challenge attribute the role of cell mediated immunity in the incidence of mange This study clearly indicated the existence of a genetic modulation of immune traits and the association of these traits with economic traits like litter traits and disease resistance

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GENETIC STUDIES ON THE IMMUNE RESPONSE OF BROILER RABBITS

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ABSTRACT OF A THESIS

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ABSTRACT

The scope and potential of broiler rabbit production as an alternate source of meat appears to be tremendous taking into account the unique biological attributes of rabbits However breeding experiments utilising temperate breeds like Newzealand White and Soviet Chinchilla under the humid tropics of the state revealed heavy pre weaning mortality high incidence of diseases sub optimal growth and reproduction Indirect selection for diseases resistance has been proposed as the most viable approach and immune responsiveness has been suggested as one of the best indicators of disease resistance

Serum gammaglobulin (SG) level Frossman antibody titer to SRBC antibody response to BRBC delayed type hypersensitivity (DTH) responses to intradermal injection of phytomitogen PHA M and contact sensitivity to DNCB challenge were assessed among 135 breeding rabbits below one year of age and belonging to Newzealand White and Soviet Chinchilla breeds The effects of breed sex sire and body weight on the above immune traits were analysed Heritability estimates were made for each of the above traits Association of diseases like coccidiosis mange and adult mortality with each of the above immune traits was worked out Association of maternal immune trait status with litter traits was assessed This research approach was aimed at developing an alternate breeding strategy in the indirect selection for disease resistance growth and viability

SG level ranged from 9 13 to 84 70 mg/ml with a mean of 28 59 mg/ml Soviet Chinchilla breed had a significantly (P = 0 048) higher SG level with a mean of 29 51 mg/ml compared to 27 25 mg/ml in Newzealand Whites differences among males and females were not significant

Sire effects was not significant on SG levels and heritability estimate was 0 1259 Adult body weight had no significant effect on SG level among broiler rabbits Association of SG level with litter size at birth was not significant But SG level had a highly significant effect on the litter size at weaning Correlation of SG level with pre weaning mortality (0 430) was highly significant (P ≤ 0 01) and negative litter weight at birth and at weaning were significantly correlated with SG level among broiler rabbits No significant association could be observed between SG level and the incidence of mange and adult mortality But a higher SG level among broiler rabbits was found to be significantly (P 0 0440) associated with the incidence of naturally occurring coccidiosis

Presence of Frossman s antibodies to SRBC was confirmed in adult rabbit sera The Forssman antibody titer ($1+\log_e$) ranged between 1 693 and 5 159 with a mean of 2 776 Breed and sex effects were not significant on Frossman antibody titer to SRBC Effect of sire on this trait was not significant and the heritability estimate was 0 360

Frossman antibody titer had no significant effect on adult body weight or litter traits among broiler rabbits Correlations of Frossman antibody titer of the dam with the litter weight at birth litter weight at weaning and pre weaning mortality were not significant No significant associations could be observed between Frossman antibody titer incidence of mange coccidiosis and adult mortality

Pre immunisation titer to BRBC among broiler rabbits was zero indicating the absence of Frossman antibodies to BRBC Antibody titers to BRBC ($1+\log_e$) were 4 594 4 425 and 4 311 respectively at the first second and third week post immunisation The highest antibody response was at the first week which began to decline gradually The influence of breed and sex on the antibody response to BRBC were not significant during the first second and third week post immunisation Sire effect was highly significant on the antibody response to BRBC during the first second and third week post immunisation in Newzealand White rabbits The effect of sire on antibody responses to BRBC was not significant during the first and third week post immunisation in Soviet Chinchilla breed though it was significant during the second week post immunisation The heritability estimates of antibody responses to BRBC were 0 9200 0 9400 and 0 9067 respectively during the first, second and third week post immunisation The correlations of adult body weight with antibody responses to BRBC during the first second and third week post immunisation were ( )0 244 ( ) 0 224 and

( )0 216 respectively The correlations were highly significant and negative

Antibody responses to BRBC during the first second and third week post immunisation was not significantly associated with litter traits among broiler rabbits The incidence of naturally occurring coccidiosis mange and adult mortality was not significantly associated with antibody response to BRBC

The mean pre injection skin thickness was 2 140 mm in Newzealand White and 2 224 among Soviet Chinchilla breed The mean PHA responses at 24 48 and 72 hours post injection were 2 259 1 544 and 0 778 mm respectively Breed effect was not significant on the pre injection skin thickness or on the PHA responses at 24 48 and 72 hours The effect of sex was highly significant in the skin thickness with males having a thicker skin compared to females The effect of sex on PHA responses at 24 48 and 72 hours was highly significant with a female superiority for DTH responses to PHA M The effect of sires was not significant on pre injection skin thickness Sire effects were highly significant on the PHA responses at 24 and 72 hours and approaching near significance at 48 hours in Newzealand White rabbits However sire effect was not found to be significant on the PHA responses at 24 48 and 72 hours post injection among Soviet Chinchillas Heritability estimates for pre injection skin thickness PHA responses at 24 48 and 72 hours were 0 7637 0 8600 0 6700 and 0 6370 respectively

Adult body weight was not significantly associated with the skin thickness and the PHA responses at 24 48 and 72 hours Litter size at birth was significantly less in thick skinned does though weaning litter size was significantly higher in them PHA responses at 24 48 and 72 hours had no significant effect on litter size at birth and at weaning or any other litter traits Pre injection skin thickness and PHA responses at 24 and 72 hours were not significantly associated with the incidence of mange coccidiosis and adult mortality But reduced PHA response at 48 hours significantly pre disposed the rabbits to body mange

Contact sensitivity to DNCB at 24 48 and 72 hours post challenge averaged 3 585 mm 1 796 mm and 1 085 mm respectively Breed and sex had no significant effect on the contact sensitivity to DNCB at 24 48 and 72 hours post challenge Sire effect on contact sensitivity to DNCB at 24 48 and 72 hours post challenge was not significant in Newzealand White rabbits Among Soviet Chinchillas also effect of sire was not significant on contact sensitivity to DNCB at 24 and 72 hours though highly significant at 48 hours Heritab lity estimates for contact sensitivity to DNCB at 24 48 and 72 hours post cl allenge were 0 3820 0 5490 and 0 3039 respectively Contact sensitivity to DNCB at 24 48 and 72 hours post challenge was not significantly associated with adult body weight litter size at birth and litter size at weaning contact sensitivity of the doe at 24 hours post challenge was positively correlated with pre weaning mortality and litter weight at birth

Lowered contact sensitivity to DNCB at 24 hours had a highly significant effect on the incidence of naturally occurring body mange among rabbit The incidence of mange was near significant level among broiler rabbits with a lowered contact sensitivity at 48 hours post challenge also No significant association could be observed with contact sensitivity to DNCB at 24 48 and 72 hours on the incidence of coccidiosis and adult mortality Correlations between serum gamma globulin level and Frossman antibody titer to SRBC (0 271) was highly s gnificant correlations of Frossman antibody titer with antibody response to BRBC during the first second and third week post immunisation was also highly significant

Pre injection skin thickness had a highly significant negative correlation with PHA responses at 24 48 and 72 hours Correlations among PHA responses at 24 48 and 72 hours were highly significant Similarly correlation among contact sensitivity reactions at 24 48 and 72 hours post challenge were highly significant PHA responses at 24 48 and 72 hours had significantly high correlations with contact sensitivity to DNCB at 24 48 and 72 hours post challenge

Prospects of utilising maternal serum gammaglobulin level as a marker in indirect selection for enhanced pre weaning survivability and growth appears to be promising Though increased SG level was found to be associated with the incidence of coccidiosis further researches on the coccidial species and host defenses are required before establishing a coccidiosis resistance phenotype

associated with this trait. The differences in sire effects among the two breeds for antibody response to BRBC and PHA responses are suggestive of the genetic structure of the two breeds, especially the Soviet Chinchilla colony developed from few animals. The significant negative correlation of adult body weight with antibody responses are indicative of lower antibody responses in heavier rabbits. Strong negative correlations between PHA responses and pre-injection skin thickness and a significant effect of contact sensitivity at 24 hours on reducing the litter size at weaning appear to suggest that a low maternal cell mediated immunity might enhance pre-weaning survivability of the kits. Significantly higher incidence of mange among rabbits with a lowered PHA response at 48 hours post injection and contact sensitivity at 24 hours post challenge suggest of an enhanced cell mediated immune response conferring mange resistance.